

# **A SYSTEMIC PARADIGM FOR EARLY IT SYSTEM REQUIREMENTS BASED ON REGULATION PRINCIPLES: THE LIGHTSWITCH APPROACH**

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## Abstract

IT system is a general term for all software based business applications used in enterprises. IT systems support the actions of an enterprise by processing information about the enterprise and its environment and by providing this information to the enterprise and its stakeholders. An enterprise's actions have a direct influence on its ability to succeed in its environment. IT systems, therefore, have a direct influence on the enterprise's long term success. Hence, IT systems are considered to be of strategic importance in most contemporary enterprises. Although enterprises, most of the time, attempt to maintain their identity, forces within them and in their environment push them to change. Enterprise strategy therefore seeks to balance the need to remain the same with the need to change. This balance is maintained by specifying change that the enterprise is capable of sustaining and that the enterprise believes are necessary for its continued success. The design of IT systems should reflect this need for stability and change.

The requirements of an IT system are the description of what the IT system will be like and how it will behave. The initial understanding of the requirements is called early requirements. Early requirements define the problems the enterprise is trying to solve and sketch the possible solutions to these problems. An envisioned IT system is often part of these solutions. Enterprise Architecture (EA) and Goal-Directed Requirements Engineering (GDRE) propose methods for defining early requirements by considering the goals of the enterprise and its stakeholders. The concept of goal is used to give structure to the different perspectives on the enterprise defined by its stakeholders and to express the resulting requirements for the IT system.

The EA and GDRE literature does not propose a conceptual foundation that gives meaning to the different kinds of goals specified by the EA and GDRE methods as well as how these goals are formed and modified in enterprises. Moreover, EA and GDRE methods are often influenced by Business Process Reengineering (BPR) which is known for specifying radical, often unsustainable change. The resulting early requirements specify goals that could have been changed or that specify too much change for the enterprise. The Lightswitch approach, described in this thesis, was designed as a tool for IT system designers to create initial requirements taking into account the enterprise's needs for stability and change in terms of goals.

The Lightswitch approach consists of a conceptualization and a modeling framework. The Lightswitch conceptualization explains the goal-directed behavior of enterprises from the standpoint of the maintenance of success in a changing environment. It is based on General Systems Thinking (GST) and Cybernetics principles. Combined, these theoretical perspectives offer an evolutionary viewpoint describing enterprises as systems that maintain their internal order by regulating their relationships with other systems. GST and Cybernetics offer a set of principles with which to understand this regulation. These principles are used in the Lightswitch conceptualization to explain how enterprises regulate their relationships with their stakeholders in order to remain successful. The Lightswitch conceptualization provides an explanation, in an enterprise context, of the different kinds of goals specified in the EA and GDRE literature.

The conceptualization forms the theoretical background of the Lightswitch modeling framework, a goal-directed modeling framework that enables IT system designers to specify early requirements for an IT system based on the enterprise's regulation of its relationships with its stakeholders. The Lightswitch framework complements existing EA and GDRE methods by enabling designers to model both the stability and the changing nature of the relationships of the enterprise with its stakeholders. These models help designers to better understand the enterprise's goals, to propose changes to these goals if deemed necessary, and to specify early requirements for the enterprise's IT systems in the form of high-level goals.

This thesis contributes an original conceptualization and method to EA and GDRE. Concretely, the Lightswitch approach consists in reflecting on the conditions that brought the enterprise-under-consideration to be what it is today, to analyze how well it is adapted to its present conditions, and to attempt to foresee some of the challenges it may face in the future. The early requirements for the IT system should reflect these past, present and future perspectives.

We present three case studies in which the Lightswitch approach was used to specify the early requirements for an enterprise IT system. Two of the case studies were performed in industrial settings.



## Version abrégée

Le nom de système IT sert souvent à désigner les logiciels, et leurs supports matériels, utilisés dans les entreprises. Les systèmes IT soutiennent les actions de l'entreprise en traitant l'information concernant l'entreprise et son environnement et en mettant cette information à la disposition de l'entreprise et de ses intervenants. Les actions que prend l'entreprise ont une influence directe sur son succès à long terme. Les systèmes IT sont donc considérés comme ayant une importance stratégique pour la plupart des entreprises contemporaines. La plupart du temps les entreprises essaient de maintenir leur identité alors que des forces internes et externes les poussent à changer. La stratégie d'entreprise cherche à maintenir un équilibre entre la nécessité de rester identique et celle de changer. Cet équilibre est maintenu en spécifiant des changements que l'entreprise est capable d'accepter et qu'elle juge nécessaires pour son succès à long terme. Le design de systèmes IT doit refléter cette nécessité d'équilibre entre stabilité et changement.

On appelle *les besoins* d'un système IT la description de ce que le système sera, ainsi que son comportement. La description initiale des besoins exprime les problèmes que l'entreprise cherche à résoudre et définit les solutions possibles à ces problèmes. Un système IT fait souvent partie de ces solutions. Les méthodes de gestion des besoins basées sur les buts (GDRE : Goal-Directed Requirements Engineering) et les méthodes d'architecture d'entreprise (EA : Enterprise Architecture) proposent d'identifier les buts de l'entreprise et de ses intervenants. Le concept de but est utilisé pour structurer les différentes perspectives concernant l'entreprise et les besoins du système IT qui en résultent.

La littérature concernant EA et GDRE ne propose pas un fondement conceptuel permettant de comprendre comment des buts sont formulés et modifiés dans l'entreprise. De plus les méthodes d'EA et GDRE sont souvent influencées par les principes de Business Process Reengineering (BPR), qui sont connus pour spécifier des changements radicaux et souvent non appropriés pour l'entreprise. Les besoins initiaux qui résultent de l'utilisation de ces méthodes spécifient des buts qui auraient pu être changés ou des buts qui impliquent un changement trop important pour l'entreprise. L'approche Lightswitch, décrite dans la présente thèse, est conçue comme un outil à l'aide duquel les concepteurs de systèmes IT peuvent créer des besoins initiaux qui prennent en compte la nécessité de stabilité et de changement de l'entreprise.

L'approche Lightswitch est composée d'un cadre conceptuel et d'un cadre de modélisation. Le cadre conceptuel permet d'expliquer le comportement *orienté buts* des entreprises, du point de vue de la maintenance du succès dans un environnement hostile. Ce cadre conceptuel est basé sur la théorie générale des systèmes et la cybernétique. Ces deux théories combinées offrent un point de vue évolutionniste qui décrit une entreprise comme un système qui survit et maintient son ordre interne en régulant des relations avec d'autres systèmes. La théorie générale des systèmes et la cybernétique proposent un ensemble de principes qui permettent de comprendre cette régulation. Ces principes sont utilisés dans le cadre conceptuel pour expliquer comment une entreprise régule ses relations avec ses intervenants pour maintenir son succès. Nous utilisons ce cadre conceptuel pour expliquer quelle est la signification, dans le contexte des entreprises, des différents genres de buts proposés dans la littérature EA et GDRE.

Le cadre de conceptualisation sert de fondement théorique au cadre de modélisation Lightswitch, un cadre de modélisation orienté buts, qui permet aux concepteurs de systèmes IT de spécifier des besoins initiaux pour le système IT en prenant comme point de départ la régulation des relations entre l'entreprise et ses intervenants. Ce cadre de modélisation enrichit les méthodes de EA et GDRE existantes en encourageant les concepteurs à modéliser aussi bien la stabilité que le changement des relations de l'entreprise avec son environnement. Ces modèles aident les concepteurs à mieux comprendre les buts de l'entreprise, à proposer des changements à ces buts si nécessaire, et à spécifier des besoins initiaux sous la forme de buts de haut niveau pour le système IT.

Cette thèse contribue à EA et GDRE en apportant un cadre de conceptualisation et une méthode originale. Concrètement, l'approche Lightswitch consiste en une réflexion sur les conditions qui ont amené l'entreprise considérée à être ce qu'elle est aujourd'hui, à analyser à quel point elle est adaptée aux présentes conditions et à essayer de prévoir certains des défis auxquels elle aura à faire face dans le futur. La description initiale des besoins du système IT devrait refléter ces perspectives passées, présentes et futures.

Nous présentons trois cas d'études dans lesquels l'approche Lightswitch a été utilisée pour spécifier les besoins initiaux de systèmes IT d'entreprise. Deux de ces cas d'étude ont été conduits dans des environnements industriels.



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## Preface

The main point of the Lightswitch approach is to ask “why”. When I was about 11 years old, I asked my mother, “when do children stop asking why?” She looked at me strangely and said, “oh when they’re about 40”. Being 40 years old now, I can see that my mother’s guess, which at the time seemed to me to be a wild and comic exaggeration, was actually a very conservative figure. There is no reason to stop asking why at any point in the life of person.

The goal-seeking worldview, as noted by Vickers (1987), does not handle these why questions very well, it only appears to be doing so. Vickers noted that when we move up the goal hierarchy, defined by the goal-seeking worldview as a given, by asking questions, we invariably arrive at a point when no “rational” answer can be given and we just stop there by saying that it is a goal that we have because we want to have it, or in Vickers’ (1987) terms “an action done for its own reason.” By choosing instead the worldview of relationship regulation, we can give an explanation to even these so called “high-level” goals that the goal-seeking worldview cannot explain. This explanation is not meant to be some doctrine of which we should not stray but rather a plausible explanation that is useful as long as it helps us to better understand the world.

The initial subject of my thesis was to encourage synthesis among managers with the help of collaborative learning tools. Even though this thesis is not explicitly about learning it does reflect about how we behave and why we behave in the way we do. This has much to do with learning. And so, I feel that this thesis has helped me tremendously to better understand myself, my family, and the society we live in. I also feel that the notion of synthesis; creating a pattern that was not there before by seeing new relationships between elements. The Lightswitch approach encourages a different point of view on enterprises and IT systems than the “traditional” goal seeking view. This alternative point of view focuses on relationships and the way they are managed and therefore encourages synthesis.

As I was writing the thesis contained in this book I very often had the thought that everything I could write was already said or written by someone else, possibly some very long time ago. However, if we only consider what other people have written in the past we wouldn’t create anything new. And the essence of life seems to be an incessant creation. One of the major requirements of a Ph.D. thesis is that it be an original work, meaning that the set of ideas expressed in the thesis have not been expressed before to the best knowledge of the candidate and the jury. In a world where millions of researchers work every day and have been working every day, for the last couple thousand years, on finding original ways to answer original questions this seems like a very serious requirement. To make sure that the ideas expressed in this thesis are original, meaning that they are new I had to read, and many times re-read, several dozen articles, books, abstracts of conference proceedings etc. And still I cannot be sure that no one has ever said what you are going to read. One possibility of making an original contribution in this setting is to narrow down the scope of what is written to a very specific field of study, say requirements engineering, and bring to this field of study a specific set of ideas from other sources. It is a safer bet that this set of ideas is new within this field. Also, the effect of this set of ideas on the prevalent ideas in this field is potentially greater than it would be in a more general setting. It is useful, in this context to quote John Dewey’s description of creativity (Barnes et al. 1994):

What is suggested must, indeed, be familiar in some context; the novelty, the inventive devising, clings to the new light in which it is seen, the different use to which it is put. When Newton thought of his theory of gravitation, the creative aspect of his thought was not found in its materials. They were familiar; many of them commonplaces—sun, moon, planets, weight, distance, mass, square of numbers. These were not original ideas; they were established facts. His originality lay in the use to which these familiar acquaintances were put by introduction into an unfamiliar context. The same is true of every striking scientific discovery, every great invention, every admirable artistic production. Only silly folk identify creative originality with the extraordinary and fanciful; others recognize that its measure lies in putting everyday things to uses which had not occurred to others. The operation is novel, not the materials out of which it is constructed.’

From Dewey’s text it is clear that any invention, small or great, is of this nature; the putting together of familiar material in a context in which it was not thought of before. Thus, introducing system science ideas into the disciplines of Enterprise Architecture and Requirements Engineering is an

invention, even though systemic ideas have been put forth a long time ago because as of yet, these ideas have not had the influence they over these disciplines.

The ideas expressed in this thesis are presented as largely coming from a number of external sources (most notably from system science), packaged in a way that they can be understood and used in a specific field (Enterprise Architecture and Requirements Engineering), and their potential influence on this field is discussed. Just like the systems I will be describing in this thesis, I undoubtedly had my own inclination to define what was relevant and what I wanted to concentrate on in the course of my research. The ideas expressed in this thesis although expressed as coming from external sources, have direct links with my whole life experience. Thus, when I sat down to write my first paper on goal modeling in the spring of 2001, I expressed my naïve ideas of the origin of goals with the following passage: “*Constraints limit our actions and are barriers for achieving our goals but they are also what makes us do things. We are, for instance, constrained by the amount of energy we can accumulate in our bodies. This constraint combined with our goal of surviving, forces us to eat on a regular basis. We then formulate goals such as obtain food, eat etc.*” I later dropped this passage from the paper I was writing because it was too naïve and I couldn’t find proven theoretical justification for what I was writing. Some six months later I read Weinberg and Weinberg’s book about regulation (Weinberg 1988) and finally understood that what I was saying in this passage is theoretically justified in the field of Cybernetics. In other words, as some of my Ph.D. colleagues experienced, I first had the intuitive ideas and then I found that someone has already said these things and put them in a coherent theory that I could use.

A PhD thesis is considered to be a one man show, but my observation is that this is rarely the case. A PhD candidate usually spends hours upon hours discussing his research ideas with others before these ideas can crystallize sufficiently to become expressible in a thesis. In my case, the discussions that influenced my thesis were conducted not only with my colleagues but also with my family and friends. This is probably due to the very general applicability of the system science principles used in this thesis. I am very grateful to all the people who knowingly or unknowingly helped me during these discussions. Naming all these people in a few lines is impossible and naming a few, leaving out the others is unfair. I will then simply say thank you everyone. I am sure you know you have helped.

Finally, I want to dedicate this book to my elder brother, Eli Regev, who passed away while I was doing the research for the thesis. Eli provided me the inspiration for the name Lightswitch for the approach I present in this thesis. You see, Eli was a very lazy person, in his room when he was a teenager the light switch was too far away from his bed. He couldn’t turn the light on and off while lying in bed. Eli loved to read and wanted to read before going to sleep, then switch off the light without getting out of bed, when he was ready to sleep. After having thought about this problem for a while, he set to work for many hours, how much I can’t tell. He drilled a tiny hole through the light switch (which was of the tilt kind) then threaded two long thin ropes, each tied on one end, through the hole. He then threaded these two ropes through a series of tiny metal brackets that he previously fixed into the wall until the two ropes arrived just above his head when he lied in bed. By pulling on one or the other ropes, Eli could finally switch the light on and off from his bed. Eli was a true engineer. His laziness lead him to work for days just to save himself from getting up every so often and switch the light off. Why did this story inspired me for this thesis? Maybe it was just because I wanted to find some special name for the approach I have developed. But maybe there’s more to it. Maybe it is the notion of investing some effort into modeling and engineering to save time down the line. Maybe it is just the opposite, instead of working so hard, why hadn’t Eli simply installed a reading lamp next to his bed? Or maybe I like the choice of the name Lightswitch simply because it reminds me that I want to see the approach described in this thesis as a so-called light weight approach, i.e. an approach that gives guidance to people but is not too prescriptive. Well, I guess that my final point is I can find as many interpretations as I want as to why I used this little story here and depending on these interpretations my conclusions will be all different. This is exactly what my thesis is about.

# 1 Introduction

The subject of this thesis is the definition of early requirements for enterprise IT<sup>1</sup> systems. IT systems is a general term for all software-based business applications used in enterprises, such as databases, Web servers, e-commerce applications, decision support systems, etc.

The requirements of an IT system are the description of what the IT system will be like and how it will behave. Several research fields share an interest in the definition of requirements for IT systems. The main fields we will mention are Requirements Engineering (RE), Information Systems (IS) and Enterprise Architecture (EA). We can distinguish between these disciplines by specifying their main interests. RE is interested in methods for eliciting, analyzing, and maintaining requirements. IS is more interested in the organizational issues surrounding the definitions of requirements from the point of view of the sharing of information in an enterprise. EA is interested in the concurrent design of the enterprise and its IT systems.

It is generally believed that some requirements are needed before an IT system can be developed. There is an on-going debate regarding the extent to which these requirements need to be specified in detail. This debate opposes those who believe that requirements need to be specified in great detail before the system building phase can begin with those who believe that detailed requirements cannot be defined independently of the building of the IT system. However, even those who do not believe in detailed requirements do acknowledge that some initial understanding of the problem to be solved and how the IT system should behave is needed. For example, the proponents of so called eXtreme Programming (XP) methods promote requirements in the form of stories that describe how the IT system will be used and what it will do for its users.

This initial understanding is called *early requirements* (Mylopoulos et al. 2001). The Lightswitch approach, described in this thesis, focuses on such early requirements and thus can be used by IT system designers on both ends of the detailed requirements scale.

Traditionally, requirements were specified by focusing on the interactions between the IT system and its users and by merely specifying what the system should do for them. This resulted in software requirements specification documents (IEEE 1998) that described required IT system properties such as: "The system shall respond to users' requests in less than 1 second." Gradually, it was felt that requirements of this kind did not contain the reasons for which they were specified, the so-called design rationale. It is now acknowledged that the reasons for specifying a given requirement are to be found in the environment of the IT system (Zave and Jackson 1997). A gradual shift in focus has occurred in recent years. We now aim at specifying and maintaining the link between requirements of the kind mentioned above and the environment of the IT system. This environment is considered to be the enterprise for which the IT system is designed. This also resulted in a shift from designing the IT system solely for its users to designing the IT system by also taking into consideration all the entities (people, departments etc) who had an interest in the results produced by the IT system, whether they are its direct users or not. These entities are called stakeholders.

The methods resulting from this effort, which we call goal-directed methods, are mainly based on the identification of an enterprise's goals and the transformation of these goals into requirements (van Lamsweerde 2001), (Mylopoulos et al. 1999), (Anton 1997). This transformation is achieved mainly by asking how a given goal can be achieved (i.e. reducing goals into subgoals) thereby creating so-called *and/or* graphs of goals in a top-down fashion (Dardenne et al. 1993). These graphs can also be constructed bottom-up. By asking why a given goal needs to be achieved, designers can identify higher level goals. Goal-directed methods combine both top-down and bottom-up analyses (van Lamsweerde 2001). This technique is also known as means/ends analysis. By using goal-directed

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<sup>1</sup> IT is a common abbreviation for Information Technology. Appendix C contains the meanings of the abbreviations used in this thesis.

techniques, it is possible to (Dardenne 1993), (Anton 1997), (Mylopoulos et al 1999), (van Lamsweerde 2000), (van Lamsweerde 2001), (Rolland 2003):

- identify and maintain some links from enterprise goals to IT system requirements, called pre-traceability in (Rolland 2003), so that when enterprise goals change, it is, in principle, possible to change the requirements
- identify and consider the relevance of alternative ways of satisfying a given goal
- identify and resolve conflicts arising from stakeholders' conflicting goals

Goal-directed methods focus on goals that represent targets for achievement, so-called achievement goals. This kind of goal specifies states that stakeholders want to reach with the help of the IT system. The focus on achievement goals is explained by the fact that they can be directly reduced into requirements for the IT system, i.e. actions that the IT system needs to take. Two other important kinds of goals have nonetheless been defined in goal-directed methods: Goals that specify states that stakeholders wish to maintain or avoid are called maintenance goals (Dardenne et al. 1993), (Anton 1997), and goals that do not have a clear cut criteria for achievement, i.e. where the states that stakeholders want to reach cannot be clearly defined, are called softgoals.

Considering an enterprise such as a library, for example, it is possible to identify a borrower's achievement goal "loan book." The state to be reached is for the book to be in the loaned state. This goal can be reduced into the achievement goal "Register loan." This goal can be assigned as a requirement for the library's IT system. The requirement specifies an action that needs to be taken by the IT system when a borrower wishes to loan a book. An example of a maintenance goal of the library is to "maintain books available to borrowers." An example of a softgoal of the library is to keep its borrowers satisfied with its service.

The proponents of goal-directed methods consider that goals represent aspects that are strategic to the enterprise. Van Lamsweerde, for example, states that

"a goal refinement tree provides traceability links from high-level strategic objectives to low-level technical requirements. In particular, for business application systems, goals may be used to relate the software-to-be to organizational and business contexts."

The insistence on strategic objectives is symptomatic of the fact that IT systems have become strategic assets for enterprises. However, enterprises, just like IT systems, also evolve in an environment with which they interact. An enterprise's strategy is formed from the enterprise's interaction with its environment. Hence to define requirements for an IT system, designers need to understand both the enterprise and its environment. It is therefore useful to introduce the concept of a stakeholder of an enterprise, which is analogous to the stakeholder of an IT system introduced above, i.e. an entity (person, or enterprise) that has an interest, a stake in the enterprise under consideration. Examples of stakeholders of an enterprise are its employees, customers, investors, suppliers, etc.

IT systems support the actions of an enterprise by processing information about the enterprise and its environment and providing this information to the enterprise and its stakeholders. The enterprise's actions have a direct influence on its ability to succeed in its environment. IT systems, therefore, also have a direct influence on the enterprise's success. Hence, IT systems are considered to be of strategic importance in most contemporary enterprises.

The relationship between an enterprise's strategy and its IT systems is bidirectional. On one hand the IT systems should be designed to support the enterprise's strategy. On the other hand the potential designs of the IT systems influence the range of possible strategies available to the enterprise.

In this thesis, we argue that goal-directed methods focus on the analysis of achievement goals and their translation into IT system requirements, whereas strategy is a continuous process in which the enterprise attempts to maintain success in a changing, often hostile environment. This continuous success is dependent on the enterprise's ability to properly act on the environment and to adapt to it when necessary. In other words, it means that the enterprise needs to manage its relationship with its stakeholders in a way that insures its continuous success, balancing both stability and change (Vickers 1987), (Weinberg and Weinberg 1988), (Mintzberg et al. 1998).

To properly design enterprise IT systems, IT system designers need tools that help them to model this process of balancing stability and change. Current goal-directed methods predominantly subscribe to the Business Process Reengineering (BPR) that prescribes radical change. We therefore propose a modeling framework, called Lightswitch, which complements existing goal-directed methods by taking the continuous process of strategy making and the balancing of both stability and change into consideration. The Lightswitch framework can be used to define the early requirements for an IT system. The Lightswitch framework consists of a set of modeling concepts and a process. The Lightswitch framework can be used by designers to analyze how an enterprise manages its relationships with its stakeholders, and to propose changes to this management based on changes in the enterprise or its environment, such as stakeholders' changing desires or changes in IT system's capabilities.

Since the management of relationships with stakeholders is a continuous process, in the Lightswitch models we use both maintenance and achievement goals, but we focus primarily on maintenance goals. To manage its relationships with stakeholders, an enterprise uses its understanding of stakeholders. This understanding is perfected by the enterprise over time and becomes part of its being. We use the concept of *belief* to represent this understanding that the enterprise has of its stakeholders. In these models we use beliefs to motivate the way a goal is reduced into subgoals. These beliefs are not considered as objective accounts of the environment of the enterprise but rather as the enterprise's particular understanding of this environment. This is different from other goal-directed methods where goal refinement is considered to proceed with objective knowledge of the environment and where this knowledge is not made systematically apparent in goal refinement trees (Dardenne 1993), (Anton 1997), (Rolland et al. 1998), (ITU 2001). The advantage of using beliefs is the ability to systematically and explicitly consider the point of view of the enterprise and its stakeholders when modeling their behavior.

The Lightswitch models are created by designers through the application of a modeling process. During this process, designers:

- identify the relationships between the enterprise and its stakeholders and create models of these relationships
- analyze how these relationships are managed
- consider the changing conditions in the enterprise and its environment
- propose, based on these changing conditions, and evaluate options for managing the relationships differently with the help of IT systems
- evaluate conditions that will prevent the enterprise from adopting the proposed changes

Based on these models, the designers can then propose changes to the enterprise. The practical usefulness of the Lightswitch modeling framework was evaluated in three case studies, two of which were performed in industrial settings.

In order to build the Lightswitch framework, we created a theoretical perspective of the subject matter of enterprises that we call the Lightswitch conceptualization. This conceptualization is based on General Systems Thinking (GST) and Cybernetics. General Systems Thinking, also called Systems Thinking or Systems Theory, is defined by Heylighen and Joslyn as:

“the transdisciplinary study of the abstract organization of phenomena, independent of their substance, type, or spatial or temporal scale of existence. It investigates both the principles common to all complex entities and the (usually mathematic) models that can be used to describe them.” (Heylighen and Joslyn 1999)

Cybernetics is defined by Adams as:

“the study of the communication and manipulation of information in service of the control and guidance of biological, physical, or chemical energy systems...Feedback and feedforward, the basic ingredients of cybernetic processes, involve information-as what is fed forward or backward-and are basic to processes such as homeostasis in biological systems, automation in industry, and guidance systems. Of course, their most

comprehensive application is the purposive behavior (thought) of cognitively goal-directed systems such as ourselves.” (Adams 1999)

Combined, these theoretical perspectives offer an evolutionary viewpoint taking as a point of departure the second law of thermodynamics. This law specifies that closed systems that have no relationships with other systems evolve toward increasing disorder. Systems, therefore, survive and maintain their order because they regulate their relationships with other systems. GST and Cybernetics offer a set of principles with which to understand this regulation. These principles are used in the Lightswitch conceptualization to explain how enterprises regulate their relationships with their stakeholders.

The Lightswitch approach provides an evolutionary viewpoint that encourages designers to reflect on what brought the enterprise to be what it is today, to analyze how well it is adapted to its present conditions, and to attempt to foresee some of the challenges it may face in the future. The early requirements for the IT system should reflect these past, present and future perspectives.

Cybernetics, in particular, explains the goal-directed nature of organized entities. The Lightswitch conceptualization, therefore, is useful for building our modeling framework. But it is also useful as a theoretical explanation of existing goal-directed methods. We see this as a contribution to EA and GDRE as it gives more meaning to the different kinds of goals defined in these methods than is available in EA and GDRE literature.

We thus improve the state of the art in goal-directed methods by:

- proposing a modeling framework that enables designers to analyze the management of relationships between an enterprise and its stakeholders and derive IT system goals with the use of maintenance goals, achievement goals and beliefs
- proposing a conceptualization of the subject matter of enterprises that gives a theoretical perspective on goal-directed methods, thus enabling a better understanding of them
- proposing improvements to these methods based on this conceptualization

The concept map in Figure 1.1 gives an overview of the thesis and describes the main relationships between the Lightswitch approach and the subjects that we explore in the thesis. The topmost frame describes the ten schools of thought of strategic management defined by Mintzberg et al. (1998), The next frame down describes the System Theory perspectives, The third frame describes the IS schools of thought as defined by Checkland, the lowest frame describes the existing methods that we seek to augment. The Lightswitch approach is represented in this last frame. It is shown as related to GDRE methods, the soft systems schools, GST and Cybernetics, as well as to the Configuration school of Mintzberg et al. Since the Configuration school takes what is most interesting in the nine other schools, we use the relationship between Lightswitch and the Configuration school as shorthand, meaning that Lightswitch has many relationships with the nine other schools described by Mintzberg et al.

The notation used to represent the Lightswitch models throughout this document is based on the Unified Modeling Language (UML), a graphical notation used mainly to model software systems. UML has become the de facto industrial standard in the software engineering and IT systems disciplines (OMG 2003). The graphical notation of UML may not be very appealing to people unfamiliar with software engineering and is not expected to be immediately understandable to stakeholders. However, the Lightswitch notation uses only a small subset of the numerous UML symbols. Thus by not introducing any new symbols, this should make it usable to designers accustomed to UML.

This document is composed of three parts:

- In Part 1 we describe the context surrounding the Lightswitch approach: In Chapter 2 we describe the schools of thought in strategic management and IS. In Chapter 3 we describe the state of the art in EA and RE methods. This enables us to define what we see as missing in EA and RE with respect to strategic management.

- In Part 2 we describe our contribution, the Lightswitch approach: In Chapter 4 we describe the conceptualization of the subject matter of enterprises. In Chapter 5 we describe the modeling framework and the contributions that we see in this work for some EA and GDRE methods.
- In Part 3 we describe the validation of the Lightswitch approach: In the form of three case studies. In Chapter 6 we describe the case study of the University of Kent at Canterbury's Templeman Library. In Chapter 7 we describe the case study of a hospital sterilization department. In Chapter 8 we describe the case study of an engineering department in a commercial enterprise.

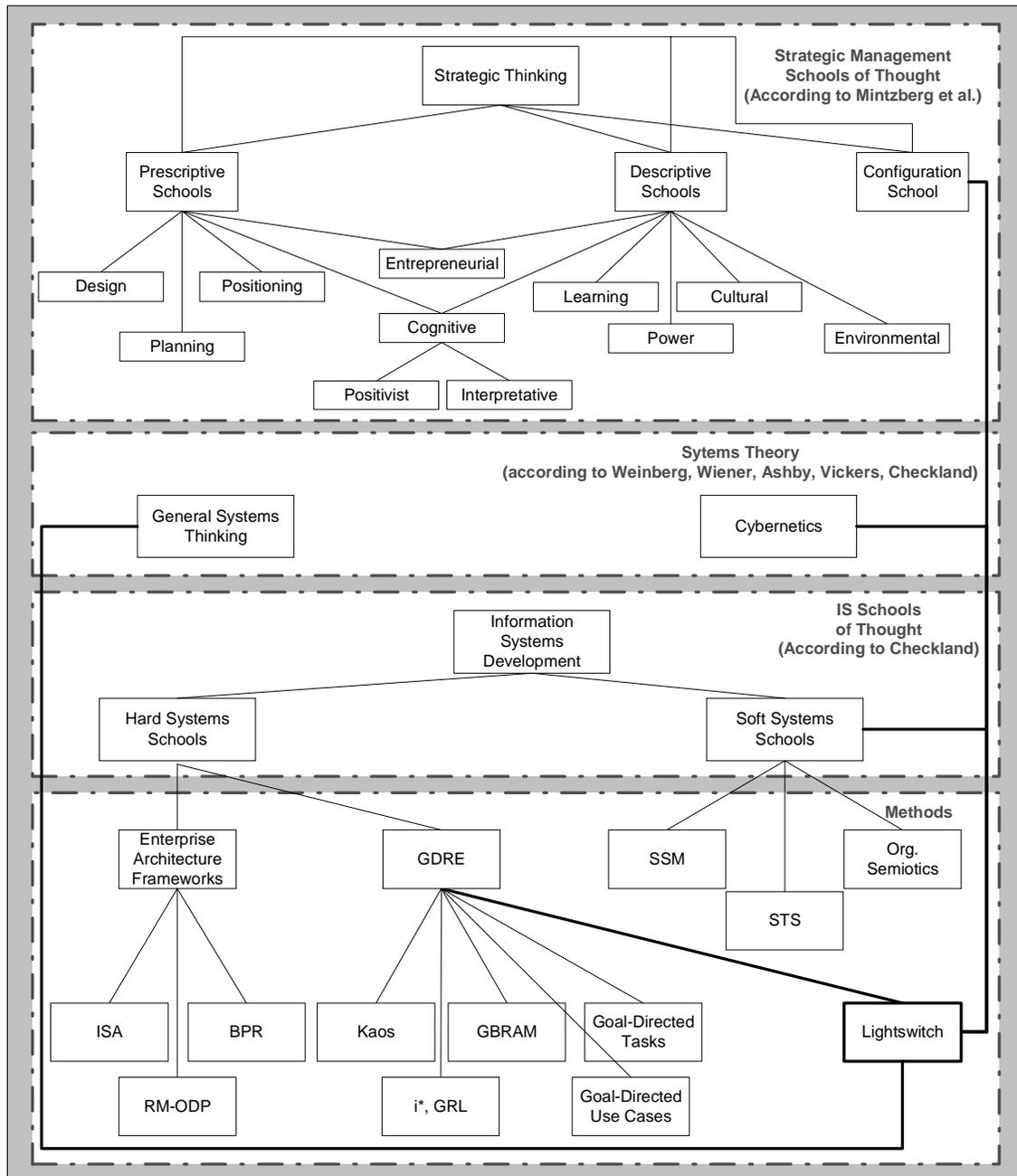


Figure 1.1 Concept map of thesis and the positioning of Lightswitch



# Part 1

## The Context

In this part we present the problems we have identified in the current methods for defining high-level goals for enterprise IT systems. Increasingly, IT systems are considered as strategic assets of an enterprise because the IT systems' capabilities have the potential of influencing the strategic directions of the enterprise. Hence, we begin by exploring the subtleties of strategic management. In Chapter 2 we explain the strategic nature of IT systems. We then give an overview of strategic management schools of thought and IS schools of thought. In Chapter 3 we present an overview of some of the more influential Enterprise Architecture (EA) frameworks and Requirements Engineering (RE) methods that have been developed in recent years.

We will show that most EA and RE methods are built on the traditional notion of strategy as a plan to achieve well defined goals. In the review of strategic management schools of thought we will show that there's more to strategy than this traditional view. In particular, we will show that an interesting question is how the strategic goals are defined in the first place. Most RE methods ignore this question and focus instead on the plans necessary to achieve the strategic goals. It is supposed that the way goals are achieved needs to be analyzed in detail and that the formation of these goals is of lesser importance. This lack of attention given to the formation of goals leads to either the automation of processes that can be changed, or to radical change that is inappropriate to the enterprise. The Lightswitch approach was designed to address these issues by enabling designers to better understand why an enterprise has a given set of goals rather than any other goals. With this understanding it is possible to explore areas of improvement with the help of IT systems. This search for improvement may very well lead to a change in the goals of the enterprise.



## 2 IT Systems, Strategic Management, and Information Systems

IT systems consist of computers, networks and the business applications running on them. Information Systems (IS) are generally thought of as consisting of IT systems and people who manage the information contained in these IT systems (Checkland and Holwell 1998), (Flynn 1992, p. 25)<sup>1</sup>. IT systems are usually classified into several types of systems. These classification schemes correspond both to the way IT systems evolved since the introduction of computers into enterprises and the functions they fill in the enterprise. Flynn (1992), for example, lists the following types of IT systems: Transaction Processing Systems (TPS), Decision Support Systems (DSS), Real Time Systems, Database Systems, Expert and Knowledge Based Systems. Neumann (1994) defines 4 basic types of IT systems listed below in the chronological order of their introduction into enterprises:

- Transaction Processing Systems (TPS),
- Management Information Systems (MIS),
- Decision Support Systems (DSS),
- Strategic Information Systems (SIS).

For Neumann, TPSs have emerged in the 1960s with mainframe computers. MISs emerged in the 1970s with the widespread use of minicomputers. DSSs emerged in the 1980s with the advent of the personal computer. And the focus on SIS has emerged in the late 1980s. Neumann states that Strategic Information Systems (SIS) are:

“those information-technology-based systems that support organizations in their quest to survive or succeed in their competitive arenas” (1994, p. vii).

For Neumann, what is common to all types of enterprises, be they business firms, monopolies, not for profit institutions, etc. is

“the potential for using information technologies to improve their relationships with their stakeholders- customers, creditors, employees, competitors, communities, stockholders, regulators, and suppliers.” (1994, p. vii).

Thus, both the IT system and the enterprise have stakeholders. This situation is described in Figure 2.1 where stakeholders are represented as internal to the enterprise (e.g. employees) and external to the enterprise (e.g. customers, suppliers). Internal stakeholders of the enterprise are stakeholders of the IT system as a function of the work they perform for the enterprise. External stakeholders may also be stakeholders of the IT system (e.g. External Stakeholder 2) since they may interact with it directly, e.g., customers using a company’s Web site or virtual store, a supplier connected to the company’s extranet.

Neumann classifies an IT system as an SIS not on the basis of the type of IT system but on the basis of the way it is used in an enterprise, stating that

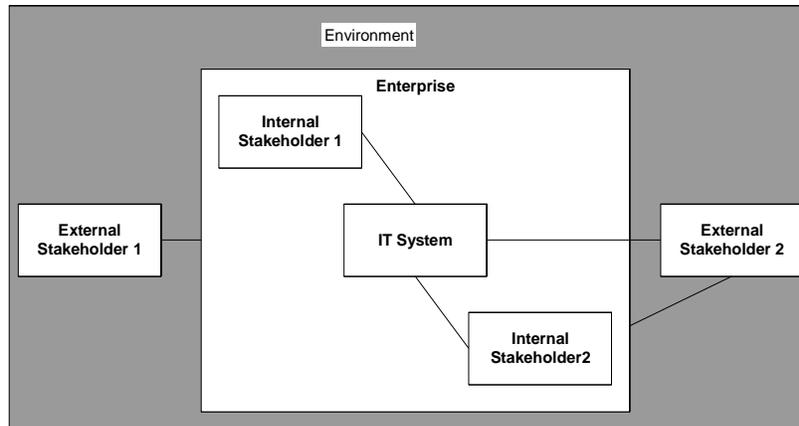
“The importance of being classified as strategic is not so much with what type of information system is built but with how the system is used” (1994, p. 22).

Hence, any IT system, be it a TPS, MIS, DSS etc., can be considered as strategic, i.e. as an SIS.

The way the IT system is used should be reflected in improvements in the relationships with the enterprises stakeholders. Thus, the focus of attention during an IT system development should be on the understanding of the relationships the enterprise manages with its stakeholders, the role of an IT system being defined in terms of its potential influences on these relationships.

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<sup>1</sup> Within the context of this thesis we chose to use the term IT systems rather than the more general term of IS. However, we will use the term IS when quoting or discussing the works of some researchers who explicitly use the term IS., such as Neumann etc,



**Figure 2.1 Stakeholders of IT system and stakeholders of enterprise**

If the IT system's role is to enable the enterprise to improve its relationships with its stakeholders, this means that the current state of these relationships is considered as being improvable, i.e., it is desirable to do better. Thus, an IT system development is generally undertaken when a problematic situation is identified in the enterprise. An IT system is envisioned as being part of the solution to this problematic situation. The IT system's part in the solution is the provision of information to the enterprise and its stakeholders and the automation of some of the activities that the enterprise and its stakeholders perform. However, an IT system may be strategic even if it improves the enterprise's relationships with stakeholders without directly interacting with these stakeholders. This is probably the case of most strategic IT systems with respect to external stakeholders. They are used internally in the enterprise and help the enterprise to improve its relationships with its external stakeholders. But the external stakeholders don't interact directly with the IT system.

In view of the above, any IT system has the potential of being strategic for the enterprise. So how can we know which IT system is or can become strategic? In other words, how do we know what relationships an existing or envisioned IT system influences and which of these relationships are strategic for the enterprise? Having defined SISs as information systems that improve the relationships of the enterprise with its stakeholders and thus contribute to the success or survival of the enterprise, Neumann defines the term strategy as:

“a broad course of action that an organization adopts to reach corporate objectives” (1994, p. 62).

This definition and variants of it are very common in the strategic management literature (Mintzberg et al. 1998, p. 9). Moreover, as we will see later, they are taken as a given in most of the approaches for IT system development. The problem is that these definitions only refer to objectives and not to the relationships of the enterprise with its stakeholders. Thus, the link between stakeholders' relationships and the objectives remains unspecified.

It seems that we need a better understanding of strategic issues and strategies as they are understood by contemporary managers. In Section 2.1 we provide an overview of these issues based on a review of the field of strategic management schools of thought performed by Mintzberg, Ahlstrand and Lampel (1998). In Section 2.2 we provide a discussion of the related issue of IS schools of thought as defined by Checkland et al. As we will see, some of the main issues raised about strategic management by Mintzberg et al. can also be identified in the issues raised about IS by Checkland et al.

## **2.1 Strategic management schools of thought**

Strategic management is preoccupied by the achievement and maintenance of a competitive advantage. Maintaining a competitive advantage is seen as the necessary condition for the long term success or survival of the enterprise. The way by which this survival is achieved is what we usually call strategy.

Mintzberg et al. (1998) distance themselves from simple definitions of strategy such as the one given by Neumann above. Rather than relying on one definition of strategy, Mintzberg et al. provide a definition in five parts (1998, p. 9-13):

- 1 **Strategy as a plan of actions:** given an objective, define a plan of actions to achieve the objective. Focus on control making sure that top management's intentions are realized.
- 2 **Strategy as a pattern of actions:** retrospective analysis of performed actions. Focus on emergence and learning.
- 3 **Strategy as position:** what position to occupy within an environment such as a niche in a market.
- 4 **Strategy as perspective:** "an organization's fundamental way of doing things."
- 5 **Strategy as a ploy:** a specific "maneuver" intended to outwit an opponent or competitor."

Part 1, strategy as a plan of actions, corresponds to the traditional definition of strategy. Mintzberg et al. argue that strategies can be seen as deliberate, i.e., the result of explicit plans defined for achieving explicit objectives

Part 2, strategy as a pattern of actions, represents the strategy that is developed when the actual course of action of an enterprise doesn't lead to the intended objective, or when this course of action doesn't even follow a pre-defined plan. Some enterprises evolve with no explicit objective and therefore no explicit strategy. However, both an objective and a strategy can be deduced from their past behavior.

Part 3, strategy as position, says that when a strategy is deliberate, it may specify a position that the enterprise may want to occupy in its environment. Even when the strategy is not deliberate, retrospectively the enterprise may find itself in such a position.

Part 4, strategy as perspective, constitutes a broader view of the position defined in part 3, i.e., whereas some people will have a very narrow view of this position, others may see it more broadly as what is unique about the way the enterprise behaves, as a perspective.

Part 5, strategy as a ploy, can be seen as either deliberate or retrospective. An enterprise can deliberately create a ploy or it can retrospectively find that it has created one.

Thus for Mintzberg et al. there are intended, deliberate strategies and realized strategies, strategy as a plan and strategy as a pattern of realized actions. Parts 1 and 2 can be seen as an orthogonal dimension to the other parts. When a strategy is deliberate, clear corporate objectives may be identified whether to create a part 3, 4, or 5 kind of strategy. Such clear objectives will be difficult to define before their achievement when the strategy is seen as a pattern of actions or as a perspective.

For Mintzberg et al. the essence of strategic management doesn't reside in adopting one or the other of these definitions but in insuring "coherence in action" (1998, p. 189). Whether this coherence is realized after the actions have been taken (retrospective) or planned in advance (deliberate). But coherence in action implies the existence of some stability. With no such stability the actions get changed all the time and no coherence is achieved, whether deliberate or retrospective. This stability, however, blinds the enterprise to changes in its environment because the enterprise needs to take some things for granted in order to focus on the strategy. Environments eventually change and render the strategy inadequate, requiring a change. Thus, strategic management is about knowing what to change and when, or in other words, to manage both change and stability (p. 15-18). Hence, Mintzberg et al. state that:

"while its literature makes clear that it is about change, strategy itself is not about change at all, but about continuity-whether as deliberate plan to establish patterns of behavior or as emergent pattern by which such patterns get established." (p. 302).

Mintzberg et al. describe ten schools of thought in the field of strategic management. These schools are the following: Design, Planning, Positioning, Entrepreneurial, Cognitive, Learning, Power, Cultural, Environmental, and Configuration. Mintzberg et al. categorize these schools into a second category level that has to do with the degree to which these schools are prescriptive, i.e. to what degree these schools view strategy formation as a top down, planned, implemented, and controlled

process. The position in the list of schools above represents the degree to which Mintzberg et al. consider a school to be prescriptive. The first three schools (Design, Planning, and Positioning) emphasize this rational process by defining strategy as something that is formulated by the top management of an enterprise, implemented by its members, and the degree to which it is attained is controlled by top management. The other seven schools are described in somewhat the order of their adherence to the prescriptive view.

As noted by Mintzberg et al. themselves, the categorization into these ten schools is far from absolute. It corresponds only to Mintzberg et al.'s model of the field of strategic management. As such it enables to present and to reflect on this field. Research and probably even more so, practice in this field often groups several fields together.

In Sections 2.1.1 to 2.1.10 we present the ten schools in the order in which they are presented in Mintzberg et al.

### **2.1.1 The Design School**

Mintzberg et al. credit the books written by Selznick in 1957 and Chandler in 1962 as having laid the foundation for the Design school. Most of their material concerning this school, however, is borrowed from the Harvard Business School's textbook: "Business Policy: Text and Cases...which first appeared in 1965 (by Learned, Christensen, Andrews, and Guth)" (p. 25). Mintzberg et al. single out Andrews as being the author of the text portion of this book, which they claim is "the most outspoken and one of the clearest statements of this school" (ibid).

The Design school is described as the most influential of the ten schools. The main premise of this school is "a model of strategy making that seeks to attain a match, or fit, between internal capabilities and external possibilities" (p. 24).<sup>1</sup> It is within this school that the popular SWOT analysis tool was formulated (p. 24). SWOT analysis describes internal capabilities as Strengths or Weaknesses and external possibilities as Opportunities or Threats. This analysis enables managers to design several alternative strategies and select one of them as the one to be implemented.

This school laid the foundations to the following beliefs:

- Strategy making occurs in three separate phases: formulation of the strategy, implementation of the strategy, control that the implemented strategy corresponds to the one that was formulated. "Action must flow from reason; effective strategies derive from a tightly controlled process of human thinking" (p. 29). It is only when a strategy is fully described that it is ready to be implemented. Hence, the strategy formulation is kept separate from its implementation.
- The formulation and control phases are performed by the Chief Executive Officer (CEO) with the aid of the board of directors "through elaborate planning, budgeting, and control systems" (p. 31).
- Strategy formulation should be a "tightly controlled process of human thought" (p. 29). The contents of strategy, on the other hand, are the product of creative insights. This prevents the Design school from saying much about the content of strategies or give details about how they formulated other than saying that they emerge through the hard thinking of the CEO.
- The strategy formulation process and the strategies themselves should be kept simple. Hence, the Design school prescribes that the strategy formulation process is both a formal process and an informal, simple one. Mintzberg et al. thus state that this "forced Andrews to tread a fine line throughout his text between nonconscious intuition on one side and formal analysis on the other, a position characterized as 'an act of judgment'" (p. 31).

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<sup>1</sup> In the field of IS, this fit between IS strategy and structure on one hand and enterprise strategy and structure on the other hand is actively being researched today (Chan 2002, Sabherwal et al. 2001).

- Strategies should be made explicit: “Strategies should be explicit to those who make them, and if at all possible, articulated so that others in the organization can understand them” (p. 32). In other words, by making strategies simple, management simplifies a complex reality enabling consistent actions to be taken by the enterprise.
- Strategies should be made specific to each enterprise with regard to its specific situation. This means that both the enterprise’s environment and its capabilities are specific to the enterprise. Moreover, Mintzberg et al., quote Selznick as saying: “commitments to ways of acting and responding are built into the enterprise,” (p. 27). In other words, the enterprise’s understanding of its capabilities and the possibilities in its environment are a basic part of its character.

Mintzberg et al. state that some of Selznick’s initial attention to the influence of values and ethics in strategy making were not given much attention in later works within this school. They refer to values and ethics as “managerial values-the beliefs and preferences of those who formally lead the organization, and...social responsibilities, specifically the ethics of the society in which the organization functions, at least as these are perceived by its managers.” They pursue by saying: “With the notable exception of Selznick (1957), however, most authors associated with this school do not accord a great deal of attention to values and ethics.”

Mintzberg et al. offer the following points in their critique the design school:

- The insistence on analysis and design rather than learning. The SWOT analysis for instance is supposed to be done by pure analytical reasoning without testing the results in real situations. Thus, an enterprise would perform its SWOT analysis then formulate a strategy without attempting to test whether the strengths it think it has really are strengths in real situations or whether the opportunities it sees in the environment can actually be exploited. So, even though the tenants of this school admit that it is difficult for individuals and businesses alike to know themselves [p. 27], they have failed to integrate learning that bridges thought and action through feedback. This absence of learning is also visible when it comes to the strategy formation process which favors a linear model of formulation, implementation, and control with no feedback loop.
- A very closely related critique is that the Design school sees the structure of the enterprise as a function of the strategy. Top management defines a strategy and designs an organizational structure that should implement this strategy. This model ignores situations where an existing structure influences the strategy or when the structure prevents some strategies from being implemented.
- The insistence on simple strategies influences managers into designing oversimplified strategies.
- Making strategies explicit promotes inflexibility. Once a strategy is defined, it takes a life of its own. This means that changing the strategy becomes more difficult than if it remained implicit.

The principles originally defined within this school may not be in use as they were defined but have evolved into the other two prescriptive schools, i.e. Planning and Positioning. Having extensively critiqued the Design school Mintzberg et al. do credit it as having “developed important vocabulary by which to discuss grand strategy” (p. 45) and by providing “the central notion that underlies so much of the prescription in the field of strategic management, namely that strategy represents a fundamental fit between external opportunity and internal capability.”

### 2.1.2 The Planning School

Mintzberg et al. credit Ansoff with the foundation of the Planning school. They describe the planning school as having borrowed most of the ideas of the Design school except for the idea that strategies should be simple and informal and the idea that strategies are formulated by the CEO. Instead, the planning school prescribes the process of *Strategic Planning*. Strategic planning is a formal process

aiming at defining formal plans for strategic objectives. These objectives are defined as goals that were formalized to the point of being quantified (p. 49). Thus, Mintzberg et al. state that

“it has almost inevitably been the planning people who have tried to distinguish goals from strategies, while subscribers to the design school rarely did so” (p. 51).

Thus for Mintzberg et al. the design school focused more on values or goals (non-quantified) while the planning school focused on quantified goals, i.e. objectives and separated their formulation from the strategy formulation. However, Mintzberg et al. state that “Values, or goal, as anyone in the design school is happy to tell you, are very difficult to formalize” (p. 51). This requirement is still felt today since, as we will see, most of the EA and RE methods specify the need to formalize goals, i.e. to express them in explicit and measurable terms.

Strategic planning turned the informal process of strategy formulation prescribed by the Design school into a highly formal process. It also made the Design school’s simple strategies into highly elaborate strategies with numerous hierarchical levels. Thus Mintzberg et al. state that most strategic planning models

“reduce to the same basic ideas: take the SWOT model, divide it into neatly delineated steps, articulate each of these with lots of checklists and techniques, and give special attention to the setting of objectives on the front end and the elaboration of budgets and operating plans on the back end” (p. 49).

Mintzberg et al., generalize the strategic planning process by suggesting that most strategic planning methods prescribed the following stages:

- Objective setting stage: definition of formal objectives
- External and internal audit stage: formalized SWOT analysis aimed at predicting long term internal conditions and external possibilities.
- Evaluation stage: Evaluation of alternative strategies in order to select one for implementation.
- Operationalization stage: formal analysis of the selected plan so that it can be implemented. The result is a hierarchy of plans to be implemented in the different hierarchical levels of the enterprise.
- Scheduling: The planning itself is planned so that the planning process can be (hopefully) made predictable. This gives rise to what can be called meta-plans or “plan to plan” (p. 53).

For Mintzberg et al., the strategic planning presents the following fallacies:

- The belief in predetermination: To engage in detailed planning, such as that prescribed by strategic planning, planners need to forecast the future in detail. Forecasting always relies on stability, i.e. the assumption that some aspects of a situation will remain stable, while others will change. Detailed forecasting relies on many such assumptions and the more of those the more it is sensitive to any of these assumptions being false. Thus, detailed planning is not practical because it relies on detailed forecasting which is not accurate.
- The belief in detachment: The belief that strategy can be formulated by analysts who are separated from the people implementing the strategy, and who are relying on numerical figures known as “hard data” representing the reality out there. This leads Mintzberg et al. to conclude that “Detached managers together with abstracted planners do not so much make bad strategies; mostly they do not make strategies at all...Effective strategists, in contrast, are not people who abstract themselves from the daily detail, but who immerse themselves in it while being able to abstract the strategic messages from it” (p. 69-71).
- The prescription of formalization: By imposing both a formalized process that has to be followed consistently and a reliance on quantifiable data, strategic planning, Mintzberg et al. argue, attempted to replace the idiosyncrasies of human strategy makers by machine like reasoning. Apparently, this did not result in good strategies (or in no strategies) because the essence of strategy making lies precisely within these idiosyncrasies that planning wanted to replace.

- The belief that synthesis will flow out of analysis. Mintzberg et al. equate strategic planning with analysis arguing that “Because analysis is not synthesis, strategic planning has never been strategy making” (p. 77). Analysis, they say may be useful before synthesis or after it but that it cannot replace synthesis, further stating that “planning, rather than providing new strategies, could not proceed without their prior existence” (ibid). Thus by prescribing a process of endless analysis in the hope that synthesis (of a strategy) will emerge, the strategic planning school fell into the same trap as the software engineering discipline, known as analysis paralysis.

Mintzberg et al. conclude their discussion of strategic planning by saying that planning has a role in enterprises but not as the generator of strategies but rather as information providers, informing the strategy process or as strategy programmers once a strategy has been defined, or yet as catalysts by encouraging “whatever form of strategic behavior makes sense for a particular organization at a particular time” (p. 78).

### 2.1.3 The Positioning School

Mintzberg et al. credit the Boston Consulting Group (BCG) and Michael Porter for the founding of the positioning school, the underlying groundwork having been made by military strategists such as Sun Tsu and Clausewitz.

Mintzberg et al. describe the positioning school as having borrowed all of the design and planning schools’ premises with one exception. While the Design and Planning schools focused on the process of strategy formulation prescribing it as more or less formal but saying very little on the actual content of strategies. The positioning school seeks to define what alternative strategies an enterprise can consider and what the best strategy should be. In order to achieve such ambitious results, the positioning school reduces the process of strategy formulation to the examination of generic conditions mostly those external to an enterprise and the selection of generic “strategic” positions that fit these external conditions. This simplifies what Mintzberg et al. refer to as “a far richer as well as messier and dynamic process” (p. 121).

The BCG technique which preceded Porter’s work, sought to establish a balanced portfolio of businesses for enterprises with diversified portfolios. Businesses were rated over two dimensions: Current market share and growth potential of the business. The analysis in these two dimensions results in the BCG Growth-Share matrix (p. 95) that has four cells:

- The Star cell represents businesses that have a high growth potential and high current market share
- The Cash Cow cell represents businesses that have low growth potential and high current market share
- The Dog cell represents business that have a low growth potential and low current market share
- The Problem Child cell represents business that have a high growth potential and a low current market share

The BCG analysis was based on the idea that Star businesses required large infusions of cash to be maintained but promised to become future cash cows. Cash Cow businesses generated cash but were doomed to become Dog businesses. Dog businesses generated little or no cash with little promise of evolving into any of the other cells. Problem Child businesses required large cash investments and were only sustainable if they could evolve into stars. Strategy in this context is about selecting those businesses that can become stars and ultimately cash cows so that the cash cows can finance the problem children until they become stars and stars until they become cash cows. Dogs are to be avoided, i.e. liquidated. Mintzberg et al. point out that while the BCG analysis gives the impression of objectivity, there’s not much objectivity in classifying a business as a dog rather than a star (p. 97). Thus Honda’s entry into the American motorcycle market would have been qualified as a dog. Honda, however, was able to create its own market and take a dominant position in it. Thus, basing strategy on

such a narrowly focused analysis can lead to divesting off of businesses that may become very successful or investing in businesses that have no future.

Porter's work since 1980 is considered by Mintzberg et al. as the main defining work behind the Positioning school. They state that Porter's work "offered a foundation rather than a framework; in other words a set of concepts on which to build rather than an integrated structure in its own right" (p. 100). These concepts are: the model of competitive analysis, the set of generic strategies and the model of value chain.

Porter's model of competitive analysis is made out of an industry (a collection of enterprises with similar products or services) and five competitive forces (often called Porter's five forces) that act on the enterprises in this industry. These five forces are:

- Threat of new entrants, i.e. the threat that new competitors entering the industry pose to those enterprises who are already in this industry. Entry barriers exist or can be devised to mitigate this threat.
- Bargaining power of suppliers, i.e. to what extent a supplier can negotiate a higher price for the products or services that it delivers to the enterprises in this industry.
- Bargaining power of buyers, i.e. to what extent buyers can negotiate lower prices for the products or services they buy from the enterprises in this industry.
- Threat of substitutes, i.e. to what extent products or services from other industries can be used instead of the products or services in the industry under consideration.
- Intensity of rivalry between enterprises in the industry.

In Porter's models these five forces determine the strategy that the enterprise is or should be following. As noted by Mintzberg et al.

"Given the range of possible external forces, one might imagine that the range of possible strategies is rather large. But Porter takes the opposite position: only a few generic strategies survive competition in the long run" (p. 102).

Porter's generic strategies are based on two competitive advantages, low cost and differentiation. These two advantages combined with the "range of market segments targeted" by the enterprise, i.e. its scope result in "three generic strategies for achieving above-average performance in an industry:" (p. 102-103)

- cost leadership, achieving the lowest production costs in an industry through economies of scale etc
- differentiation, developing unique products or services
- focus, the serving of narrow market segments the enterprise can focus on

Porter's value chain model an enterprise as a sequence of activities that are necessary to create and deliver complete products or service to its customers. Activities are classified into primary and support activities. Mintzberg et al. explain that "primary activities are directly involved in the flow of product to the customer," e.g. inbound logistics, operations, and outbound logistics. "Support activities exist to support the primary activities," e.g. procurement, technology development, human resource management, finance. (p. 104).

The shortcomings of the Positioning school according to Mintzberg et al. are mainly its narrow focus in the following areas:

- The focus on quantifiable financial data it ignores not only those factors that are not quantifiable but maybe more importantly it ignores non financial factors such as political and social factors (p. 113).
- The context of application of the positioning school is mainly "traditional big business" (p. 113). That is, rather stable enterprises in stable environments.

- The focus on external conditions. In Mintzberg et al.'s terms: "Overall much of the problem may stem from a bias in this school toward the external conditions, especially of industry and competition, at the expense of internal capabilities. The balance between the two, so carefully maintained by the design school, was thrown off once the positioning school became popular..." (p. 114)
- The strategy formulation process as detached and prescriptive. Mintzberg et al. state that the positioning school retained the notion of strategy formation already articulated in the Design and Planning schools "as a controlled, conscious process that produced full-blown deliberate strategies to be made explicit before being formally implemented"
- The focus on the "close-ended selection of generic strategic positions" instead of the "development of integrated and unusual strategic perspectives" prescribed by the Design school or "the specification of coordinated sets of plans" as prescribed by the Planning school (p. 84). The positioning school focuses on quantifiable financial conditions with the goal of selecting one of a limited set of generic strategies believed to favorably influence the future growth of the enterprise. It thus ignores conditions internal to the enterprise that may prevent it from selecting one of these strategies. Mintzberg et al. also state that: "The design school promoted strategy as perspective and encouraged its creative design. By focusing on strategies as generic, the effect of the positioning school may have been exactly the opposite. Companies can be drawn toward behaviors that are generic in their detail as well as in their orientation" (p. 116-117).

For Mintzberg et al. the main contribution of this school is in informing strategy through analysis but not in the strategy formulation itself. In other words, "the role of positioning is to support that [strategy formulation] process, not to *be* it" (p. 121). Thus, the analytical powers of the Positioning school need to be combined with the views of the other schools.

## 2.1.4 The Entrepreneurial School

Mintzberg et al. credit Joseph Schumpeter as "the seminal figure who brought the entrepreneur into economic thought" (p. 125).

The entrepreneurial school holds that the entrepreneur is the person who defines the strategy of an enterprise. The entrepreneur is not necessarily the founder of the enterprise but is a leader who has a vision for the future of the enterprise and is able to communicate this vision to the rest of the enterprise, thereby getting the enterprise to accomplish this vision. Vision is described by Mintzberg et al. as:

"A mental representation of strategy, created or at least expressed in the head of the leader. That vision serves as both an inspiration and a sense of what needs to be done, a guiding idea" (p. 124).

In this school strategy as a vision takes the form of a perspective rather than a "fully articulated plan (in words and numbers)" (p. 124). Since the strategy remains largely implicit, it remains flexible and adaptable, up to the degree of flexibility of the leader. Mintzberg et al. characterize entrepreneurial strategy as:

"both deliberate and emergent; deliberate in its broad lines and sense of direction, emergent in its details so that these can be adapted en route" (p. 125)

Entrepreneurs are seen as people driven by achievement. They are more prone to seeing opportunities and strengths where other people see threats and weaknesses. Thus, in seemingly similar conditions, where others will react defensively in an attempt to save the enterprise, entrepreneurs will attempt to redefine the rules of the game in order to save the enterprise in a kind of a forward thrust.

Mintzberg et al. state that the main strengths of the entrepreneur, defined above, are also its main weaknesses. While the flexibility of the strategy is seen as something positive, a consequence that is seen as negative is that the enterprise is totally dependent on the capabilities of its leader. If the leader fails:

- by becoming disconnected from reality,

- by being bogged down in details,
- by trying a recipe that has worked in the past but that doesn't work in present conditions
- or by disappearing,

the enterprise will suffer and may very well fail to survive. Mintzberg et al.'s example of the Steinberg retail store chain is a case in point, having grown amazingly for 60 years but gone bankrupt after the death of its founder.

### 2.1.5 The Cognitive School

For Mintzberg et al. the cognitive school "forms not so much a tight school of thought as a loose collection of research, which seems, nonetheless, to be growing into such a school. If it can deliver on its intentions, it could very well transform the teaching and practice of strategy as we know it today" (p. 150).

From Mintzberg et al.'s point of view, the cognitive school focuses on how strategy is defined by people. More generally, the cognitive sciences are interested in explaining the way people think, learn, and behave. Mintzberg et al., identify two main wings in the cognitive school. The more positivistic wing sees the human mind as a kind of camera that takes limited and distorted pictures of an external, objective world. The main effort here is on achieving a correspondence between the objective reality and the distorted representation and on creating tools that will compensate for the limitations of the mind so that successful strategies can be defined. The other wing sees the human mind as the creator of strategies. Distortions and limitations are not seen as deficiencies needing corrections but as the essence of creation.

Mintzberg et al. state that management researchers have been specially stimulated by the work of H.A. Simon, who represents the positivistic wing. The positivist wing focuses on helping managers to make decisions. This focus implies that most human action results from conscious decisions being made prior to action being taken. Mintzberg et al. (pp. 158-159) dispute this notion, saying that it is possible that a large part of human action does not proceed from conscious decisions prior to action and that many times, actions are taken in an enterprise without anyone being able to pinpoint when and by whom a decision was made to take these actions. Thus, by focusing on decision making as the essence of what happens in enterprises, the positivist wing may disrupt the creation of strategy by making it too formal.

Simon was mainly interested in the psychological processes that influence decision making. Simon's main point was that the world's complexity largely surpasses managers' limited capacity to understand it. Simon proposed that managers make decisions with a process he called bounded rationality (Simon 1996). It is assumed that rational decisions are made when all possible courses of actions are identified, all consequences of each decision are identified and weighed, and the course of action that presents the most positive consequences is selected. Simon's stated that managers don't have the time, energy, and processing power to identify all possible alternative courses of action that are available to them and their consequences. Thus, managers use bounded rationality in which they consider only some favored alternatives and their consequences. This leads to good enough decisions rather than perfect ones. In the cognitive approaches inspired by Simon, the human mind and enterprises are compared to information processing machines. The favorite analogy for this machine is a computer. Computers have or are supposed to have a perfect knowledge of their environment. Since people don't seem to possess such perfect knowledge, the cognitive school inspired by Simon sees the human understanding of the world as mired by deficiencies such as distortions, biases and simplifications (1996, p. 165). The following list gives some of these biases, attributed by Mintzberg et al. to Makridakis<sup>1</sup> (Mintzberg et al, 1998, p. 153):

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<sup>1</sup> Makridakis, S. Forecasting, Planning, and Strategy for the 21<sup>st</sup> Century (New York: Free Press, 1990).

- “Willingness to gather facts which lead toward certain conclusions and to disregard other facts which threaten them
- Inability to apply the same decision criteria in similar situation
- Failure to change (or changing slowly) one’s own mind in light of new information/evidence
- Reliance on most recent events or on events that are most easily recalled from memory to the exclusion of other pertinent information
- Unduly relying on initial information during the forecasting process
- Belief in non existent patterns or non existent causality between variables
- Tendency to see problems in terms of ones own background and experience
- Learning is inhibited due to the attribution of success to ones own skills and failure to bad luck
- Preferences for future outcomes affect people’s forecasts of such outcomes
- Excessive optimism, illusory correlation, and the need to reduce anxiety result in underestimating future uncertainty.”

From our point of view, implicit in this list of deficiencies is the assumption that somehow there is a way to know what is right from what is wrong. For example, it is assumed that the biases in the list lead to bad decisions whereas their absence would lead to good decisions. Take for example the second item, failing to apply the same decision criteria in similar situations. Why is this a deficiency, a problem? It seems to suggest that applying the same criteria would lead to a good decision. It also seems to suggest that if the situation is similar the same criteria *should* be applied and that somehow it is possible to objectively judge that two situations are indeed similar. As we will see in Part 2, these assumptions imply the existence of an objective external reality that can be judged in absolute terms by the observer who defines what constitutes a distortion of this reality, i.e. someone who can say with absolute objectivity how a situation should be judged.

The interpretative wing described by Mintzberg et al. holds that there is no such objective observer who can say what *the environment* is, it. Mintzberg et al. quote Smircich and Stubbart<sup>1</sup> as noting that:

“facts never speak for themselves. If facts seem to ‘go without saying,’ it is only because observers happen to be saying very similar things” (p. 171).

Thus, the environment is constructed or enacted rather than being perceived or existing objectively. Hence, an enterprise doesn’t exist in an environment that is independent of the way the enterprise views it and acts on it. Rather, the enterprise constructs its environment through its actions. These actions depend on its interpretations of what it considers as itself and its environment. The interpretations, in turn, are shaped by what the enterprise sees as the results of its actions, i.e. by the way it interprets its experience. The concept of environment itself is simply a convenient label for a pattern of activities, as is the enterprise itself (p. 169). This environment thus enacted becomes the reality that the enterprise and its stakeholders then contend with. Thus, this wing may better explain how enterprises make things happen, i.e., by constructing their environment.

While positivists see the points in the above list as deficiencies, the interpretivists see these as the basic ingredients of the human mind. As such, these properties can lead equally to success or failure. By correcting these deficiencies, we may as well inhibit success by trying to avoid failure. For example, it can be argued that the entrepreneurs we have seen in the previous section share some if not all of these deficiencies, such as optimism and seeing “non existent patterns” which lead them to success, precisely because other people didn’t have this optimism or didn’t see these patterns.

What neither of the two wings described above explains well according to Mintzberg et al. is the evidence of intuition and insight that seem to be the engine of creativity and major change in

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<sup>1</sup> Smircich, L., and Stubbart, C. “Strategic Management in an Enacted World.” *Academy of Management Review* (10, 4, 1985: 724-736).

enterprises (pp. 162-164). However, the interpretative wing, they say, has at least recognized and brought focus on these phenomena whereas the positivist wing ignores them almost completely. This focus may help to find the explanations to these phenomena.

### 2.1.6 The Learning School

Learning seems like an obvious property of an enterprise but it is curiously absent from the literature of the design, planning and positioning schools. Individual learning is given a prominent place in the cognitive school but collective learning gets less attention. The literature of the learning school explicitly considers learning as a collective process. Mintzberg et al. credit Charles Lindblom in the 1960's and James Brian Quinn in 1980 as being at the source of the learning school.

The learning school, as defined by Mintzberg et al., views strategy as emergent rather than deliberate. Strategies emerge as a result of a learning process that goes on within the enterprise. This school removes the separation that is prescribed by the design, planning, and positioning school between the formulation of the strategy and its implementation. Thus, the formulation and the implementation of the strategy emerge in unison by a continuous process of trial and error. This learning process can be represented as an action-feedback cycle: "a single action can be taken, feedback can be received, and the process can continue until the organization converges on the pattern that becomes its strategy" (p. 189-190). Mintzberg et al., state that such a learning cycle can make major changes in the strategy of an enterprise. By imperceptibly making many small changes over a long period of time, major changes in the strategic directions of an enterprise can be made.

Another consequence of the action-feedback cycle can be seen in Weick's work (p. 195). For Weick, understanding is only possible by retrospection, i.e., reflection about past actions. In other words, understanding requires an interpretation of past experience.

Mintzberg et al., describe Nelson and Winter's evolutionary theory (p. 182, 185). This theory specifies that change emerges from the "cumulative interaction" between routines. "Routines are repetitive patterns of activity that underpin and control the smooth functioning of the organization". Thus, a routine is any stable way of doing things in an enterprise. Routines are said to "impart stability to the organization much as gyroscopes maintain aircraft on stable courses." The interaction between routines and new situations is said to be a source of learning and change. Since the routines are interlinked, change in one of them will lead to change in another and lead to a cascading effect. For Mintzberg et al. this means that:

Management can influence the process by phasing out ineffective routines, transferring effective ones from one part of the organization to another, and inserting new routines into the organization, whether by imitation-borrowing what appears the best practice from other organizations, or by experimenting-seeing how innovation on a small scale will affect the rest of the organization (p. 185)

Mintzberg et al. state that, whereas in the prescriptive schools and even the entrepreneurial and cognitive schools strategy formulation is done by senior management (most often the chief executive), in the learning school strategies can be sparked and championed by line and middle managers or for that matter anyone with capabilities and sense of initiative within an enterprise. Those people need to persuade senior management who make judgment based on their past experience in addition to using formal methods such as capital budgeting. Thus the role of management is to provide a "strategic context" so that not all projects are carried out and those who do, can be provided the resources they need (p. 185-189).

Mintzberg et al., refer to the work of Hamel and Prahalad (p. 213-221) who specify that strategic management should be based on following three principles. These principles can be seen as necessary for the strategic context defined above:

1. Core competencies: core competencies are more important than products. They are hidden and less susceptible to being copied by competitors. They enable the enterprise to diversify into many different markets and they are key to the enterprise survival in the short and long term. Core competencies are believed to be the consequence of collective learning in the enterprise.

2. Strategic intent: a vision associated with the attention needed for motivating people and developing resources and core competencies in order to reach some long term perspective.
3. Stretch and leverage: stretch is some gap between the current resources of the enterprise and its aspiration (as probably defined in its strategic intent). Leverage is the careful use of the limited set of resources available to the enterprise. Stretch and leverage need to be kept within reasonable bounds, neither too small nor too large to keep the enterprise moving.

Mintzberg et al. include within the learning school, a short discussion of theories of chaos as they apply to strategic management (p. 221-223). The lessons from these theories are that the enterprises are fundamentally unstable non-linear systems. In such systems, small changes can have very broad effects. However, if chaos and disorder are seen as intrinsic properties of enterprises rather than alien properties to be removed through planning and control, then it means that managers should embrace chaos and disorder as beneficial and even inject some disorder themselves. Doing this is supposed to help the enterprise to create new knowledge and transcend its limits.

In their critique of the learning school, Mintzberg et al., state that learning should not be taken to mean no strategy at all. Since strategy is defined as some coherence of actions, relying on learning alone may produce no coherence because the enterprise may get buffeted in each and any direction. On the other hand, perfect coherence implies no learning and therefore no possibility to improve. Another danger of relying too much on learning is that the enterprise may be “lured, one step at a time, into an undesirable position” (p. 227). The problem of the enterprise is then to know how much learning and how much rigidity to apply so that both coherence and improvement are made possible and contribute to its long term survival.

### 2.1.7 The Power School

For Mintzberg et al. the Power school represents the study of influence and politics in the formation of strategies. Within this school they distinguish two categories of research that they call Micro Power and Macro Power.

Micro Power represents the research into political maneuvering within the enterprise, taking into account peoples’ “dreams, hopes, jealousies, interests, and fears” (p. 236). Mintzberg et al. quote Bolman and Deal as having set out the following propositions about enterprise politics (p. 239)<sup>1</sup>:

1. Organizations are *coalitions* of various individuals and interest groups.
2. There are *enduring differences* among coalition members in values, beliefs, information, interests, and perceptions of reality.
3. Most important decisions involve the allocation of *scarce resources*-who gets what.
4. Scarce resources and enduring differences give *conflict* a central role in organizational dynamics and makes *power* the most important resource.
5. Goals and decisions emerge from *bargaining, negotiation, and jockeying for position* among different stakeholders.

A question raised by Mintzberg et al. is how can there be consistency in action when political maneuvering involves stakeholders with enduring differences such as those noted by Bolman and Deal. The answer they propose is Cyert and March’s “sequential attention to goals” (p. 241). The idea is that enterprises serialize their attention to different goals required by internal stakeholders, giving attention to only one goal at a time.

Macro Power as summarized by Mintzberg et al. resembles Neumann’s point of view that we have seen at the beginning of this chapter:

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<sup>1</sup> Bolman, L. G., and Deal, T. Reframing organizations: Artistry, Choice, and Leadership, 2<sup>nd</sup> edition (San Francisco: Jossey-Bass Publishers, 1997) (p. 163).

“Micro power is about individuals and groups within the organization. Macro power in contrast reflects the interdependence between an organization and its environment. Organizations have to deal with suppliers and buyers, unions and competitors, investment bankers and government regulators, not to mention the growing list of pressure groups that may target one or another of their activities. Strategy from a macro power perspective consists first of managing the demands of these actors, and second of selectively making use of these actors for the organization’s benefit” (p. 248).

Mintzberg et al. describe the research by Pfeffer and Salancik into the ways by which enterprises influence their environments rather than only reacting to it (as is suggested by the Environmental school) (p. 248). Mintzberg et al. note that Pfeffer and Salancik state that the dominant problem of the enterprise is the management of “its exchanges and its relationships with the diverse interests affected by its actions.” Thus, “regulation and political negotiation...the management of the organization’s institutional relationships” are more important than “impersonal market forces” (p. 249).

Pfeffer and Salancik according to Mintzberg et al. propose three generic strategies that enterprises may specify to overcome this “dominant problem”: 1. deal with each demand as it arises; 2. strategically withhold and disclose information; 3. play one group against another (p. 249).

Mintzberg et al. also propose that enterprises may “seek to reduce external dependency relationships, or else come to accommodations with them-to make common cause with their environment” (p. 249). The resulting strategies for reducing external dependencies are mergers, lobbying, cartels, alliances etc. The strategies for the accommodation with the environment include “adaptations of structure and information systems” (p. 249).

For Mintzberg et al. the drawbacks of the Power school is its focus on the positive side of politics and the neglect of the negative sides such as waste of time and energy in an enterprise and the control of society by large coalitions of enterprises.

### **2.1.8 The Cultural School**

Mintzberg et al. argue that the Cultural school is the reverse image of the Power school. Where the Power school fragments the enterprise, the cultural school “knits a collection of individuals into an integrated entity.” While the Power school “focuses primarily on self interest” the cultural school focuses on “common interests” (p. 264). Mintzberg et al. credit the Swedish organization “Scandinavian Institutes for Administrative Research” for being at the core of this school.

For Mintzberg et al., the cultural school is characterized by the attention that it attributes to the phenomenon of culture in an enterprise. In extreme cases, the corporate is seen simply as a culture. Culture is defined by Mintzberg et al. as “interpretations of a world and the activities and artifacts that reflect these” (p. 265). These interpretations are said to be shared collectively in a social process. Culture is thus associated with “shared beliefs that are reflected in traditions and habits as well as more tangible manifestations-stories, symbols, even buildings and products” (p. 265). Culture is considered as the binding force that glues structure and processes together. Thus, the culture and the activities of the enterprise are closely interlinked, as one specifies the other. However, culture is known to be largely unconscious. Hence, Mintzberg et al. state that the relationship between interpretations and activities is not easy to identify, for people outside but also inside the enterprise. Mintzberg et al. go even further by pointing out that “the strength of a culture may be proportional to the degree to which it eludes conscious awareness” (p. 266).

Mintzberg et al. advance the following relationships between culture and strategy:

- 1 Culture influences the style of thinking that is favored in an enterprise. Culture is responsible for the way an enterprise views its environment and therefore defines its potential strategies. This is done by focusing on “some data for strategic making while ignoring others” (p. 269).
- 2 Culture acts as a resistance to change. “A shared commitment to beliefs encourages consistency in an organization’s behavior and thereby discourages changes in strategy” (p. 269). In other words, managers tend to “stick with the beliefs that have worked in the past” (p. 270).

- 3 If a fundamental change in strategy is sought, a fundamental change in the culture is also needed. Overcoming resistance to change can be done by making explicit as many of the beliefs of the enterprise as possible.
- 4 Culture is not only a barrier to change. More fundamentally, it is the main reason behind the success of successful enterprises.
- 5 Different enterprise cultures are the main reason behind the failure of some mergers. Different cultures usually don't blend well.

Mintzberg et al. review another interesting development in the Cultural school, the resource based theory of enterprises (p. 276). This theory (proposed by Birger Wernerfelt and later Jay Barney) views enterprises as “a bundle of resources, both tangible and intangible. What eaves this bundle into a single system is a web of shared interpretations. That is what maintains, renews, and shapes these resources” (p. 277). In this theory, the enterprise's strategy is both dependent on its resources (assets, capabilities, processes etc.) and seeks to maintain, develop and renew these resources.

For Mintzberg et al. the main contributions of the cultural school is its insistence on understanding the internal capabilities of the enterprise in a historical perspective. Thus, enterprises cannot change at will every time the environment changes. If they did, they would be changing their strategy continually, never achieving any stability. Hence, the cultural school acts as a counter measure against the changes prescribed by the positioning school (p. 280). Mintzberg et al. define this focus on stability and the explanation of all enterprise behavior through the point of view of culture as the main problem of the cultural school. Indeed they consider that overstating these aspects may result in rather static strategies (i.e., a fixation with the status quo) even where radical change is required.

### 2.1.9 The Environmental School

The environmental school, according to Mintzberg et al., is formed by people who believe that enterprise strategy is shaped by environmental forces beyond the control of the enterprise. Environmental forces shape what the enterprise becomes. The enterprise has a passive role of interpreting the environment and acting according to these interpretations. If these interpretations are wrong and the enterprise makes choices that are not favored by the environment, it is “selected out,” i.e., it dies. If the choices are in tune with the environment, the organization is said to adapt to the environment. Thus, the environment forces enterprises to cluster in.

“distinct ecological-type niches, positions where they remain until resources become scarce or conditions too hostile. Then they die” (p. 288).

Mintzberg et al. identify two main theories in this school:

- Contingency theory, which specifies that there is no one best way to manage an enterprise but that management depends on the size of the enterprise, its technology, the stability of its context, external hostility etc. (p. 289). Mintzberg et al. attribute contingency theory to the work of Pugh et al. (290).
- Population ecology, which holds that the character of an enterprise becomes fixed shortly after the enterprise was created. From then on, the enterprise becomes more and more rigid and because of internal and external forces such as investments in certain resources and technology that are too costly to change or market regulations that impose exit barriers etc. Mintzberg et al. attribute this view mainly to Hanna and Freeman.

Mintzberg et al. criticize the environmental school as failing to explain human initiative. They argue that enterprises are able to take initiative and change beyond what the environment would seem to permit them. Also, it is not clear who defines what the environment is. Where does the enterprise end and the environment begin? This is a relative issue and is not absolute. If the environment is not an absolute being then how can forces be ascribed to it and how can we know what is imposed by the environment and what is imposed by the enterprise?

### 2.1.10 The Configuration School

The configuration school is the school favored by Mintzberg et al. It integrates the views of the nine other schools by specifying that they represent techniques used by an enterprise when needed. The configuration school largely focuses on stability and change rather than change alone as in many of the other schools. This focus is apparent in the adoption by this school of the punctuated equilibrium model of evolution proposed by Stephen Jay Gould. Punctuated equilibrium holds that evolution is not made out of small adaptive changes but rather by periods of relative stability, in which small adaptive changes are made, punctuated by periods of dramatic change. Of course, as admitted by Mintzberg et al. (p. 315) what represents dramatic change to one observer may represent incremental change to another. In other words, the amount of observed change depends on the period of observation, as we will see in the next part.

In this school enterprises are seen as relatively stable configurations of entities which periodically go through phases of radical transformations. These transformations bring them into another relatively stable configuration. Configuration and transformation are explained as two sides of the same coin. One is dependent on the existence of the other. A specific configuration cannot be achieved without some transformation from a previous configuration. A transformation needs an initial configuration from which to operate and results in a new configuration. Thus Mintzberg et al. state that:

“While its [strategic management] literature makes clear that it is about change, strategy itself is not about change at all, but about continuity-whether as deliberate plan to establish patterns of behavior or as emergent pattern by which such patterns get established” (p. 302).

The reason for this focus on stability and continuity becomes clear in Mintzberg et al.’s definition of what is key issue in strategic management:

“The key to strategic management, therefore, is to sustain stability or at least adaptable strategic change most of the time, but periodically to recognize the need for transformation and be able to manage that disruptive process without destroying the organization.” (p. 305)

Thus, what seems to be the key issue is the survival of the enterprise and how to define strategies that enhance the chances of survival rather than threaten it. However, the quote above may be misleading in that it draws attention to major change as a potential threat to the survival of an enterprise. While doing so, it minimizes the potential effects of small changes. The problem is already in the distinction between small and major changes. What seems like a small change to some person may seem like a major change to another. If we model enterprises as non-linear systems then they can be sensitive to even “small” changes. Thus, even “small internal” changes in an enterprise may result in big changes for customers resulting in either positive or negative changes to the enterprise. Conversely, even quantum change still maintains the enterprise’s identity in a stable state. Also, change and more so quantum change require stability of action and stability of structure, i.e., the change is performed through sustained action which is supported by the stability of some other properties of the enterprise.

In the configuration school, strategic management is achieved by applying all of the techniques developed in the other schools at the right place and time. Configurations themselves are described by very simple models of typical enterprises (which may never be found as is in any “real” enterprise) such as adhocracy, machine, religious etc.

The configuration school is based on “lumping” (i.e., focusing on wholes and networks) as opposed to the “splitting” that characterizes the other schools. This school also relies on circular (non linear) models inherited in part from the learning school, and on interpretative concepts inherited from the cultural and learning schools.

## 2.2 IS schools of thought

In this section we will present an overview of the two dominant schools of thought in IS, the Hard systems school and the Soft Systems school. The distinction between these two schools is mainly due to Peter Checkland and his research team at the University of Lancaster (Checkland and Scholes

1990), (Checkland and Holwell 1998), (Checkland 1999)<sup>1</sup>. The strategic management perspective created by Mintzberg et al. will help us to understand these two schools. Indeed, the Hard systems school has been predominantly influenced by the prescriptive schools identified by Mintzberg et al, i.e., the Design, Planning, Positioning and Positivist cognitive schools. The Soft Systems school on the other hand, is closer to the descriptive schools of, i.e., Learning, Interpretative Cognitive, Power, Cultural, and Environmental schools. Checkland and Holwell define the difference between Hard and Soft systems thinking as the difference that characterizes positivist thinking from interpretative thinking:

“Hard systems thinking assumes that the world contains systems which can be ‘engineered’ to achieve their objectives. Soft systems thinking regards the world as problematical but assumes that the process of inquiry into it can be knowingly organized as a system.” (1998, p. 41)

Thus, both the Hard systems school and the Soft systems school share a systems science foundation. However, they differ in the way they apply these foundations to the study of enterprises and to their IS needs. The prescriptive tendency of the Hard systems school is reflected in the use of a vocabulary that equates the description of an enterprise with the enterprise itself. Thus, those who write from a Hard systems perspective tend to say that an enterprise *is* a system composed of hierarchical levels, with goals to be achieved at each level and by the system as a whole. The solutions envisioned in the Hard systems school will also tend to be prescriptive. Those who write from the Soft systems perspective will tend to say that an enterprise can be *modeled* as a system and that a hierarchical goal-directed model could be used to better understand the enterprise and evaluate different possible solutions. Checkland and Holwell (1998, p. 46) state that the Hard systems school has been the dominant school in IS but that there is increased interest in the Soft systems school.

In Section 2.2.1 we present the Hard systems school. In Section 2.2.2 we present the Soft systems school

## 2.2.1 The Hard systems school

In the Hard systems school, the enterprise is considered as a set of planning hierarchies, focused on decision making and problem solving in pursuit of goals to be achieved (Checkland and Holwell 1998, p. 48). Different types of IT systems are said to support the process of decision making in each of the layers of the hierarchy, Neumann, for example, identifies the following layers and their supporting IT systems (1994, p. 18):

- The strategic planning layer uses Decision Support Systems to make long range decisions about the objectives of the enterprise
- The management control layer uses Management information systems to make decisions about the effective and efficient use of resources in order to meet the enterprise’s objectives
- The operational control layer uses transaction processing systems to carry out specific tasks effectively and efficiently.

The focus on planning and decision making is very clear. For Checkland and Holwell, the kind of views expressed by Neumann represents the views expressed in the majority of the IS literature. For Checkland and Holwell (1998, p. 44), these views are considered as the result of the influential work of H.A. Simon. Simon was mainly interested in the processes of problem solving and decision making by human and enterprises, and their simulation with computers. Simon defines both the human mind and the computer as symbol systems. Simon explains symbol systems as:

“Symbol systems are almost the quintessential artifacts, for adaptivity to an environment is their whole raison d’être. They are goal seeking, information-processing systems, usually enlisted in the service of the larger systems in which they are incorporated” (1996 p. 22).

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<sup>1</sup> These schools are called Functionalist and Interpretivist by other researchers.

A goal-seeking system is a system that has one or several goals that it attempts to achieve. Rationality as explained by Simon, is the adaptation of the *inner environment* of the system, “its substance and organization” (p. 6), to the conditions posed by the *outer environment* so that the goals<sup>1</sup> of the system can be achieved. Thus Simon states that:

“If the inner environment is appropriate to the outer environment, or vice versa, the artifact will serve its intended purpose” (p. 6)

For Simon, this adaptation between the inner and outer environment applies equally to people and to enterprises:

“Economics exhibits in purest form the artificial component in human behavior, in individual actors, business firms, market, and the entire economy. The outer environment is defined by the behavior of other individuals, firms, markets, or economies. The inner environment is defined by an individual’s, firm’s, market’s or economy’s goals and capabilities for rational adaptive behavior” (p. 25).

Simon explains that the inner environment is usually limited in its capability to adapt to “taxing [outer] environments” (p. 12) in pursuit of its goals. This limitation is the result of the need of the inner environment to conform to the laws of nature. Thus Simon argues that:

“Economics illustrates well how outer and inner environment interact and, in particular, how an intelligent system’s adjustment to its outer environment (its *substantive rationality*) is limited by its ability, through knowledge and computation, to discover appropriate adaptive behavior (its *procedural rationality*)” (p. 25, italics in the original).

This led Simon to define bounded rationality. People and enterprises act with bounded rationality in that they make good enough decisions rather than optimal decisions as a totally rational system would do. This process of making good enough decisions is called *satisficing* as opposed to satisfying. Thus, goals are satisficed (achieved well enough) rather than satisfied (achieved completely).

For Simon, managers make decisions in order to solve problems. Problems are defined by Simon as “gaps between performance and goals” (Checkland and Holwell 1998, p. 45). Or in other words, a problem is the gap between a desired state of affairs (the goal) and the existing state of affairs (the performance). Simon’s work is focused on the closing of this gap, what he calls problem solving:

“There is now a growing body of evidence that the activity called human problem solving is basically a form of means-ends analysis that aims at discovering a process description of the path that leads to a desired goal. The general paradigm is: Given a blueprint, to find the corresponding recipe.” (1996, p. 211)

Thus, the path defined above is in fact a path between an existing state as it is sensed by the system and the state the system desires:

“Given a desired state of affairs and an existing state of affairs, the task of an adaptive organism is to find the difference between these two states and then to find the correlating process that will erase the difference.” (p. 210)

For Simon, this process of problem solving is the “basic condition for the survival of adaptive organisms” (p. 210) and the finding of the correlating process, when made conscious and verbalized is what is usually called a means-ends analysis (ibid).

However, there are several potential paths leading from the existing state to the desired state and each one has different consequences for the inner and outer environment. Thus, in the process of problem solving, decisions are made with respect to alternative paths to be taken and their consequences. But since the system making these decisions has limited capabilities, it can only examine some of the paths and some of the consequences of each path. It then acts with bounded rationality, seeking to define good enough paths rather than optimal paths, i.e., satisficing the goal rather than satisfying it.

The path is actually equivalent to a plan that is aimed at achieving the goal. Thus Simon’s work is quite close to the strategic planning school. However, Simon does recognize that strategies can emerge without central planning. Simon states that patterns may emerge in markets because the conflicting

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<sup>1</sup> Simon doesn’t distinguish between goals, objectives purposes, and ends. For Simon, these are all synonyms.

goals of the different actors, each attempting to maximize its own profit, are limited by the bounded rationality of the different actors involved (p. 33). Simon also argues that bounded rationality also works in favor of altruism or the identification of people with an enterprise's goals. The idea is that by being part of an enterprise and identifying with its goals, individuals can transcend their bounded rationality to some extent and thus receive protection by getting information from others and achieve better results by grouping their forces (p. 44-45).

In Simon's work, rationality means to have a plan that satisfies a goal. However, Simon notes that a plan without a goal is possible by resorting to the search for *interestingness* or *novelty* (p. 162). For Simon, "This kind of search, which provides the mechanism for scientific discovery, may also provide the most suitable model of the social design process" (ibid). Thus for Simon, when no explicit goal such as the maximization of some economic parameter is present in human behavior, this behavior may be explainable by its interestingness, i.e., its capacity to bring joy and satisfaction to people.

For Simon (1996) systems, hierarchies, goals, and complexity all exist in nature. For the interpretivists these are all human interpretations but for Simon these aspects of systems exist independent of any interpretation. For example, Simon notes that: Business firms, governments, and universities, all have a clearly visible parts-within-parts structure. However, Simon doesn't say that different people may see different hierarchies in an entity to which they will refer with the same name, i.e., the same system. Thus, the system, and its hierarchy, its complexity, its environment are all the same for all observers.

Simon links his work to Cybernetics and General Systems Theory by noting that Cybernetics is a combination of feedback control, information theory and computers. He connects the notion of goal to feedback control by noting that:

"Feedback control shows how a system can work toward goals and adapt to a changing environment, thereby removing the mystery from teleology<sup>1</sup>. What is required is ability to recognize the goal, to detect differences between the current situation and the goal, and actions that can reduce such differences; precisely the capabilities embodied in a system like the general problem solver" (p. 172).

Unfortunately, with this statement Simon reduced the circular process of feedback control into a linear process consisting of identifying the goal and satisfying it. Thus the essence of the feedback loop, the continuous regulation of the state of a variable, was lost in this discourse. This has been interpreted in the IS field as meaning that goals were to be identified and once identified were to be achieved. How the goal for which the feedback control works was defined and what the system does once the goal is achieved, i.e., how it may define new goals, remains undefined. While this approach may be convenient for the study of artificial systems where the goal is given from outside of the system, i.e. by the designer, it is less suitable for social systems, such as enterprises, where the goals are generated by the system itself. Further, Simon talks about "the goal" as if a given system had only one such goal, i.e. different observers agree on what is "the goal." Everyday experience, however, tends to show that people have a tendency to "recognize" different goals in a same situation, rendering the Hard systems approaches less useful when dealing with social systems (Checkland and Scholes 1990), (Checkland and Holwell 1998).

One of the main functions of an IT system is to store, process, and make information available to its stakeholders. The notion of what is information is therefore important. The prevalent definition of information in the Hard systems school is represented by the data, information, and knowledge hierarchy. For Checkland and Holwell, there are no sharp definitions of these concepts that are generally accepted within this school. Data is usually defined as facts that exist in the world regardless of their interpretation by people. Information is usually defined as data that was processed in order to be meaningful to people (generally in order to aid in decision making) (1998, pp. 92-96). Checkland and Holwell do not give the prevalent definition of knowledge in the Hard systems school. Tuomi

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<sup>1</sup> Teleology is "the doctrine that the existence of phenomena may be explained with reference to the purpose they serve." (Oxford English Dictionary, 2002).

presents such a definition by stating that “most of the time knowledge is conceptualized as meaningful, accurate, and usable representation of facts in context.” (1999).

While Simon’s work has been very influential in the management and computer sciences, with respect to IT system requirements it presents the following shortcomings:

- Simon takes what can be defined as a positivist stance. In most of his discourse he assumes that systems and their related attributes, goals, hierarchies, environments etc. exist independently of their interpretation by an observer. Thus, not enough care is taken to separate models and observed reality. This leads to the consideration of enterprises as automats that are bent on achieving goals leaving the issues of interpretations, politics, etc that we have seen in the previous section out of consideration.
- The upfront search for THE goal(s) of an enterprise limits the discussion about the nature of the enterprise and its need to satisfy multiple relationships continuously. It begs the question, how these goals were defined in the first place and what happens once they are achieved, i.e. how they are continually being changed. This is the essence of strategy as we have seen in the previous section.
- By stating that individuals and enterprises make satisficing decisions it follows that what is optimal can at least be defined even if it is not specifiable. This view implies that there is an optimal path and that the satisficing path should be as close to that optimal path as possible. But that begs the question, who defines what the optimal path is and how the is distance between the satisficing path and the optimal path defined? As we have seen in Section 2.1.5, about the Cognitive school this seems to argue in favor of an independent, objective observer who defines what is optimal and what is not and for the correction of the limitations posed by bounded rationality. In everyday life, such an observer is rarely present and we have seen that correcting these limitations may produce even less optimal results because failure and success are intimately coupled.
- Simon has reduced the circular phenomenon of life into a linear process of goal achievement. Thus, Simon’s work does not explain how goals are formed or what happens once goals are achieved. A goal is a desired state but where does this desired state come from? How was it defined by the system? How well does the system know its existing state? What does the system do once it has achieved its goal? Some of these questions can be tackled from a regulation point of view. Indeed Simon himself recognizes the importance of self regulation and homeostasis<sup>1</sup> (1996, p. 8, 33, 172) but unfortunately doesn’t explicitly link these concepts to his goal-seeking model.

## 2.2.2 The Soft systems school

Simon’s view that systems, hierarchies, goals etc. exist in reality is challenged by the proponents of the Soft systems school<sup>2</sup> (Checkland and Holwell 1998) who insist that these exist as personal interpretations of a situation. With Simon’s work we are encouraged to find the goal of the system, for example, a clock’s goal is to tell the time (1996, p. 5). However, different people may assign different goals to a system depending on their interest in it. Thus a person can assign to the clock the goal to hold loose papers on a table; or the goal to serve as a decoration. These can be linked or not linked to the clock’s ability to tell the time. Hence, the goal may not be in the clock but in the relationship between the clock and a person. So, systems, hierarchies, goals, etc. may be defined differently by different people, i.e. they are the interpretations that each observer defines of his or her situation. By

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<sup>1</sup> Homeostasis is a set of heuristics that explain how a system maintains its stability in an unstable world. Homeostasis is explained in Section 4.5.1.

<sup>2</sup> Here we consider the opponents of the Hard systems school as proponents of the Soft systems school even though they may not agree between themselves to what extent the Soft systems school is warranted.

not taking these differing interpretations into account, the Hard systems school makes it difficult to create multiple views of the same observed reality.

The proponents of the Soft systems school argue that Hard system approaches blur the distinction between the models they produce and the reality that these models represent. This in fact can be seen as a corollary to the inexistence of the observer in the Hard systems models. Thus applying the methods developed within the Hard systems school leads to the assimilation of the mechanistic models of enterprises to the enterprises themselves. Checkland and Scholes give the following description of this problem:

We could indeed examine the problems of coherently providing health care, or education, or the application of the law, by making use of the idea of a system, that is to say a whole with emergent properties, a layered structure and processes which enable it to adapt in response to environmental pressures. But it is too easy casually to say 'education system' *as if* the arrangements for providing education automatically meet the requirements of the notion of 'system'. Most people engaged in education will probably deny that the arrangements they encounter actually map the system concept! The error here is to confuse a *possibly plausible description* of perceived reality, with perceived reality itself." (1990, p. 21, italics in the original).

Thus proponents of the Soft systems school attempt as much as possible to create a separation between the reality they perceive and the models they create and reflect about. Thus the models are considered to be neither perceived reality itself, nor an assembly of pure imaginary concepts but rather concepts that are rooted in some perceived reality but that are nonetheless not the reality itself. The models created in Soft Systems Methodology (SSM), for example, are called "purposeful activity systems" (Checkland and Scholes 1990). They represent enterprises and people "as if" they had goals. SSM models include an explicit statement about the point of view from which the purposeful activity system was defined so that it is possible to create multiple models of a same observed reality from different perspectives.

Checkland and Holwell (1998) state that, as a consequence of Simon's influential work, the Hard systems school views enterprises as "social entities which set up and seek to achieve goals" (p. 48). In this school, the process that leads to the definition of these goals doesn't get much attention. As we will see in the next chapter, goals are considered to exist in the enterprise. The process of defining requirements for IT systems is described as the search for the high-level goals of the enterprise, and either their refinement into goals that can be achieved or their refinement into goals that can be satisfied. IT systems are seen as providing information to managers in order to help them make decisions that help the enterprise achieve its high-level goals. However, in a means-ends hierarchy any goal can be considered as a sub-goal of some higher-level goal. Thus, without further explanation, a high-level goal is an arbitrary notion, since we can always define a higher-level goal to a goal that was previously defined as high-level. As we will see in the next chapter, designers may need more concepts in order to define what a high-level goal is.

Whereas in the Hard system school the main focus is on the achievement of goals, SSM, for example, views enterprises as "social entities which seek to manage relationships" (Checkland and Holwell 1998, p. 48). In this school of thought, IT systems are often defined as facilitating the management of relationships. Decision making and the achievement of goals are relegated to a secondary role. The main focus is on the management of relationships and on the interpretation of information by different people. The view on the management of relationships is attributed by Checkland et al. to Vickers (1968, 1987). Indeed Vickers's work is seen by Checkland and Holwell as:

"both indebted to, but also in rather profound conflict with that of Simon, since it takes a fundamentally different view of human action." (1998, p. 46)

Vickers sought to understand not so much how enterprises achieve goals but how they set these goals in the first place. Vickers explained the formation of goals as a function of the regulation occurring in enterprises with the purpose of maintaining stability. He thus, attributed much more importance to this (hidden) regulation than to what he considered as only its most visible manifestations, i.e. the achievement of goals. Most of Vickers's writing was focused on policymaking in local authorities and government, which, as we have seen in the last section, is equivalent to strategy formation in the business world.

With respect to the question of what is information, whereas the Hard systems school explains information as objective facts (data) that are passively filtered by people, the Soft systems school gives a much larger role to interpretation. It privileges the view that there is no objective data out there independent of the way people interpret this data. In this view, people pre-define what counts as relevant information before they perceive some data that they believe are facts. Because of this view, proponents of the Soft systems school, advance different definitions of information than is found in the Hard systems school.

Checkland and Holwell, for example, add the concept that they call *capta* to the traditional data, information, knowledge hierarchy. *Capta* designates the data that a person has selected for attention. *Capta* can also be created by the person rather than simply selected or filtered from the environment. In this model, it is *capta*, not data, that is transformed into information by giving it meaning (putting it in context, relating it to other *capta*, etc). Information is then transformed in longer term meaningful structures which is knowledge (1998, p. 86-92).

More radical views are presented by people like Tuomi (1999) who argue that data does not “exist” out there, in some objective reality, waiting to be converted into *capta*, information and knowledge. Rather, Tuomi argues that knowledge is needed in order to create the basis for data to be perceived or created in the first place. In other words, an understanding of the world (knowledge) is needed in order to decontextualize this knowledge into information and later into unstructured data that can be stored in a database for example.

The Soft systems school privileges the study of how meaning is attributed to experience (Checkland and Holwell 1998, p. 96) and of cycles rather than linear hierarchies. The above views show the main differences we have seen between the positivist and interpretative perspectives of the cognitive school of thought reviewed in Section 2.1.5. Soft systems proponents frequently make another point: Hard systems approaches to IS “make little or no explicit recognition of underlying theory” (Clarke and Lehane 2000).

Regarding the influence of the Soft systems school on IS literature Checkland and Holwell state that:

“Viewed overall, IS literature offers only the rather mechanistic model of organizations which derives from Simon and is based on rational decision making in pursuit of organizational goals. The alternative interpretive strand of thinking is currently the source of much lively work, but its writers do not yet offer a detailed carefully-worked-out model of organization upon which a re-think of the IS field could be built” (1998, p. 74)

As admitted by Checkland and Holwell (1998), the Soft systems school has had much less impact on the field of IS than the Hard systems school. They offer three main reasons for this state of affairs:

- The absence of a “detailed carefully-worked-out model” of enterprises that can be a credible alternative to the “rather mechanistic model of organizations which derives from Simon and is based on rational decision making in pursuit of organizational goals.” (p. 74)
- The model of enterprises offered by the Hard systems school is “exceptionally clear, it is also intuitively convincing, as long as it is not questioned closely, and eminently teachable.” (p. 73)
- This model “fit best of all with the fundamental nature of the computer: after all what is a computer but an electronic version of a bureaucracy?” (p. 73)

To these reasons we could add a fourth which, in our view, is due to the descriptive nature of the Soft systems school (while the Hard systems school is rather prescriptive) which results in the difficulty to prescribe a solution when many views of reality need to be taken into account. The prescriptive nature of the Hard systems school methods give them the upper hand in enterprises where solutions rather than questions are sought.

Different viewpoints by Van Heusden and Jorna (2002) and by Clarke & Lehane (2000) attempt to distance themselves the dichotomy between Hard systems and Soft systems school, a dichotomy that they mainly attribute to Checkland and his colleagues. Van Heusden and Jorna (2002) for instance state that “The position of Simon is much more sophisticated and the distinction between hard and soft

social science seems questionable.” These authors attempt to reconcile the Hard and Soft views. Van Heusden and Jorna attempt to use Organizational Semiotics as their base theory while Clarke and Lehaney propose to use Critical Systems Theory.

### **2.3 Summary of schools of thought**

We have seen that strategic management is about managing continuity, which means walking the fine line between change and stability. In this view, strategic management is about understanding what to change and what not to change. This is also the basic purpose of the Lightswitch approach.

We provided a summary of each of the ten schools of thought defined by Mintzberg et al. This overview enables us to position the Lightswitch approach with respect to strategic management theories. The Lightswitch approach, as we will see in Part 2, is closer to the Interpretative Cognitive, Learning, Power, Environment, and Configuration schools. The properties of the mind that are viewed by the positivist cognitive sciences as distortions of reality are seen by the interpretivists as the inescapable consequences of the search for stability and hence of survival itself. Although these properties can have consequences that may be regarded as negative, and hence seen as biases at some point in time, they cannot be simply removed or corrected. Likewise, the routines described by the evolutionary theory (Learning school) are strongly linked to the enterprise’s word view (interpretations). Therefore, they may not be easy to phase out, transfer, or insert as suggested by the learning school. In this respect, what seems to be missing from evolutionary theory is the relationship between routines and interpretations. This relationship is explicitly made in the Lightswitch approach. In the Lightswitch approach routines are called norms. It is the interaction between an enterprise’s norms and its interpretations of the situation it is in that explains change. The Lightswitch method is oriented towards the careful change of norms and interpretations.

These norms (called routines in evolutionary theory, Section 2.1.6) are said to provide stability to the enterprise, whereas the theories of chaos view the enterprise as an unstable, non-linear system. Managers may therefore be encouraged to favor disturbances. But the norms are there to limit if not eliminate the disturbances in the first place. As we will see in Part 2, the study of regulation explains that systems need disturbances to get information on how well they regulate. But if they regulate very well (if they succeed in imposing strict norms), they have very few disturbances. This is what Weinberg and Weinberg call the “ultimate regulator paradox” (1988, p. 250). This leads to the incapability to regulate well enough and ultimately may lead to very large disturbances and a failure to survive. This explains the need to accept disturbances as part of life and to account for “small” disturbances in order to avoid “large” ones.

We have seen that the Power school attributes a central role to the control of scarce resources. As we will see in Part 2, this is also an important part of the Lightswitch approach. Especially when scarce resources become abundant and vice versa. Moreover, the choice of what resource is considered scarce often is an act of judgment, an interpretation. Changes from scarcity to abundance may be triggered by changes in the interpretation of a situation. Overall, the Power school shows the large part played by what we call the management or regulation of relationships in strategy formation and implementation. In Part 2 we will discuss many of the same issues (adaptation, control, dependency on external and internal relationships) from a systems thinking perspective

Mintzberg et al. note that strategy formation in business is called policy-making in government. They attribute the most well known work in this latter field to Graham Alison’s study of the Cuban missile crisis. As we will see in Part 2, the Lightswitch approach was influenced by another writer on policy making, Sir Geoffrey Vickers.

The configuration school takes the view that change cannot be forced on people. That it may be better to allow change to happen rather than mandate it (Mintzberg et al. 1998, p. 324). This supports the Lightswitch approach of challenging the enterprise’s interpretations and thereby relaxing the constraints on its stakeholders so that the enterprise and its stakeholders may auto-organize into a new configuration. In the process, the mission of the enterprise may change just like we show in our case study of the Templeman library in Part 3.

Mintzberg et al., insist on their view that each school simply builds a model of a complex reality. These models are often reductions and simplifications of this complex reality. This is very well captured in the words of Whitehead as quoted by Mintzberg et al. (p. 347): “Seek simplicity and distrust it.” This means that we should be careful with the simplicity of these models. In the IS development field, this point seems to be often forgotten.

Most notable in this respect is the positivist cognitive school that is seen by some as the main theory behind the so-called Hard systems school of thought in IS development. This school of thought takes a prescriptive language where the model is often mixed with reality. The methods that were developed within this school of thought are often called Hard systems methods, as opposed to Soft systems methods that take great care in separating the model from what is perceived as reality. Soft systems methods therefore tend to be more descriptive than prescriptive. Whereas Hard systems methods offer clear solutions at the expense of some disregard for the issues of stability and interpretations, Soft systems methods focus on these issues at the expense of clear solutions.

## 3 Requirements Engineering and Enterprise Architecture Frameworks

In the previous chapter we have shown that IT systems are considered as strategic assets in modern enterprises. We provided several views of what is meant by the concept of strategy. We then provided a review of strategic management schools of thought and IS schools of thought. In this chapter we will review some of the methods that have been designed during the last decades to enable people to define the requirements of enterprise IT systems. As we will see in this chapter, most of the existing methods and frameworks defined up until now in RE are based on the goal-seeking models defined in the Hard systems school.

In Section 3.1 we review a couple of so-called Enterprise Architecture Frameworks that seek to align the aspects of the IT systems with the strategy and structure of the enterprise. In Section 3.2 we provide an explanation of what is RE and review a number of RE methods. In Section 3.3 we briefly present SSM, STS and Organizational Semiotics, which are positioned as an alternative to the goal-seeking methods of the Hard systems school. For each of the methods we review, we explain our understanding of the method and conclude with a critique of its strong and weak points with respect to our needs. In Section 3.4 we summarize what we see as missing from these frameworks and methods.

### 3.1 Enterprise Architecture Frameworks

In this section we present three Enterprise Architecture (EA) frameworks, Zachman's ISA framework, RM-ODP, and Business Process Reengineering (BPR). EA frameworks are interested in the creation of alignment between an enterprise's strategy and the requirements of its IT systems. Whereas Zachman's ISA framework and RM-ODP can be seen as focused on the IT system to be built, BPR attempts to reengineer an enterprise by using potential IT system to change its way of operating, as well as its goals.

#### 3.1.1 The Framework for Information Systems Architecture

The emergence, since the 1960's, of IT systems in the enterprise has created a situation in which enterprises have become increasingly dependent on the capabilities of their IT systems. This realization led Zachman (1987) to define what he then called: A framework for information systems architecture (ISA). A later paper Sowa and Zachman (1992), proposed a formalization of parts of the ISA framework and an extension of the initial ISA framework. The ISA framework was since renamed as "The Framework for Enterprise Architecture" to show to what extent IT systems were important to the enterprise. However, we will refer to this framework as the ISA framework to distinguish it from other framework that claim to enterprise architecture frameworks such as Compaq's CSAM, now called HP Global Method for IT Strategy and Architecture (HP 2003).

The ISA framework is defined by Zachman as providing a "neutral, unbiased, independent" representation of the enterprise and its IT system (1987). For Sowa and Zachman the ISA framework's purpose is to provide an overall view of the IT system and its relationship to the enterprise and the enterprise's surrounding environment. For Sowa and Zachman, failure to provide such a view may lead to the optimization of only some capabilities of the IT system and/or the enterprise. This partial optimization may come at the expense of the optimization of the enterprise as a whole, thus leading to results that are viewed as negative.

The ISA framework seeks to integrate a number of different representations of the enterprise in a model that is independent of any of these representations. The idea is to provide a holistic view of the enterprise as a whole and at the same time segmenting this holistic view into independent viewpoints so that the each of these viewpoints can be reflected upon, in isolation from the other viewpoints. Thus Sowa and Zachman define the contribution of the ISA framework as:

"An observation of some (apparently) natural rules for segmenting an enterprise into understandable parts without losing the definition of its total integration" (1992)

The term architecture is used to show the analogy between “the construction of a computer system and the construction of a house” (Sowa and Zachman 1992). Hence, the ISA framework is based on analogies between traditional building architecture and IT systems requirements definition, design, and implementation. The analogy is based on the following process of house building:

- In response to a future owner’s initial and vague request for a house to be built, the architect draws a “*ballpark view*” that roughly represents the main items that the house will include. This view serves as an initial agreement between the owner and the architect regarding what the owner wants.
- Next, the architect draws an “*Owner’s view*” that represent what the architect proposes to build. The drawings are made in a way that is understandable to the owner.
- Next, the architect draws the “*designer’s view*” that constitute the architect’s plans in a form understandable by the architect and not by the owner. The architect plans serve as the basis for negotiation with the general contractor who will build the building
- The general contractor draws his own plans that constitute the “*builder’s view*” for the purpose of negotiating with sub-contractors
- Each sub-contractor draws his own plans that constitute an “out of context view.”
- The last view is the building itself.

	What	How	Where	Who	When	Why
Scope	List of entities important to the Business	List of processes the business performs	List of locations in which the business operates	List of organizations/ agents important to the business	List of events significant to the business	List of business goals/strategies
Business model	e.g. entity relationship diagrams	e.g. Processes flow diagrams	e.g. Logistics network	e.g. Organization chat	e.g. Master schedule	e.g. Business plan
Model of the Information System	e.g. Data model	e.g. Data flow diagram	e.g. Distributed system architecture	e.g. human interface architecture	e.g. Processing structure	e.g. Knowledge architecture
Technology model	e.g. Data design	e.g. Structure chart	e.g. system architecture	e.g. human-technology interface	e.g. Control structure	e.g. Knowledge design
Detailed description	e.g. Data definition description	e.g. Program	e.g. Network architecture	e.g. Security architecture	e.g. Timing definition	e.g. Knowledge definition

**Table 2.1 The ISA framework (Sowa and Zachman 1992)**

- The ISA framework consists of table 2.1. This table has six columns and 5 rows.

The rows represent analogs of the architectural levels described above converted to an enterprise with a focus on IT systems. The rows are named:

- Scope description (ballpark view)
- Model of the business (owner’s view)

- Model of the Information System (designer's view)
- Technology model (builder's view)
- Detailed description (out of context view)

Zachman states that each row is not merely a more detailed description of the row above it. Rather, it is a different representation done for a different purpose by different disciplines.

The columns represent the kind of questions that can be asked about each of the rows. Thus, the cells of the table represent answers to the questions: "what entities are involved, how they are processed, where they are located, who works with the system, when events occur, and why these activities are taking place" (Sowa and Zachman 1992) for each one of the views represented by a row.

The formalization of the framework was done by representing the diagrams in each cell with Sowa's conceptual graphs. The goals of the formalization were to formally define what each cell should contain and to establish the relationships between the cells. The idea is to understand the effects of changes in one cell on the other cells. However, Sowa and Zachman's formalization of the framework only applies to the three first columns. Thus, Sowa and Zachman only give examples of what representations could be used in the three last columns without prescribing what they should contain.

The scope description row represents externally visible aspects of the enterprise. The cells of this row represent the following:

- The cell at the intersection with the *what* column represents business entities that are important to the enterprise.
- The cell at the intersection with the *how* column represents the business processes that the enterprise performs
- The cell at the intersection with the *where* column represents the geographical locations of the enterprise

The model of the business row represents relationships between the entities defined in the scope description row. The cells of this row will represent

- relationships between business entities
- relationships between business processes
- logistical relationships between the geographical locations of the enterprise

Sowa and Zachman state that the order of the columns does not represent a hierarchy of importance. This comes from Sowa and Zachman's preoccupation that people from different disciplines will give more importance to one column at the expense of the other columns. For example, Sowa and Zachman state that traditional programmers have a bias toward function. They may give more attention to the How column, leading to a sub-optimization of the other columns. According to Sowa and Zachman specifying an order of the columns will result in a (prescriptive) method which will invariably embody value judgments. While insisting on not specifying an order of importance for the columns, Sowa and Zachman do specify the order of the rows.

From our point of view, the analogy with architecture may have been carried too far. It turns the IT system development into a top-down process reminiscent of the strategic planning methods. Building a house is far different from developing an IT system. People usually know much better what they want from a house than what they want from an IT system. What you can get from a house is much better understood and is more stable than the capabilities of an IT system. A house has boundaries that we perceive much better than the boundaries of an enterprise. The relationships of the house to its environment can be defined in physical terms and constrain what is possible to build much more than the relationships of an enterprise to its environment. For all these reasons and probably more, the ISA framework provides good model for positioning different methods for IT system development rather than a prescriptive, independent and objective model as claimed by Zachman.

Also, apart from the strategic planning orientation of the framework, its segmentation of the different representations (i.e., the columns) is too extreme. By separating the different representations of the enterprise into separate cells in the table, it artificially creates barriers between models that would benefit from being merged. The ISA framework requires that entities and their relationships, their functions, the people who manipulate them and their motivations be separated into four separate columns with four different notations. Thus, the end/means hierarchy (why) is separated from the entities and their relationships (what), from the activities performed on these entities (how), and from the people performing these activities (who). From our point of view these aspects can and should be modeled together. Also, the separation of the what and the who columns is quite artificial. Indeed Sowa and Zachman define that the who column is also applicable to machines or software agents. It thus becomes difficult to place entities in one or other of the columns.

We position the Lightswitch approach as a combination of the four columns (why, who, what, how). The Lightswitch approach is applicable to the two topmost rows, the scope and the business model. Hence, the Lightswitch approach can be used to:

- Model what are the resources and people constituting the enterprise
- What their relationships are
- How they manage these relationships

### 3.1.2 The Reference Model of Open Distributed Processing

The ISO Reference Model of Open Distributed Processing (ISO 1995) is an international standard which was designed to serve as a framework for specifying distributed IT systems made of heterogeneous resources and that potentially span multiple enterprises (ISO 1995, Part 1). The idea that the term distributed systems usually refers to distributed information systems is implicit in most of the RM-ODP publications. RM-ODP is comprised of the following five viewpoints (ISO 1995, Part 1, p. 8):

- “the *enterprise viewpoint*, which is concerned with the business activities of the specified system;
- the *information viewpoint*, which is concerned with the information that needs to be stored and processed in the system;
- the *computational viewpoint*, which is concerned with the description of the system as a set of *objects* that interact at *interfaces* - enabling system distribution;
- the *engineering viewpoint*, which is concerned with the mechanisms supporting system distribution;
- the *technology viewpoint*, which is concerned with the detail of the components from which the distributed system is constructed.”

The partitioning of the specification into separate viewpoints was done with the aim of reducing the complexity of modeling a complete system with a single description language (ISO 1995, part 1, p. 8) (Farooqui et al, 1995). Each ODP viewpoint represents a facet of the specification of the system. Each viewpoint has an associated viewpoint language which is different from the other viewpoint languages (ibid). However, all the viewpoint languages share the same common set of concepts defined in the ODP foundations (ISO 1995, part 2). As noted by Linington (1999), “the viewpoints are interrelated but are chosen to allow substantially independent development of detail, as long as the key areas of overlap are identified and handled in a consistent way.”

As with the EA framework, the five viewpoints taken together are considered to represent a holistic view of the distributed system (Steen and Derrick 2000). Also, as in the ISA framework, each viewpoint is described in a specific language. Unlike Zachman’s ISA framework, though, the five viewpoints are not considered as “architectural layers, but rather as different abstractions of the same system” (Farooqui et al. 1995). Thus, RM-ODP does not prescribe a strategic planning process as the ISA framework does. However, it is generally acknowledged that the enterprise viewpoint defines the overall context, and therefore the constraints that the other viewpoints need to satisfy. Thus, Linington states that: “Most specification activities which use the ODP viewpoints begin with the enterprise

specification in order to establish the purpose, scope and policies of the ODP system” (Linington et al. 1998).

It is in the enterprise viewpoint that the requirements of the IT system are modeled as defined by Farooqui et al:

“Enterprise viewpoint: It is directed to the needs of the users of an information system. It describes the (distributed) system in terms of answering what it is required to do for the enterprise or business, It is the most abstract of the ODP framework of viewpoints stating high level enterprise requirements and policies” (Farooqui et al. 1995).

Farooqui et al. define that the areas of concern of the enterprise viewpoint are “enterprise needs of IS; objectives and roles of IS in the organization” and its role in software engineering is “requirements capture and early design of distributed system” (1995). In the next section we will briefly describe the enterprise viewpoint language standard. This language is usually called the ODP Enterprise Language (ISO 2002). It has recently been standardized as part of the ISO RM-ODP standard<sup>1</sup>.

### 3.1.2.1 RM-ODP Enterprise Language

The purpose of ODP-EL is defined as:

“The purpose of this Recommendation | International Standard is to provide a common language (a set of terms and structuring rules) to be used in the preparation of an enterprise specification capturing the purpose, scope and policies for an ODP system” (ISO 2002).

The term ODP system is equivalent to what we call IT system in this thesis. The IT system being used within an enterprise, ODP-EL provides concepts that can be used to specify the enterprise. Since the focus of the recommendation is on the IT system itself, the enterprise is considered as forming the environment of the IT system:

“An enterprise specification describes the structure and behaviour of the system within its environment. It explicitly includes those aspects of the environment that influence the behaviour of the ODP system – environmental constraints are captured as well as usage and management rules” (ISO 2002).

The ODP-EL standard recommendation explicitly links Enterprise Language to the field of Enterprise Architecture by stating that part of the purpose of this recommendation is to:

“Ensure that the enterprise language when used together with the other viewpoint languages is suitable for the specification of a concrete application architecture to fill a specific business need” (ISO 2002)

and to the field of Requirements Engineering by stating the following:

“When preparing a specification, there are many approaches that are used for understanding, reaching agreement about, and specifying systems in the context of the organizations of which they form a part. Many of these approaches fall into the categories often referred to as analysis or requirements specification. They can provide useful insights into both the organization under consideration and the requirements for systems to support it, but they often lack the rigour, consistency and completeness needed for thorough specification. It is a key objective of this Recommendation | International Standard to provide a way of relating the commonly used concepts and underlying principles of such approaches to the modelling framework of the RM-ODP” (ISO 2002).

ODP-EL consists of a collection of modeling elements and their relationships. This collection of modeling elements is used in order to build an enterprise specification. An enterprise specification is defined as:

“An enterprise specification of an ODP system is a description of that system and relevant parts of its environment. The enterprise specification focuses on the scope and purpose of that system and the policies that apply to it in the context of its environment.

NOTE - The environment of an ODP system and the ODP system itself may span multiple organizations.” (ISO 2002)

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<sup>1</sup> The information we present here is based on a draft version of the standard. Some differences may exist between our quotes and the finalized standard.

The main modeling element of the ODP-EL is called a community. An ODP community generally models an enterprise but it can also be the model of a more transient configuration of enterprises. For example, a community may model a customer or a store but it can also model the transient union of the two enterprises as when the customer is in the store. An ODP community is defined as:

“a configuration of enterprise objects that describes a collection of entities (e.g. human beings, information processing systems, resources of various kinds and collections of these) that is formed to meet an objective. These entities are subject to an agreement governing their collective behaviour. The assignment of actions to the enterprise objects that comprise a community is defined in terms of roles” (ISO 2002).

The concept of objective is defined as:

“Practical advantage or intended effect, expressed as preferences about future states” (ISO 2002).

This definition is further enhanced by the following two notes:

“1 – Some objectives are ongoing, some are achieved once met.

2 – In the text of ITU-T Recommendation X.903 | ISO/IEC 10746-3 [3-5] the terms, purpose and objective, are synonymous. The enterprise language systematically uses the term, objective, and emphasises the need of expressing objective in measurable terms” (ISO 2002).

For Linington (1999) an ODP community’s objective describes what the community “is trying to achieve, in terms of what it is trying to maximize or minimize.” The reference to a single objective for a community is purposeful. Hence, ODP-EL further specifies that:

“Every community has exactly one objective. The objective is expressed in a contract which specifies how the objective can be met. An objective can be a composition of sub-objectives” (ISO 2002).

The contract is the agreement that governs the collective behavior of the enterprise objects that compose the community. The contract:

- “states the objective for which the community exists,
- governs the structure, the behaviour and the policies of the community,
- constrains the behaviour of the members of the community,
- states the rules for the assignment of enterprise objects to roles.” (ISO 2002)

The concept of Policy is considered as central in the ODP-EL. A policy is defined as a “named placeholder for a piece of behaviour” (ISO 2002). More specifically, a policy is defined “as a set of rules related to a particular purpose” (ibid). Rules are defined in terms of the Deontic Logic constructs of *obligation*, *permission*, and *prohibition* augmented with the construct of *authorization*. The latter has been added to the basic Deontic Logic constructs in order to take into account behavior that cannot be prevented, i.e., an empowerment. ODP-EL defines that a policy exists in order to constrain the behavior of the community so that the objective of the community can be achieved:

“The policies of a community restrict the community behaviour in such a way that it is possible to meet the objective. Such policies result in behaviour that suits the objective of the community” (ISO 2002).

The concept of ODP policy is informally defined by Linington (1999) as “a synonym for preferred behavior.” A Policy is said to involve a number of non trivial choices (ibid), i.e., it is neither a choice that is made in only one isolated cases nor does it imply an immediate decision. Although the ODP-EL standard does not explain it, Linington explains the correspondence between an ODP policy and the norms of the enterprise:

“Policies typically reflect some social norms such as legal norms from the underlying jurisdiction domain, management norms emanating from the rules of a particular organization or the norms adopted by various non-formal social groups” (1999).

Linington also states that a Policy relies on a set of invariants for the policy to be effective. According to Linington et al. (1998) ODP policies also specify the assignment of enterprise objects to roles.

Even though the RM-ODP framework is mainly focused on the specification of an IT system (much like the EA framework), the enterprise viewpoint doesn’t necessarily have that focus. An ODP

community may represent an enterprise or an IT system. Indeed, in most ODP-EL publications it is used to model an enterprise.

From our point of view the use that is made of the ODP-EL modeling elements shows a mechanistic view of the enterprise. Thus the main role attributed to the IT system in the ODP-EL related literature is the role of controlling the application of policies (Steen and Derrick 1999a), (Steen and Derrick 1999b), (Steen and Derrick 2000), (Durán and Vallecillo 2001), (Lupu et al. 1999). For example, the most popular example used in this literature is the case of the Templeman library. In this case, the library community's objective is defined as: "to share a collection of books and periodicals amongst a group of members" (Steen and Derrick 99b) or as: "to share this collection amongst the members as fairly and efficiently as possible" (Steen and Derrick 99a). This definition of the objective of the library leads to the following definition of what is seen as the main policy of the library:

"In order to ensure that this objective is met, a borrowing policy is established, which documents the permissions, obligations and prohibitions for the various roles in the library community."  
(Steen and Derrick 1999a)

The result of this focus on the objective and policies as constraining the behavior of communities results in an IT system whose role is to control the application of the policies (Steen and Derrick 99a, Lupu et al. 99). No attempts are made in the ODP-EL literature to propose changes to the declared policies of the enterprise. No analysis is made of the effects of the policies on the enterprise's members. Thus, the objective and policies of an enterprise are taken as absolute and unchanging. In part this state of affairs can be seen as the result of the focus of the ODP-EL on the modeling elements such as Community, Policy Objective, etc. and the lack of a conceptualization of the observed reality of enterprises. Indeed, ODP-EL doesn't contain an explanation of how enterprises are understood and how the modeling elements of ODP-EL correspond to this understanding of enterprises. Since no explicit enterprise conceptualization is given to connect the ODP-EL modeling elements to the reality of an enterprise, the impression that results is that the designer is free to build any enterprise model that suits her without referring to the reality of the enterprise. This impression is counterbalanced by statements such as the ones made by Lington with respect to the relationships between the concepts of Policy and the norms of an enterprise, and by the following statements by Steen and Derrick:

"There is a subtle distinction between an enterprise model and an enterprise specification. A model is a description of an existing situation - a real enterprise - and will describe the specific objects making up the community and their actual behaviour. A specification is a more abstract description of a desirable or future situation. It specifies how an enterprise should be organized and how it should ideally behave. If a specific model is consistent with a specification, then we say that the model satisfies or conforms to the specification. For a particular specification, there may be many ways of implementing it, resulting in different models"  
(Steen and Derrick 99b).

And:

"Another way of viewing the difference is to think of policies as describing the ideal and desirable behaviour within an enterprise whereas the enterprise behaviour is a model of the actual behaviour. The latter may or may not conform to the ideal expressed in the policies. Policy specifications therefore often contain prescriptions of what to do in case some rule is violated" (Steen and Derrick 99b).

However, the disconnect between the ODP-EL models and the observed reality can be clearly seen in the example of the Templeman library described above. In the ODP-EL literature it is taken as a fact that the objective of the library is "to share a collection of books and periodicals amongst a group of members" but the library regulations that serve as the documentation basis for the ODP-EL models don't make any mention of this or any other objective. The library regulations only list the rules of use of the library. Where does this objective come from then? Who decided that this is the objective the library has or should have? How does the choice of this objective constrain the enterprise model produced? Since these questions go unanswered, the objectives and policies are defined in an absolute way and it seems that they cannot be changed.

### 3.1.3 Business Process Reengineering

The origins of the Business Process Reengineering (BPR) movement can be traced to Hammer and Champy's book, "Reengineering the Corporation" (1993). The BPR movement has been extremely influential in management and IS thinking.

Hammer and Champy take the view that modern enterprises are the product of the industrial revolution. These enterprises methods of work (the business processes) were basically defined at a time when management methods prescribed chopping up the overall work needed to produce and deliver goods to customers into elementary tasks that could be performed without thinking. Enterprises then needed to put all these tasks together again into a meaningful whole (1993, p. 29). To do this they needed to develop large bureaucracies that monitored the status of the tasks and relayed the result of each task to the next task. From Hammer and Champy's point of view this led enterprises into a crisis that began in the 1970s. This crisis was largely due to enterprises focusing inward on the tasks that they were performing rather than outward towards their customers. It thus spelled the enterprises' inability to adapt to a changing environment. Enterprises that couldn't adapt were doomed to disappear. For Hammer and Champy, the required change could not be performed by evolving the existing processes of enterprises but by rethinking them from the core. Thus BPR prescribes radical change, rather than the continuous change favored by most other methods such as Total Quality Management (TQM) (Hammer and Champy 1993, p. 49), (Munkvold 2000). This radical change is enabled by:

- focusing on the value created for customers rather than on the current processes and structure of the enterprise, thus designing processes starting from a clean sheet of paper (Hammer and Champy 1993, p. 49)
- searching for ways to integrate these processes with those of the enterprise's suppliers
- using IT systems as the essential enabler (p. 44) for obtaining needed information, coordinating tasks, minimizing controls and handing over of tasks from one person to another.

BPR focuses on a business process as a whole, rather than on individual activities (or tasks). A business process is distinguished from an activity by the value that it gives to customers. Individual activities are not considered as giving this value. For Hammer and Champy a business process is:

"a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer." (1993, p. 35)

The most used example of a process in the BPR literature is order fulfillment. As described by Hammer, it:

"produces value [to the customer] in the form of delivered goods to customers. It is comprised of a great many tasks: receiving the order from the customer, entering it into a computer, checking the customer's credit, scheduling production, allocating inventory, selecting a shipping method, picking and packing the goods, loading and sending them on their way." (1996, p. 5)

In BPR each one of the tasks defined in the process doesn't bring value to the customer in isolation. Only when the process is driven to completion and the goods are delivered to the customer in the order fulfillment example, does the customer receives some value from the tasks performed by the enterprise.

Hammer and Champy argue that in traditional enterprises people focus on tasks that were made as simple as possible, to the point of losing the overall process of which these tasks are a part. They thus state that in a traditional enterprise:

"People involved in a process look *inward* toward their department and *upward* toward their boss, but no one looks *outward* toward the customer." (1993, p. 28)

In BPR it is believed that looking predominantly outward toward the customer will enable the radical change required for the enterprise to survive in an environment for which it was not designed to operate in the first place, i.e. when dramatic improvement is necessary rather than incremental improvement. Hence Hammer and Champy specify that:

“In reengineering, radical redesign means disregarding all existing structures and procedures and inventing completely new ways of accomplishing work. Reengineering is about business reinvention-not business improvement, business enhancement, or business modification.” (1993, p. 33)

It is further believed that by abandoning existing structures and focusing on radical change, the enterprise can be fundamentally challenged in what it does and why it does it rather than how to do what it is already doing better:

“In doing reengineering, business people must ask the most basic questions about their companies and how they operate: Why we do what we do? And why we do it the way we do? Asking these fundamental questions forces people to look at the tacit rules and assumptions that underlie the way they conduct their businesses. Often, these rules turn out to be obsolete, erroneous, or inappropriate.” (p. 32-33)

As an example, Hammer and Champy argue that asking how to perform credit checks more efficiently assumes that credit checks need to be done. However, the cost of credit checking may exceed the risks from bad debt. Maybe checking the credit is not really necessary, or not necessary in all cases.

Hence, for Hammer and Champy

“conventional processes are replete with checking and control steps, which add no value but are included to ensure that people aren’t abusing the process.” (1993, p. 58)

The overhead cost of these checks can be higher than the losses from potential abuses. They advocate simplifying processes so that only aggregate, deferred controls are made in order to cut costs and speed up the process. But no control at all would overly expose the process to abuse. The question then is how much checking and control is necessary and at what point it becomes counter productive.

The dramatic improvement specified by BPR and the radical solutions that it prescribes means that not all enterprises would want to undertake such an effort. Hammer and Champy state that three kinds of companies turn to reengineering: Those that are in deep trouble, those that foresee trouble ahead, and those that want to keep ahead of their competition (p. 34).

Reengineering focuses on processes only. Structure, as in some of the strategic management schools, is considered as wholly dependent on strategy:

“Reengineering must focus on redesigning a fundamental business process, not on departments or other organizational units. Define a reengineering effort in terms of an organizational unit, and the effort is doomed. Once a real work process is reengineered, the shape of the organizational structure required to perform the work will become apparent. It probably will not look much like the old organization; some departments or other organizational units may even disappear...” (p. 40-41).

“Companies that have reengineered their processes have the ability to combine the advantages of centralization and decentralization in the same process. We will encounter this theme at Hewlett-Packard...where a standard purchasing system and a shared database allow the company to combine the best of both worlds.” (p. 63)

Hammer and Champy define the business system diamond that has four points (1993 p. 80-81):

- Business processes,
- jobs and structures,
- management and measurement systems,
- values and beliefs

Each of the four points is connected to its successor point. The diamond, in fact, defines a cycle in which the business processes shape the jobs people perform in the enterprise and the enterprise’s structure; this in turn needs a specific management and measurement system tailored to the jobs performed by the people and the organization’s structure. The management and measurement systems in turn define the values and beliefs within the organization. These values and beliefs support the business processes. Hammer and Champy’s point in defining this model is to prescribe that “All four points on the business system diamond have to fit together or the company will be flawed and misshapen” (p. 81).

From our point of view what seems to be ignored by Hammer and Champy is that any existing enterprise already has a similar cycle that defined much of its behavior. The problem faced by BPR is that reengineering such a cycle is quite difficult and potentially hazardous. Thus, Hammer (1996, p. 7) reports that reengineering efforts saved enterprises by destroying them.

The strong points, dangers and problems linked to BPR can be summarized as follows:

- By redesigning a process from scratch it is possible to eliminate checks that provide no value but it is also possible to overlook important checks that are essential.
- BPR prescribes fewer checks in business processes but not much advice is given on what checks to do and what checks not to do. For example, performing a credit check during an order fulfillment process may not be necessary at all. Not because the enterprise accepts the risks of not checking the credit but because there may be other mechanisms that constrain customers to pay as is the case in some countries. On the other hand the focus on value to be delivered to the customer sweeps under the rug the need for the enterprise to not allow the customer to abuse its processes. The checks are an essential part of the business process. We could, for example, design a business process that delivers goods to customers without requiring them to pay for these goods. Such a business process would give value to customers but not to the enterprise.
- Radical redesign of business processes gives little attention to factors that limit the change capacity of the enterprise. For example, little attention is given to limiting factors due to enterprise's relationships with its suppliers. The enterprise is considered all powerful with respect to its suppliers whereas customers are considered all powerful with respect to the enterprise. Redesigning processes while ignoring current structure implies that the enterprise has an infinite capacity to change.
- At the heart of Hammer and Champy's thinking is the belief that we are living in an era where customers have a vast choice of suppliers. It is, therefore, customers who have the upper hand in negotiations with, and enforce their rules on, suppliers (1993, pp. 18-21).
- The examples given by Hammer and Champy show a tendency to favor integrated solutions where suppliers' and consumers' inventory are merged (p. 22, 43). The benefit of improved performance is thus associated with high risks if anything goes wrong on either consumer or supplier end.
- BPR prescribes that business processes should be designed from the point of view of the value they deliver to customers. However, the notion of a customer is as simple as it might look. In his later book, Hammer defines customers as: "people whose behavior the company wishes to influence by providing them with value" (1996, p. 97). With this definition, people who do not directly pay for a product or a service can still be considered as customers, as in the example of the customers of a pharmaceutical company who are: "the patient who takes the medicine, the doctor who prescribes it, the pharmacist who dispenses, [etc]." (p. 98). However, Hammer does not consider employees, shareholders, suppliers etc. to be customers even though they fit the definition of people whose behavior the enterprise wishes to influence by providing them with value. This in itself may limit innovation when the enterprise fails to realize that a supplier, for instance, can also be viewed as a customer.
- Finally, BPR seeks innovation over automation, i.e. the use of IT systems to do things that were not possible without it as opposed to automating the existing business processes. Pursuing innovation in this sense seems to be the right thing to do but it seems that BPR has gone overboard by ignoring what exists.

## 3.2 RE methods

The classical definition of requirements is: A specification of what the (IT) system<sup>1</sup> should do without specifying how it should do it (Lauesen 2002, p. 24), (Anton 1997). This seems like a definition of an ideal case that is difficult to attain since, as Lauesen points out, in practice it is difficult to separate the “what” from the “how.” The people and enterprises that an IT system serves are usually called the stakeholders of the IT system. Thus, when we speak about requirements we are not talking about all the properties of an IT system but only those properties that are of interest to those stakeholders who use or are affected by the use of the IT system. We make this distinction between the stakeholders because the developers of the IT system are also its stakeholders but they are interested in both the “what” and the “how” whereas the other stakeholders are more interested in the “what” than in the “how.”

Defining the requirements for IT systems is a subject that has preoccupied people concerned with IT system development from the very early days when computers were introduced into enterprises. It is now well accepted that most IT system project fail due to requirements related problems (van Lamsweerde 2000, van Lamsweerde 2001).

In the past, IT system project management theories prescribed the need to define all requirements before the development of the IT system could begin. This is known as the Waterfall model, using the metaphor of water flowing from higher to lower ground to depict the prescription of capturing the requirements then analyzing them then designing the system, testing it, deploying it etc. This process is reminiscent of the prescriptive strategic management schools separation of the formulation of the strategy and its implementation. It is now accepted that it is practically impossible to do so because requirements change with time, most notably during the development project itself. Diving into an IT development project with no requirements at all is also seen as leading to the delivery of the wrong IT system. Proponents of so called Agile methods such as the Agile Alliance (<http://www.agilealliance.org/>) now prescribe the specification of just enough requirements for the project to begin; with the requirements being refined and updated as the project evolves (Beck 1999), Cockburn 2000). The question is how much requirements are necessary upfront.

Lauesen (2002) notes that the most serious problems identified in requirements are related to products being delivered that do not match customers’ expectations. Thus, according to Lauesen, the delivered product fails to adequately support the user tasks and does not enable the customer to “obtain his desired business goals.” That is, “even if the customer gets what the requirements say he should get, he gets a system that doesn’t fully satisfy his real needs.” Lauesen attributes this to requirements that either do not mention the necessary functions or do not describe these functions in a useful form. (p. 18).

Requirements engineers refer to the process by which they identify requirements with stakeholders as *requirements elicitation*. According to the Merriam-Webster dictionary, to elicit means to bring out something latent or potential. Thus, requirements engineers take the view, at least implicitly, that requirements exist in some latent form before they are discovered through the process of elicitation.

According to Lauesen the barriers to requirements elicitation include the following (2002, p. 334-335):

1. Many times stakeholders cannot express what they need. They may not share the same perceptions of their problems with an external observer.
2. “Many users have great difficulty explaining what tasks they perform, and even more difficulty in explaining why they carry out these tasks.”

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<sup>1</sup> Lauesen (2002, p. 22) explains the use of the term “the system” as follows: “In requirements contexts it [the system] often means the product to be delivered.” Wherever possible, we will explicitly speak about the IT system rather than the system in order to distinguish between IT systems and any other subject of interest that can be described as a system such as an enterprise for example.

3. "Often stakeholders specify a solution instead of a demand." For example, specifying that a decision support system is needed whereas the problem may be that they are unable to implement decisions that have been made. The envisioned solution, therefore, will not solve their problems.
4. "Stakeholders find it difficult to imagine new ways of doing things, or imagine the consequences of doing a familiar task in a proposed new way."
5. "Often different stakeholders have conflicting views." Agreeing on requirements that satisfy these conflicting views is likely to be difficult.
6. "Stakeholders will often reject proposals due to a general resistance to change."
7. It can be difficult to have all stakeholders agree on which requirements are essential and which requirements constitute a luxury.
8. "Demands change over time. External factors change and priorities change. Once a demand is met, new ones turn up as a result."

Requirements engineering has emerged as a field of research independent from the disciplines in which it was incepted, software engineering, systems engineering, computer science, in an effort to manage all aspects of requirements in order to specify complete and correct requirements despite problems such as those listed above.

Requirements engineering was defined by Zave as:

"Requirements engineering is the branch of software engineering concerned with the real-world goals for functions of and constraints on software systems" (Zave 1997).

Taken literally the reference to "real-world" goals seems to suggest a rather positivist viewpoint. And indeed Nuseibeh and Easterbrook (2000) state that "many requirements engineers adopt a logical positivist approach". Zave's definition has been generalized by the RE community in the following way:

Requirements Engineering (RE) is the branch of systems engineering concerned with managing desired properties and constraints of software-intensive systems and with goals to be achieved in the environment. It is concerned with these aspects from the problem analysis stage to the implementation and maintenance stages of a system. ([www.re03.org](http://www.re03.org))

Thus we observe a gradual shift towards the consideration of IT systems that are not only software programs. However, the focus is still on the IT system to build. This focus that requirements engineers often have on the IT system is sometimes seen as a potentially harmful. Robertson and Robertson, for example, state that

"the further away from the anticipated automated system you look, the more useful and innovative your product is likely to be" (1999, p. 56).

While Zave and Jackson state that:

"It is not necessary or desirable to describe (however abstractly) the machine to be built. Rather, the environment is described in two ways: as it would be without or in spite of the machine and as we hope it will become because of the machine" (1997).

The question then becomes, what is the environment of the IT system and how it can be described. The environment of an IT system is usually thought of as being the enterprise for which it is built. The definitions of RE given above reflect the point of view, largely shared among requirements engineers, that the enterprises and stakeholders that constitute the environment of an IT system are mainly motivated by the satisfaction of goals.

This point of view leads RE researchers and practitioners to identify goals to be achieved by enterprises and stakeholders and to transform these goals into requirements for the IT system. For those methods to be successful, they need, as input, goals that the enterprise seeks to satisfy. Thus they implicitly assume, or sometime explicitly state, that goals are to be found in the enterprise

documentation, in scenarios, during interviews, brainstorming sessions etc. Thus van Lamsweerde states that:

“Requirements engineering research has increasingly recognized the leading role played by goals in the RE process” (van Lamsweerde 2001).

Goals, in this context, are understood as giving the rationale for stakeholders’ actions and hence, serve as the rationale for software system requirements.

Thus, van Lamsweerde defines RE as:

“Requirements engineering (RE) is concerned with the identification of the goals to be achieved by the envisioned system, the operationalization of such goals into services and constraints, and the assignment of responsibilities for the resulting requirements to agents such as humans, devices, and software” (van Lamsweerde 2000)

There is some confusion in the RE literature as to whether this focus on goals is shared across the RE discipline or whether it is more specifically centered in the so called, Goal-Directed (or Goal-Oriented) Requirements Engineering. Thus van Lamsweerde later states that:

“Goal-oriented requirements engineering is concerned with the use of goals for eliciting, elaborating, structuring, specifying, analyzing, negotiating, documenting, and modifying requirements.” (van Lamsweerde 2001)

And Anton states that:

“Goal-driven approaches focus on why [software] systems are constructed, providing the motivation and rationale to justify software requirements” (Anton 1997, p. 15).

We will refer to the methods that place a high emphasis on goals in RE as to Goal-Directed Requirements Engineers (GDRE). GDRE methods can be seen as a subset of RE methods, which propose techniques for defining the complete requirements for a software system starting from stakeholders’ goals. However, we will show that most other RE and enterprise architecture methods give goals a very important place.

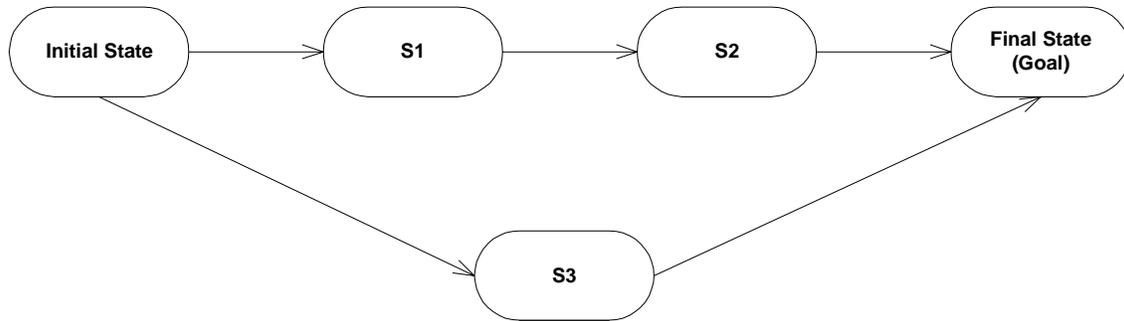
Anton explains what sets GDRE methods apart from more “traditional” RE techniques in the following way:

“Traditional systems analysis focuses on what features (i.e. activities and entities) a system will support. Goal-based approaches focus on why systems are constructed, providing the motivation and rationale to justify software requirements. The notion of focusing on the why is not new; organizing requirements around goals is new” (Anton 1997, p. 24)

GDRE methods are mainly built on the notion that goals can be arranged in a hierarchical order, from high-level to low level goals, as indicated by van Lamsweerde:

“Goals may be formulated at different levels of abstraction, ranging from high-level, strategic concerns (such as “*serve more passengers*” for a train transportation system or “*provide ubiquitous cash service*” for an ATM network system) to low-level, technical concerns (such as “*acceleration command delivered on time*” for a train transportation system or “*card kept after 3 wrong password entries*” for an ATM system)” (van Lamsweerde 2001).

GDRE methods are mainly based on problem solving techniques developed in Artificial Intelligence (AI). The main technique used in these methods is *goal-reduction*. Goal reduction is a technique used to *reduce* a goal into subgoals. A goal is usually defined as a state to be achieved. Mylopoulos et al. (2001), for example define the concept of goal as: “condition or state of affairs in the world that the stakeholders would like to achieve.”

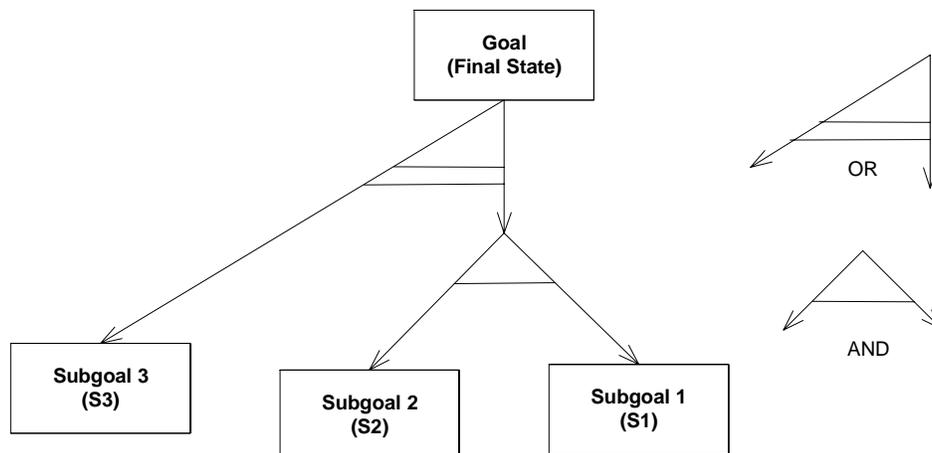


**Figure 3.1 States needed to achieve a goal (UML state diagram)**

Figure 3.1 enables us to explain what is meant by goal reduction. If we define a goal of interest as being: some final state to be achieved from some initial state, several intermediate states can be defined as being necessary to be achieved. These intermediate states are called subgoals of the goal of interest. All these subgoals are considered to be necessary for the achievement of the goal of interest. Therefore, the relationship between them is said to be an AND relationship, since subgoal 1 and subgoal 2 etc. all have to be achieved for the goal of interest to be achieved.

Another consideration is that there are multiple ways of achieving some goals, i.e., many different intermediate states can be defined between the initial and final states. This consideration leads to the definition of alternative subgoals which are said to have an OR relationship, since subgoal 3 can be achieved for the goal of interest to be achieved. The OR relationship is also said to represent a different path to reach the goal of interest. The AND and OR relationships can be joined since on the different paths that lead to the final state several intermediate states can be distinguished. Thus a graph such as the one in Figure 3.2 is constructed.

The techniques used to *reduce* a goal of interest into subgoals that have AND and OR relationships are called *goal reduction* (or sometimes goal refinement). The resulting graph in Figure 3.2 is known as an And/Or graph, Goal-reduction graph, or Goal-refinement graph. Goal reduction techniques have initially been proposed as problem solving techniques in Artificial Intelligence (AI). The goal-reduction graph in Figure 3.2 is equivalent to the UML state diagram in Figure 3.1. In order to achieve the goal (reach the final state), the subgoals 1 and 2 need to be achieved or subgoal 3 alone can be achieved.



**Figure 3.2 Goal reduction graph (AND/OR graph)**

Goals that are closer to the root of the goal reduction graph are known as higher-level goals than goals that are farther from the root. Higher level goals are found by asking why questions on lower level goals. Lower level goals are found by asking how questions on a higher-level goal. Moving up the

goal-graph by asking why questions is often referred to as *goal abstraction*, this acts contrary to goal reduction.

This focus of GDRE methods on goals is explained as resulting from the following observations (van Lamsweerde 2001):

- Goals are more stable than the requirements that implement them. (van Lamsweerde 2001), (Anton 1997). The higher level the goal is the more stable it will be (van Lamsweerde 2001).
- Goal refinement techniques give traceability from organizational goals to IT systems requirements, as stated by van Lamsweerde (2001): “More explicitly, a goal refinement tree provides traceability links from high-level strategic objectives to low-level technical requirements. In particular, for business application systems, goals may be used to relate the software-to-be to organizational and business contexts.”
- Goals enable to verify that the requirements are complete. If the requirements can be proved to satisfy all the stakeholders’ goals, then the requirements are complete.
- Avoiding irrelevant requirements. Goals enable requirements engineers to define which requirement is irrelevant and which is not.
- Goals enable requirements engineers to better explain requirements to stakeholders.
- Goals enable requirements engineers to manage conflicting requirements
- Goals enable requirements engineers to consider alternative design decisions
- Goals and scenarios are considered to be a basic driving force behind requirements

In GDRE methods, goals are identified by using the following techniques (van Lamsweerde 2001), (Anton 1997):

- Understanding stakeholders’ problems and negating them
- Systematically searching for intentional keywords in
  - interview transcripts
  - enterprise policies
  - enterprise mission statements
  - enterprise goals
  - workflow diagrams
  - scenarios written with stakeholders

This last point, analysis of scenarios is very popular. Most GDRE methods rely on a tight coupling of goals with scenarios.

GDRE methods consistently make reference to BPR and sometimes to strategic planning as the “organizational theory” of choice. Goals are implicitly and explicitly considered as the ultimate explanation of human behavior.

Examples of GDRE methods are KAOS (Dardenne 1993), GBRAM (Anton 1997), ESPRIT CREWS (Rolland et al. 1998), i\*, Tropos, GRL (Mylopoulos et al 2001), (Mylopoulos et al. 1999), (Yu and Mylopoulos 1994), essential use cases (Constantine 1995), goal-oriented use cases (Cockburn 2000), and Lauesen’s goal-oriented tasks (Lauesen 2002).

In Section 3.2.1 we present the KAOS method. In Section 3.2.2 we present the i\*, Tropos, and GRL families of methods. In Section 3.2.3 we present the GBRAM methods. In Section 3.2.4 we present essential and goal oriented use cases. In Section 3.2.5 we present goal oriented tasks.

### 3.2.1 KAOS

KAOS is a formal approach for analyzing goals and produce requirements based on pre-stated goals. There is an abundant KAOS literature, e.g., (Dardenne et al. 1993), (van Lamsweerde et al. 1995), (van Lamsweerde et al. 1998), (Darimont and van Lamsweerde 1996), (van Lamsweerde 2000), (van Lamsweerde 2001). KAOS is largely the product of van Lamsweerde at the Catholic University of Louvain, Belgium.

The KAOS approach is mainly oriented towards insuring that high-level goals identified by stakeholders to concrete system requirements. The method is composed of:

- A specification language based on concepts such as object, action, agent, goal, constraint, etc. This language also used a so called real-time temporal logic to represent constraints on past and future states. The temporal primitives are, for example:
  - in the next state
  - in the past state
  - always in the future
  - always in the past
- An elaboration method for transforming stakeholders' goals into requirements for the software system. This method includes classical questions such as how and why to refine and abstract goals in the goal-reduction graph: the identification of pre, post and trigger conditions of goals, the identification of agents to which goals are to be ascribed, identification and resolution of conflicts etc.
- A meta-level knowledge base used for guiding decisions during the elaboration process. This meta-level knowledge base contains
  - a classification of goals
  - rules for insuring the consistency and completeness of requirements
  - tactics and heuristics for driving the elaboration and selecting among alternative goals

For our point of view, the most interesting aspect of KAOS is the classification of goals. KAOS classifies goals into: achieve, cease, maintain, avoid and optimize goals. Achieve and cease goals are said to generate behaviors. Maintain and avoid goals are said to restrict behaviors. Optimize goals are said to compare behaviors (Dardenne et al 1993).

From our point of view, the KAOS literature doesn't explain the need to classify goals in this way. KAOS uses domain knowledge that is considered as objective knowledge, to reduce goals into subgoals (Dardenne et al. 1993), (Darimont and van Lamsweerde 1996). Also, KAOS does not encourage the challenging of goals given expressed by stakeholders with the exception of conflict resolution (van Lamsweerde et al. 1998). Thus, KAOS provides tools for transforming stakeholders' goals into requirements but without making sure that these are the right goals to base the requirements on.

### 3.2.2 i\*, Tropos, and GRL

i\* is a modeling method that aims at modeling "strategic relationships" between actors that represent stakeholders and their goals. i\* can be used to:

- explore alternative business processes by showing how the actors depend on each other for the achievement of goals
- to evaluate the merit of different alternative non perfect solutions for the satisficing of ill defined non-functional requirements

Tropos is a software development method that includes i\* as its requirements method. GRL is an international standardization effort of i\*. There is an abundant literature on this family of methods,

e.g., (Nixon 1992), (Yu and Mylopoulos 1994), (Mylopoulos et al. 1999), (Mylopoulos et al 2001) (ITU 2001). In this discussion will focus on GRL and i\*.

GRL is part of a standard draft of ITU that is called URN, for User Requirements Notation. There are two parts to this standard: URN-FR refers to the Functional Requirements part and URN-NFR refers to the Non Functional Requirements. GRL is the language proposed to describe URN-NFR.

GRL has evolved from the basic idea that there are two kinds of requirements Functional Requirements (FR) and Non Functional Requirements (NFR). FR are understood as those requirements that describe what the system should do for its stakeholders. NFR are understood as whatever is non FR, i.e., issues such as, customer satisfaction, increase of market share, availability, security, adaptability etc. (Nixon 1992), (Mylopoulos et al 1999).

GRL is said to offer the capability to model intentions:

“There are three main categories of concepts: *actors*, *intentional elements*, and *links*. The intentional elements in GRL are goal, task, softgoal, resource and belief. They are intentional because they are used for models that allow answering questions such as why particular behaviours, informational and structural aspects were chosen to be included in the system requirement, what alternatives were considered, what criteria were used to deliberate among alternative options, and what the reasons were for choosing one alternative over the other” (ITU 2001).

The ITU document defines that modeling intentions gives the modeler a higher level (or strategic) view of requirements compared with what is considered as traditional modeling of requirements where detailed specifications of IT system behavior are modeled:

“This kind of modelling is different from the detailed specification of what is to be done. Here the modeller is primarily concerned with exposing "why" certain choices for behaviour and/or structure were made or constraints introduced. The modeller is not yet interested in the "operational" details of processes or system requirements (or component interactions). Omitting these kind of details during early phases of analysis (and design) allows taking a higher level (sometimes called a strategic stance) towards modelling the current or the future software system and its embedding environment” (ITU 2001)

The basic idea of GRL is that these issues can be captured with the concept of softgoal. While goals are defined as:

“a condition or state of affairs in the world that the stakeholders would like to achieve,” (ITU 2001).

A softgoal is defined as a goal for which:

“A softgoal is a condition or state of affairs in the world that the actor would like to achieve, but unlike in the concept of (hard) goal, there are no clear-cut criteria for whether the condition is achieved, and it is up to subjective judgment and interpretation of the developer to judge whether a particular state of affairs in fact achieves sufficiently the stated softgoal” (ITU 2001).

The main modeling elements in GRL are: Actor, Goal, Softgoal, task, resource, and belief. A task specifies a particular way of doing something.” A resource is an artifact shared by actors. The concept of belief is defined as

“Beliefs are used to represent design rationale. Beliefs make it possible for domain characteristics to be considered and properly reflected into the decision making process, hence facilitating later review, justification and change of the system, as well as enhancing traceability” (ITU 2001).

Notice that this definition doesn't describe to whom a belief belongs. If a belief is a design rationale we are drawn to the conclusion that it belongs to the designer rather than to the stakeholder. The GRL literature does not explain how beliefs are formed or how they should be used. Thus, the concept of belief is only occasionally used in GRL and i\* models that appear in the literature.

Goals, Softgoals, tasks, and beliefs are called intentional elements in GRL. GRL defines a number of relationships between the modeling elements including:

- Means-end links reflect how goals are achieved
- Decomposition links show what are the component of a task

- Contribution links show how one intentional element influences the achievement of another intentional element. Contribution links serve to create an argumentation structure in order to evaluate the merit of different alternative designs mainly in terms of the satisfaction of softgoals.
- Dependency links establish a relationship between two actors. They contain what are called dependums. A dependum can contain a goal, softgoal, task or resource.

In GRL, as in KAOS, goals are considered to have been predefined. The distinction between goals, softgoals, and tasks is also considered as non problematic. Thus GRL is very effective in evaluating different design alternatives once the main goals of the stakeholders have been identified.

According to Kavakli (2002), i\* makes fewer assumptions about the need for an IT system than methods such as KAOS and GBRAM, it is thus useful in an earlier phase when the debate centers about how to resolve some problem rather than what the goals of the IT system should be.

The purpose of GRL is to model strategic relationships and reflect about their needs but it doesn't offer tools for representing the constraints imposed by the context of an enterprise and the different interpretations that stakeholders may have of these constraints.

From our point of view, GRL proposes most of the right modeling elements: ill defined or never ending (soft) goals, beliefs to document design rationale, argumentation links to show favored and non-favored solutions, network of inter-dependent actors, and the distance from the IT system to build. Unfortunately, GRL publications provide no theoretical explanations for the modeling elements that were selected, making them somewhat arbitrary. Maybe because of this lack of theoretical underpinning, the level at which the relationships between the actors are modeled seems somewhat arbitrary. Hence, the relationship between a store and a customer will consist mainly in the customer purchasing items from the store while the store relies on the customer for increasing its market share. The relationship between an insurance company and a client will be modeled at the level of negotiating a claim. The alternative solutions will thus range from this level down the goal hierarchy, i.e., different ways of purchasing an item, different ways of negotiating a claim etc. Questions such as: Why does the store want or need to increase its market share? Why does it think that increasing this market share is best done by selling items to customers and by having happy customers? Why would customers buy items from this store rather than from any other store? Are not asked nor answered. Thus, even though the aim is to expose strategic issues, these are only modeled from the narrow point of view of selling an item to a customer rather than the more holistic view that will model how the store balances its relationships with customers, suppliers, investors, regulators etc.

### 3.2.3 GBRAM

The Goal Based Requirements Analysis Method (GBRAM) proposed by Anton (Anton 1997), (Anton and Potts 1998), seeks to correct for the deficiencies observed in other GDRE methods such as KAOS and i\* with respect to the identification of high-level goals. Anton claims that "current goal-based methods have not provided adequate strategies for the initial identification of goals" (1997, p. 20) Thus, contrary to other GDRE methods, GBRAM doesn't assume that high-level goals have been previously specified.

"Existing goal-based methods usually fail to address the initial identification and origin of goals, taking previous documentation of the goals for granted" (p. 67).

"In contrast to other approaches, GBRAM focuses on the initial identification and abstraction of goals from all available sources of information regardless of the scope of the knowledge base" (p. 67)

"Using GBRAM analysts must first explore the available information to identify and extract goals from these sources" (p. 74).

Thus, in GBRAM, the origin of goals is considered to be the available information sources, scenarios, etc. Stakeholders identification proceeds from the identification of goals, as defined by Anton:

"The stakeholders for each goal are determined by asking "Who or what claims a stake in this goal?" and "Who or what stands to gain or lose by the completion or prevention of this goal?" (p. 79).

One of the main preoccupations in GBRAM is the need to create models that are understandable by stakeholders.

The GBRAM inquiry process follows the following activities:

- Extracting goals from natural language documents, interviews policy statements etc (p. 73)
- Identifying goals and stakeholders and matching stakeholders with goals. (p. 73)
- Organizing goals by considering their precedence relationships and classifying these goals into different types of goals, mainly into maintenance and achievement goals. (p. 73)
- Refining goals, eliminating redundancy and reconciling synonymous goals (p. 95)
- Elaborating goals, uncovering hidden goals and requirements by identifying goal obstacles and scenarios (p. 95, 96)
- Operationalizing goals, transforming goals into a software requirements document by formalizing goals into goal schemas and identifying the actions necessary to support the goals. (p. 71, 95).

In GBRAM, the source of goals is said to be the input document identified above. Goals are identified through the following technique:

“To identify goals, each statement (or piece of information) is analyzed by asking, “What goal(s) does this statement/fragment exemplify?” and/or “What goal(s) does this statement block or obstruct?” (Anton 1997, p. 75)

In GBRAM the general concept of goal is defined as:

“Goals are targets for achievement which provide a framework for the desired system. Goals are high level objectives of the business, organization, or system. They express the rationale for proposed systems and guide decisions at various levels within the enterprise. Corporate profits maximized is an example of a high-level enterprise goal.” (Anton 1997, p. xx)

“Achievement goals are objectives of an enterprise or system.” (Anton 1997, p. xx)

GBRAM built upon the maintenance goal notion already introduced by KAOS. GBRAM gives the following definitions for achievement goals and maintenance goals:

- “An achievement goal is satisfied when the target condition is attained.
- “Maintenance goals are those goals which are satisfied while their target condition remains constant or true. They tend to be operationalized as actions or constraints that prevent certain states from being reached. In general, maintenance goals map to nonfunctional requirements.” (Anton 1997, p. xx)

GBRAM further establishes some relationship between achievement and maintenance goals:

“Maintenance goals are usually high-level goals with which associated achievement goals should comply.”

Even though the importance of maintenance goals is acknowledged, Anton states that:

“GBRAM focuses primarily on achievement goals because they map to actions that occur in the system and aid analysts in specifying the functional requirements necessary to satisfy the needs of the stakeholders and customers.” (Anton 1997, p. 84)

“Maintenance goals are classified by considering each goal and asking: ‘Does this goal ensure that some condition is held true throughout all other goal operationalizations?’ ‘Does this goal affect decisions at various levels within the organization?’ and ‘Is continuous achievement of this goal required?’ Maintenance goals can also be identified by searching for certain key words (i.e. provide and supply) that suggest a continual state within the system” (Anton 1997, p. 85).

In GBRAM, maintenance and achievement goals are distinguished based on keywords that found in the natural language documentation. Table 2.2 gives those keywords for achievement and maintenance goals:

Achievement Goals Keywords (Anton 1997, p. 87)

Maintenance Goals Keyword (Anton 1997, p. 85)

- Achieve
- Make
- Improve
- Speedup
- Increase
- Satisfied
- Completed
- Allocated
- Maintain
- Keep
- Ensure
- Avoid
- Know
- Monitor
- Track
- Provide
- Supply
- Found out

**Table 2.2 Keywords for classifying achievement and maintenance goals (Anton 1997)**

For our purposes, apart from the classification of achievement and maintenance goals, the following heuristic defined in GBRAM is of importance:

“Analysts should first seek to understand the stakeholder’s application domain and goals before concentrating on the actual or current system so that the system requirements may be adequately specified. Previous research indicates that customers tend to express their goals within the context of their application domain, not in terms of an existing or desired system” (Anton 1997, p. 149).

Anton provides the following example of this principle:

“The goal of a college financial services system is not to maintain a financial ledger/database (system goal) as typically described by management level stakeholders, but to ensure that, among other requirements, the budget remains balanced; sponsors are charged according to their contracts; and faculty are paid according to state research contracts, as typically described by customers using their application domain vocabulary” (Anton 1997, p. 149).

Having said that, Anton does not give further details on how the judgment about what is the “real goal” is done. Is it possible that for the database analyst, the financial system serves precisely to maintain the database? Is it possible that at the same time, for the financial analyst the goal of the financial system is to maintain a balanced budget, charge sponsors and pay faculty?

From our point of view, GBRAM presents the following problems:

- Goals are presumed to exist. No theoretical explanation is given as to the nature of goals
- Goals “extracted” from artifacts are not questioned as to their validity. The goal set is classified, reconciled, expanded etc. but is not fundamentally challenged. In other words, the question, why are the identified goals necessary for the stakeholders is not asked
- As in KAOS there is no explanation of the role goals represent in human affairs. No enterprise model is proposed. In GBRAM there is no explanation of why maintenance goals are needed or exist.
- The influences of the resulting goals on the enterprise structure are not analyzed.
- The structure of the enterprise is not modeled, i.e., the stakeholders are modeled as individuals rather than members of an enterprise. Few attempts are made to understand the enterprise in its environment. Policies and goals are not understood in terms of past experience of the enterprise.
- The focus of the analysis is on building an IT system that satisfies stakeholders’ goals within the enterprise in question.

The main point in GBRAM is the process and heuristics that enable analysts (as they are called in GBRAM) to elicit goals from stakeholders and specify scenarios for their achievement. This is lacking in both GRL and KAOS. However, GBRAM is very focused on goals of the IT system and therefore focuses on achievement goals because they pertain to functional requirements. Ultimately, the result is an IT system that automates existing business processes without attempting to provide innovative solutions. These solutions must have been specified before the GBRAM analysis is started. Thus GBRAM is useful for generating requirements for an IT system when the high-level goals for the IT system are already known.

### 3.2.4 Essential and Goal Oriented Use Cases

The concept of a *Use Case* was first introduced into RE by Jacobson et al. (1992). The idea was to describe a user's "behaviorally related sequence of transactions in a dialog with the system" (p. 127). Thus, a use case represents a subset of a user's interactions with the IT system. The names given to use cases by Jacobson et al. represent actions such as "Acknowledge flight, Check schedule, and Confirm booking" in the case of a flight system (p. 128).

Constantine (1995), and Constantine and Lockwood, (1999), showed that designers embed many design decisions about the user interface of the IT system in these use cases. From Constantine and Lockwood's point of view, this resulted in systems being developed that didn't adequately support users' work. Constantine and Lockwood describe the problem faced by designers as:

"How do we distinguish what is truly necessary to support the work from what users may say they want or from what we are by habit prepared to offer? How can we describe and represent this work, and how can we then use our understanding of the work to design the architecture of the user interface to support it?" (Constantine 1995).

To represent "what is truly necessary" as opposed to the details of the interactions and to move away from what designers are used to provide users, Constantine and Lockwood proposed the concept of *Essential Use Case Modeling*:

"Essential use case modeling can be thought of as more usage-centered than user-centered, a "teleocentric" (purpose-centered) approach to design, rather than a "user-centric" one. Users are certainly not unimportant in this view, but they are most important as sources of understanding regarding the effective support of their work" (Constantine 1995).

An essential use case is defined as:

"a simplified and generalized form of use case, an abstract scenario for one complete and intrinsically useful interaction with a system as understood from the perspective of users who play a particular role in relation to the system" (Constantine 1995).

An essential use case contains only the interactions of the user with the IT system that are necessary to achieve a user's goal. Constantine and Lockwood's classical example is the Automatic Teller Machine (ATM). Rather than describing the interactions of an ATM in detailed form: User inserts an ATM card into the ATM's card reader; user types her PIN; user types the amount to withdraw etc. An essential use case will only specify the steps deemed necessary by the designer so that the ATM will be able to satisfy the user's goal: to get cash. Thus, an essential use case specifies the following interaction: User identifies herself to ATM; ATM verifies identity of user; ATM offers choices; user selects a choice; ATM gives money; user takes money.

For Constantine and Lockwood, an essential use case represents an ideal case and serves as a measure for good user interface design. It also enables designers to specify alternative user interfaces that support the user's goal. Thus, instead of specifying that all ATM's use a card reader as a means for identifying the user, the designers can think of other identification means such as, finger prints, signature recognition etc. The alternatives are not limited to the use of technology. By identifying that the user's goal is to get cash as fast as possible, it becomes clear that a fast cash option of a pre-selected amount from a pre-selected account can be specified (Constantine 1995).

Constantine and Lockwood further define that "essential use cases are not invented in a vacuum" (Constantine 1995). The definition of essential use cases is based on *role model* that describes "the

roles that users play in relation with the system” (ibid). A user role is defined by Constantine and Lockwood as:

“A user role is an abstraction from the behavior of actual users who might interact with a system in similar or related ways. A user role is a collection of common interests, behaviors, and responsibilities” (Constantine 1995).

While Constantine and Lockwood implicitly state that the steps defined in the use case are dependent both on the user’s goal and constraints imposed on this goal, they stop short of explicitly discussing this issue. Also, an essential use case only describes a dialog between user and system. No other entities are involved. Finally, in Constantine and Lockwood define only two levels of modeling essential and detailed. A use case is either essential or detailed. Cockburn (2000) explicitly discusses the constraints that shape a use case; he defines a use case as a contract between multiple stakeholders and he specified multiple levels of use cases. Hence, the work of Cockburn can be seen as a generalization and enhancement of Constantine and Lockwood’s framework<sup>1</sup>.

Cockburn defines a use case as:

“The use case describes the system’s behavior under various conditions as the system responds to a request from one of the stakeholders, called a primary actor. The primary actor initiates an interaction with the system to accomplish some goal” (2000, p. 1).

Here the notion of “the system” has been extended to mean more than just the IT system to be developed. Thus, Cockburn states that:

“When use cases document an organization’s business processes, the system under discussion (SuD) is the organization itself. The stakeholders are the company shareholders, customers, vendors, and government regulation agencies. The primary actors include the company’s customers and perhaps their suppliers” (p. 2).

To distinguish between use cases for the IT system and use cases for the enterprise, Cockburn defines three different design scopes to be included in each use case: The Enterprise design scope applies to use cases where the SuD is the business itself. These use cases are called business use cases. The System design scope applies to use cases where the SuD is the IT system. The Subsystem design scope applies to use cases where the SuD is a part of the IT system.

Cockburn defines that the SuD is “a mechanism to carry out a contract between various stakeholders” (p. 23). Therefore, the system’s behavior as described in the use case is designed to satisfy the interests of the stakeholders. Hence the ATM refuses to deliver to the user more money than the user has in her account so that the bank’s interests are satisfied. Thus, Cockburn specifies the stakeholders interests serve to define the use case steps in a way that insures that these interests are satisfied. To completely specify a use case, all stakeholders and their interests need to be defined (2000, p. 30).

For Cockburn as for Constantine and Lockwood, a use case’s name defines its “topmost” goal. Cockburn states that a topmost goal is achieved through subgoals and that: “subgoals can be broken down into subgoals indefinitely” (p. 24). For Cockburn the most difficult part of writing use cases in controlling the subgoal granularity. He thus defines a set of levels for goals that should help designers to specify at what goal/subgoal level they are writing a specific use case. Cockburn’s classification scheme defines three broad classes of goals: Summary level goals, User level goals, and Detail level goals. Cockburn uses the separation from sea and sky as a metaphor for naming these levels. White (color of sky) is reserved for summary level goals. Blue (meeting of water and sky) is for user level goals. Indigo (underwater) is reserved for detailed goals. For Cockburn, the most important goals are the user level goals. They are the goals that the primary actor or user have when they use the IT system (p. 62). Cockburn further states that these user level goals are extremely important because:

“The shortest summary of a system’s function is the list of user goals it supports-this is the basis for prioritization, delivery, team division, estimation and development” (p. 63)

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<sup>1</sup> We are not implying here that this is historically true. Only that from our point of view, Cockburn’s work can be seen as generalizing and adding more business modeling issues to Constantine and Lockwood’s work.

In attempting to define what goal is a user level goal Cockburn defines that it is what a person wants from a system “now.” This means that a goal qualifies for a user level if it is something that one or two people might want to achieve in a time span of some 20 minutes (p. 62). If the thing to be achieved is substantially longer than that, say handling an insurance claim, that it is a summary goal.

Summary level goals are defined as “showing the context in which user goals operate” (p. 64). Cockburn states that “summary use cases typically execute over hours, days, weeks, months, or years.

For Cockburn, goals are discovered by orchestrating brainstorming sessions among the designers.

From our point of view, Cockburn’s framework has the following advantages and disadvantages;

- As we have seen the main focus is on goals that can be satisfied in a short time span because these are the goals that have the most immediate influence on the IT system’s requirements. Thus, for business use cases the goals suggested by Cockburn’s examples seem quite low level from a business perspective.
- With respect to the other GDRE methods, Cockburn adds the notion of systems as satisfying multiple stakeholders’ interests. This goes one step toward the notion of the enterprise as regulating multiple relationships. For example, government regulators such as the Internal Revenue Service are named as stakeholders in the case of a store.

### 3.2.5 Goal Oriented Tasks

Lauesen (2002) describes a set of techniques for identifying, analyzing, validating, and documenting requirements. Lauesen’s main goal seems to be the specification of requirements for which a supplier of an IT system can take responsibility.

It is difficult to summarize the techniques described by Lauesen in a few lines. However, from our point of view, Lauesen’s techniques consist in identifying stakeholders’ goals, writing tasks that achieve these goals, writing use cases that separate the activities to be done between IT system and user, validating the resulting requirements with respect to quality aspects, and writing a coherent requirements document.

At the beginning of the requirements definition phase of a project, Lauesen as well as Robertson and Robertson encourage designers to create a context diagram (Lauesen 2002, p. 76), (Robertson and Robertson 1999, p. 45). A work context diagram shows the relationships of the system to be developed with its stakeholders. The system can include IT systems and people. The system is not described in detail, only the services it provides to its stakeholders and the information it requires of them are represented in the diagram. The context diagram defines the context of the development to be performed by the designers. It specifies what is included in the system and what is not. Lauesen states that:

“It is extremely useful to outline a context diagram early in the project and keep it updated during analysis. Making the diagram can reveal amazing differences in the understanding of what the product really comprises.” (2002, p. 77)

However, Lauesen notes that context diagrams are rarely used in large projects (p. 78).

Lauesen distinguishes between three domains (p. 20):

- The product, which in our vocabulary is the IT system to be delivered.
- The inner domain (also called the domain) consists of “the product plus the surrounding work area” the surrounding work area typically groups the product’s “immediate users and their activities, as well as any special systems that the product must communicate with” (p. 20).
- The outer domain (also called the business domain) consists of the clients of the inner domain.

These domains result in 4 levels of requirements:

- The goal level represents goals formulated by clients in the business domain.

- The domain level represents tasks that users wish to perform to achieve the goals formulated at the goal level.
- The product level represents descriptions of functions provided by the product to support the tasks formulated in the domain level.
- The design level represents descriptions of the interface the product should have with its users and the other systems it interacts with.

Thus business goals are traced to tasks which are traced to functions and interfaced of the product. Tasks are defined as “what the user and product do together to achieve some goal” (p. 92). Lauesen uses task descriptions before specifying use cases. Tasks descriptions do not differentiate between what the product does from what the user does. A task description merely reduces a task into an ordered list of subtasks. Thus a task description is equivalent to the goal reduction techniques used by the other GDRE methods. Once the sufficient level of tab tasks has been reached, user cases are written to allocate the subtasks to the user and the product. The result is no early focus on the IT system to be built but rather a focus on the nature of the work to be accomplished.

Lauesen has developed a technique called Task & Support in order to evaluate different possible solutions to support a given task with respect to a set of problems formulated by the stakeholders. For example, for a task such as find a room for a hotel guest, an identified problem may be that guests want neighboring rooms. A possible solution is for the IT system to show free rooms on floor maps (p. 105). This technique is very close to the technique we use in the Lightswitch approach of satisfying goals with beliefs.

From our point of view, what is missing from Lauesen’s work is what we could term a higher-level analysis which seeks to understand why the stakeholders have defined these goals rather than any other goals and what other goals they could formulate, which will result in an IT system that will be better suited to their needs. The context diagrams could be useful for this purpose but as currently defined and used they are fairly limited. The models created with the Lightswitch approach, can be seen as extended context diagrams enabling designers to define the context of the work to be accomplished, the wishes of the different stakeholders and how to satisfy them.

### **3.3 Soft systems methods, SSM, STS, and Organizational Semiotics**

The three main families of methods related to the soft systems school that we present in this section are

- Soft System Methodology (SSM).
- Socio-Technical Systems (STS) methods.
- Organizational Semiotics methods.

We review SSM, STS, and Organizational Semiotics together because they oppose the Hard systems school. This is not necessarily the view adopted by the proponents of these methods. As we have seen in our review of the Soft systems school of thought, both STS and organizational Semiotics view themselves as bridging the gap between the Hard systems and Soft systems schools of thought.

#### **3.3.1 SSM**

We have already mentioned SSM in Section 2.2.2 when we discussed the Soft systems school of thought. The proponents of SSM position it as an alternative to the methods we have reviewed in the previous section and which can be seen as generally subscribing to the Hard systems school of thought. SSM is based on the belief that human action is not so much goal-directed (i.e. teleological)

but rather that it appears to be goal-directed<sup>1</sup>. Thus in SSM there is a very specific distinction between conceptual models that contain goals, called purposeful actions, and observed reality. This is a distinction rarely done in the other goal-directed methods where goals are considered to exist in reality. SSM's basic tenet is that the models we create serve to inform us about the reality of enterprises and to serve as the basis of a debate about these enterprises. This debate is useful in order to define what actions can be taken in some situation that is seen as problematic (Checkland and Holwell 1998), (Checkland and Scholes 1990).

SSM as explained by Checkland and Scholes (1990, p. 27-53) consists of recognizing that the source of an intervention such as the development of an IT system in an enterprise results from the current situation being judged as a problematic by at least one person. Some improvement of the situation is therefore felt as needed. "Would be improvers" (that we call designers) of the situation then create models that contain purposeful activities. These models are based on tasks and issues in the real world as they are perceived by designers. Parallel to these models being built, three types of analysis serve to assist in their creation. These types are: Analysis of the intervention, social systems analysis, and political system analysis. The resulting models are compared with the perceptions that the designers have of the real world, changes to the real world are proposed that are "systemically desirable and culturally feasible." These propositions then lead to actions taken to "improve the situation" (p. 28-29).

The initial understanding of the problematical situation is done with reference to its historical roots. As defined by Checkland and Scholes:

"The situation itself, being part of human affairs, will be a product of a particular history, a history of which there will always be more than one account. It will always be essential to learn and reflect upon this history if we are to learn from the relative failure of classical management science, since that is surely due to its attempt to be ahistorical. In so doing it has limited itself to dealing only with the logic of situations. We are not indifferent to that logic, but are concerned to go beyond it to enable action to be taken in the full idiosyncratic context of the situation, which will always reveal some unique features" (1990, p. 28).

Compared to the Hard systems based methods, SSM presents the following particularities:

- Systems with goals are explicitly considered as models of perceived reality rather than reality itself. Thus a distance is kept between the machine like descriptions of human behavior as they are depicted in the models and the richer aspects of this behavior
- Related to this first observation, SSM encourages the creation of several systems representing a given situation. The system that is called the "primary-task system" (p. 31), is the one corresponding to the explicit representations of the tasks performed by people. For example, a store selling goods with an IT system that tracks inventory records payments etc. The other systems are based on the issues debated in the enterprise under consideration. These systems are called "issue-based relevant systems" (p. 32). These may be, for example, a system to resolve conflicts between management and employees. The designers have much more freedom in defining issue-based systems than they have for defining the primary-task system. Checkland and Scholes claim that "working with both kinds of relevant systems frees the thinking" (p. 32).
- The systems identified in SSM are considered as transformation processes, transforming inputs into outputs. Instead of simply giving short names for the identified systems, SSM prescribes that systems be named with a "Root definition" (p. 33-36). The elements of a root definition are the following (they can be remembered by referring to the mnemonic CATWOE):
  - "C customers: the victims or beneficiaries of T
  - A actors: those who would do T
  - T transformation process: the conversion of input into output

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<sup>1</sup> some have proposed the use of the term teleonomy for this appearance of goal-directedness, for example, the planets give the impression of having the goal of continually moving around the sun, see (Checkland 1999, p. 75).

- W      weltanschauung: the worldview that makes T meaningful in context
- O      owners: those who could stop T
- E      environmental constraints: elements outside the system which it takes as given”
- The intervention system analysis, i.e. the analysis of the intervention that attempts to solve the identified problem, seeks to identify the people or enterprises who occupy the following three roles:
  - The client: “the person or persons who caused the study to take place...it is a question worth asking because it is wise to keep in mind (but not be dominated by) the client’s reasons for causing the intervention to be made” (p. 47).
  - The ‘would be problem solver’: “whoever wishes to do something about the situation in question...the intervention had better be defined in terms of their perceptions, knowledge and readiness to make resources available” (p. 47).
  - The problem owner: who has a vested interest in the situation<sup>1</sup>?
- The social system analysis seeks to identify, in the problem situation, social roles, the norms that their behavior is expected to conform to, and the values by which their performance is judged with respect to the norm (p. 49). These roles, norms, and values change continuously and are defined and refined by each other in a circular way. Checkland and Scholes state that this social system model is a drastic simplification of Vickers appreciative system.
- The political system analysis seeks to make explicit the power struggles that are considered as endemic in human affairs but that usually remain unexpressed. The purpose of the analysis is to seek the accommodation between the needs of the people involved. As explained by Checkland and Scholes:

“What is looked for in the debate is the emergence of some changes which could be implemented in the real world and which would represent an accommodation between different interests. It is wrong to see SSM simply as consensus-seeking. That is the occasional special case within the general case of seeking accommodation in which the conflicts endemic in human affairs are still there, but are subsumed in an accommodation which different parties are prepared to ‘go along with’. [In macro politics the anomalous post-Second World War status of Berlin provides a good example of an accommodation, in this case concerning the multiple occupation of that city by East and West as represented by Warsaw Pact and NATO countries. In this example the accommodation was tested to the limit by the Russian blockade of West Berlin in the late 1940s, which provoked the airlift to break the blockade; the accommodation over Berlin held, just; there was never East-West consensus...]. (1990, pp. 29-30).

- With respect to the requirements of an IT system, SSM is said to tackle a question that is regarded as crucial to the proponents of SSM: “which of the huge number of information systems that we could put together, should we?” (p. 53). In essence SSM attempts to define the overall functionality of the IT system. What we call the high-level goals in this thesis. SSM’s purposeful activity models also serve as the basis for information flow models that are used as the basis for the design of the IT system (p. 53). The idea is that IT systems are used in enterprises to share information and attribute meaning to it.

SSM seems to be defining a much more thorough investigation of a problematical situation than the other RE methods. It takes into account the interpretations of the people involved in the intervention and separates the models that they create from their interpretations of reality. The situation is investigated also from its historical perspective thus taking into account what we have seen in Chapter 2, that future strategy is not independent of history.

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<sup>1</sup> Checkland and Scholes do not provide a clear definition of the problem owner. This is an inference based on the examples that they provide on page 48.

The IT system to be built receives much less attention than the problematic situation. Thus, SSM doesn't count on the pre-existence of goals in the enterprise as a starting point for the requirements process but rather constitutes what we can describe as a holistic approach to a situation described as problematic. It is worth noting that the purposeful activity systems created with SSM are drawn as what SSM proponents call rich pictures. These rich pictures are comparable to activity diagrams as they are defined in standard RE languages such as UML. However, whereas for other RE methods, these activity diagrams represent real-world goals, in SSM they are only one amongst a number of possible models of this real-world.

From our point of view, even though the focus of SSM is said to be on the management of relationships (Between an enterprise and its stakeholders and between people within the enterprise), stemming from Vickers's work, the SSM purposeful activity systems describe transformations from inputs to outputs rather than the explicit management of relationships. Thus, even though Vickers was preoccupied with the maintenance of stability and the regulation of relationships, these issues are not considered explicitly in SSM.

### 3.3.2 STS

STS can be seen as a counter movement to the belief by its proponents that the methods based on the Hard systems school focus on the technical and economical portions of the organizational change problem at the expense of the social portion. This belief leads the STS approach to specify the need by designers to (Munkvold 2000):

- jointly optimize the technical and social system,
- to focus on the quality of work life (QWL) of workers at all levels of an enterprise,
- to require the participation of the different stakeholders in the design process,
- to encourage the use of semi-autonomous work groups in enterprises

As further noted by Munkvold, STS and BPR seem to specify very similar design methods but "while BPR advocates radical change, STS prescribes continuous change." STS is also believed to focus more on humanistic issues whereas BPR focuses on economical objectives. This difference in focus is evident in Mumford's account of STS:

Socio-technical designers always try to see complex system design as a unified process. This means taking account of technical, economic, organizational and social issues at every stage of the design process. It also requires answering questions such as 'What is the nature of the problem we are trying to solve?' 'How did it arise and why does it need to be addressed now?' 'What difficulties are likely to be encountered along the design route?' 'What are the consequences of a successful solution and what will happen if the system is only partially successful or proves a failure?' Also, 'In what areas of system design process are the greatest risks likely to occur and what is the nature of these risks?' This process is similar to that of a doctor who practices holistic medicine. He or she will focus on the needs of the whole person and not just on one or two obvious symptoms or complaints." (Mumford 2000).

Indeed, BPR is only interested in the way things are today as a point of departure on how to radically change them. BPR is not interested in why things are the way they are and why they need to be addressed now.

Some STS authors also claim that they work from a perspective that transcends the divide between the Hard systems and Soft systems schools. They refer to Critical Systems Thinking (CST) as a way to avoid both the inability of the Hard systems school to take social issues into account and the Soft systems school to take political issues into account.<sup>1</sup> According to Clarke and Lehane (2000), CST includes both Critique and Complementarism. Critique is viewed as the examination and re-examination of taken for granted assumptions and the conditions that gave rise to them.

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<sup>1</sup> This is a strange critique done to SSM since, as we have seen, SSM does take the political aspects of a situation into account.

Complementarism is seen as the judicious use of the right method at the right time. Hence CST can be seen as the IS equivalent of Mintzberg et al.'s Configuration school<sup>1</sup>.

From our point of view, STS is very interesting because of its insistence on analyzing and designing both social and technical viewpoints in an enterprise, its specification of continuous change and the analysis of why things are the way they are. However, we have not found clear and specific guidelines in the STS literature on how to perform these activities, for example, in terms of management of relationships, regulation, or even goal-orientation. Also, STS seems to be far removed from RE which is unfortunate because it should be at its core since RE is really about socio-technical issues. We thus see the Lightswitch approach as a contribution to STS and a possible bridge between RE and STS.

### 3.3.3 Organizational Semiotics

Semiotics is a discipline interested in the use of signs by people, their interpretations, and the attribution of meaning to these signs. The proponents of Organizational Semiotics hold that enterprises should be studied from the point of view of the representations (signs) that they use and the way that the interpretations of these signs lead to patterns of behavior. It is therefore very close to sense-making as proposed by Weick (Van Heusden & Jorna 2002).

Organizational Semiotics seems to have developed out of the work of Stamper who adapted the more general discipline of Semiotics to the study of enterprises (Chong and Liu 2002).

According to Chong and Liu (2002), traditional Semiotics is made of three fields in which signs are studied:

- “Syntactics: formal structures, language logic, data, records, deduction software, files, ...
- Semantics: meanings, propositions, validity, truth, signification, denotations, ...
- Pragmatics: intentions, communication, conversation, negotiations, ...”

They state that Stamper added three more fields to the fields above (ibid):

- “Physics: signals, traces, physical distinctions, hardware, component density, speed, economics, ...
- Empirics: pattern, variety, noise, entropy, channel capacity, redundancy, efficiency, codes, ...
- Social world: beliefs, expectations, commitments, contracts, law, culture, ...”

Chong and Liu (2002) further state that, “these introductions later form the basis for developing a set of semiotic methods for studying the use of signs in an organization, a sub-field of what is now known as organizational semiotics.”

Organizational Semiotics now encompasses and uses a large number of theories and techniques such as Hermeneutics (the interpretation of texts), speech acts, semantic analysis, norm analysis etc.

Semantic analysis, according to Chong and Liu (2002):

“Enables one to understand the business domain through a rigorous process that reveals the dependencies of concepts upon one another clearly expressing them in a graphical form known as a ‘semantic model’.”

Norm analysis, seeks to understand the patterns of behavior of an enterprise. Chong and Liu (2002) state that:

“Norms help members of an organization to establish what patterns of behavior are legal and acceptable within a given social context. An individual member in the organization, having learned the norms, will be able to use the knowledge to guide his or her actions.”

Norm analysis distinguishes between four types of norms which, as stated by Chong and Liu (2002) “in one way or another, affect a person’s intentions and actions.” These types of norms are:

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<sup>1</sup> While not ascribing to CST, the examination of taken for granted assumption is one of the important features of the Lightswitch approach.

Perceptual norms: “concern with the way in which we divide up the world into the phenomena to which we attach names such as marriages, poverty, and copyright.”

Evaluative norms: “allow us to make judgements about what we have felt and recognized and, indeed to decide what perceived patterns are worthy of repeated recognition.”

Cognitive norms: “can be recognized because their consequent parts affect our beliefs respectively.”

Behavioral norms: “govern how people or organizations behave.”

With respect to behavioral norms Chong and Liu (2002) state that,

“Behavioral norms are more observable and are the ones that affect and regulate humans’ behaviour in an organization. They have a prescriptive and proscriptive function in governing the behavior of agents and are expressed in the form of ‘you are obliged, permitted, or forbidden to behave in certain way’.”

We can see that what is called norms in Organizational Semiotics is what we encountered as the concept of Policy in ODP-EL (Section 3.1.2.1). Both define rules that are expressed using the Deontic Logic constructs of obligation, permission, and prohibition. However, as we have seen in Section 3.1.2.1, ODP-EL uses an additional construct called Authorization.

Norm analysis has been applied to further the understanding of business processes by studying business processes as behavioral norms and analyzing them with Deontic logic.(Shishkov et al. 2002).

From our point of view, Organizational Semiotics contains several important elements that can be found in the Lightswitch approach as well, the focus on norms, their interpretation, and the assimilation of business processes to norms. However, the literature we have seen in Organizational Semiotics, while talking in passing about the function of norms as regulating behavior, stops short of studying this regulation in detail. As a result, norms are seen as rather static properties of an enterprise. The main focus is on the understanding of existing norms rather than an understanding of how they came to be and how they will change in the future.

### **3.4 What is missing from EA and GDRE**

EA and GDRE methods have produced the many useful modeling concepts and techniques for using them. However, they are missing the following items.

- EA and GDRE methods lack an evolutionary perspective that explains the on-going nature of strategy making. These methods focus on achievement goals rather than the on-going cycle of maintaining the enterprise’s identity. Hence, they do not deal with questions such as: Is a goal specified by stakeholders a necessary goal with respect to current or foreseeable conditions in the environment and the enterprise? How will changes in the environment and the enterprise affect the goals specified by the enterprise and its stakeholders, not only how the goals are to be achieved but also what goals are to be achieved. Are the presently identified goals the ones that the IT system should be designed for, or do they reflect past conditions that may no longer hold?
- A related issue is the lack of appreciation for the issues of norms and interpretations in the behavior of enterprises as shown in some of the strategic management schools of thought and in the Soft systems schools of thought. This lack of appreciation is apparent in the focus of EA and GDRE methods on achievement goals and in goal refinement techniques that use seemingly objective constructs such as domain knowledge and constraints.
- EA and GDRE methods do not provide a theoretical explanation of what goals are. They simply state that goals represent the achievement or maintenance of a state of affairs. Or that some goals may never be completely satisfied. For example, no explanation is given as to the reason of existence of a maintenance goal. If some state is achieved, why is it that a goal is needed to maintain it? From our point of view, this lack of explanation of what goals are, leads to a situation where either goals expressed by stakeholders are taken as a given and the requirements for an IT system are defined for these goals. Or the goals are abstracted by

asking why they are needed, moving up the goal hierarchy to levels that are of no interest to the problem at hand.

For example, one of the most cited examples of information systems in the GDRE literature is the meeting scheduler. The high-level goals of the meeting scheduler are considered to be non problematic. These consist of such goals as meeting scheduled, participants identified, participants invited, agenda specified etc. Anton for example states the following: "Ideally, goals are high-level objectives such as "meeting scheduled" (Anton 1997, p. 63).

However, it can be argued that these high-level goals are simply means to an end. A higher level goal may be to hold meetings rather than to schedule them. The relevant high-level goal would then be meeting held rather than meeting scheduled. However, this goal can also become a means to an end. The end could be to manage projects, one of the means being to hold meetings in order to manage the projects.

The "high-level" goals could be further abstracted by asking why an enterprise manages projects leading to such high-level goals as creating new products. Moving further up the goal hierarchy we may identify such goals, as making money, being happier etc. as shown by Zave and Jackson (1997):

"Requirements engineering is about the satisfaction of goals [Dardenne et al. 1993]. But goals by themselves do not make a good starting point for requirements engineering. To see why, consider a project to develop a computer-controlled turnstile guarding the entrance to a zoo [Jackson and Zave 1995].

If the engineers are told that the goal of the system is to deny entrance to people who have not paid the admission charge, they may decide that the goal has been stated too narrowly. Is not the real goal to ensure the profitability of the zoo? Should they consider other ways of improving profits, such as cutting costs? What if there is more money to be made by closing the zoo and selling the land? And what is the goal of profit? If the goal of profit is the happiness of the zoo owner, would religion or devotion to family be more effective? Obviously there is something wrong here. Almost every goal is a subgoal with some higher purpose. Both engineering and religion are concerned with goal satisfaction; what distinguishes them is their subject matter.

The engineers should be told, in addition to the goal, that the subject matter is the zoo entrance. This information should take the form of designations of phenomena observable at the zoo entrance, such as visitors, coins, and the action of entering the zoo. These designations circumscribe the area in which alternative goal satisfaction strategies can be considered, at the same time that they provide the basis for formal representation of requirements."

Thus, the means-ends analysis needs to be complemented by other concepts, i.e., the designations envisioned by Zave and Jackson. In most GDRE methods the means-ends analysis is complemented with the use of scenarios, use cases or tasks. However, these complements may also be insufficient because scenarios may often only describe how to achieve the pre-stated goal, and without proper attention may not expose norms and differing interpretations about them.

It could be, as stated by Cooper (Cooper 1996), that what people in enterprises really want is to avoid meetings rather than to hold them. Such issues may not surface with goal and scenario coupling because scenarios are defined as ways to achieve a given goal. In this view the unwillingness of people to participate in a meeting (i.e. their interpretations that most meetings are a waste of time) is viewed as an obstacle rather than as an opportunity to manage projects differently.

The point is that a meeting scheduler that attempts to enforce meetings on people may not be the right solution. Thus, the discovery and formalization of the meeting scheduler goals and complementing them with scenarios, use cases, or tasks, may not help the designer to define an IT system that will support the people in the enterprise to avoid unnecessary meetings. What the designer could ask is: Why people in the enterprise think that they need a meeting scheduler? This will result in the understanding of:

- their norms, i.e. their work patterns
- the interpretations of their norms and those of their environment, including interpretations about the potential capabilities of an IT system

- the relationships that are important to them and how they manage these relationships
- what changes could be made to the way the relationships are managed, changes that may be necessary because of changes in conditions within the enterprise and its environment. This will result in new norms and new interpretations

Understanding these new norms and interpretations could then help designers to understand what could be expected from an IT system, i.e., in what way an IT system may help the enterprise and its stakeholders. For example, what kinds of meetings the people in the enterprise usually hold? Why do they hold these meetings, i.e. what relationships do they manage with external and internal stakeholders, i.e. what are their norms? How are these relationships interpreted by the different stakeholders? What kinds of meetings are interpreted as unnecessary meetings, what meetings are interpreted as necessary? Does it seem necessary to change these norms and interpretations? How could the IT system help people to avoid these unnecessary meetings or change their interpretations of what meetings are necessary? The EA and GDRE methods we have reviewed do not offer adequate tools for such a reflection.

## Part 1 Summary

In this part we have shown the need to view IT systems as strategic enterprise assets, both formed by, and forming, enterprise strategy. We have reviewed the dominant schools of thought in strategic management and information systems. We have then summarized the state of the art in methods designed to specify IT systems requirements. We identified a number of strengths and weaknesses in the way these requirements methods approach the strategic aspects of enterprises and IT systems.

Our review of strategic management schools of thought provided a framework with which we could analyze the enterprise architecture frameworks and requirements engineering methods that we presented in Chapter 3. As we have shown, these have been mainly influenced by the Hard systems school of thought. They therefore focus on goals to be satisfied, on planning, on decision making, and the positioning of the enterprise within an objectively defined environment. Missing from this school and hence from the related methods are concepts such as interpretations of one's actions and those of the environment, existing structure as it influences these interpretations and hence possible strategies, what is required for the continuous existence of the enterprise etc. Hence, the circular on-going nature of strategy is not taken into account when goals are considered as targets for achievement.

The EA and GDRE methods we have overviewed in Chapter 3 propose some very useful concepts such as context diagrams, maintenance goals, achievement goals, softgoals, beliefs etc. However, none of them offers a theoretical explanation for these concepts. Although most of these methods define concepts such as maintenance goals and softgoals, they nevertheless focus on achievement goals. Moreover, no theoretical justification is given to maintenance goals and the link with achievement goals is quite fragile. Beliefs are only used occasionally in one of these methods (GRL).

We believe that to explain what goals are, why and how they are defined by people and enterprises, cannot be explained by referring only to goals. Some other concepts are necessary. Combined, GST and Cybernetics give a plausible explanation of human action devoid of the separation of political/social/individual issues. It is therefore a good conceptual basis for explaining goals. The Lightswitch approach offers such a conceptualization. This conceptualization gives us the following results:

1. A definition of goals based on a solid theoretical viewpoint itself based on accepted natural science principles.
2. An independent viewpoint from which we can evaluate and reconcile different goal-directed approaches. For those who do not define what goals are, we provide this definition. For those who define different kinds of goals (maintenance/achievement vs. goal/softgoal) we show their similarities.

Based on this conceptualization we define the Lightswitch goal-directed modeling framework. This modeling framework uses the concepts of maintenance, achievement goals, beliefs, and community. All these concepts have been defined in one or more EA or GDRE methods. The modeling framework also comprises a set of heuristics for analyzing business processes from a regulation point of view and a design process where the regulation of the relationships between the enterprise and its stakeholders is analyzed. Different options for adapting this regulation to present and foreseeable conditions are evaluated and IT system goals are defined for these options.

Since we offer an interpretative conceptualization coupled with a goal-directed modeling framework that seeks to evaluate options but not prescribe them, we see Lightswitch as being at the junction of prescriptive and descriptive approaches as well as the Hard and Soft systems approaches.

# Part 2

## The Lightswitch Conceptualization and Modeling Framework

As we have seen in Part 1, in order to understand the requirements of an IT system, we need to understand the enterprise and its environment, which the IT system will serve. In order to understand this enterprise and its environment, we need to have some explanation about what enterprises are and how they can be modeled. We have seen that EA and GDRE methods do not offer an explicit explanation, although they use an implicit one. Their implicit explanation is that enterprises are assemblies of people and resources that are set to achieve well defined goals. The result of this implicit explanation is that the high-level goals of the enterprise seem to be predefined. They simply need to be discovered by interviewing stakeholders, analyzing written material, or creating scenarios. Although these activities are important, they could be complemented with an understanding of why the stakeholders attempt to achieve certain goals and not others. The Lightswitch conceptualization and modeling framework, (the Lightswitch approach) helps designers to achieve such an understanding by only assuming that the enterprise attempts to maintain its identity in a hostile environment. Hence in the Lightswitch approach we do not assume that the high-level goals of the enterprise have been predefined. We only assume that the enterprise regulates some relationships. The aim of this regulation, as we will show in this part, is to maintain the identity of the enterprise.

We call this explanation of the reality observed in enterprises the conceptualization. By the term conceptualization we mean an integrated set of concepts that explain part of the behavior and structure pertaining to a domain of interest<sup>1</sup>. In this part we develop such a conceptualization, built from concepts that are not directly related to the concept of goal and its synonyms, purpose, aim etc. This gives us three benefits (or we could say that we achieve three goals):

- We form a conceptual basis for understanding what goals are and how they are formed in enterprises.

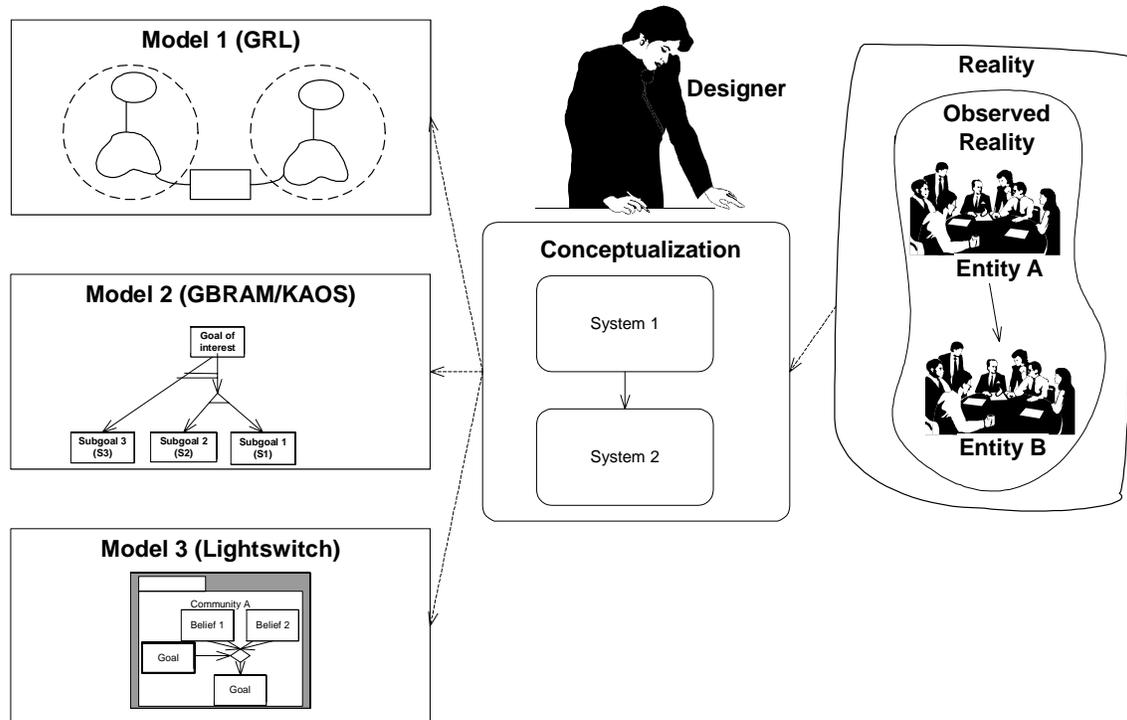
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<sup>1</sup> What we call conceptualization is often called a conceptual model, we don't use this term because it conflicts with our use of the terms "model" and "modeling framework" for the models built with respect to the conceptualization

- We can thus make contributions to the EA and GDRE methods by explaining the relationships between the different kinds of goals defined in these methods and propose some changes to these methods.
- We propose the Lightswitch modeling framework that designers can use to create models of the enterprise as a system that regulates relationships within the enterprise itself and with other enterprises. The benefit of the Lightswitch models resides in their use as a medium for discussion about current goals pursued by the enterprise based on the relationships that it regulates, and IT system goals that can help the enterprise better regulate these relationships and therefore pursue different goals.

The figure below shows a model of the relationships between the observed reality, the conceptualization, and the modeling frameworks that can be defined based on this conceptualization.

In Chapter 4, we explain our conceptualization of the subject of enterprises. In the first part of Chapter 5 we use this conceptualization to define the Lightswitch modeling framework (a set of modeling elements and a modeling method). In the second part of Chapter 5 we formulate our contributions to the different EA and GDRE methods we have reviewed in Chapter 3.



**Relationships between observed reality, conceptualization and goal modeling frameworks**

## 4 The Lightswitch Conceptualization

In this chapter we develop what we call our conceptualization of the reality we observe in enterprises. This conceptualization gives us the needed vocabulary to describe this observed reality and serves as the basis for the modeling elements and techniques that we introduce in the next chapter. We begin this chapter (Section 4.1) by explaining the epistemological principles of the Lightswitch approach, or in less technical terms, the relationships between the models created by designers and the reality they observe. In Section 4.2 we examine the very basic notions of systems modeling. This examination leads us to understand the role of the observer in the definition of what a system is. In Section 4.3 we examine stability and change in a system from the point of view of an observer. In Section 4.4 we address the issue of the identity of a system. Finally in Section 4.5 we discuss the issue of regulation. We will discuss a number of regulation strategies that enterprises are likely to specify.

### 4.1 Models and Reality

The questions we address in this section are related to the relationships between the enterprise models that we create and the enterprises as we can observe them in what we call “reality.” The debate about this relationship has traditionally been marked by the opposition of two extreme worldviews that we can call positivism<sup>1</sup> and solipsism. The middle path between these two extremes can be called interpretivism.

Solipsism is “the classic philosophic tradition which held that only one’s interior life exists” (Maturana and Varela 1998, p. 134). In our words solipsism means that people create interpretations which have no connection to the world outside of the mind of these people. Positivism is the opposite extreme to solipsism. Positivism holds that an objective reality exists independent of any interpretation. Interpretivism, just like Maturana and Varela’s approach to cognition, takes the middle path between solipsism and positivism by holding that people act based on their interpretations of the world but that these interpretations are not pure products of their imagination. Thus, interpretivists hold that these interpretations are grounded in the experience of these people in their world and are continuously updated to reflect what people understand from the results of their actions and the actions of other people. As humans, we have very similar sensing mechanisms and so our experiences have patterns that other people agree with. On the other hand, we are embedded in different contexts (cultural, geographical, economical etc) which create different experiences and the definition of different patterns by different people. Observed reality, therefore is what a group of people agree upon as being their reality. Observed reality, in other words, correspond to our shared experience. Thus, the interpretations that we have are not pure fictions that have no connection with some observed reality, nor do they represent an objective account of this reality.

Since people are somewhat all the same and at the same time somewhat different from each other, we can expect interpretations to contain some aspects that several people will agree on and some aspects that these people will not agree on. In an IT system development project, the designer’s mission is to create a shared understanding about their needs between the people for whom the IT system is intended (stakeholders of the IT system). This understanding is needed so that the IT system’s desired features can be decided upon and the system has a chance of being accepted by its stakeholders. To create this shared understanding, the designer creates explicit models that describe aspects of the observed reality and that serve as a medium for discussions about this observed reality with the stakeholders. Hence, as explained by Checkland and Scholes (1990, p. 21), models enable designers and stakeholders to reason about the reality they observe, but they should not be mistaken for observed reality itself, because one person’s observed reality is likely to only approximately match another person’s observed reality.

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<sup>1</sup> We adopt the term positivism to maintain the continuity with the vocabulary of part 1 where we talked about the positivist cognitive school and its influence on the Hard systems IS literature.

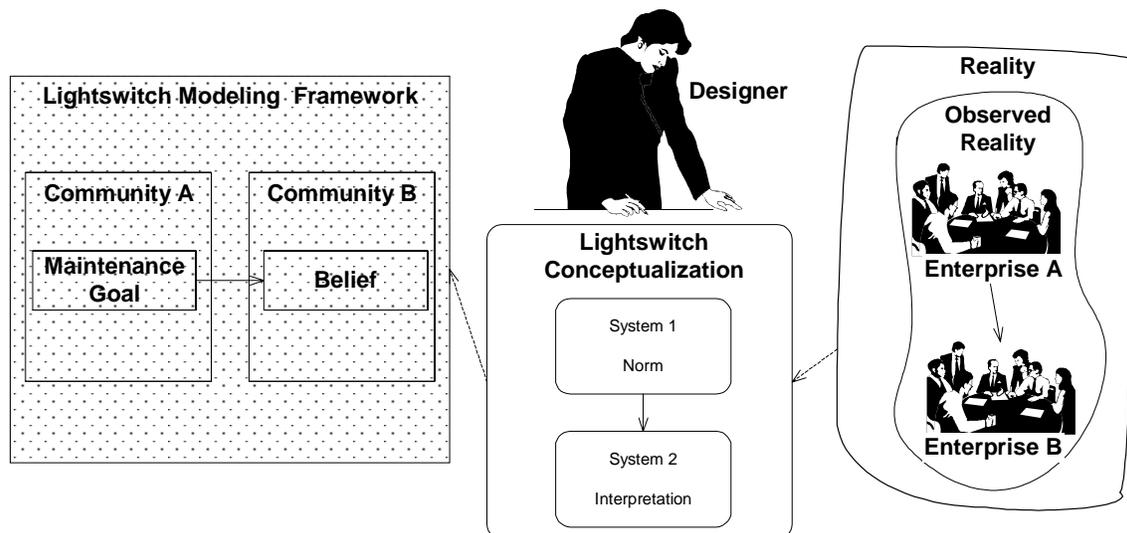
Since the designers and stakeholders at least agree that they are modeling something that can be described as the same observed reality, the models they create serve as a medium for comparing one designer's observed reality with the reality observed by the other designers. Thus, an agreement on some observed reality and a comparison between models and observed reality are necessary for modeling and intervening in enterprises. However, before designers can compare models and perceived reality, they need to have some concepts to describe this perceived reality. This is what we call the conceptualization (of perceived reality). The Lightswitch approach is made out of a conceptualization of the observed reality of enterprises using systems science and cybernetics principles and of a modeling framework that enables designers to create models based on this conceptualization. The designer may attempt to act on or within the enterprise with respect to his or her model of the enterprise.

The conceptualization provides a theoretical viewpoint on the observed reality of enterprises which at the same time constrains what can be discussed about enterprises and provides concepts for such discussions. Without this conceptualization we would not be able to say much about enterprises.

The conceptualization based on the interpretative viewpoint has two implications. The designers model their observed reality with their own interpretations. The models they create contain the interpretations of the stakeholders and enterprises. These interpretations define the stakeholders' and enterprises' actions in the same way that the designer's interpretations define its actions.

In the Lightswitch approach we use both of these implications.

1. We consider models to be interpretations of the designer as he or she observes enterprises and their stakeholders. These models will contain what is called in RE *domain knowledge*. Domain knowledge is the prior knowledge of the designer about the observed reality. The use of domain knowledge by the designer is both necessary and inevitable. However, domain knowledge may prove to not correspond to what the other stakeholders perceive in situation being modeled by the designer. It is therefore important to use the models defined by the designer as basis for discussion with stakeholders.
2. These models describe the different interpretations that stakeholders and enterprises have about their own actions and the actions of others. These interpretations shape, and are shaped by, the actions of these stakeholders and enterprises in a circular process.



**Figure 4.1 Relationships between observed reality, conceptualization and the Lightswitch modeling framework**

Figure 4.1 shows the relationships that a designer creates between the reality she observes, in which she sees entities such as people and resources working together, and the conceptualization of this observed reality in terms of systems (representing people, enterprises, machines) that have

interpretations of each other's norms. The designer then uses this conceptualization to create models that help her to reason about this observed reality with the stakeholders. In the case of Lightswitch these models will contain communities, maintenance goals, achievement goals, and beliefs. If another modeling framework is used such as GRL for example, then these models will contain actors, goals, softgoals, resources, tasks, and beliefs.

In the example shown in Figure 4.1 the designer sees two enterprises Enterprise A and Enterprise B that interact together. The designer conceptualizes this interaction as two systems, System 1 that represents Enterprise A and System 2 that represents Enterprise B. System 1 has some norm and System 2 has an interpretation of this norm. The designer then builds a goal-directed model where these two systems are modeled as communities with Community A representing System 1 and Community B representing System 2. Community A's maintenance goal represents System 1's norm and Community B's belief represents System 2's interpretation.

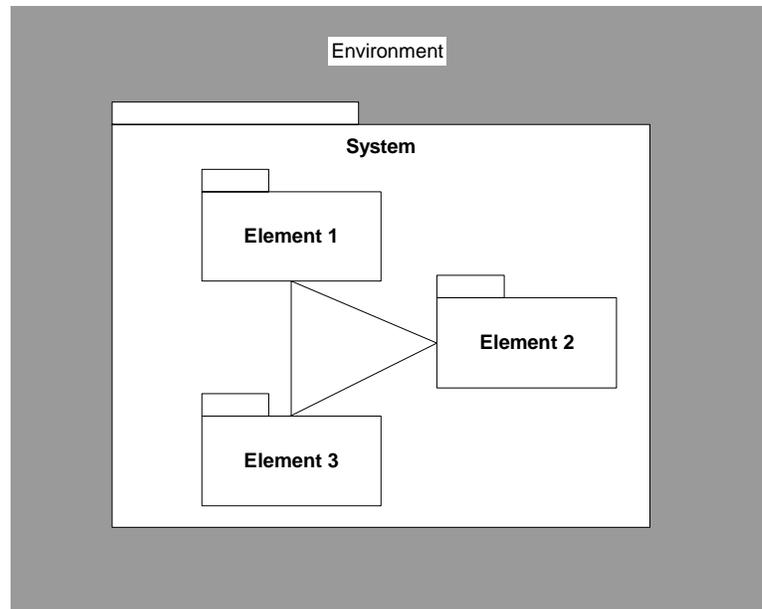
Maybe because we are limited in what we can express in our models, be they graphical, formal, or natural language with respect to what we know (Polanyi 1983), our models tend to be somewhat mechanistic. It is generally difficult and often impossible to represent the richness of a situation in a model. Furthermore, the predictions made with the help of a model often do not materialize in practice. Models, then, are a two-edged sword. They enable the designer to reason reality, but if they are mistaken for observed reality itself which is why we take great care in separating them (Checkland and Scholes 1990).

## 4.2 Enterprises and Systems

The common definition of a system is "as a set of elements standing in interrelations" (von Bertalanffy 1968, p. 55). Synonyms for the term element found in the GST literature include object, entity etc., however, we will stick to the use of the term element. We will use the term relationship to refer to an individual interrelation between two or more elements.

So a system is a set of elements, but as noted by Weinberg (1975, p. 63) this definition doesn't say where this set comes from. In other words, this definition does not tell us how it is that some elements are in the set and some are not. Since we assume an interpretive view we state that the set is not an absolute property in the world out there but rather that it is the interpretation of an observer. We call *observer* the person making the judgment about which set is a system and what elements belong to this set. In this view, the set itself is an *interpretation* of the observer. An interpretation, then, is a relationship between observed and observer. The observed is what we call *the entity* in accordance with the conventions of RM-ODP (ISO 1995, Part 2). Hence a system is a set of interrelated elements representing an entity in the observed reality as defined by an observer.

The set that an observer defines as a system establishes the frontier that the observer identifies between system and environment. The set of elements and their relationships constitute the system. All other aspects of the reality of the observer she considers as being the environment of the system (Figure 4.2).



**Figure 4.2 System and Environment**

Notice that each element in the set is considered as a whole, i.e., not containing any elements within it. The observer can also describe each of these elements as a system composed of interrelated elements. When doing this, the observer creates what is called a *hierarchy*<sup>1</sup> of systems that are contained within each other. The observer can group sets of elements modeled as wholes and constitute *levels* in the hierarchy (Miller 1995), (Simon 1986). A synonym for level is the term *layer* (Checkland and Scholes 1990). We will use the term *organizational level* in our discussion. The observer can, for example, model an enterprise as a system made up of a set of elements such as interrelated departments. Each department can be modeled as a system made up of a set of elements such as employees and IT systems. Thus, a hierarchy is formed from the enterprise modeled as a set of departments and IT systems modeled as wholes (this can be called the enterprise level), to people and IT systems modeled as wholes (this can be called departmental level). Since any element can be described as a system if we analyze its constituent elements, the difference between these two concepts is purely a matter of point of view. The observer refers to an entity as an element when she is not interested in its internal constituents but only in its externally visible properties. She refers to an entity of interest as a system when she wishes to model the entities that she observes inside this entity of interest and their interrelations.

As shown by Weinberg and Weinberg (1988, pp. 144-150), the boundary that is formed around the system (such as the enclosing rectangle in Figure 4.2) defines an idealized situation. It is at best a very rough approximation of what would be a very complicated curve if we wanted to draw a boundary around something that we observe such as a company for example. Since the boundary associated with an element is a matter of judgment, what is defined as being inside the element and what is defined as a relationship is a matter of judgment too. Thus relationships should be seen as an integral part of the element itself since it is not possible to create a clean separation between element and relationship. Moreover, we note that von Bertalanffy describes the elements of a system as “standing in interrelations.” This definition is somewhat different from the more popular definition of a system as a set of elements and relationships between these elements, (for an example, see Weinberg 1975, p. 63).

<sup>1</sup> The term hierarchy has at least two meanings: “1. A body of persons organized or classified according to rank or authority. 2. A body of entities arranged in a graded series” (American Heritage 1991). In the Systems Sciences, the second meaning is given to this term. Simon, for example, defines the terms hierarchical system or hierarchy as: “a system that is composed of interrelated subsystems, each of the latter being in turn hierarchic in structure until we reach some lowest level of elementary subsystem” (1996, p. 184). Thus hierarchy in our context has no power or authority connotations.

The difference resides in the consideration of the elements together with their relationships and not as separate from these relationships. Indeed, an element of a system is not independent from the relationships that it has with the other elements of the system, as we will see in the next section when we describe the concept of open systems.

In the rest of the thesis, we will use the term *sub-system* to refer to an element of a system. The term sub-system better conveys the idea that an element is seen by the observer as part of a larger system. We use the term supra-system to refer to this larger system as seen from the point of view of one or more of its sub-systems. Any sub-system can be considered as a whole or as a composite containing sub-systems.

The observer can identify properties of the system when considered as a whole. These properties do not exist in any of the sub-systems taken individually or if even one relationship or sub-system is removed from the system. These properties are called *emergent properties*. Hence, emergent properties depend on the observer. Different observers are likely to define different properties that emerge in a system. The classical example of a transportation system, such as a bicycle, emerging from the assembly of wheels, rods, a chain etc. takes for granted that the observer, knows, discovers, or imagines that such an assembly could be used for transportation rather than for any other use, such as a ladder, a clothes hanger or anything else that could be imagined.

When we represent enterprises as systems (whether explicitly or implicitly), we observe that some entities, such as people and machines, cluster together to form systems that we call enterprises. For an observer, an enterprise emerges as a single system separate from its environment and that has relationships with other systems/enterprises. As observers, we sometime have the impression that enterprises act as one person and we ascribe emergent properties such as intentions to them as if they were a one and indivisible system (Checkland and Holwell 1998, p. 80). We can also analyze the enterprise by modeling it as a system that has a set of sub-systems and relationships between these sub-systems. These sub-systems can be departments, people, business units etc. The sub-systems are subject to constraints such as performance assessment, budget restrictions etc. The sub-systems, in turn, provide a service to the enterprise by developing products and services, providing these to customers etc. In the rest of the thesis we will use the term enterprise when we refer to systems that represent entities such as people and IT systems.

The discussion above enables us to propose the following concepts and their definitions:

**Def 1: System** is a set of interrelated sub-systems that describes an entity in the (observed) reality as defined by an observer.

**Def 2: Sub-system (of a supra-system)** is a system that is subject to the constraints and protection of its supra-system as defined by an observer.

Note: The sub-system is considered by the observer as being contained within the supra-system.

**Def 3: Supra-system (of a sub-system)** is a system that constraints and protects the sub-system as defined by an observer.

**Def 4: Environment (of a system)** is all of the systems distinguished by an observer that, from the point of view of the observer, are not sub-systems of the system or the system itself.

Note: The environment of a sub-system can be seen as its supra-system and the environment of the supra-system.

The relationships between the sub-systems represent the exchange of information between these sub-systems. In the context of this thesis, we define information as something that enables an enterprise in a given context to distinguish between some sub-systems and to define what is common between some

other sub-systems<sup>1</sup>. This definition is well in-line with Maturana and Varela's assertion that as human beings we are immersed in the action continually making distinctions

“The act of indicating any being, object, thing, or unity involves making an act of distinction which distinguishes what has been indicated as separate from its background. Each time we refer to anything explicitly or implicitly, we are specifying a criterion of distinction, which indicates what we are talking about and specifies its properties as being, unit, or object. This is a commonplace situation and not unique: we are necessarily and permanently immersed in it” (1998, p. 40).

Thus, information is the basic “thing” that enables us to make these distinctions. However, we don't define information as data being given meaning by an enterprise. Rather we define information itself as an emergent property of the relationship between two or more systems. This definition is in line with our interpretative worldview where facts (data) do not exist outside of a given interpretive context.

The discussion above gives us the following definitions:

*Def 5: Information (for a system)* is something that, from the point of view of the system, enables the system to distinguish one system from another or to define what is common in a set of systems.

*Def 6: Relationship (between a set of systems)* is the exchange of information between the systems as defined by an observer.

From the point of view of one of the systems, the relationship with another system is an interpretation. This interpretation can be expressed in a variable of the system. The concepts of state and variable and interpretation are introduced in the following sections.

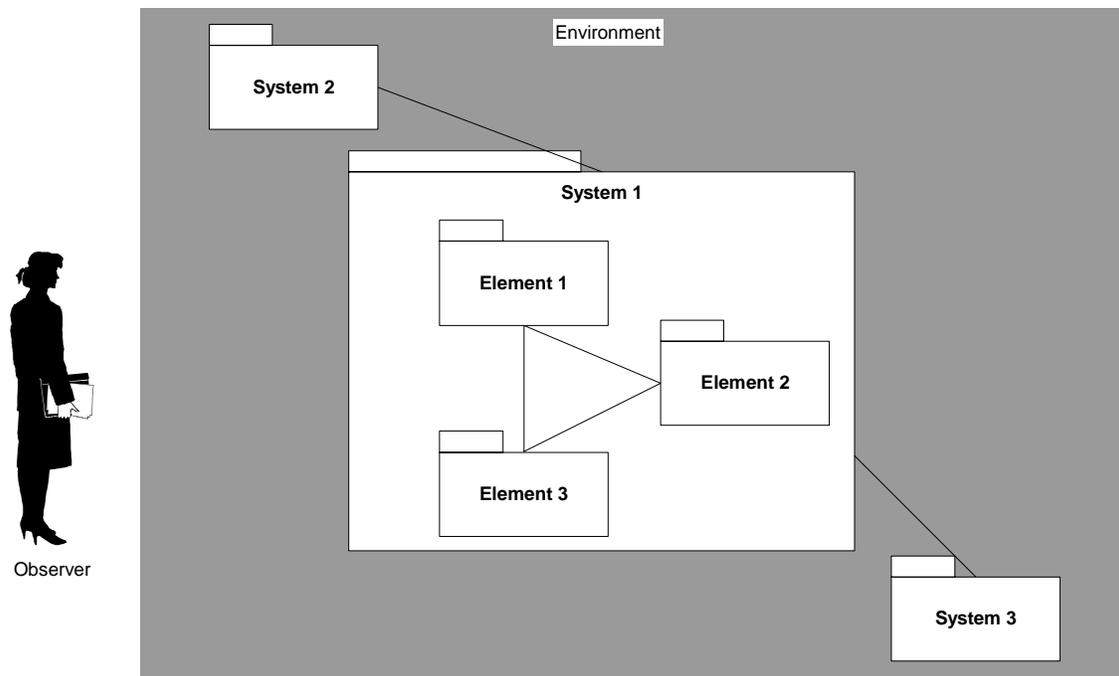
### **4.3 Stability and Change**

“We are immersed in a life in which the world as a whole obeys the second law of thermodynamics: confusion increases and order decreases. Yet, as we have seen, the second law of thermodynamics, while it may be a valid statement about the whole of closed system, is definitely not valid concerning a non-isolated part of it. There are local and temporary islands of decreasing entropy in a world in which the entropy as a whole tends to increase, and the existence of these islands enables some of us to assert the existence of progress” (Wiener 1954, p. 36)

The general tendency of the universe towards an increase in entropy (i.e. an increased confusion or disorder) provides a physical explanation to our everyday observation of an ever changing world. Thus in this thesis, we take the second law of thermodynamics as a given. In a world that does not exhibit such a tendency towards disorder, the present discussion will not apply. If we accept this law, however, then we can see that the general tendency of the universe towards increased entropy (increasing disorder) works against organized systems to remain organized (Wiener 1954, p. 37). In other words, stable systems are continuously threatened with instability. This means that we cannot take the existence of organized systems (islands of decreasing entropy) such as people, enterprises, or IT systems, as a given.

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<sup>1</sup> I wish to thank Andrey Naumenko for helping me with this definition.



**Figure 4.3 An Open System**

As explained by Wiener, the interior of the system in Figure 4.2 will evolve towards disorder unless the system has connections with other systems in its environment, i.e., if the boundary is permeable (Figure 4.3). In Figure 4.3, System 1 uses its relationships with System 2 and System 3 to maintain the stability of its internal order, i.e., to maintain the sub-systems as separate sub-systems and to maintain their relationships. Thus, by being open to other systems (i.e. to its environment), System 1 gets some benefits in terms of the order that it is able to maintain within itself, but it also becomes vulnerable to the failure of its relationships with these systems. In order to guard itself from these failures, it needs to impose order on these relationships themselves. This imposition of order is called *regulation* in GST.

Enterprises can thus be seen as open systems that have inputs and outputs, or more generally, relationships with other systems in their environment. These relationships enable enterprises to maintain their organization by exchanging information with these other systems. For this exchange of information to be profitable to the enterprise, so as to enable the enterprise to maintain its organization, the enterprise must impose order on these relationships. Indeed, relationships are a mixed blessing. In the absence of some control, relationships are as likely to threaten the stability of the enterprise as they are to support it. Thus, enterprises are forced to impose order on, i.e., regulate these relationships. In other words, enterprises regulate the relationships they have with other enterprises and thus maintain the stability of their internal relationships.

The boundary that the observer defines around a set of sub-systems (their supra-system) isolates the sub-systems from influences by the environment (Weinberg and Weinberg 1988, pp. 177-181). This supra-system provides its sub-systems with an environment in which they are isolated to some extent from the influences of the environment of the supra-system. This is what the Weinbergs call the “internal environment” (p. 178). The internal environment can be seen as imposing constraints on the sub-systems in exchange for this isolation. The sub-systems, in turn, provide a service to their supra-system in exchange for this isolation. The sub-systems shown in Figure 4.3 will not be able to survive as if taken out of the isolation of the supra-system. In exchange, they have to conform to constraints imposed on them by the supra-system. Hence, each sub-system in the supra-system is constrained in its possible actions by its relationships with other sub-systems and its relationship with the supra-system. The Weinbergs further note that the isolation provided by the supra-system to its sub-systems

is not absolute, “but merely makes it ‘less easy’ for the internal environment to come into equilibrium with the exterior” (ibid).

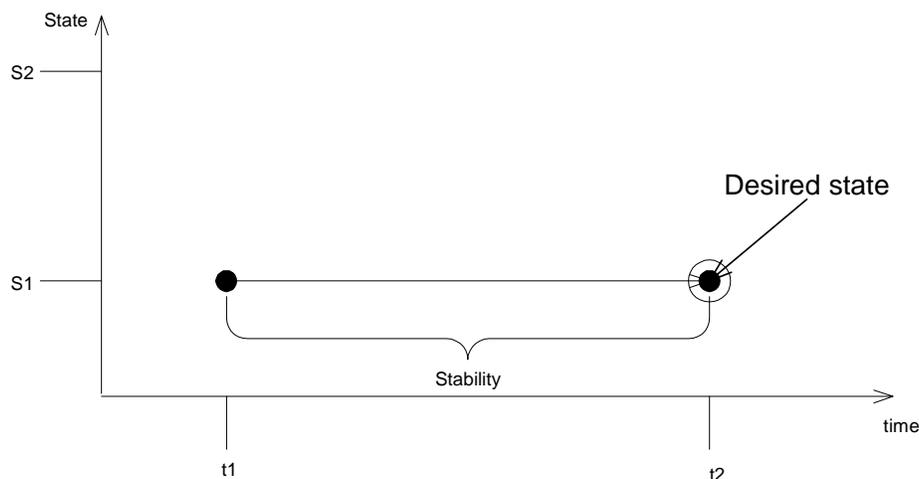
By preventing the equilibrium between the environment and its sub-systems, the system prevents the change of some of the distinctions and relationships between its sub-systems and some of its own relationships with the environment this is the stability of the system. This stability is necessary for the observer to observe the system.

We define the state of a system as some aspect of the system that the observer observes as not changing. That is, a state is something that an observer observes to be stable within some period of observation. Since the system is subject to influences from the relationships that it has with systems in its environment and from its sub-systems (as a consequence of the second law of thermodynamics), in time, it will move from one state to another. Thus absolute stability probably doesn’t exist. Systems appear stable only within some period of observation.

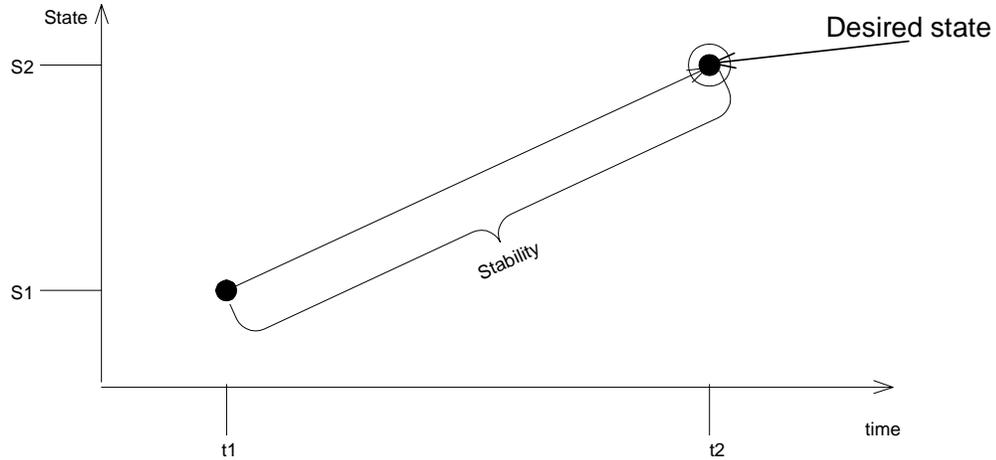
Since the states of the system vary in time, it is useful to define the concept of variable. A variable is a feature that an observer sees in a system, which can have multiple states. For example, in an enterprise, we can define the variable ‘number of employees.’ This variable can accept states within the set of positive natural numbers from 0 to infinity.

When the observer observes that the state of one or more variables of a system has changed, she infers the existence of an action. In other words, actions are considered as the source of changes of variables that observers observe. But in order to observe what has changed, we need to refer to what has not changed. For example, if an observer says that an enterprise has changed its strategy, she at least refers to the enterprise which she considers not to have changed. If she would have seen the enterprise as changing identity as well, she would not have been able to compare its previous strategy with the current one and thus observe the change. Also, if the enterprise never changed any of its aspects the observer is likely to lose any interest in it and stop observing it. Thus, we can say that stability is necessary for change to be observed (or to happen) and change is required for stability to be observed (or to happen). Or as defined by Weinberg, “We understand change only by observing what remains invariant, and permanence only by what is transformed.” (1975, p. 155)

The concept of system applies equally to actions and to states. In the case of an action, the action can be considered as a whole or as a set of sub-actions and the order in which these sub-actions are performed (equivalent to the interrelated sub-systems). In the case of states, a state can be considered as a whole or as a set of sub-states and their relationships.

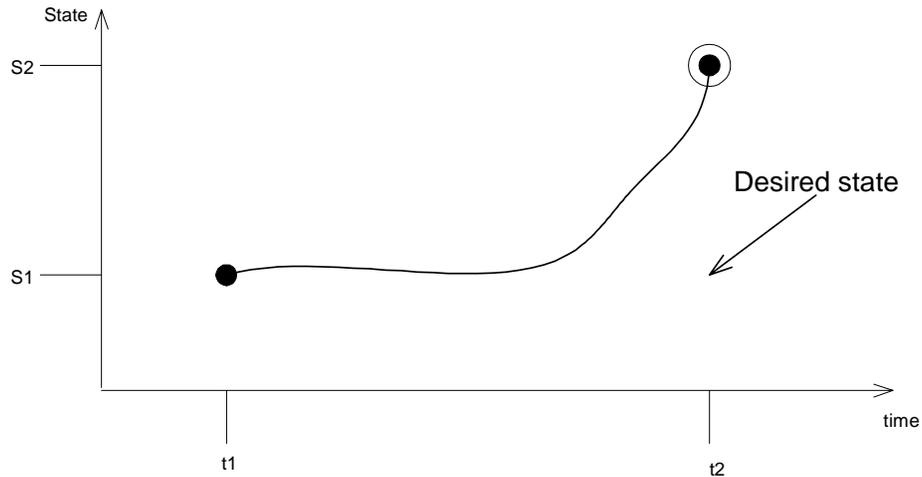


**Figure 4.4 Stability of a variable**

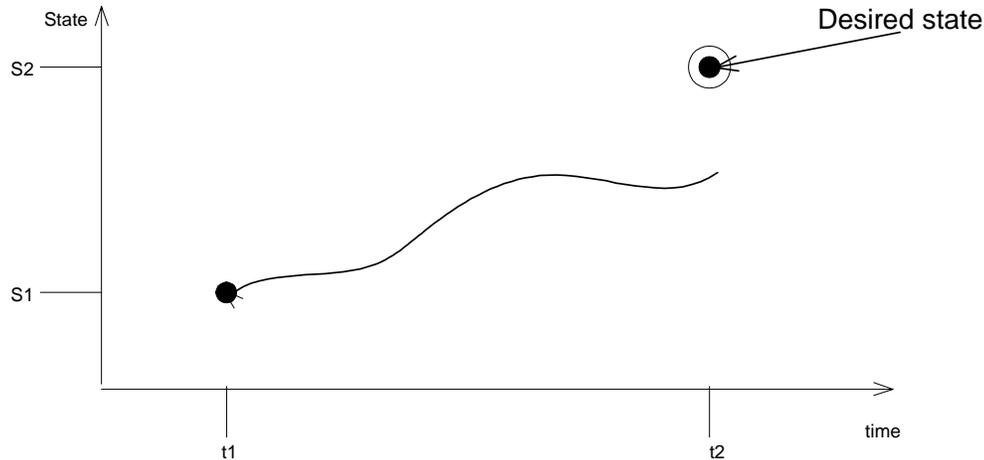


**Figure 4.5 Stability of an action**

Both actions and states need to have some stability for an observer to observe them. This is shown in Figure 4.4 and Figure 4.5. These figures represent hypothetical variable of some system varying in time. In Figure 4.4, the system's variable is stable. The variable remains in state S1 as time flows from t1 to t2. Figure 4.5 shows the stability of an action as the variable changes from state S1 at time t1 to state S2 at time t2. Effort is needed in both cases, to maintain the stability of the variable with respect to change, and to maintain the change of the variable itself with respect to stability. In both cases, in case of failure to maintain stability, the resulting state of the variable will not be S2 but some other state. This is shown in Figure 4.6 and Figure 4.7



**Figure 4.6 Non-stability of a variable**



**Figure 4.7 Non-stability of an action**

We have seen that inside any given system, stability exists otherwise we would observe no system at all. Within this system, change can be analyzed as the analog construct for the stability within an unstable environment. The sub-system attempting to create change in a stable environment will face the analog problems of the system attempting to maintain stability in an unstable environment.

The Weinbergs (1988, p. 122-140) generalize the distinction between state and action to structure and behavior. The Weinbergs argue that it so happens that some states are more stable than others, they tend to not change for a while. This non change we identify with structure. What changes, we identify with behavior. Thus, what we identify as the structure of an enterprise, its departments, buildings, reporting chain, etc., simply represents those states that we identify as not changing for long periods of time. A long period is obviously a relative time span with respect to the observer and the observed enterprise.

The Weinbergs further remark that what we identify as structure is linked to our sense of what is durable. Structure is seen as hard and solid while behavior is considered as ephemeral. The Weinbergs argue that we may be fooled by our senses. Many times it is the behavior that proves durable while the structure proves ephemeral. For example, companies may restructure but their behavior remains the same. Thus, the Weinbergs define structure as “that which stands, which remains, which is unchanged, regardless of its physical properties” (1988, p. 125). In the Lightswitch approach we identify the structure as being the stable states of the enterprise and its relationships with internal and external stakeholders. Indeed, the relationships that an enterprise regulates constrain its capacity to change at the same time that it enables the enterprise to maintain its stability, as we will see later in this chapter.

In general, stability cannot be equated with either goodness or badness. Stability can be judged as bad by some observers and good by others as stated by Ashby:

“stability is not always good, for a system may persist in returning to some state that, for other reasons, is considered undesirable. Once petrol is lit it stays in the lit state, returning to it after disturbance has changed it to “half-lit”—a highly undesirable stability to a fireman” (1956, p. 81)

A similar example in an enterprise is that some people may regard the stability of an enterprise as a sign of its unwillingness to change while others will see it this same stability as a virtue. It is thus possible to define a Stability/badness matrix: stable and good, stable and bad, unstable and good, unstable and bad (Weinberg 1975, p. 233).

This discussion gives us the following definitions:

**Def 7: State (of a variable)** is a value defined by an observer that the variable can have at a given moment in time.

**Def 8: Variable (of a system)** is a concept defined by an observer as belonging to the system, which can have one state at a given moment in time and another state at a different moment in time.

**Def 9: Action (of a system)** is a concept defined by an observer as belonging to the system, which changes a variable from one state to another during some time interval

**Def 10: Stability (of a system)** is the set of variables which the observer observes in the system, which the observer observes as not changing states during some time interval.

#### 4.4 Identity

The observer can define a subset of the variables of the system as constituting the system's *identity*. This subset of variables is called the *identity variables* (Weinberg 1975, p. 245). By saying that these aspects of the system are variables, we acknowledge that they can change states. However, in order for the observer to define that a system she is observing is the same from one observation instant to another, these identifying variables should not have states that go beyond some limits defined by the observer. For example, if IBM stopped selling computers and began selling food, for some observers this would not be IBM anymore. For others, as long as it keeps its name and logo, it is still IBM regardless of how much the products that it sells have changed.

This definition of the identity of a system is identical to what Ashby defines as *survival*. For Ashby, survival means the stability of a set of essential variables (or identifying variables) (1956, p. 197). We can thus define the survival of an enterprise as the maintenance of some identifying variables within the some limits, both of which are set by an observer.

For the observer to be able to observe that these identifying variables are within the defined bounds, the identifying variables and the bounds must have some stability. To return to the example of the enterprise, if the number of employees changes daily from zero to fifty or if the number of products changes from ten to one hundred, will the observer say that it is the same enterprise? Also, if the bounds on the number of employees that the observer considers to constitute part of the identity of the enterprise changes daily, the observer may change her mind daily on whether what she observes is the same enterprise. Thus, the identity of an enterprise modeled as a system is always relative to the observer's stability, the duration of observation, and the stability of the observed. IBM, for example, may be observed to have the same identity if we only use its name and logo as identifying variables, and if we observe it for a period of 60 years. If we take the number of employees as the identity, or the nature of its products, we may conclude that its identity has changed. Also, the identity of IBM may have no meaning if the period of observation is 100 years or more.

Once the observer has identified the sub-system, she considers some other variables of the sub-system as some non identifying variables of the sub-system. For example, if we define an IBM's identifying variables as name and logo, then we can identify the number of people working at IBM, the products IBM sells etc as non identifying variables, i.e., as transformations IBM can go through without losing its identity.

For another observer, or for the same observer at some other time, the set of identifying variables may change and therefore the set of non identifying variables will change too. Thus the set of identifying variable determines what an observer identifies as changing or not changing, i.e., as change or stability. For example, what for one observer is the same IBM but of different size and products will be, for another observer, an enterprise that went through major change (see Ashby 1956, p. 215).

The observer's stability implies that its interpretations have their own stability. Thus, the interpretation is partly autonomous for, even though it is expressed by the observer, it also depends on the observed. The observer may change his or hers interpretation following changes in the observed but it can also maintain its interpretation and not take into account changes in the observed. This means that interpretations are neither mere reflections of some external reality nor isolated views independent of this external reality.

Thus Enterprises can be said to maintain a set of variables that define their identity and therefore their survival as defined by observers. Which set of variables is selected by an observer to define this identity depends on the observer. Customers may identify a company by the quality (defined by themselves) of its customer service. Investors are more interested in the financial health (defined by themselves) of the company. Employees may be more interested in the benefits they receive, in the

kind of work they are likely to be involved in, and in the working environment offered by the company. Very often observers can define sets of identifying variables that the enterprise is not even aware it is maintaining.

**Def 11: Identifying variables (of a system)** is a set of variables that an observer defines as making this system different from all other systems.

**Def 12: Identity (of a system)** is the set of identifying variables of a system as defined by an observer.

## 4.5 Regulation Strategies

“Continuity depends on regulation; stability, not change, requires explanation. Where we once sought causes to account for change, we now seek regulators to account for enduring form” (Vickers 1987, p. 24)

The mere existence (or rather observation) of systems in the face of forces seeking to increase their entropy (making them indistinguishable from their environment) needs explanation. Vickers implies that this stability is somewhat synonym for continuity. This continuity, he says, depends on regulation. For Vickers a system is regulated if it is:

“governed so that none of its variables will stray beyond its acceptable limit with the time span contemplated by the would-be regulator” (Vickers 1987, p. 62).

To regulate in this context can be understood as bringing order into disorder. As defined in the Merriam-Webster dictionary:

“to bring order, method, or uniformity to <regulate one's habits>” (Merriam-Webster 2002)

Maintaining order in a sea of disorder specifies survival. We have seen that survival (or simply existence) means the maintenance of a set of identifying variables within some limits; both the set of identifying variables and the limits being defined by an observer.

In the following sections we describe a number of regulation strategies that systems can use to maintain their identifying variables within these limits. This should not be seen as a comprehensive list. The number of regulation strategies and their combinations are probably infinite.

### 4.5.1 Homeostasis

Homeostasis as explained by the Weinbergs (1988, p. 184-187) is a set of heuristics with which to understand the relative stability of systems. Homeostasis is defined as:

“a relatively stable state of equilibrium or a tendency toward such a state between the different but interdependent elements or groups of elements of an organism, population, or group” (Merriam-Webster 2002).

In our terms, this is a system's relative stability or tendency towards stability. The person credited with having defined the principles of Homeostasis is the physiologist Walter B. Cannon. Cannon's principles are reproduced in the following list (Weinberg and Weinberg 1988, p. 186-187):

1. “In an open system, such as our bodies represent, compounded of unstable material and subjected continually to disturbing conditions, constancy is in itself evidence that agencies are acting or ready to act, to maintain this constancy<sup>1</sup>.”
2. “If a state remains steady it does so because any tendency towards change is automatically met by increased effectiveness of the factor or factors which resist the change.”
3. “The regulating system which determines a homeostatic state may comprise a number of cooperating factors brought into action at the same time or successively.”

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<sup>1</sup> Cannon uses the term constancy rather than stability. In this thesis we use these terms as synonyms

4. “When a factor is known which can shift a homeostatic state in one direction it is reasonable to look for automatic control of that factor, or for a factor or factors having an opposite effect.”

Cannon speaks about a regulating system as determining a homeostatic state. As defined by the Weinbergs, the term Homeostasis roughly means “remaining the same” (1988, p. 184). Thus a homeostatic system seeks to limit the permissible change to some of its variables that it considers as forming its identity so that the system as a whole remains the same over time.

We can summarize Cannon’s message as follows:

If, as observers, we are able to observe systems in a world in which the second law of thermodynamics is applicable, it is because these systems have some stability. This stability in an unstable environment is sufficient evidence that there are multiple factors that are already active (actions that are already taken) or are ready to be activated (actions that the system or its environment are ready to take) to maintain these systems stable. Furthermore, if such a system remains stable, it is because each time one of its variables changes outside of the acceptable limits, the factors that maintain it within these limits become more effective in maintaining the state of the variable within the limits. Some of the factors described above are applied at the same time, while others are applied when those already active cannot cope with the change. The factors described above are further controlled by other factors so that they don’t overdo their job and set the state of the variable outside of the other end of the acceptable limit.

An example of a homeostatic behavior is a financially troubled company. When the change in the company’s finances, say its revenues and/or income, falls below expectations thus representing a non-welcome change, several actions will be taken simultaneously and in succession to compensate for this change. These actions might be to invest in new products, and reduce expenses. If things get better, it means that the effectiveness of the enterprise to face such non-welcome change has probably increased (at least with respect to the conditions that prevailed while the actions took place). If, on the other hand, things don’t get better, successive action is to be expected, such as more reduction in expenses. However, reducing expenses below some point is likely to cause more harm than good, because it may be an indication that the attempts to reduce unnecessary spending have also stopped necessary spending such as investments for the future. Hence, some factors are probably in place to safeguard against spending cuts that are judged as too radical. Moreover, if the enterprise is unable to cope with the change, external systems may intervene to save it, such as its investors, government agencies, and even suppliers.

Cannon’s principles apply to stable systems in an unstable environment and composed of inherently unstable sub-systems. The dual point of view can be taken in we want to study systems that attempt to change in a stable environment and that are composed of stable sub-systems. Such systems can be found within the stable, homeostatic systems defined by Cannon (and that we have mentioned in Section 4.3. In that case, we can interpret Cannon’s four principles as specifying that

1. Change is itself evidence that factors are active or are ready to be activated to maintain this change.
2. If a variable continuously changes it is because any tendency towards stability is automatically met by increased effectiveness of the factor or factors which resist the stability.
3. The regulating system which determines the changing state of a variable may comprise a number of cooperating factors brought into action at the same time or successively.
4. When a factor is known which can maintain a variable in a homeostatic state it is reasonable to look for automatic control of that factor, or for a factor or factors having an opposite effect.

In light of this description, we can wonder why such a complicated system of factors exists, whether they act towards stability in a changing environment or towards change in stable environment. A plausible answer is to remember that Cannon was a physiologist and was describing the way the human body maintains its identity, i.e., how it survives in a tough environment. Surely, we wouldn’t want our survival to be due to only one regulating factor. Regulating factors may break or they may be

fooled into the wrong action. If we only have one such factor, the chances for non survival can be quite large. This discussion applies to enterprises as much as it applies to the human body. According to the Weinbergs, it applies to systems that were either designed with many cooperative factors in the first place, or that developed such factors by surviving in a tough environment (1988, p. 184). Thus, the homeostatic principles can be proved very valuable when studying enterprises, which can be thought of as systems that survive in a tough environment.

Cannon's principles give us the general directions in which to look for when analyzing the stability of enterprises. Thus, we should look for what variables the enterprise seems to be maintaining in a relatively stable state. As with the multiple regulating factors, there will usually be many such variables. The choice of these variables depends on the nature of the enterprise and its interpretations of its environment. By way of simplification we can say that commercial companies, for example, tend to maintain revenues and profits or the rate of change of these revenues and profits within limits that they believe are required by their stakeholders. Public sector organizations tend to maintain their monopolies and the work patterns of their employees. Governments tend to maintain the social cohesion of their country etc.

Thus, any enterprise will have a large number of variables that it maintains in relative stability. We can select one for analysis and apply Cannon's four principles to it. We will then ask the following questions:

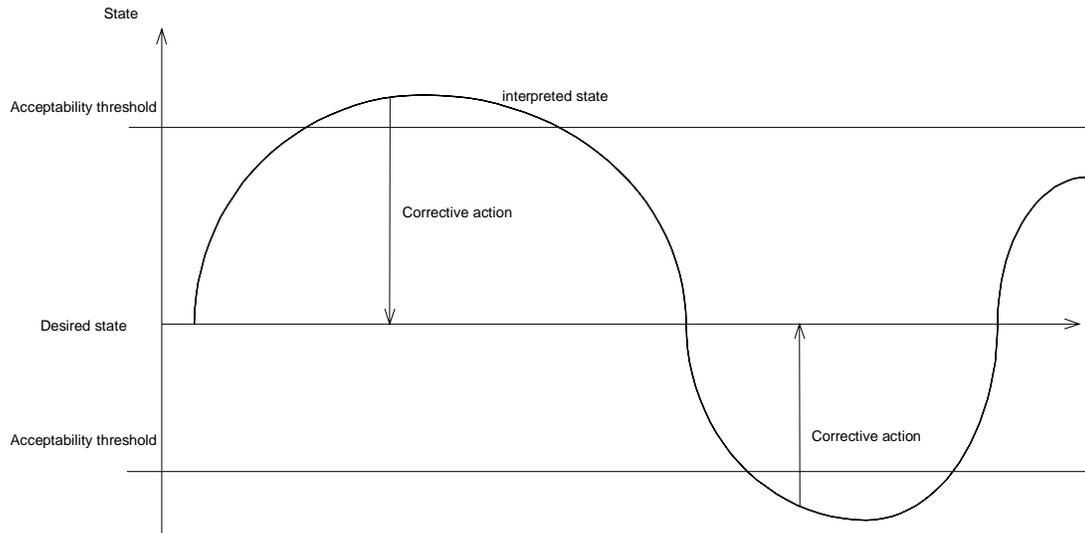
- What are the acceptable bounds for this variable and who defines them?
- What factors maintain this variable stable or what factors we can identify that are ready to get into action to maintain this variable stable if we attempt to change its state outside of the acceptable bounds?
- What tendencies towards change have there been in the past? How did these tendencies been met by factors that resisted the change? If we attempt some change, how would the effectiveness of the forces against change increase?
- What factors can we see as cooperating simultaneously or in succession to the maintenance of the stability of the variable?
- What factors will automatically enter into action if a change is attempted both from the outside and the inside of the system?

A good example of cooperating factors is the set of rules regulating borrowing time limits in libraries. There are several factors that cooperate at the same time and successively. Most libraries force people who want to borrow books to become members of the library. By becoming a member, the borrower renounces his or her anonymity and becomes known to the library. If the member then fails to return a book on time, she will be reminded by the library to return it. These two factors (becoming a member and the reminder) are cooperating simultaneously. The reminder would not work if we didn't know who the borrower is. Failing to return the book after the reminder has been in effect for a while usually triggers a monetary penalty that the member is supposed to pay when the book is returned. This is a successive factor than gets into action only when things get worse. If things get even worse, other successive factors follow in the form of borrowing exclusions, and sometime action in courts etc.

Whenever we want to change some stability, we should ask ourselves whether changing this constancy is a good thing. The answer to this question will depend on whether we consider the constancy as good or bad. Moreover, in a homeostatic system many factors are used at the same time or successively to keep the system stable. Each of these factors relies on the successful regulation of one or more other factors. Thus, the homeostasis principles remind us that changing this constancy will affect other constancies. This is motivated by the realization that the constancy we are examining is very often a factor that plays a role in some other constancy.

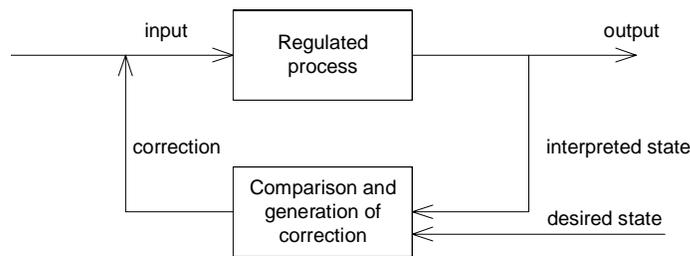
## 4.5.2 Regulation by norm

The process implied by Cannon's principles can be represented in a diagram such as Figure 4.8. Whenever a change is detected on the constancy of some variable, i.e., whenever the state of the variable is interpreted as being outside of some desired (or stable) state, a corrective action is automatically taken to bring the state of the variable closer to its desired state. The curve shown in Figure 4.8 can be achieved through a process known as the *Error-Control Process*.



**Figure 4.8 A simple error-control process**

The error-control process is very well known to engineers. It is the process used to control the state of some variable that cannot be guaranteed to not vary in time. This process is used in such mechanisms as the automatic pilot, a thermostat, a pressure regulator etc. For these mechanisms, external forces acting on the system influence the state of a variable that needs to be kept in a desired state. For example, the presence of wind and other disturbing forces make an airplane move away from its desired heading and this heading needs to be corrected by an automatic pilot. The error-control process describes the basic behavior of a feedback mechanism. Indeed, this process assumes that the state of the controlled variable can be known or rather interpreted and acted upon by the controlling mechanism.



**Figure 4.9 A simple feedback loop**

For engineers this feedback mechanism at its simplest form (Figure 4.9) consists of reading the value of an output variable; comparing this value with the desired value of the output, thus generating what is called an *error*; generating a correction for this error and mixing this correction with the input to produce an output that is closer to the desired value. The correction can be either designed to counter the tendency of the controlled variable as is shown in Figure 4.8 and described in the homeostatic principles, or it can be designed to amplify the tendency of the controlled variable. The first case is often called negative feedback and the second, positive feedback.

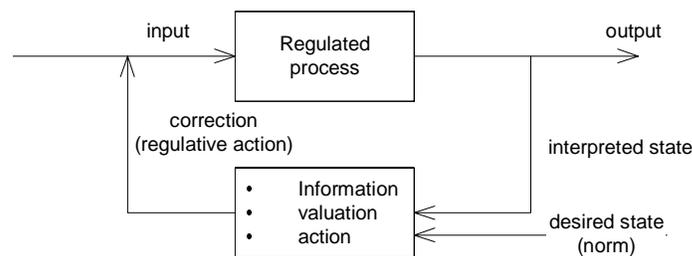
Control engineers know very well that the comparison with the desired state should not be too fine for otherwise the error signal will not have sufficient stability but it should not be too coarse for it may lead to an error signal that is too large to be corrected. In the first case the error signal will oscillate at a frequency that may render the system unstable, in the second case the error signal will be more stable but its amplitude may, at times, be too great to be corrected fast enough and the system will not maintain its desired state correctly. Thus the comparison is done against upper and lower limits of the desired state rather than the desired state itself. These limits are called acceptability threshold in Figure 4.8 that shows a very simplified regulation with the desired state represented as a straight line and in the face of continuous influence on the desired state.

We can see that this comparison against upper and lower limits is the same argument we have developed with respect to the identity of a system, i.e., the identifying variable is maintained within some bounds and the bounds themselves are maintained within some bounds.

A well known characteristic of error-controlled regulation is that the controlled variable always fluctuates around the desired state. The Weinbergs (1988, p. 221) list three reasons for this:

- The delay in reaction to a change in the state of the controlled variable. The system needs to first detect that a state of the variable is out of the desired state before the corrective action can be taken.
- Interference with other regulatory mechanisms. The system cannot apply rapid, large changes because it may affect other regulation mechanisms.
- The loss of information about the success of the regulation as the regulation becomes more successful. If the system is very successful in regulating the variable, the error is null. This is equivalent to not having a feedback loop at all. The system cannot know if it doesn't receive an error because it is perfectly regulating the variable or because the feedback loop doesn't function. This loss of information means that the system doesn't know whether it is still regulating the variable or not and thus may lead to the failure of the regulation.

If this fluctuation of the state of the controlled variable is unacceptable to the system, it can attempt to compensate for it by developing a more sophisticated error-control. This is likely to help with the two first reasons above (Weinberg and Weinberg 1988, 223-225). To compensate for the third reason, the error-control mechanism can anticipate future changes and thus become less vulnerable to changes once they have occurred (see Section 4.5.4).



**Figure 4.10 Vickers's three regulatory phases**

Vickers (1968, 1987) defined a conceptual framework for understanding enterprises from the point of view of the regulation of relationships. Vickers (1968, p. 117-118) distinguished in the regulative cycle implemented by the feedback mechanism three phases that he called information, valuation, and action (Figure 4.10):

- In the information phase an observation is made of the state of affairs of interest
- In the valuation phase this observation is compared with the desired state, that Vickers calls the *norm*, and a signal is generated that reflects the difference between the norm and the observation

- In the action phase an action that is, in principle, coherent with the signal is taken. Vickers calls this action, *regulative action*. The result of the regulative action is then observed again and is “fed back” as information in the first phase of the following occurrence of the cycle.

For Vickers, regulative actions are taken when the state of affairs is judged to be too far from the norm, much as the homeostatic system brings in several factors to control a variable that is out of its desired state. A regulative action has a specific state of affairs that triggers the action and a specific state of affairs that is needed to be achieved.

Vickers associates three kinds of judgments with the three phases defined above:

- Reality judgments are made in the information phase
- Value judgments are made in the valuation phase
- Action judgments are made in the action phase.

With respect to Vickers’s conceptualization, we can consider the concept of interpretation of a system as the combination of reality and value judgments.

**Def 13: Interpretation (of a system)** is a variable of the system whose state represents a set of variables, in itself and its environment, that the system chooses to observe, the states the system observes in these variables, and the value of the comparison that the system observes between these states and the states defined by some of the system’s norms as defined by an observer.

Note: An interpretation is the result of a relationship between the system and a set of other systems. The relationship is to be understood in the sense given by our definition of relationship.

Vickers defines the concept of norm as, (1987, p. 14) “*governing relation by which the actual course of affairs may be judged.*” In terms of our discussion, a norm can be understood as the stable state (and therefore stable action) maintained by an enterprise. We have seen, in our discussion of homeostatic systems that the stable states maintained by some system are used by other systems to maintain their own stable states. Thus, enterprises come to depend on their own norms and the norms set by other enterprises. Because of this dependency, they tend to judge the course of affairs with respect to these norms that they have come to depend on. This is what Vickers calls the readiness to distinguish some aspects of a situation rather than others and to classify and value these aspects in a certain way rather than any other way (1987, p. 16). As examples of this case consider the human body’s reliance on the stable chemical composition of the atmosphere. Not only do we rely for our survival on this stable composition, we also tend to see this stability as good and when this stability is threatened we tend to see it as bad. Similarly, some investors in the stock market rely on the stability of the fluctuations of stock values. For those relying on fluctuations these fluctuations are seen as norms to be maintained. For those who lose money at some point because of such fluctuation, the same situation is seen as a rather bad norm.

**Def 14: Norm (of a system)** is a variable of the system whose state represents what is acceptable to the system as defined by an observer

**Def 15: Regulative action (of a system)** is an action taken by a system in order to bring its interpretation of a variable that represents the state of a relationship closer to a norm when the system interprets that the state of this relationship has drifted, is drifting, or will drift out of a threshold associated with the norm.

Vickers argues that the human task of regulation is much more complicated than, for example, an automatic pilot’s task (1987, p. 17-18). Whereas in the automatic pilot the norm is given from outside the system, the norm of a human system is largely self set. Since norms are self set, they evolve over time, as do the associated acceptability thresholds (see Figure 4.11), the interpretations and the

regulative actions likely to be taken. These changes are what we define as learning or adaptation to the environment.

Also, the set of actions that may result in human regulation is unspecifiable and may be connected with the norm only through the interpretations of the enterprise. For example, an enterprise in financial difficulties may create new products as a regulative action, thus spending more money in the short term in the hope of fixing its financial problems in the long term. The link between the regulative action and the norm can be done through the interpretations of the enterprise.

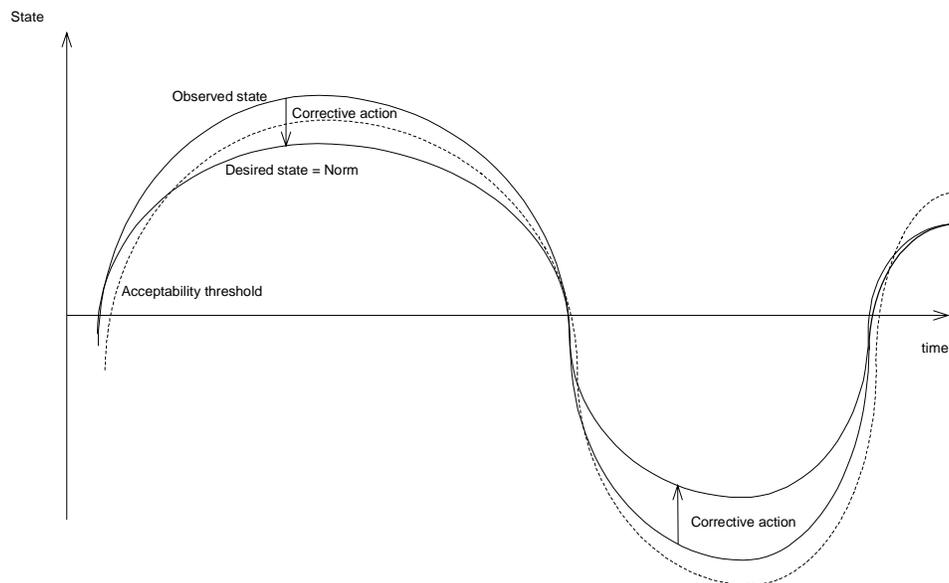
Another complication is introduced by the existence of numerous norms to be satisfied simultaneously. Also, contrary to the automatic pilot where the norm is given (and we don't ask the automatic pilot to judge which norm to apply in what circumstances), in a human system a judgment is necessary to select the relevant norms in a particular context from a multitude of possible norms (Vickers 1968, p. 128). Thus, the norms themselves can be understood as interpretations.

The set of definitions above enable us to define the concept of a regulation (or regulatory) mechanism of a system as the set of interpretations, norms, and regulative actions of the system. A system's regulatory mechanisms constrain the possibilities of actions of the system and the systems with which it maintains relationships. We can thus define the concept of a learning action of a system as the changes made to the system's regulatory mechanism:

**Def 16: Learning action (of a system)** is the changes the system makes to its interpretations, norms, acceptability thresholds, and regulative actions.

Often the norms maintained by a system cannot be interpreted by observers as being a consistent whole, but rather as creating conflicting demands. Vickers gives the following example of a government's task:

"Controlling the balance of payments is for a government only part of the total task, a task which involves pursuing also a vast variety of other norms not wholly consistent with each other and greatly exceeding in the total demands the aggregate resources available. The whole task can be neither completely specified nor completely performed." (Vickers 1987, p. 15)



**Figure 4.11 Regulation with a changing norm**

For an example of a situation with numerous norms, consider the case of health care provision. In any country there are multiple norms about the quality of care, distribution of care to people, the price of health care, the training of doctors and nurses etc. It is frequent for western governments to struggle with the issue of health care, i.e., what price is acceptable, for what quality, for what patients, by how many health professionals, with what kind of medication and procedures etc. The debate produces ever

changing norms that, as described by Vickers do not appear to be wholly consistent and that do not appear to be completely specifiable or resolved.

Moreover, the state curve plotted in Figure 4.8 and Figure 4.11 are not the result of a direct representation of the state of the relationship between two enterprises but rather the interpretation of one of the enterprises of the state of the relationship, i.e. Vickers' reality judgment. One of the reasons human social systems seem so complex, is that this interpretation of the relationship is proper to each enterprise and its nature varies widely from one enterprise to another. Not only, are the thresholds of acceptability different but the states of the curve themselves are different in nature.

As can be seen from Figure 4.8 and Figure 4.11 "positive" gaps from the desired state result in corrective action in the same way that negative gaps do. Indeed, too much of a good thing can also be seen as bad. This could be seen as a consequence of Cannon's fourth principle, the automatic control of factors that can throw the state of a variable out of the acceptable bounds when trying to correct it. For example, it is known that economic growth needs to be regulated if we don't want it to become uncontrolled and lead to future recessions. Thus, when the economy is growing too fast, government regulators will step in to slow this growth. If the economy doesn't grow fast enough, government regulators will attempt to speed up the growth. One of the main instruments the government has to regulate growth is the basic interest rate. The judgment on when to apply an interest rate increase or decrease depends on how far the growth of the economy is judged to be from the norm, i.e., from what is acceptable. This judgment itself is built on an assessment of the situation (reality judgment). The assessment of whether the economy is growing too fast or too slow is done by measuring so called economic indicators. By measuring mainly these economic indicators (and not any other state of affairs), the government shows a readiness to view only some aspects of the reality as we will discuss in Section 4.5.6.

For Vickers human behavior is not restricted to the specification of regulative actions in the face of gaps with norms (1987, p. 16). Vickers argued that people have a distinct capability to appreciate relationships in time through such mechanisms and anticipation, and changes in appreciation. Through anticipation an enterprise takes regulative action before the gap can be detected. Changes in appreciation are said to occur when regulative action doesn't necessarily follow when a gap is detected between the norm and the reality judgment. Instead of taking a regulative action, an enterprise may also modify its interpretations and norms. This modification (changes in appreciation in Vickers's vocabulary) can be seen as learning or adaptation to the environment defined above. We will explore these issues in the next sections when we examine the strategy of specialization.

Norms as we have defined them here are generally not set and regulated by some authority. Many norms have simply evolved to their present state through the evolution of the system's interactions with its environment while others are set explicitly and regulated by some authority as in the case of laws or government regulations. In a system with tightly coupled sub-systems, regardless of whether a norm is explicitly set and regulated by one of the sub-systems or whether it is simply the result of the coupling of the sub-systems, it is likely that many of the sub-systems will come to count on this norm (Weinberg and Weinberg 1988, p. 283-285), therefore producing a homeostatic variable out of a norm that was defined arbitrarily to begin with.

Such coupling can also produce a norm that counts on another norm. The norm that is counted on can be any stable state even one that represents a fluctuation of other states or even randomness. For example, many investors in the stock market count on the fluctuations of the stock to make profit. While the state of the stock is fluctuating, this fluctuation itself is a stable state, a norm that people exploit. Another example is the randomness of security codes. Security algorithms count on this randomness, which for them represents a norm without which they will not operate correctly.

According to the Weinbergs (1988, p. 172-173), most regulation strategies are based on two basic strategies. These basic strategies are aggregation and specialization. For the Weinbergs, systems use aggregation as a strategy for becoming less vulnerable to unknown threats and specialization as a strategy for dealing with known threats (p. 173). In the next Section we discuss aggregation.

### 4.5.3 Aggregation and reserves

Aggregation can be understood as the composition of sub-systems that compose a system. The Merriam-Webster dictionary defines aggregation as (Merriam-Webster 2002):

**Aggregate:**

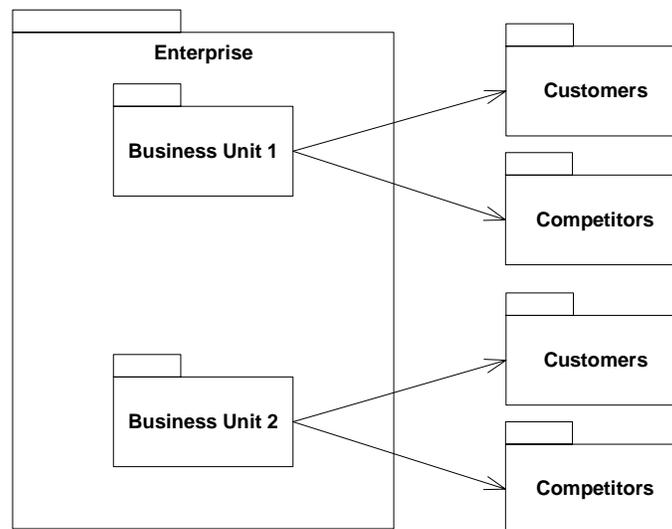
1. Gathered together into a mass or sum so as to constitute a whole; total. [...] -n. 1. Any total or whole considered with reference to its constituent parts; an assemblage or group of distinct particulars massed together; gross amount: *“An empire is the aggregate of many states under one common head”*

The parts mentioned in this definition are what we have called sub-systems and the whole, total, or assemblage is what we have called the system. Thus, the notion of aggregate draws our attention from the system as a whole to its sub-systems, namely to the question, why are there several sub-systems in a system?

For the Weinbergs, aggregation, or the existence of these sub-systems is the base on which all other regulation strategies are built:

“Concealed by our impression of a relatively stable, structured world is the unceasing regulatory activity of aggregates. Aggregate survival is the most elementary form of regulation, both in the sense of the simplicity with which it may be understood and modeled and in the sense that it is the foundation on which other regulatory mechanisms are built.” (Weinberg and Weinberg 1988, p. 164-165)

The existence of several sub-systems in a system helps the system to survive the failure of one or more of its sub-systems, where a monolithic system representing only one sub-system will not survive the failure of its one and only sub-systems. Aggregates, therefore, represent a redundancy that enables the system to survive the failure of one or more of its components (Weinberg and Weinberg 1988, 13-15).



**Figure 4.12 Aggregation into several business units**

Aggregation can also be considered as representing the constitution of reserves (Weinberg and Weinberg 1988, p. 262-265). Reserves reduce the need for precise regulation (either through anticipation or feedback). When the regulation is not too precise, the system can use some of its reserves to compensate for its inability to either react fast enough to changes or to predict what these changes would be. For example, a library may carry several copies of popular books because it cannot predict when more than one borrower would need them simultaneously. It is thus less vulnerable to changes in the borrowing patterns of its borrowers. However, reserves represent a cost for the system,

both in building the reserves and in their maintenance. Thus, the library can probably not carry multiple copies of all its books.<sup>1</sup>

When the reserves are large with respect to the needs of the system, the system may completely ignore their existence (Weinberg and Weinberg 1988, p. 264). For example, as long as the quality of air didn't begin to deteriorate, people didn't give much attention to the reserve of oxygen creation and CO<sub>2</sub> removal by plants. However, these reserves, small or large, are important parts of the regulation mechanisms which come to rely on them. It can even be argued that the larger the reserves the more important they are for the survival of the system and the more hidden they are from the system.

On the other extreme is the notion of scarce resources. When there are no reserves of some resource, access to this resource are likely to be highly regulated. Scarce resources are regulated because they are essential to the survival of the system. The survival of the system of interest often depends on sharing these resources among several sub-systems in a way that insures that no one sub-system can possess them completely at the expense of other sub-systems as well as on the management of these resources so that they are not depleted over time. The more a resource is important to the system's survival and the more it is interpreted as being scarce, the more it will be regulated.

When a system needs to adapt to a situation where scarce resources become plentiful and vice versa its regulation needs to change fundamentally (Weinberg and Weinberg 1988, p. 324). Technology in general and IT systems in particular have the potential to cause just such changes requiring a fundamental change of regulation in enterprises, we will discuss this point further in Section 4.5.6

The notion of aggregates also draws our attention to the observation that a system made of aggregates, i.e., sub-systems, is not a simple summation of its parts. The system applies multiple constraints to keep its sub-systems within some bounds to as to maintain the stability of its identifying variables. These constraints are the norms and interpretations we have identified in the previous section. Homeostatic mechanisms attempt to insure that the norms are respected by the aggregates. The norms may either specify the survival or destruction of the system. However, the success of this survival or destruction is also dependent on the adequacy of these norms with the environment of the system.

An enterprise, for example, can be seen as an aggregation of people. These people in turn are aggregated in units, usually called departments or services. These departments may be aggregated in business units etc. This aggregation helps the enterprise to survive even if one or more of its people, departments, or business units fail to survive (Figure 4.12). Homeostatic mechanisms exist in the enterprise to attempt to insure that these sub-systems (business units, departments, people) conform to the norms of the enterprise and therefore maintain its identity.

#### 4.5.4 Specialization

Thus, specialization is the concentration on a specific influence that may affect stability. Through separation of variables a system identifies separate influences and provides specific factors to regulate each of these influences.

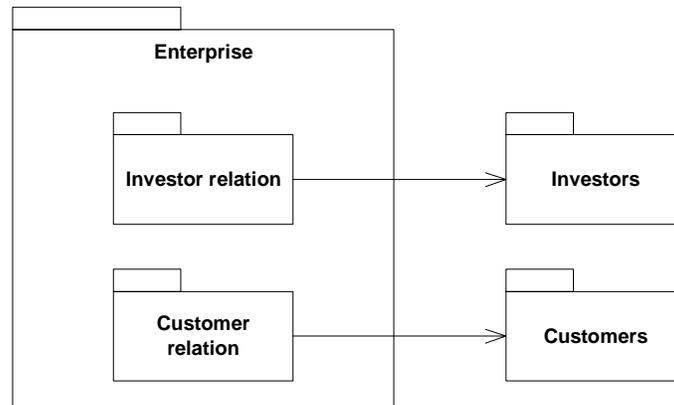
Specialization is complementary to aggregation. As shown by the Weinbergs (1988, p. 66-69), if all the sub-systems of a system were truly identical, they could only compensate for one influence; they would also all fail at the same time, thus providing compensation at all. Thus the system needs to strike a balance between specialization and aggregation so that its sub-systems would be both

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<sup>1</sup> This is the case at least as long the cost of reproduction and storing are as high as they are for physical books. This constraint may of course be lessened with the advent of electronic books. However, the cost of the reserve is then offset by the need to have electronic gear (computers, hand-held devices etc) to read books with all of these devices conveniences and inconveniences (electricity consumption, batteries etc).

interchangeable and specialized to a degree that helps the system face its known and unknown influences.

Thus enterprises have departments that specialize in customer relationships, supplier relationships, investor relationships etc (see Figure 4.13). Each such department can be seen as a specialization for a specific influence.



**Figure 4.13 Specialization and aggregation**

Indeed, for an enterprise, a relationship with people and other enterprises is the source of opportunities and threats. However, the very definition of whether a relationship is a threat or an opportunity depends on the enterprise's interpretations. The same aspects of a relationship can be defined as threats for some enterprise and as opportunities for another enterprise. Moreover, since threats and opportunities are interpretations, they have their own stability, partly independent of the actions that triggered them. Thus, instead of talking about threats and opportunities, we refer to these as influences in order to maintain a more neutral tone with regard to what their actual interpretation may be. This may help us to more easily change interpretations with respect to what is a threat and what is an opportunity. In this section we will therefore speak of influences and compensation for influences. This will lead us to generalize some of the Weinbergs' regulation principles that were originally stated in terms of threats and protection from threats.

Separation of variables (Weinberg and Weinberg 1988, p. 169-175) enables the specialization of some of the sub-systems of a system in order to provide specific compensation mechanisms for each influence that the system thinks it may face. Thus specialization represents anticipation for possible future influences based on past influences. This anticipation, in principle, helps the system to complement the feedback mechanisms we have seen in Section 4.5.2 so as to overcome some of this mechanism's deficiencies, e.g. fluctuations of regulated variable, loss of information on the success of the regulation when the regulation is very effective.

Aggregation and specialization are complementary approaches but they are also antagonistic. When an enterprise specializes one of its departments to regulate one kind of influence it loses its ability to use this department to regulate a different kind of influence. It thus loses some of the benefits of aggregation. Aggregation also works against specialization since, through aggregation the enterprise attempts to maintain the ability of its departments to compensate for multiple influences.

Specialization also depends on aggregation. Thus an enterprise would not be able to specialize one of its departments if it didn't have several departments.

Through specialization an enterprise comes to resemble its environment. If the enterprise sees investors in its environment it may well have a specialized department for dealing with them. This is what the Weinbergs call the Parallel principle:

“A regulator must be “like” the environment it regulates.” (1988, p. 206)

This principle enables us to understand what to expect in the behavior of the environment when analyzing the regulation of an enterprise. We can see this principle as simply a different way of saying

that system and environment co-evolve in time, adjusting themselves to each other. This is what Maturana and Varela call structural coupling:

“We speak of structural coupling whenever there is a history of recurrent interactions leading to the structural congruence between two (or more) systems” (1998, p. 75).

Structural coupling specifies that the system and environment co-create each other. Through its actions, the system prompts its environment into creating some conditions and the environment does the same for the system. Notice that the environment doesn't specify what the system's conditions should be. It only inspires these conditions through its actions. The system is responsible for specifying its responses to these actions. This is also true for the inverse relationship, between system and environment (Maturana and Varela 1998, p. 96). Thus, the results of the system's actions on its environment and the actions of the environment on the system are largely unpredictable for each of them because they only prompt the other into action (or inaction) but do not specify these actions (or inactions).

This shows us that the enterprise we are analyzing is part of a network of relationships that has evolved together and that presents some congruence, i.e., a kind of agreement, in their actions, as we have shown in our discussion of tightly coupled systems in Section 4.5.2. Thus, changing the enterprise's regulatory mechanisms is likely to disrupt its relationships with its environment as we show in the discussion of flareback in Section 4.5.6.

By analyzing the regulatory mechanisms of an enterprise, we can make assumptions about what its relationships are and how they behave. However, we should be careful when using this principle. As cautioned by the Weinbergs (1988, p. 325-328), some regulation mechanism may be effective against some influences without the system having an explicit model of these influences. It is also possible for the system to be compensating for past or imaginary influences that cannot be identified by the designer. When the latter happens, we can

- infer that the enterprise is regulating relationships with respect to past influences, in which case its regulation may need to be revised, or
- search more for the influences in the environment that may be eluding us

We can also attempt to predict future changes in the environment that may influence the enterprise and for which we believe that the current regulation mechanisms are not adequate. However, these predictions are notoriously inaccurate in a large part because we can only predict the future by reference to past experience but the future is not always like the past. Also, whenever we believe that the regulation is inadequate and that it needs to change we need to be careful and remember that changes to the regulation mechanisms of a system may result in unexpected results. Also, we should remember that the interpretations that comprise the regulation mechanism of an enterprise may be the hardest thing to change.

#### **4.5.5 Multiple influences and compromises**

The Weinbergs (1988, p. 212) differentiate between two broad categories of regulatory mechanisms that systems can employ: conditional and unconditional mechanisms. Unconditional mechanisms are those that operate all the time regardless of the existence of a particular influence (these are usually called passive mechanisms but the Weinbergs prefer to call them unconditional because they can be thought of as always active). Conditional mechanisms are those that operate only when certain conditions apply.

The Weinbergs argue that every regulation mechanism carry a cost in its development, application, and maintenance in operation. Unconditional mechanisms operate and compensate for potential influences regardless of their existence at any given time. They carry a higher cost in building and maintenance and resources they take away from the system that could be used for other purposes. Conditional mechanisms don't operate all the time and may consume fewer resources but they also need to be maintained. In particular, the mechanism that triggers them needs to be an unconditional mechanism or else, the conditional mechanism will not operate when needed.

Good examples of such mechanisms are:

- The borrowing time limit in a library. This is an unconditional mechanism. It applies to all borrowers regardless of the ability or inability of a specific borrower to return a book on time.
- The penalty imposed on borrowers if they fail to return a book on time. This is a conditional mechanism which is only applied to a specific borrower when he or she fails to return a book on time.

In principle, unconditional mechanisms carry a higher cost than conditional mechanisms. Applying time limits to all borrowers is definitely costly to the library in terms of employee time and it annoys borrowers. However, conditional mechanisms are more likely to fail. The library, for example, may miss imposing a penalty on a borrower who exceeded a time limit. Thus, both conditional and unconditional mechanisms carry a cost to the system and it is not clear when it is better to have one or the other. The library could decide to not apply a time limit on borrowing for every borrower but only on borrowers who fail to return books within some reasonable time. This would mean less cost for the library when dealing with “good” borrowers but it could raise the risk of mistaking a “bad” borrower for a “good” one or vice versa. In the first case, the library may lose some efficiency by failing to recover some books on time. In the other case it may lose a customer if it makes the “good” borrower angry.

The application of conditional mechanisms, therefore, is subject to two kinds of mistakes called Type I and Type II errors in statistics. They correspond to (Weinberg and Weinberg 1988, p. 214):

- Type I error: Believing a hypothesis when the hypothesis is wrong
- Type II error: Not believing the hypothesis when the hypothesis is correct

In the library example, a type I error would be to impose a penalty on a borrower believing that she was late returning a book when in fact she returned a book on time. A type II error would be to fail to impose a penalty when the time limit has passed.

Enterprises risk making such errors either because their regulatory mechanisms fail (e.g. when a time limit expiration does not trigger the imposition of a penalty on a borrower) or because it is impossible for the enterprise to predict what relationship constitutes a threat.

As an example of such errors consider the way enterprises separate opportunities from threats. Enterprises constantly attempt to perform such a separation in order to define their strategy but the opportunities and threats are not easily, if at all, separable. Customers, for instance, represent a source of opportunities in terms of revenues enabling the company to maintain its profits, employee benefits, customer service level, price paid to suppliers etc. But customers also represent a threat in terms of non-payment of services, security breaches, employee overload etc. The enterprise has to protect itself from these threats to some degree. Enterprises thus attempt to restrict their relationships to people and enterprises which the enterprise perceives as presenting opportunities only. For example, enterprises usually want to do business with customers who they feel are able to pay their bills. However, these attempts of separation between threats and opportunities can never be perfect since “good” customers can become “bad” ones. “Reliable” employees may become “unreliable”, unreliable employees may become reliable etc. Thus a same relationship may present both opportunities and threats to the company. To offset for its inability to separate threats from opportunities, the enterprise is forced to make compromises and apply restrictions to all customers regardless of how attractive they seem to be, an unconditional mechanism. The enterprise may ease some restrictions on customers who prove to be reliable, a conditional mechanism. However, this does not mean that these customers will remain reliable in the future.

Such impossibility to know in advance when a threat is present leads the Weinbergs to state that regulators need to tread “the thin line between type I and type II errors” (1988, p. 215). In other words, enterprises need to find a balance in their use of unconditional mechanisms that may limit the risk of not acting when an influence that would require action is presented but that may not be regarded as efficient and the conditional mechanism which may be regarded as more efficient but which has a higher risk of not acting when needed.

Enterprises also need to strike a balance between their use of specialization and aggregation. Specialization, as we have seen compensates for specific influences. But how does a system know what these specific influences are? Obviously, the system needs to know a specific influence in order to be able to build a special factor to regulate it. If the system doesn't know of specific influences or fears that these influences may change in the future, it has to keep general purpose sub-systems in order to compensate for these yet unknown influences. This motivates the Weinbergs to define what they call the first and second laws of regulatory compromise:

The Weinbergs' first law of regulatory compromise:

“Aggregation gives protection against the unknown; specialization against the known; and the use of each sacrifices some opportunity to use the other.” (1988, p. 173)

The Weinbergs' second law of regulatory compromise:

“There is a limiting factor to every regulatory strategy.” (1988, p. 174)

According to the Weinbergs, systems that face multiple influences cannot compensate as efficiently against all of them as if they only had to compensate only one. This is what the Weinbergs call “the problem of multidimensional regulation” (1988, p. 168):

“When a system has to deal simultaneously with two threats protection against one will increase vulnerability to the other.”

An enterprise is a good example of a system that needs to regulate multiple relationships. A company, for instance, cannot rely only on customers to maintain its identifying variables. It needs the help of investors, employees, suppliers, and government regulators. Failing to correctly regulate relationships (i.e. in a way that is acceptable to those being regulated) over the long term, usually spells the demise of the company. Thus, failing to correctly regulate relationships with its investors may mean no financial resources available. Failing to correctly regulate customer relationships leaves the company with no customers willing to purchase its goods or services. The same goes for employee relationships etc. Thus an enterprise cannot hope to completely satisfy any of its relationships or to compensate completely for the influences that they pose.

By overly adapting to the needs of one of these relationships, an enterprise runs the risk of antagonizing its other relationships. A company could, for instance, be tempted to overly satisfy customers by providing them with free services. Over time this may prevent the company from paying its employees and suppliers and prevent it from generating sufficient return on investment for its investors. The company also runs the risk of being suspected of unfair trade, thus antagonizing its relationships with government regulators. A similar situation is possible if the company overly adapts to any subset of its relationships (investors, employees, suppliers or government regulators) at the expense of other relationships.

Hence, the enterprise is forced to find a compromise as to the degree of its adaptation to the different demands of its relationships. It is forced to regulate its relationships but this regulation should not overly antagonize any important relationship either.

The lessons from the above discussion are that it is the balance between aggregation and specialization, regulation by error and anticipation, conditional and unconditional mechanisms that provides for a good regulatory strategy by minimizing the risks that influences pose to the identity of the enterprise. We can therefore expect enterprises to employ sets of such strategies that are dependent on each other for their success. In the example of the library, the borrowing time limit may be quite useless if it is not backed up by the conditional mechanism of imposing penalties, whereas imposing penalties, means that a time limit exists and is communicated to borrowers.

This need for a balance between the different mechanisms developed, maintained, and operated by a system is supplemented by Vickers's assertion that regulation is an optimizing-balancing process (Vickers 1968, p. 115). Optimizing refers to the good enough solutions given to what Vickers calls the functional relationships that can be equated to what we call influences. In other words, optimizing represents the satisficing of services rendered by the system. Balancing refers to the necessity to maintain a balance in what Vickers calls the metabolic relationships, and that we have called

information. In other words, it is the balance maintained between the inflow and outflow of information. Vickers notes that these two needs, the optimizing and the balancing, are strongly related since the metabolic and functional relations are simply two aspects of the same relations (ibid). Indeed, balancing the metabolic relations is needed so that the functional relationships can be optimized and vice versa. A library, for example, must maintain a balance between the inflow and outflow of books (as well as money and people) so that it can provide a good enough service to its borrowers. This can be seen as a generalization of Mintzberg et al.'s point of the main contribution of the design school: The balance that was sought between strengths and weaknesses on one hand and threats and opportunities on the other hand. Vickers point shows that not only this balance is sought but also the need to optimize functional relationships. Moreover, our conceptualization shows that strengths, weaknesses, opportunities, and threats are interpretations. Interpretations of external factors (factors that are considered to be outside the system) are what we refer to as opportunities and threats. Interpretations of internal factors (factors that are considered to be inside the system) are what we refer to as strengths and weaknesses. From this viewpoint, the optimizing-balancing process seeks to give good enough answers to threats and opportunities given a set of strengths and weaknesses.

#### 4.5.6 Regulatory models and observation readinesses

To improve its optimizing-balancing process, a system has to have some knowledge of the influences that it needs to regulate and it needs to have some knowledge of its ability to respond to these influences. One way of acquiring this knowledge is through the feedback mechanism we have in Section 4.5.2. As the system evolves through time, the influences that it sees in the environment and the feedback it receives about the results of its actions enable it to build some understanding of what influences it has lived through and how its actions compensated these influences. This understanding is what the Weinbergs call the *regulatory mode*<sup>1</sup> (1988, p. 238-241). The system uses this model to predict what influences it *will* go through. The regulatory model enables the system to better regulate its relationships than if it uses only a feedback mechanism. In principle, the regulatory model provides better regulation if:

- The model accurately represents the possible environmental influences on the system and the capability of the system to respond to these influences.
- The model is coupled with sensing mechanisms that enable the system to detect changes in the state of the environment and in its capabilities to respond to them
- The model is coupled with mechanisms that enable effective actions in the face of detected influences

Also, since the system can only build its regulatory model from past observations of the environment, its regulation will be effective only if the future happens to be like the past (Weinberg and Weinberg 1988, p. 251). If the future doesn't resemble the past, the system's regulatory mechanisms may not serve it well. Thus, the system is forced to have some specialization but not too much, so as to be able to respond to the uncertainties of the future, which goes back to our argument about compromises in the previous section.

Consider, for example, the case of a library that has just been founded. It knows of no other libraries on which to base its regulations on. So when the first borrowers borrow books, they may simply take the books and go. After a while, though, the library may realize that borrowers do not return the books quickly enough and that this prevents other borrowers from borrowing the already borrowed books. It may then ask borrowers to return the books after a specified borrowing time. This means that it has to have several special functions, such as a borrowing desk to supervise who borrows what book and to set the borrowing limit; a person who regularly checks for expired borrowing delays and sends recall

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<sup>1</sup> Weinberg also note that the concept of regulatory model should lure us to expect to find a real model in the entities that we analyze. In other words, we can infer that such a regulatory model exists from the behavior of the entity but we should remember that the regulatory model exists only in our own model and not in the reality we observe.

notifications to borrowers; etc. Thus, the library anticipates that borrowers will not return books quickly enough and creates specialized functions to guard itself against such an influence on what it considers as important, i.e., its ability to serve most of its borrowers.

Without this experience of dealing with borrowers and their particular actions, the library would have been unable to specify these specialized functions. Moreover, if the borrowers would all have returned their books very quickly, the library would have never specialized in this way and would have not imposed borrowing limits. A library today doesn't start from scratch as in our example. Rather it applies some generic library model and creates specialized functions from the beginning of its operations. In doing so, the library in effect anticipates future influences before it was even subject to one. It does so by applying the past experience of other libraries. This works because the patterns of actions of borrowers are very well known. However, if this pattern of behavior came to change or if the nature of books as non shareable items came to change (which is more probable), the library will have to modify these specialized functions to the new environment.

When the system encounters influences that its regulatory model did not account for, it may well cease to exist or not exploit an opportunity. On the other hand, when the system attempts to anticipate influences in its environment and act upon them with a model that does not correspond to the capabilities of the environment, the result is often a flareback (Weinberg and Weinberg 1988, p. 308-313). Instead of a compensation of the influences as imagined by the system, these become even stronger and other undesired influences appear as well. The Weinbergs state that flareback often happens when we try to achieve greater efficiency. For example, when trying to more efficiently eradicate a population of unwanted insects (1988, p. 309-311), we risk having a much larger population of these insects later on because the insect population is naturally regulated by birds. Eradicating the insects also eradicates the birds and when the few surviving insects develop resistance to the poison we inflicted on them, they have no natural regulators and thus their population explodes. The Weinbergs attribute flareback to the direct influence on one of the members of a pair of mutually regulating systems. In the example above, the birds regulate the population of insects and the insects regulate the population of birds. Directly influencing either the bird population or the insect population leads to a non-regulation of the other population. Since each population has a natural tendency towards growth when it is not regulated, it explodes.

In our example of a library, we can see that a tighter regulation over borrowed books by, for example, imposing stiffer fines on borrowers when they fail to return a book on time, may lead to a dwindling of borrowing and ultimately to less resources in the library for regulating the borrowed books. Here the idea is that the books in the library are regulated by the joint regulating effects of the library and the borrowers.

A link can be made between a system's regulatory model described by the Weinbergs, and Vickers's notion of readinesses. Vickers states that enterprises build, through their experience, what he calls readinesses to see their world in a certain way (during the information phase), to value this information in certain way (during the valuation phase), and to act in specific ways (during the action phase). Thus, for Vickers a person or a society:

“is characterized by its current state of organization in each of these three dimensions-by the kinds of information it is ready to notice, the kinds of valuation it is ready to make, and the kind of actions it is ready to take” (1968, p. 119)

For Vickers as for Maturana and Varela these readinesses (or in Maturana and Varela's terms “what counts as relevant” (1998, p. 253)) do not constitute a distortion of reality as it is sometime thought of, but constitute the very way a person or an enterprise's views the world, i.e., an essential part of that person's or enterprise's identity. The readinesses of the information and valuation phases constitute what Vickers calls the Appreciative System:

“I will credit the appreciating agent with a set of readinesses to distinguish some aspects of its situation rather than others and to classify and value these readinesses; and I will describe these readinesses as an appreciative system. I call them a system, because they seem to be organized as a whole [...] being so interrelated that a change in one part of the system is likely to be affected by and dependent on changes in others” (1987, p. 16).

The readiness to view, value and act in a certain way shapes the behavior of the enterprise. Moreover, as stated by Vickers (1987, p. 20), the influences which the enterprise senses are themselves a product of its readiness to view and classify reality in a certain way. This selection and classification process also has repercussions on what value will be given to the influences pre-selected for attention. We can see that the readinesses Vickers is talking about match the regulatory model defined by the Weinbergs. Both refer to what we can identify as an integrated system with its own regulative mechanisms which aims at adapting the overall enterprise to its environment as well as to shape this environment to what the enterprise expects to see in it. Hence, it is necessary for the enterprise to specialize its understanding of the state of affairs in order to be able to define more effective regulative actions. On the other hand this specialization prevents the enterprise from understanding the state of affairs in any other way and thus prevents the enterprise from acting in any other way. We have a homeostatic system where what makes the enterprise efficient also makes it less able to change. Or as stated by the Weinbergs, "The same mechanisms that prevent us from being poisoned also prevent us from being medicated." (1988, p. 182)

Moreover, the Weinbergs argue that the development and maintenance of a regulative model represents an important investment to a system. It is painstakingly built, perfected and enhanced over time. It is therefore quite difficult to change (1988, p. 265-267). Vickers makes the same point about the upper limit that exists on the possible rate of change of the appreciative system, "which cannot be passed without disaster" (1987, p. 24). In other words, the regulatory model of a system cannot change too rapidly without this change itself creating influences that will affect the stability of the system. These influences obviously can be judged as either good or bad.

A necessity for rapid change in the regulatory model is often introduced when resources that were previously scarce become abundant, or vice versa when abundant resources become scarce. The regulatory model of a system that has survived for a long time in an environment where some resource has traditionally been scarce will be subject to intense change when the resource becomes abundant (Weinberg and Weinberg 1988, p. 322-324). A desert people will have a tough time adjusting to an environment where water is abundant. Similarly, a population accustomed to an abundance of water will have a hard time adjusting to life in the desert. Most of the time, the scarcity or abundance of a resource is so ingrained in the system's regulatory model that it fails to see this scarcity or abundance. Only when scarcity becomes abundance or vice versa will the system realize what it took for granted before. Abundant resources that are taken for granted is what we called hidden reserves in Section 4.5.3. However, we should be careful in the judgment about what constitutes a scarce resource and what doesn't. Skinner and Cleese (1987, 1995) argue that some people love to be a scarce resource when given to someone, it is lost. These people will therefore carefully regulate love as a scarce "resource." However, other people feel that love is a resource that can be recreated at will, i.e. a very abundant resource. The more it is given to others the more others return it. These people will regulate love as an abundant resource.

In our example of the library, books represent a scarce resource to be shared by many potential borrowers. We can speculate about what would happen if it became cheap and easy to duplicate books. Most probably, the very reason of existence of the library will be challenged. It will need to find a different mission than simply sharing books among people.

The Weinbergs' regulative model and Vickers's appreciative system are what we have called interpretations. The interpretations of an enterprise are therefore closely linked to its actions, neither of which can change without the other changing. Also, the rate of change of both interpretations and actions is limited without loss of identity. Therefore, in our conceptualization we consider that during the history of the enterprise's interaction with its environment, the enterprise of interest builds an elaborate set of interpretations which it uses a mechanism for regulating its internal and external relationships. These interpretations are supported and support the actions of the enterprise with regard to internal and external events. The enterprise continually revises its interpretations with respect to the way that it interprets the results of its actions. This is what we call learning, or adaptation. However, there are upper limits on the amount of learning or adaptation that an enterprise can handle in a given time. Even though it is probably impossible to make these limits explicit, it does mean that we should approach organizational change with utmost care.

A parallel can be made between the above discussion about specialization and its dangers and the critiques against Porter's generic strategies made by Mintzberg et al (1998). Porter's strategies are examples of total specialization. An enterprise is expected to specialize by either (Mintzberg 1998, p. 103):

- Cost Leadership, being a low cost manufacturer obsessed with the cost/quality ratio
- Differentiation, developing unique products or services
- Focus, focusing one of the above on narrow market segments

Mintzberg et al., (1998, p. 104) state that Porter's generic strategies were criticized by several authors on the grounds that they "cause inflexibility and narrow an organization's vision." Our discussion of specialization and the readinneses that accompany it show that this is indeed a very potent threat to the survival of an enterprise. The point is that if the enterprise can count on a relatively unchanging environment, its best strategy would be to specialize by focusing on a low cost or differentiation strategy in a niche. However, doing so means that over time the enterprise will develop norms and interpretations that will limit its ability to develop or even consider other strategies. In a changing environment, this means that it will be vulnerable to competitors who may exploit new technology or different customer preferences. Thus, in a changing environment, it is probably better to strike a balance between aggregation and specialization. This balance is needed in order to achieve good enough performance for known customer needs while maintaining the enterprise's capacity to develop and consider different strategies. In essence, the enterprise needs to make compromises.

#### 4.6 Review of main concepts and definitions

In Figure 4.14 we provided a UML class diagram representing the main concepts of the Lightswitch conceptualization and their relationships. The definitions of these concepts are summarized in Table 4.1.

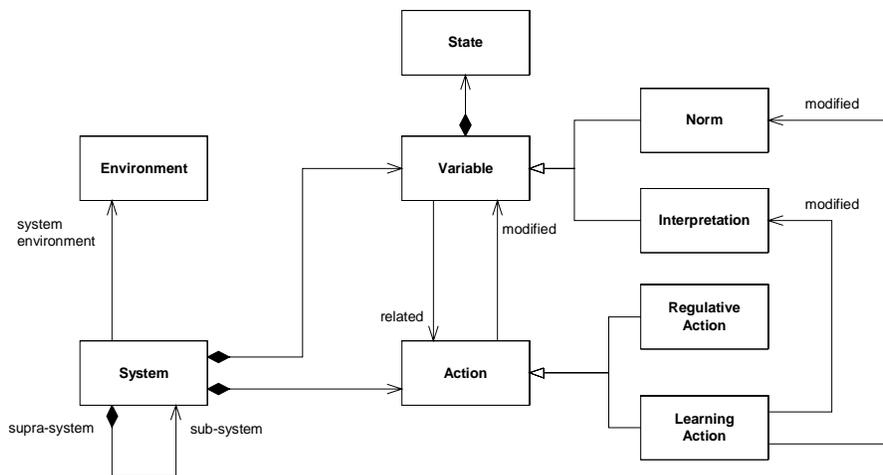


Figure 4.14 UML class diagram of the main Lightswitch conceptualization concepts

**Def 1: System** is a set of interrelated sub-systems that describes an entity in the (observed) reality as defined by an observer.

**Def 2: Sub-system (of a supra-system)** is a system that is subject to the constraints and protection of its supra-system as defined by an observer.

**Def 3: Supra-system (of a sub-system)** is a system that constraints and protects the sub-system as defined by an observer.

**Def 4: Environment (of a system)** is all of the systems distinguished by an observer that, from the point of view of the observer, are not sub-systems of the system or the system itself.

**Def 7: State (of a variable)** is a value defined by an observer that the variable can have at a given moment in time.

<p><i>Def 8: <b>Variable (of a system)</b></i> is a concept defined by an observer as belonging to the system, which can have one state at a given moment in time and another state at a different moment in time.</p> <p><i>Def 9: <b>Action (of a system)</b></i> is a concept defined by an observer as belonging to the system, which changes a variable from one state to another during some time interval</p> <p><i>Def 13: <b>Interpretation (of a system)</b></i> is a variable of the system whose state represents a set of variables, in itself and its environment, that the system chooses to observe, the states the system observes in these variables, and the value of the comparison that the system observes between these states and the states defined by some of the system's norms as defined by an observer.</p> <p><i>Def 14: <b>Norm (of a system)</b></i> is a variable of the system whose state represents what is acceptable to the system as defined by an observer</p> <p><i>Def 15: <b>Regulative action (of a system)</b></i> is an action taken by a system in order to bring its interpretation of a variable that represents the state of a relationship closer to a norm when the system interprets that the state of this relationship has drifted, is drifting, or will drift out of a threshold associated with the norm.</p> <p><i>Def 16: <b>Learning action (of a system)</b></i> is the changes the system makes to its interpretations, norms, acceptability thresholds, and regulative actions.</p>
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**Table 4.1 Summary of concepts and definitions of the Lightswitch conceptualization**

## 4.7 Summary

In this chapter we have built the foundations on which the Lightswitch approach, described in the next chapter, is built. In particular, we have seen that enterprises can be modeled as systems. A system is a set of interrelated sub-systems defined by an observer. By defining this set of sub-systems and their relationships, the observer defines a system and its environment. Thus, observers identify an enterprise as a set of sub-enterprises with relationships between these sub-enterprises. Observers also can identify emergent properties in the whole constituted by these sub enterprises and their relationships.

We have defined the concept of the identity of an enterprise as the stable state of a set of variables selected by the observer. For observers to be able to distinguish an enterprise, the enterprise's identity variables need to have some stability with respect to the length of observation. The observer must also maintain its observation stable. We thus have two semi-independent systems, the observer and the observed.

We have shown that states and actions both have stability. A state is some aspect that an observer defines as not changing. An action is a change of states. Both need to be stable to be identified by an observer. Moreover, observers may identify a set of states that remains stable for longer periods of time than others. This is what they identify as structure. A set of actions that observers identify as stable they call behavior.

In a world governed by the second law of thermodynamics, which defines that closed systems evolve towards disorder, open systems can maintain their internal order by regulating relationships with other systems. Thus an enterprise, which constitutes an island of order, needs to regulate its relationships with other enterprises. This regulation is necessary because relationships with other enterprises represent threats for the stability for any given enterprise.

We have defined the concept of a norm as some state that the enterprise maintains stable. We have seen that enterprises become dependent on each other's norms. Because they are dependent on these norms, enterprises attempt to force each other to remain within these norms. Thus, enterprises regulate relationships by maintaining these relationships within some norms. Norms can therefore be seen as constraints that limit and support action at the same time.

When an enterprise senses that the state of a relationship doesn't satisfy a certain set of norms, it may take some regulative action that it believes will make the state of the relationship satisfy the set of norms. Regulative action is what we commonly call an objective, goal, end etc. Because, the set of norms is generally quite large and not necessarily consistent, regulation represents an optimizing and balancing act, i.e., optimizing the satisfaction of some of the norms in the set while attempting to not cause dissatisfaction of the other norms in the set.

In order to be able to take regulative action, the enterprise must make some judgment about the state of the relationship, the gap between this state and the norms, and the applicability of the regulative action. It can also predict future gaps from past ones, what we have called anticipation. We called these judgments, interpretations. Interpretations represent the way an enterprise sees itself and its environment and is part of its identity. Thus, an enterprise is also an observer and its interpretations evolve semi independently from the state of its relationships.

Regulative action is not always taken when the interpretation is that a state of a relationship doesn't satisfy a set of norms. The enterprise can also change its interpretations and norms. These changes represent what we call learning or adaptation. These changes, while not perceived as leading to immediate action, do change the future actions of the enterprise. Thus, the pattern of actions of an enterprise is tightly related to its interpretation. If the interpretation changes, the pattern of actions changes and vice versa.

We have reviewed a number of regulation strategies that enterprises can adopt, i.e., aggregation, specialization, conditional and unconditional mechanisms, error and anticipation, etc. We have seen that through specialization, an enterprise's interpretations and regulating mechanisms become adapted to its environment. We have seen how this adaptation is both necessary for the survival of the enterprise in a given environment but constitutes a problem when the environment changes. By analyzing an enterprise's interpretations and regulating mechanisms, we can understand some aspects of its present or past environment. If we are not able to identify the influences that match these interpretations and regulation mechanisms in the present environment or if we believe that the future environment will not present these influences, we may want to modify the interpretations and regulation mechanisms. Sometimes we may be justified in doing so because the future aligns itself with our beliefs but sometime the future does not agree with us. Many companies bet on some changes in the future that fail to materialize and some others succeed. There are no perfect answers to this dilemma since we can only know the future from the past and the future doesn't always resemble the past.

In the next chapter we will show how the Lightswitch conceptualization serves as the basis for the creation of goal directed models. The Lightswitch models and the list of heuristics derived from the conceptualization enable the designer to understand some of the interpretations and regulation mechanisms of an enterprise. The designer could use these models to understand what changes are desired by the enterprise or its stakeholders, what some of the consequences of these changes could be, and how an IT system could help to implement these changes.

## **5 Goal Modeling Frameworks**

In the previous chapter we developed a conceptualization of the reality we observe in enterprises. This conceptualization is based on regulation principles. In this chapter we will use this conceptualization to explain the Lightswitch framework and to give a theoretical explanation to some of the concepts used in the RE methods we have surveyed in Part 1. We also compare some of these RE methods with the Lightswitch modeling framework and formulate changes that we believe could enhance these methods.

In Section 5.1 we explain how the concept of goal can be related to the Lightswitch conceptualization. In Section 5.2 we explain the Lightswitch modeling framework in detail. In Section 5.3 we compare the Lightswitch framework with RM-ODP Enterprise Language. In Section 5.4 we compare the Lightswitch framework with several GDRE methods.

### **5.1 Regulation and goals**

People used to apply goal based explanations to many systems whose behavior they couldn't explain with other means. Thus, the stable movement of planets was explained in terms of purpose, i.e., a planet's purpose was to move around the sun. However, in present days, we tend to apply this interpretation to people, social systems, and artificial systems only, to the exclusion of so called

natural systems. This change is mainly due to the power of the natural sciences, physics, biology, chemistry, in explaining natural phenomena.

In Chapter 4 we proposed a conceptualization of enterprises based on regulation principles. In this conceptualization we did not mention the concept of goal, purpose, aim and their synonyms. In this section we connect the Lightswitch conceptualization with the concept of goal.

Ashby (Wiener 1954, p. 37-38) has explicitly made the connection between regulation and goals by showing that any system made out of even random sub-systems will tend to have some states that will be more stable than others. Since a stable state will, by definition, last longer than transitory states, as human beings we interpret this as the system's desire to remain in this stable state. Hence, we refer to this stability as a goal-seeking behavior, i.e., as observers we say that the system has the goal, objective, or purpose to move towards (and remain in) this stable state, even though no goal was programmed into it. Thus, Ashby defines goal-seeking as, "Behavior that is goal-seeking is an example of behavior that is stable around a state of equilibrium" (1956, p. 81).

In Chapter 4 we have referred to these states of equilibrium as norms. We have seen in Chapter 3 that the concept of Maintenance Goal as used in GDRE represents the maintenance of a state of affairs and thus can be seen as representing a norm.

We have seen in Chapter 4 that when the state of affairs is judged to be out of the norm, a regulative action is likely to be performed. The expected result of the regulative action, i.e. the state to be achieved is what is called Achievement Goal in GDRE. Thus, the concept of Achievement Goal corresponds to the expected result of a regulative action as defined by a stakeholder. This expected result is what we have referred to as a norm in Chapter 4. Thus, often an enterprise specifies the same achievement goals over and over again so as to bring its interpretations closer to the norm. However, the norm, as we have seen, is often a changing norm and some of the achievement goals evolve as well. For example, a typical hardly evolving achievement goal for General Motors is to sell a car to a customer who expresses an interest in buying one. An evolving achievement goal for General Motors would be the quality of the cars that it manufactures which evolve as quality norms from within General Motors and those imposed by government bodies and customers evolve.

In Section 4.5.2 we have shown that tightly coupled systems come to rely on each other's norms either by design or through evolution. Enterprises can be considered as such tightly coupled systems both in their internal operations where their sub-systems rely on each other's norms and in the reliance of any given enterprise on the norms maintained by other enterprises. An observer dependent on the norm of an enterprise is likely to consider this norm as the purpose of the other enterprise. This purpose, however, is likely to be only one of the norms maintained by the enterprise.

Weinberg shows this by quoting James G. Miller as having stated that an enterprise such as:

"General Motors exists to put out cars, not metal scraps, although it extrudes both. Universities exist to produce educated persons and scholars, not retired professors or academic failures" (1975, p. 57).

In other words General motors' purpose is to manufacture cars. A university's purpose is to produce educated persons and scholars. Weinberg argues that even though these purposes sound "incontrovertible" (i.e. incapable of being disputed, unquestionable), the ascription of one purpose rather than another to a system can be questionable. Weinberg states that we would think otherwise if Miller would have written:

"Beavers exist to control floods, not to produce piles of wood chips. The oceans exist to produce fresh fish, not mud deposits or dead whales washed ashore." (p. 57)

For Weinberg we deny the notion of purpose when we speak of the natural world but we find it perfectly suitable when we speak of man-made systems. Weinberg's point with this comparison is to show that purpose is not an absolute notion. For Weinberg, talking about a one and only purpose of a system is the result of thinking in absolute terms and that we exercise such thinking even though we know that

“much of the dissatisfaction with our man-made systems stems precisely from disagreement about what the ‘purpose’ of the system is: that is, what the system ‘really’ is.” (p. 57)

Hence, Weinberg notes that the system of which we are talking, “has no ‘purpose,’ for ‘purpose’ is a relation, not a thing to ‘have’” (1975, p. 57). That is, purpose and “what the system ‘really’ is” is the expression of the norm that the observer expects from the observed. Hence, Weinberg argues that:

“To the junk dealers, General Motors does exist to put out scrap metal, yet the stockholders probably couldn’t care less whether General Motors is producing cars or string beans, as long as it is producing profits.” (ibid)

To see why this is the case, we can observe that the terms purpose or goal define some desired state of a variable, i.e. some future state of the variable with respect to its current state. We have seen in Chapter 4 that the identity of a system is made of the set of variables that an observer defines as constituting this identity. However, since we don’t subscribe to the solipsist tradition, we don’t mean that observers have total liberty in selecting these variables. We don’t subscribe to the positivist tradition either so we don’t mean that observers describe the same variables on which they necessarily have to agree. Hence, different observers will be able to agree on some of the variables and not on others. In Weinberg’s examples, we see that different observers agree on the name of an entity (e.g. General Motors) and probably some identifying variables they see in the entity (cars being manufactured, metal scraps being output, buildings, employees etc) but not on other identifying variables. In the case of General Motors these differing variables represent what the observers define as the norm maintained by General Motors that is most important to them, which for them represents its purpose.

Thus, General Motor’s norm of putting out scrap metal is used by junk dealers for maintaining their own norm of recycling this scrap metal. Stockholders need General Motor’s norm of producing profits to maintain their own profit making activities. Furthermore, since the enterprises are tightly coupled, it is reasonable to assume that General Motors itself counts on the junk dealers’ norm of removing scrap metal from its facilities probably as much as it counts on the stockholders’ norm of trading its stock. If the junk dealers stopped removing scrap metal from General Motors facilities, General Motors would cease to be able to produce cars as surely as if stockholders would stop trading its stock.

When considering actions, the expected result of an action is also likely to be defined differently from one stakeholder to another. Indeed, observers enjoy some freedom in defining the identifying variables and expected states as outcomes of actions. Therefore they usually differ in their assessment of the goal of some action or set of actions. Hence it is very common for people to disagree on the “real goal” of a set of actions. In other words, the identity of the action is somewhat different for every observer.

This discussion leads us to conclude that an enterprise has at least as many goals as it has stakeholders and probably far more because every individual stakeholder may have several expectations from the same enterprise, what we have called interpretations in chapter 4. The designer needs to take these different interpretations into account. Hence, the common RE definition of a goal as states that stakeholders want to achieve or maintain can be augmented by seeing these states to be achieved or maintained as interpretations made by some observer. We can identify two different cases for these interpretations:

1. The observer is the same stakeholder as the one who performs the action, in which case the stakeholder interprets its own actions as leading to the goal desired by itself (a kind of consciousness).
2. The observer is a stakeholder who interprets the outcome of the actions of another stakeholder.

In both cases the designer operates as a third observer, deciding what interpretations to include in the model and adding his or her own interpretations. The designer’s aim is to perform the optimizing-balancing process on the enterprise so that the enterprise can satisfy the service it renders to the stakeholders who depend on its norms and at the same time balance its demands from these

stakeholders with respect to its own norms. In theory this would require of the designer the capability to model the way the enterprise satisfies several goals at the same time.

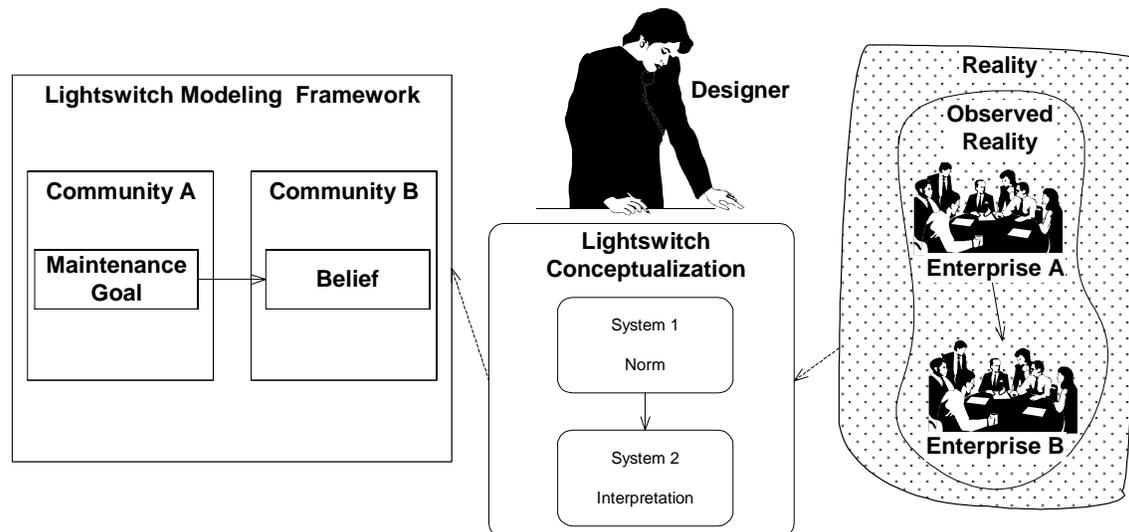
In the Lightswitch modeling framework, we therefore, do not consider that a given enterprise has a specific purpose or goal other than to maintain its identity. In order to maintain its identity it regulates relationships with its stakeholders. Each such regulation is considered as a goal of the enterprise. As of yet, we don't have the modeling capabilities to model the satisfaction of all these goals at the same time.

In practice, therefore, modeling several goals at the same time is performed by taking one goal at a time and modeling what it would take to achieve it. When one goal is picked for attention (be it a maintenance or an achievement goal) the goals of the other stakeholders are considered as constraints on the satisfaction of the goal under consideration (Vickers 1987, p. 32-33). In the example of General Motors, the goal of outputting cars is constrained by its need to also get rid of metal scraps. General Motors may be tempted to find easy solutions to this constraint such as dumping the metal scraps behind its factories but the norms of the society act as further constraints and may prevent it from doing so thus limiting its range of possible actions. When modeling the satisfaction of goals, we need to take these constraints into account. However, the norms do not constrain an enterprise directly. Rather, their meaning is interpreted by the enterprise. Hence a same norm may be interpreted differently by different enterprises and these differences in interpretations need to be taken into account when modeling regulation with goals.

This way of modeling is not as satisfying as if we could consider all goals (or at least a subset) at the same time. However, with our modeling capabilities today, we cannot do it. Goal modeling is therefore a simplification of the direct modeling of regulation.

## 5.2 The Lightswitch modeling framework

Having established the relationship between goal modeling and the Lightswitch conceptualization, we now present the Lightswitch modeling framework in detail. The Lightswitch modeling framework is composed of a set of modeling elements, a graphical notation to represent these elements, and a modeling process that designers can use to build the Lightswitch models and reflect about the relationships between these models and the designers' and stakeholders' observed reality.



**Figure 5.1 Relationships between the Lightswitch modeling framework and the Lightswitch conceptualization**

Figure 5.1 shows in general terms the Lightswitch modeling framework (on the left of the figure) and its relationships with the conceptualization we have proposed in Chapter 4. In the modeling framework we model communities that represent systems in the conceptualization. The systems

represent enterprises in the observed reality. These communities have beliefs that represent interpretations in the conceptualization and goals that represent norms and regulative actions in the conceptualization. All these concepts are the interpretations of the designer.

In Section 5.2.1 we define the Lightswitch modeling elements. In Section 5.2.2 we define the Lightswitch models. In Section 5.2.3 we define the Lightswitch modeling process.

### 5.2.1 The Lightswitch modeling elements

The terms used in the Lightswitch models were selected to be compatible with the GDRE methods we have presented in Chapter 2. We use the terms belief, achievement goal, and maintenance goal to represent interpretations, regulative actions, and norms respectively. However, we chose to use the term community to represent an enterprise because we think that it better reflects the social and collective aspects of an enterprise than terms such as agent, or actor, more popular in GDRE.

We have selected to use the concept of maintenance goal as it is used in GBRAM and KAOS. The name maintenance goals only defines that some variable is maintained in an approximate stable state, not that the corresponding relationship is maintained in precisely the state specified by the maintenance goal. Thus, a maintenance goal may represent:

- The state where one enterprise attempts to avoid a relationship with another enterprise despite attempts by the other enterprise to establish a relationship.
- The more or less stable provision of a service by one enterprise to another
- The tracking or monitoring of some state
- Attempts to continually improve the state of some variable of the enterprise or its environment
- Etc.

Contrary to GBRAM (Table 2.2), improvements, speedups, increases etc, will be modeled as maintenance goals unless specific measures (qualitative or quantitative) are provided to distinguish them as achievement goals. Thus, a goal such as “improve revenues” is, for us, a maintenance goal, whereas in GBRAM it will be categorized as an achievement goal and in GRL it will be categorized as a softgoal. We select to categorize it as a maintenance goal because it is a never ending goal, it sounds like a state that the enterprise is trying to maintain over an indefinite period of time. However, “improve revenues by 10% for next fiscal year” is, for us, an achievement goal. It has a specific moment in time when it has to be achieved and specific measures to validate its achievement.

The set of terms we use is very small. It reflects our belief that during the initial phases of the requirements definition process designers need light-weight methods so that they can rapidly assess a situation, model it and use these models to discuss the situation with stakeholders.

The following is the list of terms used in the Lightswitch models and their definitions. The definitions refer to systems in the observed reality. A system may represent an enterprise, person, or an IT system.

*Def 18: Community* is a modeling element that represents a *system*.

Note: Communities can have sub-communities and supra-communities

*Def 19: Sub-Community* is a modeling element that represents a *sub-system*.

*Def 20: Supra-Community* is a modeling element that represents a *supra-system*.

*Def 21: Belief (of a community of interest)* is a modeling element that belongs to the community of interest and that represents an *interpretation* of a *system*.

Note: Because beliefs represent interpretations that emerge from the past interactions of the enterprise with other enterprises, it is not always possible or practical to trace the source of some beliefs. These beliefs will appear to be self standing. They will influence maintenance goals but will not be traced to their origins.

**Def 22: Maintenance goal (of a community of interest)** is a modeling element that belongs to the community of interest and represents a *norm* of the *system* of which the community is the model. A maintenance goal is satisfied for as long as the system maintains its norm.

Note: In earlier versions of the Lightswitch approach, norms that were considered to be maintained with no particular intention on the part of the community and norms that were considered to be intentionally maintained were modeled with two separate modeling elements. The idea was to show that some norms just happened to be maintained by some community. This led to more complicated models in which it was not clear which modeling element to use. We later chose to merge the two concepts into one modeling element. As a result we have a much more elegant approach. The downside is that models sometime show communities that have the intention of maintaining some norm which seems unnatural or non-warranted. However, this leads to very interesting discussions when stakeholders object to a maintenance goal being intentional. The discussion may show that the norm may be maintained with no explicit knowledge of the enterprise. This realization may lead to an attempted change of the norm or an acceptance of the norm.

**Def 23: Achievement Goal (of a community)** is a modeling element that belongs to the community of interest and represents a *regulative action* of the *system* of which the community is the model. The interpretation of the system that triggers the action (by being outside of the threshold associated with a norm of the system) is called a pre-condition of the goal. The interpretation of the system that represents the expected final state of the action is called the post-condition of the goal. An achievement goal is satisfied as soon as its post-condition is reached or the community believes that the post-condition cannot be reached.

Note: It may be that the result of the regulative action is not directly linked to the norm. For example, a company in financial trouble invests in new products. The post condition is linked to the norm only through the interpretation of the company that this investment will bring its finances into the norm.

## 5.2.2 The Lightswitch models

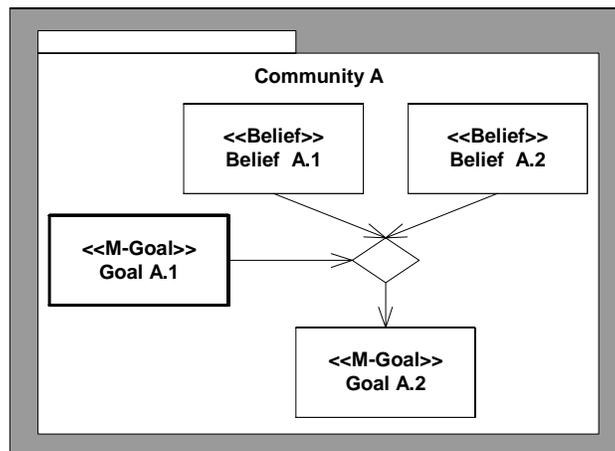


Figure 5.2 A sample model of a community

The notation used to represent the Lightswitch model elements is based on the Unified Modeling Language (UML) (OMG 2003). Figure 5.2 shows a first sample model of a community. In this figure we can see that:

- Communities are represented as UML packages. The name of each community is displayed at the top of the folder like shape representing the community.

- The shaded rectangle around the community represents the environment of the community that is not considered in the model. Its existence is nevertheless reminded because it most probably influencing the community in some way.
- Maintenance goals, achievement goals, and beliefs are represented as UML classes within communities. They are distinguished through the use of UML stereotypes, i.e., a maintenance goal is designated by <<M-Goal>>, an achievement goal by <<A-Goal>>, and a belief by <<Belief>>.
- Relationships are represented with UML associations. These can be uni-directional or bi-directional.
- UML N-ary associations are used to represent multiple relationships between beliefs and goals. N-ary associations are especially used to represent goal reduction, i.e., showing how one or more goals are related to one or more sub-goals through the consideration of one or more beliefs. The higher-level goal is the goal that is represented as an input into the n-ary association (appears in bold in Figure 5.2). The lower level goals are represented as results of the n-ary association.
- The symbol for the n-ary association also represents a decision in UML. This is also appropriate since the goals can be seen as a decision to act based on a set of beliefs.

We prefer to use the N-ary association for the goal reduction rather than the more traditional “association class” style (Figure 5.3) used for example in GRL (ITU 2001) because the latter is less practical when several beliefs are used for the goal reduction, or when several subgoals are the result of the goal reduction, or when several goals are reduced with several beliefs into several subgoals (Figure 5.4).

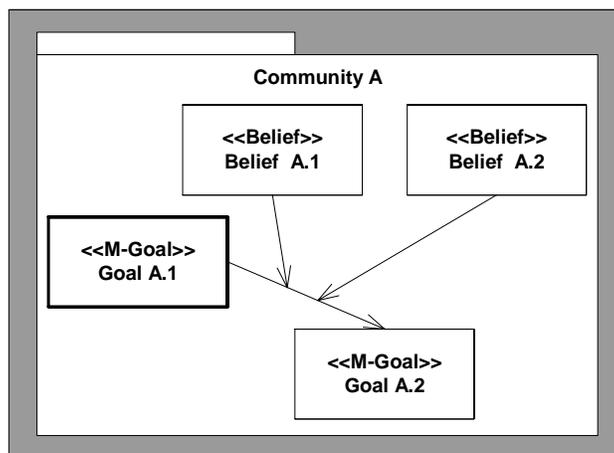


Figure 5.3 Multiple goal reduction (GRL style)

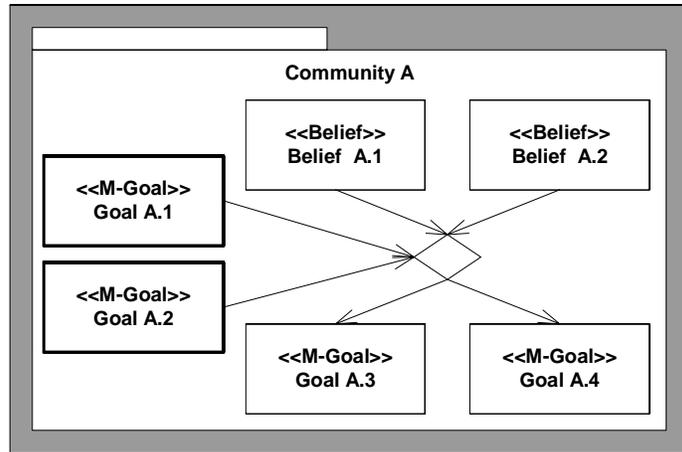


Figure 5.4 Multiple goal reduction (Lightswitch style)

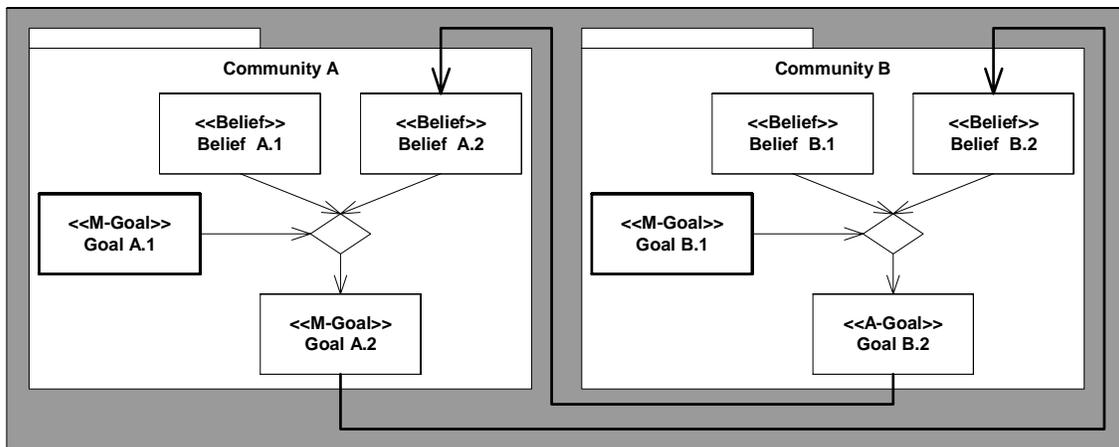
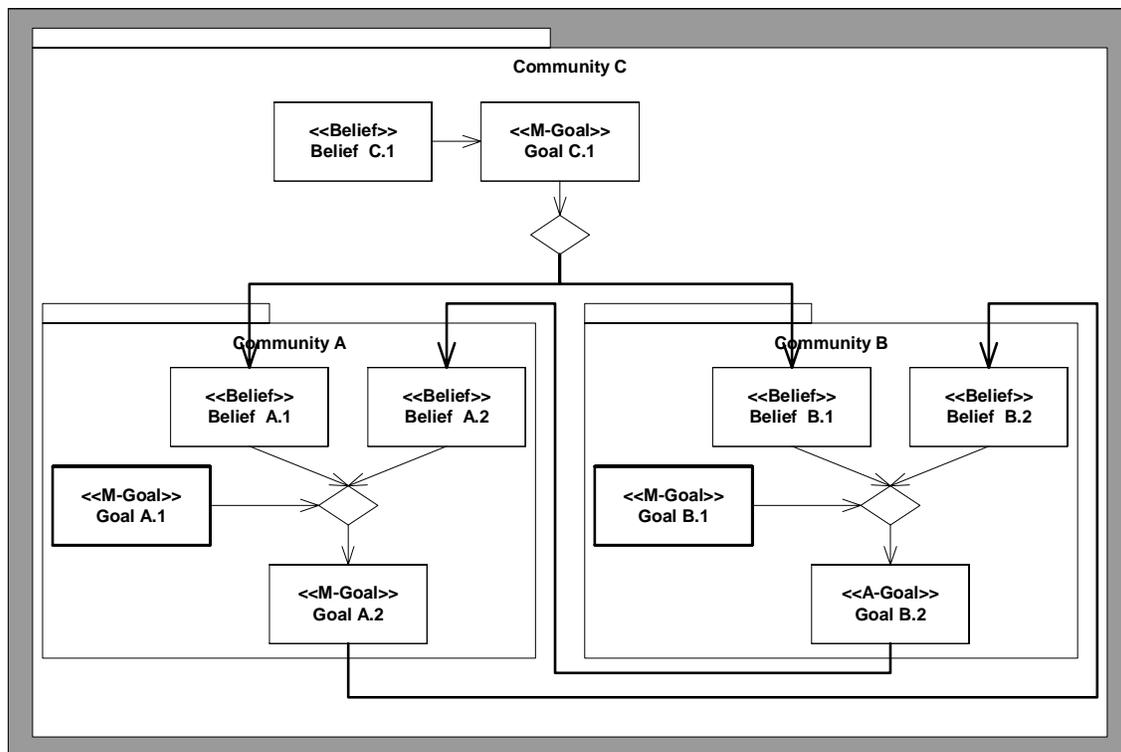


Figure 5.5 A sample interaction between two communities

Figure 5.5 shows the interaction between two communities. Community A's Goal A.2 influences Community B by being connected to Community B's Belief B.2. In the same way, Community B's Goal B.2 influences Community A by being connected to Community A's belief A.2. Thus each community influences the actions of the other by influencing its beliefs and thereby its goal reduction. The influences of one community on another are represented in bold to attract the modeler attention to them.



**Figure 5.6 A sample interaction of two communities within a supra-community**

Community A and Community B can now be modeled within the larger context of the supra-community C (Figure 5.6). With respect to community C, Community A and Community B are sub-communities. Community C also has a belief and a maintenance goal. The maintenance goal Goal C.1 influences both Community A and Community B by being linked to Belief A.1 and Belief B.1.

Since there is potentially a very large number of beliefs and goals to consider, the Lightswitch models can become heavily populated. In order to reduce the visual clutter, we sometime replace beliefs and maintenance goals that mirror each other with small, empty rectangles. Figure 5.7 shows such a simplification. The left side of the Figure shows a normal mode. The right side of the Figure shows a simplified model.

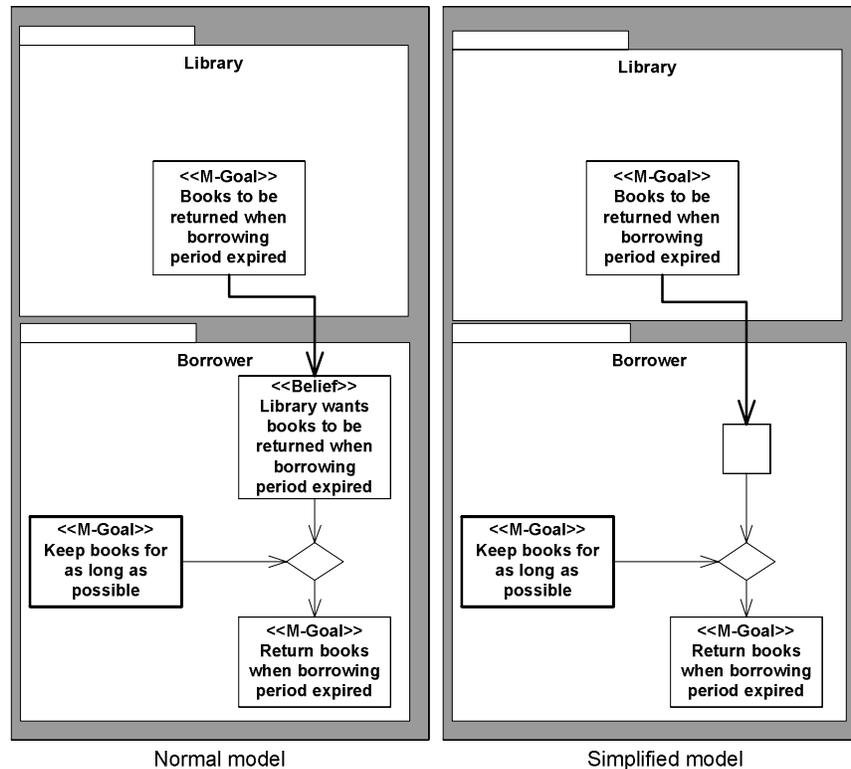


Figure 5.7 Model simplification

The part of the Lightswitch community model that connects the source goal to the subgoals specifies a goal-reduction in logic programming terms. The goal reduction specified in the Lightswitch models can be expressed as beliefs in logic programming (Kowalski and Sadri 1999). Logic programming beliefs are used to reduce a goal to subgoals in what is called backward reasoning. A logic programming belief is expressed as:

conclusion if conditions

This belief is used to reduce a goal matching the conclusion to the subgoals corresponding to the conditions (Kowalski 2002). The set of conditions can include conjunction (AND) and disjunctions (OR) of conditions. The Lightswitch models only represent a conjunction of conditions.

The goal reduction proposed by the model in Figure 5.7 can be expressed in Logic Programming as the following belief:

“A person keeps books for as long as possible; if, for every book that the person borrows, the person returns the book when the borrowing period has expired.” (Kowalski 2003)

Even though they carry the same name, Lightswitch beliefs and logic programming beliefs do not convey the same information. Whereas in logic programming beliefs are used to represent the way an agent reduces goals to subgoals, in Lightswitch beliefs represent the interpretations a system has about itself and its environment. The Lightswitch beliefs are to be used by designers in order to explain why a certain goal reduction is favored over another. In this respect Lightswitch beliefs are closer to GRL beliefs that document design rationale as we have seen in Section 3.2.2. Hence, in Lightswitch models, beliefs are expressed in declarative form whereas goals are expressed in imperative form. In the example in Figure 5.7, the borrower’s belief that the library wants books to be returned when the borrowing period expires motivates the borrower to have the subgoal of returning books when the borrowing period has expired.

Finally, when describing the models we build, we use *italics* when referring to modeling elements representing the communities in the Lightswitch models. This is essential in showing that we are not

reasoning about the actual entities in the reality that we observed but rather on a model that has some correspondence with this observed reality.

### 5.2.3 The Lightswitch method

In Part 1, we have seen that RE methods use sources such as interview transcripts, scenarios, policy statements, mission statements, etc. to identify requirements. GDRE methods, more specifically, identify stakeholders' goals in these sources. However, in Section 5.1 we have seen that the goals expressed by stakeholders will be a function of the regulation that the stakeholders perform. In the Lightswitch approach we use the same sources used by GDRE methods to understand the regulation but instead of identifying goals, we identify regulation mechanisms (interpretations, norms, and regulative actions) and the way they regulate the relationships between the enterprise and its stakeholders. Thus, rather than asking "what goal does this statement/fragment exemplify" as is prescribed by GBRAM and other methods, we propose to ask: "what relationships does this statement defines and how does it attempt to regulate them?" Moreover, by asking: "Why does this relationship(s) need to be regulated?" the designer will be able to identify "hidden" relationships that are not expressed in the initial statement.

#### 5.2.3.1 Analyzing the regulatory functions of business processes

Many of the norms and interpretations that constitute an essential part of the regulation mechanisms of an enterprise remain implicit. They are not written anywhere but seem to be shared all over the enterprise. These norms can be studied by analyzing the patterns of behavior of the enterprise. These patterns of behavior are usually referred to as *business processes* see Section 3.1.3. In Section 3.1.3 we have seen that in BPR a business process is typically defined as, "a related group of tasks that together create a result of value to a customer" (Hammer 1996, p. 5).

We have seen that this definition doesn't explain why the tasks constituting a business process are defined in a certain way. For example, in the quintessential example of a business process, the order fulfillment, Hammer states that: "we might say that the order fulfillment process creates three outputs: the delivered goods, the satisfied customer, and the paid bill" (p. 9). In BPR, only one of these outputs qualifies as value to the customer, the delivered goods. This doesn't explain why the other two outputs are necessary. Another example corresponding to the order fulfillment process, often given in BPR, is the task that consists of verifying the credit rating of the customer. How is this task connected to the value for the customer? So, is the paid bill a value for the customer or for the enterprise? Is checking the credit rating of the customer, of value to the customer or to the enterprise?

Another example, not related to order fulfillment consists of the contracts customers are required to sign when opening bank accounts, obtaining insurance policies etc. These contracts usually contain many clauses that protect the enterprise from intentional or unintentional faults of the customer. How are these clauses related to value that the contract gives to the customer?

The Lightswitch conceptualization, gives us a set of conceptual tools with which we can understand the regulatory functions of business processes. From that point of view a business process delivers value to the customer while protecting the enterprise and its other stakeholders. This protection may be acceptable to customers or it may scare them off. Notice that this protection may be of indirect value to the customer because it maintains the enterprise in business so that the customer may rely on the enterprise for its future needs.

Hence by considering that a business process regulates the relationships between the enterprise and its other stakeholders (investors, suppliers, employees etc.), we can expect to identify the regulation strategies we have listed in chapter 4. Business processes can be represented as sets of partially ordered activities or as sets of rules that specify the activities that should be carried out and their partial order. By asking why each rule is necessary, or why a given activity is needed as well as why they are performed in the specified order, we identify which relationships are important to the enterprise, how it interprets these relationships and how it regulates them. The regulation strategies of an enterprise also rely on the existence of regulatory mechanisms that exist within the enterprise or

outside of it. For example, credit checking in an enterprise relies on credit checking mechanisms that may be provided by other enterprises. Those in turn rely on reporting mechanisms by banks and on government regulations.

For example, the following business process is extracted from a use case named “Get Paid for a Car Accident” (Cockburn 2000, p. 5):

1. Claimant submits claim with substantiating data.
2. Insurance company verifies claimant owns a valid policy.
3. Insurance company assigns agent to examine case.
4. Insurance company verifies all details are within policy guidelines.
5. Insurance company pays claimant and closes file.

This process can be described in terms of a set of related tasks, such as: submit claim, verify claimant owns a valid policy, assign agent, examine case, verify all details are within policy guidelines, pay claimant, close file. This same process can be described in terms of a set of rules such as:

1. Whenever a claimant has a car accident, they submit a claim.
2. When a claimant submits a claim, they submit substantiating data.
3. Whenever the insurance company receives a claim, it verifies that the claimant owns a valid insurance policy.
4. Whenever a claimant owns a valid insurance policy, the insurance company assigns an agent to examine the case.
5. Whenever the agent finished examining the case, the insurance company verifies all details are within policy guidelines.
6. Whenever all details are within policy guidelines, the insurance company pays the claimant and closes the file.

Notice that to express the process as a set of rules we needed to fill in the gaps between the activities, i.e. the conditions in which some of the activities apply. For instance, in rule 5 we assume that the insurance company verifies the details after the agent has finished examining the case. This however, is not specified in the original process.

Expressing the process as a set of rules has the advantage of drawing attention to the pervasive nature of the tasks defined in the process. Using words such as when and whenever, we see that this process was defined precisely because the set of tasks that compose it are pervasive, i.e., they are executed over and over again whenever a claim occurs. Hence, these rules can also be thought of as norms. We would tend to see them as norms of behavior. Furthermore, the roles named in the process, such as, claimant, agent, insurance company, policy, policy guidelines, claim, file, etc. are also norms. We would tend to see them as structural norms. These will inform us about the stakeholders that the business process explicitly regulates. Note that the heuristics in Section 5.2.3.2 will help us to identify stakeholders whose relationships are implicitly regulated by an enterprise’s business processes.

Our way of expressing business processes can be seen as a lightweight version of norm analysis as it is used in Organizational Semiotics (Section 3.3.3). In norms analysis, norms that can represent business processes and are expressed with the following template (Shishkov et al. 2002):

```
whenever <condition>  
if <state>  
then <agent>  
is <deontic operator>  
to <action>
```

Chong and Liu offer a slightly different template (Chong and Liu 2002):

```
“IF <certain conditions apply>
```

THEN <agent>  
 Is <obliged/permitted/forbidden>  
 To perform <action/speed act> or adopt <a state>”

These templates closely resemble condition action rules as they are used to model human cognition (Kowalski and Sadri 1999).

Condition-Action rules are expressed in the form:

IF set of conditions THEN set of actions

Condition action rules are expressed in more neutral way without the added constraints imposed by Deontic logic (Kowalski and Sadri 1999). We can thus have more freedom in expressing possible actions, not just obligations, permissions and prohibitions but also, empowerments, encouragements etc.

We can thus use Condition Action Rules as an alternative description of business processes. In the example above it will give us the following process:

7. If a claimant has a car accident then they submit a claim.
8. If a claimant submits a claim then they submit substantiating data.
9. If the insurance company receives a claim then it verifies that the claimant owns a valid insurance policy.
10. If a claimant owns a valid insurance policy then the insurance company assigns an agent to examine the case.
11. If the agent finished examining the case then the insurance company verifies all details are within policy guidelines.
12. If all details are within policy guidelines then the insurance company pays the claimant and closes the file.

Condition action rules, as well as business processes, don't state the goal for which they were defined explicitly. If a goal is sought, it needs to be inferred from the context. However, as we have seen in Section 5.1, the goal of a business process is different for each stakeholder. In the example above the goal of the claimant can probably defined as “Get Paid for Car Accident.” The goal of the insurance company may be expressed as “Pay Claimant for Car Accident” or it could be “Handle claim” or “Handle claim as fairly as possible” etc.

We can see that the original name given by Cockburn to the use case that describes this process is “Get Paid for Car Accident.” It was obviously defined from the point of view of the claimant. However, the set of tasks is obviously defined from the point of view of the insurance company. We could, for example, ask how tasks such as verifying the validity of the claimant's policy help the claimant to get paid. From the point of view of the claimant this verification is not needed at all. By extension of this observation, we can see that all the tasks defined in this process (with the exception of the pay claimant task) are actually designed to serve the insurance company rather than the claimant. Thus we see that the definition of a business process as regulating relationships between the enterprise and its stakeholders holds.

Thinking of business processes as regulatory mechanisms rather than as set of activities designed to provide a value to a customer, exposes their role in the maintenance of the identity of the enterprise, i.e. in its survival. Indeed, if the business process given as an example above did not include activities such as checking that the claimant has a valid policy, it may quickly go out of business.

Thus business processes can be understood as regulating relationships with multiple stakeholders. Payment, for example, is required to maintain the flow of money positive to the enterprise. Credit checking is required to guard against customers who may not pay after they received the goods. It also relies on the existence of credit mechanisms and credit checking mechanisms. Payment in advance is required also to minimize risks from customers who cannot be trusted to pay later. These tasks and

their order are a function of the norms of the enterprise and the enterprise's interpretations of the norms imposed by its stakeholders.

In this view a business process provide value to one stakeholder while insuring that counter value (payment, labor, investment) is provided by the stakeholder so that the enterprise may maintain its internal structure and provide value to its other stakeholders. The question is how much value is given with respect to how much counter value, i.e. how the enterprise performs Vickers's optimizing-balancing process. In Hammer and Champy's words, the question is how much control (how many checks) are to be included in a business process and how to define the value that it provides. Many times, the checks defined in a business process may alienate customers and employees but not enough checks are also a prescription for problems. Business processes could be improved by relaxing the constraints they impose on both customers and employees while maintaining the minimum necessary checks to avoid foreseeable problems.

A similar point of view is given by Joseph Lampel (Mintzberg et al. 1998, p. 214):

"A learning organization rejects the adage if it ain't broken, don't fix it." All the processes that regulate work in the organization can be improved even when they appear efficient under superficial scrutiny. The source of the improvements is often buried deep within existing ways of doing things. A learning organization undertakes a periodic reexamination of systems, routines, and procedures to discover whether they still perform a needed function and should be retained. New technology, new knowledge, and new practices often allow organizations to redesign routines to make them more efficient and effective" (Mintzberg et al. 1998, p. 214).

Lampel's assertion calls for several comments:

- Lampel acknowledges that processes regulate work rather than simply drive for a specific result. This point of view is also expressed by Sowa and Zachman (Sowa and Zachman 1992).
- New knowledge is what we have defined so far as changes in interpretations. New practices can be seen as redundant in this sentence since the practices of the enterprise are its processes or routines, as Lampel calls them.
- Lampel suggests that deep scrutiny of processes may be necessary to identify improvements. This means that we should accept to go into the details of a process in order to find improvements that may have considerable impacts on the enterprise and its stakeholders
- Lampel suggests that periodic reexamination of business processes is necessary because new technology, new knowledge and new practices may enable the enterprise to define processes that regulate its relationships with stakeholders more adequately.

With respect to the last point, we can ask why the enterprise needs to perform this periodic reexamination at all. Why can't the business processes be adapted continuously to the shifting conditions of the enterprise? This point can be explained by referring to our discussion of stability in Chapter 4. If the enterprise modified its processes faster than its stakeholders can adapt to the changes, it will not regulate the relationships with these stakeholders efficiently. If a company changes its processes daily or every minute, its customers would not be able to understand how to obtain services from the company, its employees would not be able to perform the needed tasks because they keep changing, the suppliers would not be able to supply the company etc. So the enterprise can only reexamine its processes every so often.

Business processes are defined with current technology in mind and with respect to current interpretations of what is of value to the customer and what needs to be protected from the customer. Even if a business process as currently defined is as efficient as can be thought of, it will become inefficient over the years as more activities are added to it in an ad hoc manner to account for changing conditions, as technology changes and as customers' preferences change. However, once a company went through the reengineering of its processes it is not really willing to do it again for some time, typically many years.

The corollary to this assertion is that at any given time, the processes present some disconnect with respect to the present conditions. When an IT system is envisioned for an enterprise, it is a good time

to reexamine its processes and see whether the disconnect with present and foreseeable conditions should be addressed before the IT system goals are defined or not. In the words of Hammer and Champy this means that:

“In doing reengineering, business people must ask the most basic questions about their companies and how they operate: Why we do what we do? And why we do it the way we do? Asking these fundamental questions forces people to look at the tacit rules and assumptions that underlie the way they conduct their businesses. Often, these rules turn out to be obsolete, erroneous, or inappropriate.” (1993, p. 32-33)

While these fundamental question, however, we should not forget that the homeostatic system (the enterprise) may resist these changes, sometimes quite fiercely. This resistance is legitimate (at least from the point of view of the system) since the system would not exist if didn't resist change to some extent.

The following section lists a set of heuristics that enable the designers to identify regulation strategies in business processes during the Lightswitch design process. These heuristics help to understand the business processes of an enterprise in terms of the stakeholders whose relationships they regulate and what kind of regulation they perform. This understanding helps the designers to create the Lightswitch models described in Section 5.2.2, to compare these regulation strategies with current and foreseeable conditions and thereby to specify changes to the business processes.

### **5.2.3.2 Regulation identification heuristics**

#### **H1. Identifying regulated relationships**

Description: Systems that are named in business processes have an existence which is not ephemeral. Business processes are quite stable with respect to the lifetime of the enterprise. The systems that they refer to are fairly stable as well. For these systems to be stable within the context of the enterprise, the enterprise must continuously regulate its relationships with these systems. Thus, the mere naming of a system in a business process suggests a regulation of the relationship between the enterprise and the system.

Examples: The naming of systems such as customers, suppliers, IT systems, services, resources, etc. all are potential sources for regulated relationships.

#### **H2. Identifying norms that depend on each other**

Description: A given norm usually relies on the stability of one or more other norms. To understand how the given norm remains stable, it is necessary to understand on what other norms it relies and how these other norms contribute to the overall stability. The related norms can be provided by the enterprise or by its environment.

Examples: A library's norm limiting the period during which a book can be borrowed can be maintained if the borrower is known to the library. The Borrower can be known to the library if there is a mechanism for identifying people. Identification mechanisms may rely on a network of relationships (a new borrower is introduced by a known borrower) or on an independent identification system such as a state issued identity card. Without these related norms, the library would not be able to implement a time limit regulation of the access to its books. Similarly, a disciplinary action in an enterprise is only applicable to people who are subject to the norms of the enterprise, i.e., people whose behavior is, to some extent, regulated by the enterprise.

#### **H3. Identifying aggregation**

Description: Identify statements that describe several systems of more or less the same nature at the same organizational level. These systems likely function as aggregates, insuring the proper functioning (or survival) of the supra-system even when some of them fail.

Examples: several departments in an enterprise; several check-out lines in a super market; several borrowing desks in a library; several library officials etc

#### **H4. Identifying specialization**

Description: Identify statements that describe systems that regulate influences from a limited number of sources only. Instead of being able to respond to any influence that may present itself to the enterprise, these systems can only respond to a subset of all possible influences.

Examples: Any kind of specialized department such as sales, customer relationships, engineering, marketing etc.; different kinds of items carried by a store or library; quick check-out lines in a super market etc.

#### **H5. Identifying (hidden) reserves of resources**

Description: Identify statements that explicitly or implicitly suggest the presence of an accumulation of resources. These can either be explicit statements about existing inventory or statements that suggest an imbalance between production and consumption of resources or between the actual cost of a resource and its price. Explicit inventory is identical to aggregation but many reserves are so pervasive that we simply ignore them. The identification of reserves also helps to identify stakeholders that are not named in business processes.

Examples: Services and goods offered for free or for less than the cost to produce them suggest that either some unnamed stakeholder is financing the enterprise (this stakeholder will have (hidden) powers over the enterprise), or that the enterprise is depleting previously accumulated reserves. No restrictions on money spending.

#### **H6. Identifying scarce resources**

Description: Identify statements that describe restricted access to resources. These restrictions mean that the associated resources are or have been scarce and essential to the survival of the enterprise. The more the access is restricted the more the resource can be assumed to be or to have been scarce and important to the enterprise. Two resources that are very often closely protected in enterprises are time and money but many other exist, such as books in a library, water in dry regions, food in times of war, etc. When there is ample supply of a resource, we often have the effect of hidden reserves described in the previous heuristic. Scarce resources themselves are a regulation mechanism that enables the system to not specify other regulation mechanisms. For example, the rarity of good quality copying devices such as CD burners enabled the music industry to not have too stringent copyright laws. The advent of such devices has the effect of creating more stringent copyright regulations. Thus we can infer the existence of scarce resources when we don't find evidence of regulation.

Examples: An office open hours restricting the time within which its people accept interruptions; Restrictions on access to books in a library; Restrictions on money spending.

#### **H7. Identifying compromises and dissatisfactions**

Description: Business processes regulate multiple relationships and therefore often represent compromises where the affected stakeholders cannot be completely satisfied. It is important to identify areas of dissatisfaction resulting from compromises. Compromises can be identified and dissatisfaction inferred whenever a business process imposes restrictions on stakeholders.

Examples: Customers of a company are required to pay for the services they receive. Maybe they would be happy to receive the services for free but the company needs to also satisfy its shareholders, its employees, its suppliers, etc. and cannot provide a service for free (unless it uses hidden reserves, see H3, which it may not be able to do forever).

#### **H8. Identifying backup regulation mechanisms**

Description: Identify statements that express actions that can be performed when a given regulation mechanism failed to provide a satisfactory result. Note though that the question which mechanism is the main regulator and which is the backup may not be answerable because of the set of mechanisms that may operate together each providing backup for the other.

Examples: The possibility for an enterprise official to manually intervene in an automatic process; Paper records that are kept in case of failure of an IT system; Fines applied when a book is not returned to a library on time;

### **H9. Identifying regulation by error**

Description: Whenever an action is described as necessary as a response to some event, it may be inferred that it is done in an attempt to bring the interpretation of the state of affairs closer to some norm. This case is usually what is referred to as a goal (achievement goal in GDRE). The interpretation of the state of affairs is the pre-condition for the action; the norm is the outcome of the action.

Examples: A customer calls to place an order. The interpretation is that the customer may place an order but hasn't done so yet. The norm is for the customer to place the order.

### **H10. Identifying regulation by anticipation**

Description: Any norm imposed on a stakeholder can be seen as an anticipation of a future unacceptable behavior on the part of the enterprise. Any constitution of reserves can be seen as an anticipation of a future shortage of resources.

Examples: Credit checking can be seen as an attempt to anticipate the future behavior of a customer from past behavior. The enterprise verifies whether in the past the customer had credit problems and if so anticipates that the customer will create credit problems in the future. The enterprise may attempt to avoid the relationship with this customer as an anticipation of future problems. Requiring customers to pay for goods they buy before the goods are given (or delivered) to them is an anticipation of the customer not paying after they have received the goods. Security checks anticipate future break-ins. Creating cash reserves for future difficult times; Preventive maintenance for equipment is anticipation of future break downs.

### **H11. Identifying conditional and unconditional regulation mechanisms**

Description: Some norms specify unconditional mechanisms that operate regardless of the existence of the influences that they are designed to compensate. Conditional mechanisms are those that operate only when certain conditions apply.

Examples: The norm that specifies a customer must pay for goods they purchase before they receive the goods is an unconditional mechanism if it doesn't depend on the specific customer or specific situation in which the sale is done. If the payment can be made before or after the delivery of the goods then the mechanism is considered as conditional. Often, what we perceive as structure can be considered as unconditional mechanism. A building always isolates its occupants from outside weather even if the weather happens to be considered as good.

### **H12. Applying the parallel principle**

Description: By analyzing the business process we can make assumptions about what the environment of the enterprise is like. We can hypothesize that the environment accepts or used to accept the norms imposed by the process. We can hypothesize that the norms of the process compensate for existing, past, or foreseeable influences.

Examples: If a business process of a library specifies that fines are imposed on borrowers if they fail to return books on time, we can hypothesize that borrowers put themselves in conditions for paying these fines by not returning the books on time and when they do, they accept to pay the fines.

## **5.2.3.3 The Lightswitch design process**

The Lightswitch method, in effect, constitutes a business process. It is a list of related tasks that together enable the designer to create an understanding of some of the behavior of the enterprise and its environment and to match this behavior with what the designer see as present and foreseeable conditions. These aspects may help the designer to define IT system goals that support the enterprise in its changing environment and hopefully contribute to the enterprise's survival.

As in any business process, the related tasks are only partially ordered, i.e., the tasks can be performed in the "ideal" sequence defined above or in other alternative sequences but not in any random sequence. For example, the goals and beliefs of the enterprise and stakeholders can only be modeled

once the enterprise and stakeholders have been identified. The relationships between the goals and beliefs can only be identified once the goals and beliefs themselves have been identified. However, once some of these tasks have been performed in the specified sequence, the process can be altered into performing the tasks in different sequences. For example, the designer can define tentative IT system goals once some stakeholders have been identified just by applying her own interpretations of the perceived reality (see Section 4.1) before a more complete understanding of the enterprise and its stakeholders has emerged.

The following list gives a global view of the Lightswitch design process:

1. Identify relationships
2. Analyze how the relationships are regulated
3. Identify changing conditions
4. Identify, evaluate, select options and IT system goals

Note that conflicts are not treated explicitly in the Lightswitch models. However, modeling the goals of the enterprise and its stakeholders in terms of the maintenance of identity may help to resolve conflicts because the different parties in the model don't seem to have arbitrary or evil goals. They have certain goals and not others because they attempt to maintain their own identity and this may be as valid as maintaining the identity of another party as described by Maturana and Varela (1998). In this case, accommodation as proposed in SSM (Checkland and Scholes 1990) is a better solution than the imposition of one party's goals over the other. Of course, this relativist viewpoint, taken to an extreme, means that we accept the actions of all other parties because they are part of their identity. While we believe that in most circumstances it is better to seek such accommodation, in some circumstances such an accommodation is not considered as possible. In such cases one party's goals will prevail, the question is in what cases. Good judgment is obviously necessary and this means moderation. However, moderation itself has its limits as summed up by the Weinbergs: "Moderation in all things-even in moderation" (1988, p. 175), which means that in most cases it is better to be moderate but sometimes it is useful to take extreme positions.

Each of the tasks forming the Lightswitch design process can be refined into sub tasks in order to give a more detailed view of how the Lightswitch models are used to reason about the regulation of the enterprise. The following list gives this detailed view for each task in the Lightswitch design process.

### ***Step 1: Identify relationships***

The goal of this step is to build the initial Lightswitch model based on the available documentation sources and consisting of communities that represent the enterprise and its stakeholders. The following steps are applicable:

1. In the sources available for analysis identify the enterprise of interest and its stakeholders. Any enterprise or person named in the sources is potentially a stakeholder. These stakeholders can be considered as internal or external to the enterprise of interest.
2. Model the enterprise of interest as a community of interest. Model internal stakeholders of the enterprise of interest as sub-communities of the community of interest. Model stakeholders that are considered external to the enterprise of interest as communities that are external to the community of interest.
3. Add a supra-community that comprises the community of interest and the external communities. Name the supra-community with respect to the relevant context. If relevant, repeat step 1 on the enterprise modeled by the supra-community. See for example Figure 5.8. Notice that in this example, we do not as yet name the supra community. We will do this when we know whether we want to focus on the investors or customers relationships.
4. Apply the heuristics H3 (aggregation), H4 (specialization), and H12 (parallel principle) to better understand the how the communities are structured to compensate existing influences.

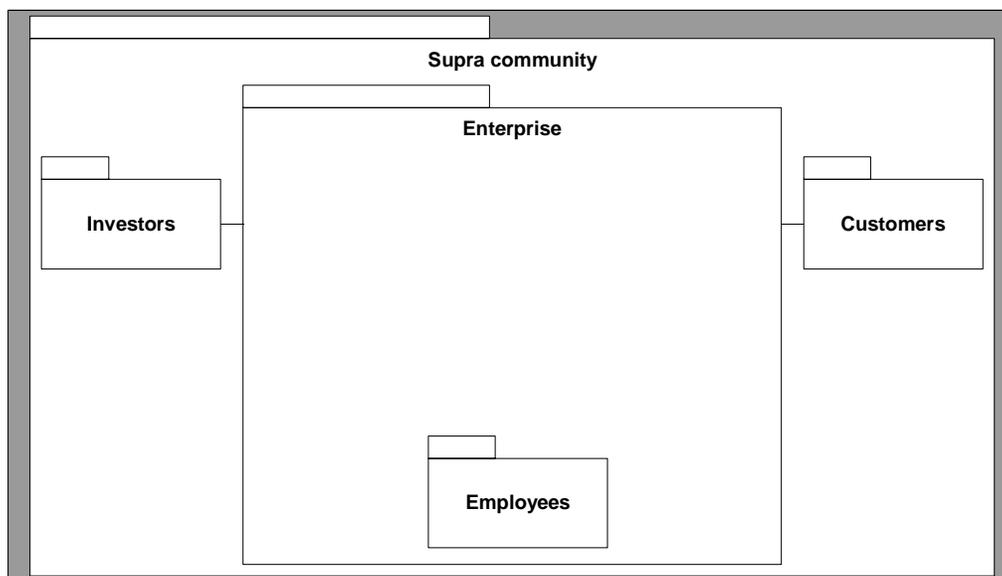


Figure 5.8 An enterprise and its stakeholders

### *Step 2: Analyze how the relationships are regulated*

The goal of this step is to understand how the relationships between the enterprise and its stakeholders are regulated. The following steps are applicable:

1. Assign one maintenance goal to the community representing the enterprise of interest for each one of its stakeholders (see Figure 5.9). These maintenance goals model the enterprise of interest's regulation of its relationships with its stakeholders. These goals may express the maintenance as well as avoidance of relationship.

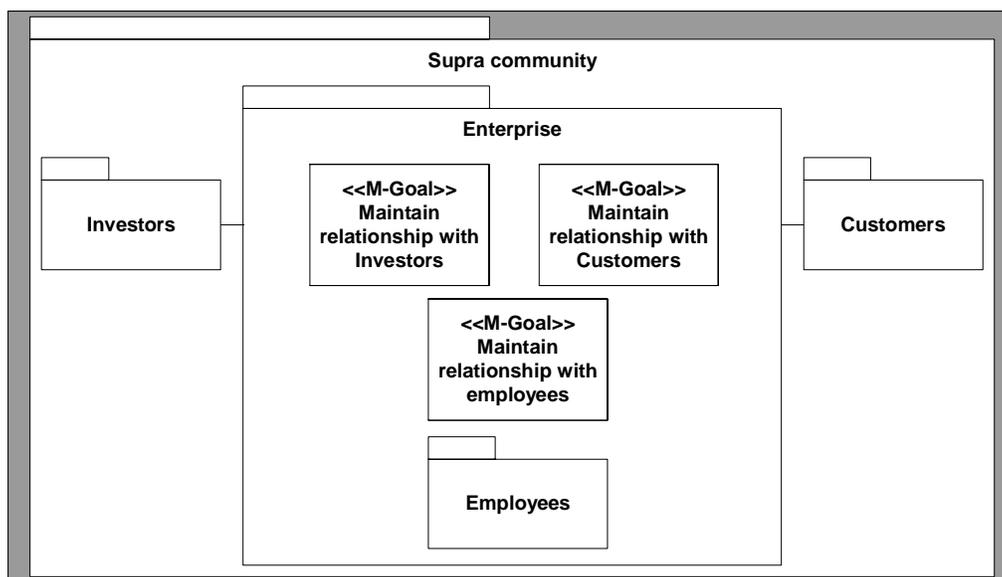
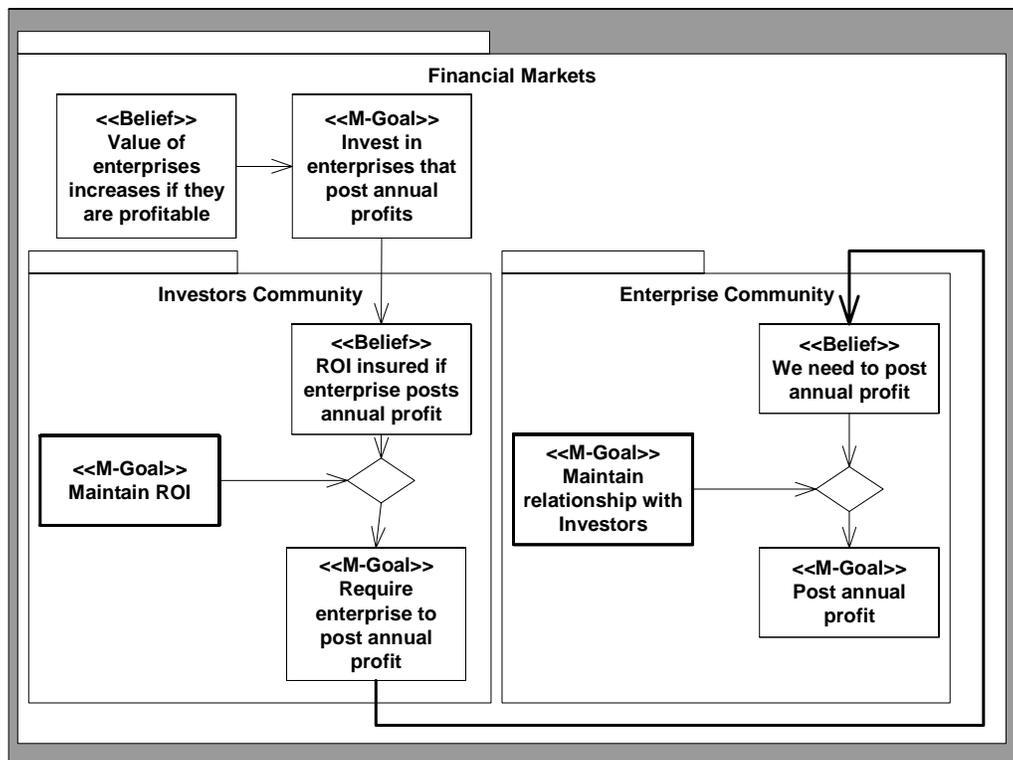


Figure 5.9 Stakeholders and maintenance goals of an enterprise

2. Reduce each maintenance goal in turn into sub-goals. This reduction is done by considering the beliefs to the community representing the enterprise as shown in Section 5.2.2. These beliefs represent the interpretations that the enterprise has of the nature of the relationship with the stakeholder of interest. An interpretation as we defined it in Chapter 4 represents the way

an enterprise classifies and values some aspect of its reality. In our models, therefore a belief may be connected to a goal of the stakeholder of interest or to a goal of another stakeholder. Often such a connection cannot be made for lack of information or because it will make the model too complicated. In that case the belief is left unconnected.

3. In order to connect the beliefs of the community of interest with the communities representing the stakeholders, the goals of these latter communities need to be identified and reduced at the same time. For example, to model the regulation of relationships between an enterprise and an investor, we will model the investor as a community having the goal to maintain its return on investments (see Figure 5.10). The investor community will have a belief that a return on investment is insured when the community representing the enterprise posts an annual profit. This allows us to reduce the goal of the investors into asking the enterprise community to post an annual profit. We will model the enterprise community as having a belief that investors want it to post an annual profit. We have thus reduced both the goals of the investors community and the enterprise community synchronously in order to show their relationships. Notice that since we focus on the enterprise's relationship with its investors, we have named the supra community Financial Markets.



**Figure 5.10 Example goal reduction for investors relationships**

4. Within the context of the satisfaction of a goal by a community, the beliefs of the community are both what enables the community to satisfy the goal and the constraints on this satisfaction. In the example in Figure 5.10, without the belief that an annual profit is required, the enterprise may simply waste its resources.
5. Repeat this sequence for each maintenance and achievement goal of interest. This step implies a structural and behavioral decomposition.
6. All the heuristics in the previous section can be used to understand how the communities and are structured, what kind of resources (ample, scarce) the communities believe they have, how specialized they are, etc.

### ***Step 3: Identify changing conditions***

The goal of this step is to identify current or foreseeable conditions that may render the current regulation inadequate. The following steps are applicable:

1. In the Lightswitch models we analyze the maintenance goals, beliefs and structure (in terms of sub-communities) of each community and compare them with an assessment of the current conditions. The heuristics in the previous section can be used to identify changing conditions. For example, in the case study of the Templeman library in Part 3, we hypothesize that the goals of the library show that it believes that books are scarce resources. This may change in the future with the emergence of digital books. The library's goals are likely to change as a consequence.
2. The conditions that may render the current regulation inadequate often represent dissatisfactions with the way things are believed to be now. We analyze the models and identify dissatisfactions. For example, in the sterilization department case study, the current regulation is seen as inadequate partly because it is believed to be wasting too many resources.
3. Another possibility is for the current regulation to be judged as non-adequate because future conditions are believed to threaten it. In the example of the sterilization department, the obsolescence of the current IT system is believed to mandate a change, not because it is not currently adequate but because it may not be adequate in the future. In the case of the Templeman library, it is the emergence of digital libraries that is seen as threatening the current regulation.

### ***Step 4: Identify, evaluate, select options and IT system goals***

The goal of this step is to identify options that change the regulation of the enterprise to fit the current or foreseeable conditions identified in the previous step, to evaluate each option, to select one of the options, and to define IT system goals for the selected option. The following steps are applicable:

1. Specify options for different configurations of communities, maintenance goals and beliefs that take into account the conditions identified in step 3.
2. Evaluate how each option changes the regulation of the community of interest with its internal and external communities. Specify advantages and disadvantages of each option as well as beliefs that make an option viable or not viable. The heuristics in the previous section can be used in this evaluation. For example, scarce resources turned into ample resources and vice versa may provoke undesired behavior or difficulties to adapt to the new situation. Conditional and unconditional mechanisms may become ineffective as a result of the changes etc.
3. The heuristics in the previous section could be used to identify some of the factors that may act in favor or against any of the changes proposed in the identified options. For example, a specialized community will have difficulties changing into a general purpose community and thus will oppose such a change. More generally, designers may expect a tendency by every community to maintain its norms and resist change, whether the designers believe that this change is in the best interests of the community or not. In the Templeman library case study, for example, we show several factors that may act against the envisioned change in the Templeman library's mission toward an active enabler of the research performed in the university. Such factors may, for example, be the refusal of the university to fund such a project.

Once some of these factors are identified, the designer may choose to either

- confront them and force the desired change
- work around them without direct confrontation
- suggest other options
- abandon the change

4. Decide which option is preferable with respect to current and foreseeable conditions. Enterprises sometime maintain relationships that designers may believe to be not in best interests of the enterprise. Sometimes enterprises avoid relationships that the designers believe the enterprise should pursue. However, when proposing some change in an enterprise, the designers have to be careful because, as we have seen, the enterprise's norms and interpretations are what enabled the enterprise to survive until today. Hence, the designers cannot simply dismiss the enterprise's current regulation as inadequate and propose changes that do not take these regulations into consideration.
5. Specify IT system goals for the preferable option

We have seen in Chapter 4 that regulation is an optimizing balancing act. By this optimizing balancing act we meant the optimizing of some relationships while maintaining a balance between the multiple regulated relationships. Thus, the role of the IT system can be described as enabling the enterprise to implement regulation mechanisms that offer better optimization of some relationships while balancing the overall set of relationships. For example, in order to balance the conflicting demands between its suppliers, investors, employees and customers, an enterprise could use an IT system to reduce the cost of managing customer relationships while satisficing the service given to them, through better prediction of customers' buying patterns it could "guarantee" a level of orders to its suppliers and thus negotiate lower prices. This optimization could help it, in principle, to give better wages and working conditions to its employees and better return on investment to its investors. In some cases IT systems are the only tool that may help the enterprise to accomplish this optimizing balancing process.

An IT system can be modeled as a sub-community of the community of interest specialized in providing information to the community of interest about itself and its relationships. In this view, the IT system should be designed so that it can inform the community of interest about the states of its relationships so that the enterprise can take the appropriate actions in order to maintain its identity.

We have seen Lampel's view in the previous section about conditions that enable enterprises to make changes to their business processes. Lampel cited three such conditions: New technology, new knowledge, and new practices. Advances in IT systems in particular, change the possible regulation mechanisms that the enterprise can apply on its relationships. Such advances have the faculty to:

- Convert scarce resources into ample ones. For example, producing printed documents. Prior to the wide spread use of computers in offices, it was difficult and time consuming to produce a printed document. With a computer and a printer, printing a document is as easy as clicking on a button. This makes it easier to share documents but has the secondary effect of filling offices with printed documents, as documents are reprinted and re-reprinted when minor errors are discovered in them. The value of the printed document has fallen from very high to very low. The potential of transforming scarce resources into abundant ones may have the most dramatic effect on regulation. To compensate for such transformations an enterprise needs to make large changes in its regulation mechanisms as we have discussed in Chapter 4.
- Improve anticipation of future patterns of behavior with finer analysis of past behavior. For example, with an IT system, it is in principle easier to remember and therefore analyze past behavior of suppliers and customers. Improved scheduling of production cycles.
- Improve detection of undesired states of a variable. Subject to the fallacy of whether the interpretation of the IT system is a faithful representation of stakeholders' interpretations. For example, an enterprise IT system can easily detect and alert employees to the non payment of a bill by a customer. However, if the customer did pay the bill but this was not registered in the IT system, the customer will be hassled for no reason.
- Automated processing, for example, automatic recalls of unpaid bills or non returned books, automatic reordering of inventory items etc.
- IT systems can improve the capability of the enterprise to share information across space and time. These improved capabilities enable the enterprise to adopt more aggregation mechanisms because of the potential improvement in coordination between aggregates. For

example, relying on a distributed IT system, an enterprise can more easily manage several warehouses coordinating movement of inventory between them if necessary to compensate for different demand cycles. A supermarket chain can use its IT system to direct customers to another store when it is out of stock of some merchandise.

This list above is a non exhaustive list of both changes that an IT system can induce in the regulation mechanism of an enterprise and the changes that it can cause indirectly by improving the regulation mechanisms of its stakeholders. The list shows that an IT system can change the regulation mechanisms of the enterprise directly and indirectly. Through automated processing, the IT system can be a direct regulation mechanism directly acting on stakeholder relationships by, for example, automatically sending recalls on unpaid bills. Through most of the other mechanisms, the IT system acts indirectly by modifying the enterprise's interpretations and therefore its regulation mechanisms.

### **5.3 ODP Enterprise Language**

In Part 1, we gave an overview of the RM-ODP standard and related the Lightswitch approach to the part of RM-ODP called the Enterprise Language (ODP-EL for short). As in Lightswitch, the main modeling element of ODP-EL is the Community. A community is said to have one and only one objective. The behavior of the community is said to be governed by a policy in order to achieve the community's objective. ODP-EL does not provide a theoretical explanation that may help to understand why these specific modeling elements were selected and why they are specified in this specific way. The work we have done in specifying the Lightswitch approach enables us to provide such an explanation and to challenge some of the premises behind these definitions. This gives us the possibility to formulate changes to ODP-EL that, we believe, will make it more suitable to its intended use, i.e., creating enterprise specifications for enterprises in changing environments. In this section we will focus on the explanations and changes to the concepts of objective, policy, and process.

ODP-EL doesn't include a conceptualization of observed reality such as the one we have provided in Chapter 4. Changing the ODP-EL definitions to the Lightswitch modeling elements definitions introduced in Section 5.2.1 will require the incorporation into ODP-EL of the Lightswitch conceptualization as well. This is likely to cause changes to ODP-EL that will no doubt be too large to be accepted by the standardization body. We therefore recommend only small changes that we consider to be good enough for the purpose of adapting ODP-EL to be used for creating enterprise specifications for enterprises in changing environments.

#### **5.3.1 Explicitly defining maintenance goals**

As we have seen in Part 1, the concept of objective is defined in ODP-EL as:

“Practical advantage or intended effect, expressed as preferences about future states” (ISO 2002).

This definition is further enhanced by the following two notes:

“1 – Some objectives are ongoing, some are achieved once met.

2 – In the text of ITU-T Recommendation X.903 | ISO/IEC 10746-3 [3-5] the terms, purpose and objective, are synonymous. The enterprise language systematically uses the term, objective, and emphasises the need of expressing objective in measurable terms” (ISO 2002).

Note 1 seems to be making the case for the differentiation between achievement and maintenance goals. We have defined maintenance goal as a concept that represents a norm, i.e., a relatively stable state over some period of time. We understand the word ongoing to mean a maintenance goal while “achieved once met” we understand to mean an achievement goal.

Based on these similarities, our recommendation is to make the distinction between maintenance and achievement objectives explicit and less ambiguous by changing Note 1 above to:

1 – Some objectives express future states that can be defined as identical to present states. These objectives are satisfied for as long as the preference about these future states is maintained by the community. Some objectives specify future states that are sensibly different from present states. These objectives are satisfied once the future states are reached.

### 5.3.2 Taking into consideration multiple objectives

An ODP-EL community is defined as a configuration of objects that is formed to meet one and only one objective. This objective can be a composition of sub-objectives. In the context of this thesis, we see this requirement as an unnecessary and harmful constraint. As we have seen in Chapter 4, an objective (or goal, or purpose) is a relationship between an observer and an observed entity. Thus an ODP-EL community may have as many objectives as it has stakeholders and sometimes more because every stakeholder may have several interests in the same community. Requiring that only one objective be specified for the community is likely to focus the attention of the designer on only one of these stakeholders or on only one aspect that a stakeholder desires, at the expense of the other stakeholders' desires. The example of the Templeman library in Chapter 6, where several ODP-EL related publications specify a limited and partial objective, seems to strengthen this impression, even if it is far from being a scientific evidence.

It could be objected, to our argument, that the individual stakeholder objectives can be joined to produce what ODP-EL specifies as a composition of sub-objectives. We will thus have an objective in the form: "the community's objective is to do what is needed to satisfy stakeholder 1 and do what is needed to satisfy stakeholder 2 and etc." Even though this is in principle possible, in practice the requirement of one and only one objective do not attract the attention of the designer to the possibility or desirability of defining multiple objectives. We thus recommend that an explicit statement be added as note to the standard to encourage the definition of multiple objectives for a community. These can be joined in a composition. We recommend the following Note:

Note – Each sub-objective is aimed at the satisfaction of a relationship that the community has with another community.

The second part of the definition of community objective defines that an objective is expressed in a contract. The contract is said to state the objective for which the community exists (see Chapter 3). However, the contracts specified by enterprises which form the source from which the ODP-EL contract is specified rarely include an explicit statement of its objective. For example, an insurance or bank contract usually only specifies what ODP-EL calls policies (obligations, permissions, prohibitions, authorizations etc) without clearly specifying what the objective of the contract is. This may be so because the objective of the contract is to provide some service to the customer while protecting the interests of the enterprise. Such explicit statement in the contract may clash with the marketing statements about total customer satisfaction. Since ODP-EL emphasizes the need, by the designer, to explicitly specify the objective of the contract and to specify this objective in measurable terms, the designer is forced to find the objective outside of the contract. If this objective is not explicitly specified elsewhere, the designer is bound to propose some objective of his or her own making. Obviously, this objective then needs to be validated by stakeholders. In order to help designers and stakeholders to define objectives that match stakeholders' needs it is important in our view to either add a statement in this sense to the notes of the community objectives or make it clearer in the annexes of the standard where an explanation is given about the standard and how to use it.

Our proposed statement is:

The objective of a community usually can be defined as offering some service to one or more stakeholders while insuring the survival of the community with respect to the beliefs the community holds about itself and its environment.

### 5.3.3 Adding beliefs to the Policy concept

ODP-EL specifies the concept of policy as follows (ISO 2002):

"A policy identifies the specification of a behaviour, or constraints on a behaviour, that can be changed during the lifetime of the ODP system or that can be changed to tailor a single specification to apply to a range of different ODP systems. Changes in the policies of a community during its lifetime can occur only if an enterprise specification includes behaviour that can cause such changes.

NOTES

1 – A policy is named place-holder for a piece of behaviour used to parameterise a specification in order to facilitate response to later changes in circumstances. The behaviour of systems satisfying the specification can be modified by changing the policy value, subject to constraints associated with the policy in the original specification. In these terms, a policy is an aspect of the specification that can be changed, and a policy value is the choice in force at any particular instant. Thus one might speak of a scheduling policy with a FIFO policy value.

2 – Policy may, for example, be used to configure generic components to apply them in some specific situation, or to express a pervasive decision that affects many components.”

Thus a policy defines some changeable behavior. However, ODP-EL doesn't specify how a specific policy came to be in a specific community. Why is it that the community doesn't have a different policy and under what conditions the policy might change?

A policy is further defined as (ISO 2002):

“6.4.1 Policy: A set of rules related to a particular purpose. A rule can be expressed as an obligation, an authorization, a permission or a prohibition.

NOTES

1 – Not every policy is a constraint. Some policies represent an empowerment.”

The set of rules comprising a policy are said to restrict (or constrain) the behavior of the community (ISO 2002, clause 7.7):

“The policies of a community restrict the community behaviour in such a way that it is possible to meet the objective. Such policies result in behaviour that suits the objective of the community.”

By restricting the behavior of the community, a policy, in effect, specifies a behavior that is acceptable to the community. Hence, the concept of policy can be seen as modeling what we have called a norm in the Lightswitch approach, i.e., an interpretation that defines states that are acceptable to the enterprise. A policy is a modeling concept and thus corresponds to the Lightswitch modeling concept of maintenance goal. However, as we have seen in 5.2 maintenance goals are not independent of the beliefs that motivate them. Making these beliefs explicit is a necessary step towards understanding how the community views itself and its environment and is thus necessary if we want to understand how the policies were shaped and specify changes to these policies (which is one of the objectives of ODP-EL, as we have seen above).

We can thus propose the following changes to the definition of Policy in ODP-EL:

6.4.1 Policy: A set of rules related to a community objective<sup>1</sup>. The rules are defined with respect to the community's beliefs about the state of its relationships with internal and external communities. A rule can be expressed as an obligation, an authorization, a permission or a prohibition.

And to clause 7.7 above:

The policies of a community restrict the community behaviour in such a way that it is possible to meet the community's objective. Such policies result in behaviour that that is acceptable to the community.

We would add the following definition of the concept of belief:

Belief: A statement about the state of one or more relationships of the community and the meaning of this state to the community.

Note: A belief connected to an objective defines a policy.

The components of a policy are defined as (ISO 2002, clause 7.9.1):

“The specification of a policy includes:  
-- the name of the policy;

---

<sup>1</sup> Notice that in the statement above, we also correct for the misplaced use of the term purpose rather than objective in clause 6.4.1.

- the rules, expressed as obligations, permissions, prohibitions and authorizations;
- the elements of the enterprise specification affected by the policy;
- behaviour for changing the policy.

The behaviour for changing the policy may include behaviour that changes the rules of that policy and behaviour that replaces that policy with a named different policy.

#### NOTES

- 1 - The behaviour may include constraints on changing that policy
- 2 - Behaviour for changing the policy may be null, i.e. the policy is not changed during the lifetime of the community)"

We would change this clause as follows:

The specification of a policy includes:

- the name of the policy;
- the rules, expressed as obligations, permissions, prohibitions and authorizations;
- the elements of the enterprise specification affected by the policy;
- the beliefs and objective that justify the policy
- behaviour for changing the policy.

The behaviour for changing the policy may include behaviour that changes the rules of that policy and behaviour that replaces that policy with a named different policy. This behavior should also specify how the beliefs of the community that justify the policy should change to reflect the change in policy.

#### NOTES

- 1 - The behaviour may include constraints on changing that policy. These constraints may be related to the inability to change the beliefs of the community that justify the policy.
- 2 - Behaviour for changing the policy may be null, i.e. the policy is not changed during the lifetime of the community)

The changes above reflect our position that a policy concept should be linked with a belief concept in order to encourage changes to policy that are in-line with interpretations of current and future trends. In other words, the concept of belief related to a policy enables the designer to advance reasons for the policies being what they are and not any other policies in the infinite range of possible policies. In the above example of a scheduling policy with a FIFO value, we can ask what are the beliefs that justify the need for a scheduling policy in this specific community and what are the beliefs that justify the FIFO value for the scheduling policy.

## 5.4 GDRE

The work described in this thesis complements existing RE and GDRE methods with a regulation oriented conceptual framework of enterprises and a modeling framework that helps designers to explore regulation aspects in enterprises. In the following paragraphs we explain the relationships that we see between the Lightswitch approach (conceptual framework and the modeling framework) and the GDRE methods. In line with the work done in SSM but in sharp contrast with current research in GDRE, we provide a conceptualization of the observed reality of enterprises that is separated from the modeling framework. This enables us to show that goals can be seen as modeling elements that represent a conceptualization in which no goals are present. Doing this enables us to compare different GDRE methods and propose improvements to these methods.

Surprisingly, whereas the term “regulation” is frequently used in human affairs, the discussion of regulation is largely missing from the RE literature in general and GDRE literature in particular. For example, the business rules that the Templeman library described in Chapter 6 applies to borrowers are called “Library Regulations.” GDRE techniques will study those regulations in terms of goals to be achieved and states to be maintained but will not address the regulation aspect of these rules. Another example is Sowa and Zachman’s paper mentioned in Part 1 (Sowa and Zachman 1992). The main metamodel described in this paper defines that business rules regulate business relationships.

Unfortunately, this assertion is not commented in the paper and the EA framework focuses instead on a means-ends analysis, where regulation is absent. So there are repeated indications of the interestingness of the subject of regulation in RE but we haven't found any substantial RE related work in this area. This is all the more surprising that the subject of regulation is tightly coupled with the subject of goals as identified by early cyberneticians, most notably Wiener and Ashby, and later systems thinkers such as Vickers and the Weinbergs. Thus, we see regulation, not as a separate subject from goal-seeking behavior, but rather as the theoretical framework that provides a plausible explanation of goal-seeking behavior.

From a regulation point of view, a goal is seen as the intended result of an action as defined by an observer. Practically, this means that any system and any action may have as many goals as observers care to define.

GDRE methods consider goals to simply exist, waiting to be extracted from stakeholders and textual information about their activities. No further explanation is given to the fact that people and enterprises appear to exhibit goal-seeking behavior. The Lightswitch conceptualization takes this issue of goals one step further by asking why is it that people and enterprises appear to exhibit goal-seeking behavior. In Chapter 4, we have proposed a conceptualization based on general systems and cybernetics theories that gives a theoretical explanation of goal-seeking behavior. Notice that up to that point we have not created a new theory but only brought together several known theories. One of the contributions of this thesis, however, is in the relationship we establish between this conceptualization and GDRE: This enables to explain the different terms used in GDRE beginning with the concept of a goal and continuing with the related concepts of achievement goal, maintenance, goal softgoal etc. in non-goal related terms. We consider this clarification of the concepts used in GDRE as an important contribution to the field of RE in general and to the field of GDRE in particular.

#### **5.4.1 The absence of the observer**

GDRE methods generally do not specify the concept of observer. Goals and constraints on their satisfaction are therefore defined as absolute notions. For example, a goal is usually defined as a state to be achieved by a system but this definition doesn't say according to whose view this state was defined.

Constraints are defined in GBRAM as placing conditions on the achievement of a goal (Anton 1997, p. xix). KAOS relies on so called domain knowledge for goal refinement (Dardenne 1993). GRL specifies that beliefs "make it possible for domain characteristics to be considered and properly reflected into the decision making process..." (ITU 2001). Constraints, domain knowledge and beliefs can all be seen as modeling what we have called interpretations. The advantage in seeing them as interpretations is that they no longer represent absolute statements about reality but rather an observer's view of this reality. They then become more malleable. It is easier to understand how the constraints on the achievement of a goal could be different once they are seen as the interpretations of an observer.

Seeing goals and constraints as interpretations of an observer, knowing that these interpretations are themselves the observer's understanding of norms and that these norms are subject to the principles of regulation (e.g. homeostasis) helps to understand how these goals and constraints may be changed or not changed.

#### **5.4.2 Clarification of definitions of goals**

In KAOS maintenance and avoidance goals are defined as: "Maintain and Avoid goals restrict behaviours" (Dardenne et al. 1993). In GBRAM maintenance goals are defined as: "Maintenance goals are those goals which are satisfied while their target condition remains constant or true" (Anton 1997). Neither KAOS nor GBRAM related publications explain the need to restrict behavior; to maintain some condition constant; or to apply continuous effort to do so. The conceptualization in Chapter 4 explains the need of enterprises and people to restrict behavior specifically in order to maintain some conditions constant so that the identity of the person or enterprise is maintained. This

conceptualization also explains the need to apply continuous effort to insure this constancy because of the tendency of entropy increase to continuously challenge any state that the system may achieve. Thus we provide a rationale for the existence of the concept of maintenance goal.

Moreover, if maintenance goals represent norms and norms are only approximately satisfied at any given time, it follows that the state defined by a maintenance goal (that is either satisfied or not satisfied) represents an ideal situation that may not correspond to the messier situation in the observed reality.

Softgoals, as defined in GRL, can be seen as an attempt to get closer to this observed reality by not considering that goals can be defined as either satisfied or not satisfied but rather as somewhat satisfied. Unfortunately, without introducing the concept of observer, it is difficult to say why a certain goal cannot be completely satisfied and why some other goal can. A goal such as goods delivered to customer is generally considered as a hard goal (meaning that it is either achieved or not achieved), whereas a goal such as increase market share is considered as a soft goal. However, by introducing the concept of observer, we can see that even the achievement of a hard goal may be subject to debate. The customer to whom an order was shipped may say that they didn't receive the goods whereas the shipping enterprise may state that the order was indeed delivered. The quality of the delivered goods may also be questioned by the customer and not by the enterprise that shipped them. Indeed, if we add the concept of an observer, any goal may become a softgoal.

### 5.4.3 Relationships between maintenance and achievement goals

In KAOS it is not specify what relationships may exist between the different goal types that they specify. For example, how are maintenance goals related to achievement goals. GBRAM addresses this issue but remains quite evasive, relying on vague descriptions and examples. Consider for instance the following statements from GBRAM:

- “achievement goals are best mapped to actions that occur within the [IT] system, while maintenance goals tend to be nonfunctional (e.g. constraints that prevent things from occurring)” (Anton 1997, p. 50).
- “A distinction that can be made between maintenance and achievement goals is that maintenance goals have a pervasive effect on achievement goals. In contrast, achievement goals are relatively self contained” (Anton 1997, p. 86).

Thus, Anton defines that maintenance goals place constraints on achievement goals but without giving any rationale for these statements nor is it defined what kinds of constraints these may be. In Chapter 4 we have provided such a rationale. We also explained when achievement goals (regulative actions) are specified with respect to maintenance goals (norms) and beliefs (interpretations of a current state of affairs).

### 5.4.4 The role of beliefs in goal refinement

Most GDRE methods do not state explicitly how goal refinement is performed. The goal refinement trees that we showed in Part 1 relate goals to subgoals without explicitly showing why a certain refinement was favored over another. In some GDRE publications it is stated that constraints enable to refine goals into subgoals, e.g. (Anton 1997), (Dardenne 1993). Thus, these constraints are the rationale for goal refinement. However, most goals refinement models used in GDRE do not include a rationale for the refinement they propose. In KAOS, domain knowledge is used for the goal refinement but this knowledge is considered as absolutely true and is not shown in the goal refinement tress. Thus, GBRAM and KAOS use the AND/OR graphs rather than newer models that incorporate beliefs in goal refinement, such as Logic Programming (Kowalski and Sadri 1999).

GRL does specify a modeling element called Belief that provides a rationale for the decisions made during the design (design rationale), a belief is defined as:

“Beliefs are used to represent design rationale. Beliefs make it possible for domain characteristics to be considered and properly reflected into the decision making process, hence facilitating later review, justification and change of the system, as well as enhancing traceability” (ITU 2001).

This definition doesn't state to whom a belief belongs? By this statement, we mean that whereas a softgoal is defined in GRL as a state of affairs desired by an actor, the definition of the concept of belief does not associated a belief with an actor. Hence, it seems that in GRL models, a belief is used to document beliefs of the designer. In Lightswitch a belief belongs to a community and represent how the related enterprise interprets its state and the state of its environment. This enables the designer to model beliefs of one community about the goals of other communities, thus providing a rationale for goal refinement. Beliefs, therefore, are not absolute notions as in other GDRE methods but only correspond to the way the enterprise views the world. This enables the designer to propose models with different beliefs leading to different goal refinements and therefore to different goals for the IT system.

### 5.4.5 The role of norms and interpretations

The Lightswitch conceptualization shows the major part played by norms and their interpretations by different stakeholders in shaping enterprise behavior and therefore enterprise goals. There are an enormous amount of norms in any enterprise, most of which are so ingrained in the enterprise's behavior and so obvious to stakeholders that they generally go unnoticed. However, they provide a powerful rationale for goals. By showing that maintenance goals can be understood as representing these norms. Thus by providing a modeling approach where these norms can be modeled together with interpretations of these norms to reflect about current goals of an enterprise and possible future goals, we believe we have provided a substantial contribution to the definition of goals for IT systems. For example The Lightswitch conceptualization explains the rationale behind statements such as Anton's point about the goal of a system as we have shown in Chapter 3:

“The goal of a college financial services system is not to maintain a financial ledger/database (system goal) as typically described by management level stakeholders, but to ensure that, among other requirements, the budget remains balanced; sponsors are charged according to their contracts; and faculty are paid according to state research contracts, as typically described by customers using their application domain vocabulary” (Anton 1997, p. 149).

Remember that Anton does not specify why the goals of the financial services system should be seen as ensuring a balanced budget, paid sponsors, and paid faculty. The Lightswitch conceptualization explains this statement by showing that the financial services system serves the needs of a financial services department. This department is a regulation mechanism created by the university to regulate the financial aspects of its relationships with some of the university's stakeholders. In this example these stakeholders are the sponsors and faculty. However, there are some hidden stakeholders who can be identified by asking why the budget needs to remain balanced. This will point us to the university's relationships with its investors and controllers, who might be government institutions or private ones. These stakeholders have norms such as expecting a balanced budget. The university's norm of maintaining a balanced budget can be seen as its conformance to the expectations of its investors. Failure to conform to this expectation (by losing money for example) may mean for the university to be shut down because investors are not willing to offset the money lost by pouring more money into the university. Note that making too much money may also be problem for the university, especially if it is a state owned university, which may not be expected by people to be a profit making business. Anton's example also points to several other norms, such as “faculty are paid according to research contracts.” This norm can be explained as conforming to what faculty are expecting from the university. Failing to conform to these expectations may mean for the university to lose its faculty and hence its capacity to teach.

Thus, the financial services system is expected to help the financial department to insure that these norms are respected, hence the goals stated by Anton.

## Part 2 Summary

In this part we gave a detailed explanation of the Lightswitch approach and described its contributions to both enterprise architecture frameworks and to GDRE.

The Lightswitch approach consists of:

- a conceptualization of the reality we observe in enterprises using General System Theory and Cybernetics, regulation principles
- a goal-directed modeling framework for creating models of this reality

The modeling goal-directed modeling framework itself consists of:

- a set of modeling elements,
- a graphical notation that uses these elements,
- a set of heuristics for identifying regulation in enterprises
- a goal-directed process for modeling the results of this regulation

Lightswitch is a GDRE approach built bottom-up from the basic assumption of a world governed by the second law of thermodynamics and nevertheless containing organized entities such as people and enterprises. These organized entities can be modeled as systems by people. The person creating such models is called the observer in GST and Cybernetics. We make the further assumption that some mechanisms enable organized entities to exist in a world that privileges chaos. These mechanisms are called regulation mechanisms in GST and Cybernetics. From the point of view of the observer these regulation mechanisms act against undesired change. They are thus responsible for maintaining the identity of the system as seen by some observer and for resisting change that can be seen as beneficial by other observers.

Thus, the Lightswitch analysis gives us the following benefits:

- An explanation of why the stakeholders express some goals and not others.
- The view of the concepts of business processes as regulating relationships and providing heuristics for understanding what kind of regulation they represent and therefore how they may be changed when dissatisfaction exists as to its efficiency or when the state of affairs is seen as likely to change.
- The designer is encouraged to reflect on how the enterprise and its stakeholders interpret their relationships and with other stakeholders, thus forming a network of regulated relationships.
- An understanding of whether the regulation is adequate in the current environment of the enterprise. Indeed, we have seen that, although regulation is necessary for the survival of the enterprise, the more successful it is in a certain environment, the more it is subject to fallacies when the environment changes. It is necessary to take this aspect into consideration before the requirements of the IT system are defined or else these requirements will be based on the non-adequate regulation.
- The models created by the designer may help the designer to understand how an IT system can help the enterprise to achieve an adequate regulation with respect to current or foreseeable expectations by its stakeholders. This results in high-level goals that are assigned to the IT system. These high-level goals can be used as a basis for the requirements of the IT system.

Following the description of the Lightswitch framework, we explained how the conceptualization, the modeling framework and the modeling process could contribute to the RM-ODP Enterprise Language standard and to several GDRE methods. Our recommendations centered on an explanation of goals in terms of the regulation concepts. We provided a definition of goals in terms of norms, regulative actions and beliefs and we discussed the need to better understand the links between these concepts when we want to specify implementable change in enterprises.

# Part 3

## Experimentation

In this part we present three case studies that were used to validate the Lightswitch approach.

In Chapter 6 we present the case of the University of Kent's Templeman Library. The case was constructed by analyzing the concrete set of rules (called regulations by the library) of the Templeman Library as they are published on the Library's web site. This case involved only a theoretical analysis of the regulations. No interviews were conducted. This analysis enables us to understand the reason for the existence of the different rules of the Library and the way these rules may influence the productivity of the Library's clients. This understanding enables us to propose high-level goals for a hypothetical IT system that may enable the Library to offer a better service to its clients and may be used to ease the regulations that it imposes on its clients.

In Chapter 7 we present a case conducted as part of a concrete project at the Lausanne University Hospital (CHUV). The subject of the case was the analysis of the opportunities to change a legacy IT system at the central sterilization department of the hospital. The case was conducted over a period of 2 months. It involved interviews, discussions, and visits of hospital facilities.

In Chapter 8 we present a case based on a diploma project conducted by a computer science undergraduate student with the supervision of the author. The project performed for and at the facilities of ABB Sécheron, a wholly owned subsidiary of ABB Switzerland in Geneva that designs, manufactures and sells power transformers. The project aim was to analyze the adequacy between some of the business processes and the IT systems of one of ABB Sécheron's business units.

## 6 The Templeman Library Case Study

To illustrate the Lightswitch method we will use the case of the University of Kent at Canterbury's Templeman Library. The complete Library documentation is available the Library web site at the following address: <http://library.ukc.ac.uk/library/>. The part that is relevant to this discussion is reproduced in Appendix B.

We chose to use the Templeman Library's documentation as a case study for this thesis for two main reasons.

- a. It has been used in the past as an example for applying ODP Enterprise Language concepts, most notably by Steen and Derrick (Steen and Derrick 1999a, Steen and Derrick 1999b, Steen and Derrick 2000, Durán and Vallecillo 2001).
- b. It provides a, well documented, real life case of an enterprise that illustrates most of the regulation principles that we have identified in chapter 4.

In their paper, Steen and Derrick (Steen and Derrick 99) used part of the Templeman Library documentation to show how ODP Enterprise Language policies can be formalized. According to Steen and Derrick, the Library

“maintains a collection of books, periodicals, and other items, that may be borrowed by its members. The primary objective of a library community thus is to share this collection amongst its members, as fairly and efficiently as possible. In order to ensure that this objective is met, a borrowing policy is established, which documents the permissions, obligations and prohibitions for the various roles in the library community.”

The Library's documentation doesn't state what the objective of the Library is. Thus, we can say that the above objective stated by Steen and Derrick is their definition of what the objective of the Library is or should be. The view that this is the objective of the Library may or may not be shared by the Library stakeholders. The Library may have multiple objectives that it needs to satisfy at the same time and that cannot be reduced to just this one objective. The objective of satisfying its borrowers by fairly and efficiently sharing its collection among them is one of these objectives. However, the borrowers, for example, may not be satisfied with the Library's service even if the objective stated by Steen and Derrick was perfectly met. Indeed, this objective misses, among other things, the need to maintain a collection of items that borrowers will find interesting. What use is an efficiently shared collection if it only contains items that are of no interest to borrowers? Other objectives pertaining to the Library's other stakeholders may be:

- Not spending more money than is allocated to the Library and efficiently using this money
- Maintaining a steady stream of purchases from suppliers
- Maintaining a working environment in which the Library personnel likes to work

Also, if part of the objective of the Library is to fairly share the collection of items, why is it that, as we will see, different borrowers have different borrowing rights? This brings the question of who defines what is fair and what is not. Obviously, within this Library context, it is fair that students have fewer rights than faculty. The other part of the objective, efficiently sharing the collection, can also be challenged. Before we set out to design an IT system for the Library, shouldn't we make sure that the policies in place contribute to sharing the collection efficiently?

Note that the main section of the Library's documentation, the one that contains most of the rules of the Library is named “Library Regulations.” This in itself may suggest that what is at stake here is the regulation of relationships rather than the achievement of some objective.

The Library documentation contains several sections describing the various services offered by the Library and instructions on how to use them. The sections most important for the present discussion are entitled:

- Library Regulations

- Borrowing Books and Journals
- External Borrowers

These sections contain rules to be observed by people using the Library services. The Library Regulations section, for example, contains a collection of some 40 rules categorized into 6 sections. These rules range from the definition of the different categories of Library users (academic staff, undergraduate students, post graduate students etc) to very specific rules such as what desk borrowers need to go to and what paperwork they need to fill, depending on the different items they want to borrow (books, periodicals, short Loan Collection etc). In the following discussion we use parts of the three documentation sections, listed above, that we assemble as needed in order to illustrate the Lightswitch method.

## 6.1 Step 1: Identifying relationships

Figure 6.1 shows a part of the Library documentation. In this part, we highlighted the terms that help us to understand the Library's relationships. This part gives the definition of some of the terms used throughout the Library documentation. In particular, it defines the main clients that the Library sees itself as serving and a broad definition of the provided services called "facilities of the Library." This part classifies the clients into roughly 4 categories of users: Academic staff, undergraduate students, postgraduate students, and other persons. A subscription charge is required of "other persons" but no mention of charges is made with respect to the three other categories of users.

Using this documentation, we can model the Library and its stakeholders.

### **(1) Terms Used in these Regulations**

The term "academic and related staff" means those members of the staff of the University who are paid on academic and academic-related salary scales and also academic staff who have formal Visiting or Honorary status.

The term "undergraduate" means a student registered for part or all of the course of study leading to a first degree, diploma (except a postgraduate diploma) or certificate of the University.

The term "postgraduate" means a student registered as a candidate for a higher degree, postgraduate diploma or postgraduate certificate of the University.

The phrase "facilities of the Library" includes access to materials, staff time, services, and space provided for users. The use of such facilities may require the payment of a prescribed charge and may be restricted or withdrawn at the discretion of the Librarian. The additional regulations which apply to campus computing services are set out in the separate Regulations for the use of Computing Services.

### **(2) Library Users**

(i) The facilities of the Library including borrowing rights are available to all academic and related staff, all other staff, and registered postgraduate and undergraduate students of the University who comply with the Regulations set out below.

(ii) The facilities of the Library including borrowing rights are also available to postgraduate research students of the University who have completed the period of registration and who have paid the charge prescribed for the use of University facilities while writing up their theses.

(iii) The facilities of the Library may also be made available by special permission of the Librarian to other persons.

### **(3) Subscription charges**

The facilities of the Library are available to users specially admitted under 2(iii) on payment of the prescribed charges in force at the time of application. Such charges may be altered or waived at the discretion of the Librarian.

## External Borrowers

### Application

Anyone wishing to be registered as an external borrower of the Templeman Library should apply in writing to: The Director of Information Services and Librarian, Templeman Library, University of Kent at Canterbury, Canterbury, Kent CT2 7NU.

**Figure 6.1 Initial source used for identifying the Library and its stakeholders**

The highlighted terms in Figure 6.1 give us the following list of entities:

- library
- university
- librarian
- users
- undergraduate students
- postgraduate students
- academic staff
- other persons
- facilities of the Library
- materials
- staff time
- services
- space
- payment
- prescribed charge
- campus computing services
- borrowing rights
- external borrowers

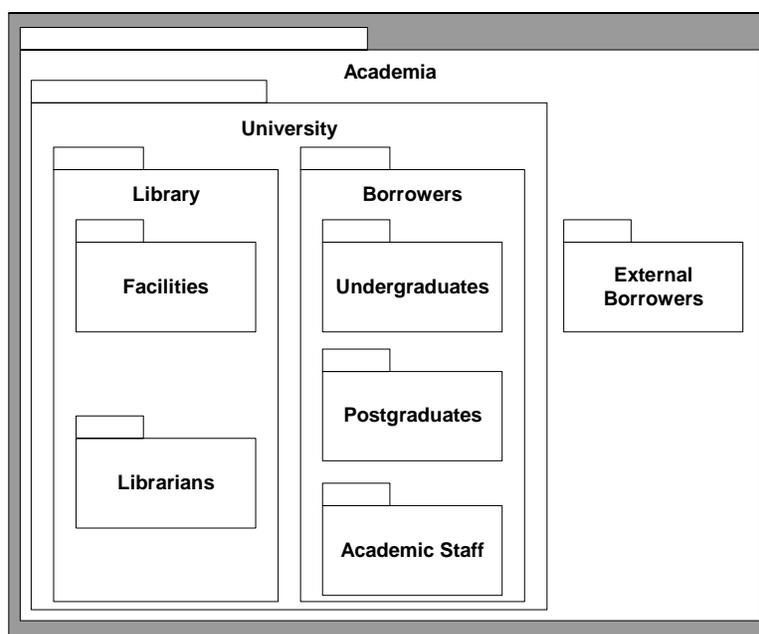
The text in Figure 6.1 explains some of the relationships between these entities. For example, that the Library is part of the university, that the Library provides the “facilities of the Library” to users of the Library; that these facilities include “materials, staff time, services, space, and borrowing rights,” and possibly other things; that users of the Library are undergraduates, postgraduates, academic staff, and other persons; that undergraduates and postgraduates are students at the university whereas academic staff are people who are paid by the university.

We further infer that “other persons” represent either personnel of the university that is not in any of the categories described above or an “external borrower” as indicated by the last statement in Figure 6.1. We hypothesize that “external” means external to the university.

The terms borrower and user seem to be used interchangeably in the Library documentation. We will use the term borrower in the rest of this chapter. For reasons of simplicity, we reduce the list above to

a smaller list of entities that we consider as enterprises and that we will analyze further. Those enterprises are:

- library
- university
- librarian
- borrowers
- undergraduates
- postgraduates
- academic staff
- facilities of the Library
- external borrowers



**Figure 6.2 Initial relationship model of the Templeman Library**

We represent the enterprises we have identified in the list above as communities in Figure 6.2. The community named *Library* represents the enterprise we study, the Templeman Library. The other communities represent the stakeholders of the *Library*. In the model in Figure 6.2 we:

- group the different *borrowers* considered as *internal borrowers* of the university in the *borrowers* community
- group the *facilities* and *librarians* communities in the *Library* community
- group the *Library* and *borrowers* communities in the *university* community
- place the *external borrowers* community outside the *university* community
- group the *university* and *external borrowers* communities in a supra-community called *academia*

The choice of *academia* as the supra-community is purely pragmatic. This choice means that we somehow consider *external borrowers* to be interested in academic affairs such as research and

teaching. This choice may make the designer blind to other potential users of the Library. However, we will not address this issue further in this section.

We can analyze the model in Figure 6.2 to expose the following norms of the university:

- The university has undergraduate students
- The university has postgraduate students
- The university has academic staff
- The university has a Library

The Library uses the norms of the university for the stability of its own norms (Heuristic H2). If the university didn't consistently distinguish between undergraduates, postgraduates and academic staff, the Library would have more trouble making this distinction. Also, if the university didn't have a well distinguished boundary between people who are part of the university and people who are not part of it, the Library would have difficulties distinguishing external borrowers. As we will see, these norms are extremely important to the Library because the Library uses them as the basis of its regulation mechanism.

Figure 6.3 shows another part of the Library documentation. This part defines the behavior that the *Library* expects of the *borrowers* and the behavior that the *borrowers* can expect from the *Library*.

#### **(4) Borrowing**

(i) Material may be removed from the Library only after the relevant borrowing procedure has been followed. Any removal or attempted removal of an item without complying with this procedure constitutes an offence and renders the borrower liable to disciplinary action.

(ii) The borrower must hand items with bar-coded labels from the main loan collection together with a valid Library card to an assistant at the Main Loan Desk. To borrow all periodicals, the borrower must fill in and sign a separate loan voucher for each item and hand periodicals and vouchers to an assistant at the Main Loan Desk. To borrow material from the Short Loan Collection, the borrower must hand to an assistant at the Short Loan Collection desk details of the item to be borrowed together with a valid Library card. To borrow material from the Audio-Visual Materials Collection the borrower must comply with the loan procedure in force.

(iii) There are prescribed periods of loan for material not specifically confined to the Library and limits on the numbers of items allowed on loan to a borrower at any one time. Details of the current arrangements are available from the Main Loan Desk.

(iv) Loans may be renewed if the item is not required by another borrower. Telephone renewals are not permitted except in the case of part-time or disabled students.

#### **Restrictions on Borrowing**

(v) No current number of a periodical, or other material specifically confined to the Library may be removed from the Library except with special permission of the Librarian.

(vi) The borrowing of items from the Short Loan Collection is restricted in various ways which are specified at the time of borrowing. Details are available from the Short Loan Collection desk.

(vii) Items borrowed must be returned by the due day and time which is specified when the item is borrowed.

(viii) Periodicals may not be borrowed by undergraduates except with the written authorisation of their Tutor or the member of the academic staff for whose course the periodical is needed, or the special permission of the Librarian.

(ix) After a main loan collection item has been in the possession of any borrower for a week it may be recalled if required by another user.

(x) The Librarian may recall material at any time, if it is required for special purposes, and may withhold or

restrict the circulation of any item.

## **Borrowing Books and Journals**

### **Undergraduates**

Undergraduates may borrow 8 books from the open shelves + 4 books from the Short Loan Collection. They may not borrow periodicals. Photocopies of articles on reading lists are usually available from the Short Loan Collection.

Books on the open shelves may be borrowed for four weeks unless they are in the following restricted loan categories:

### **One Week Loan Books**

Books on the open shelves with a one week date label may be borrowed for one week only.

### **Postgraduates**

Postgraduates may borrow 16 books or periodicals from the open shelves plus 4 books from the Short Loan Collection.

Periodicals not confined to the Library may be borrowed for one week.

Books on the open shelves (except those on one week loan: see above) may be borrowed for:

Taught postgraduates - 4 weeks

Research postgraduates - 10 weeks

### **Teaching Staff**

Teaching staff may borrow 24 books or periodicals from the open shelves plus 4 books from the Short Loan Collection.

Periodicals not confined to the Library may be borrowed for one week

Books on the open shelves (except those on overnight or one week loan: see above) may be borrowed for up to one year.

### **Part-Time Students**

Part-time students have the same borrowing rights as full-time students. In addition, students on part-time courses have their own Part-Time Collection of books and articles which can be obtained from the Short Loan Collection counter and taken out for a week. Special arrangements are available for telephone renewal from both the PTC and SLC.

### **Renewals**

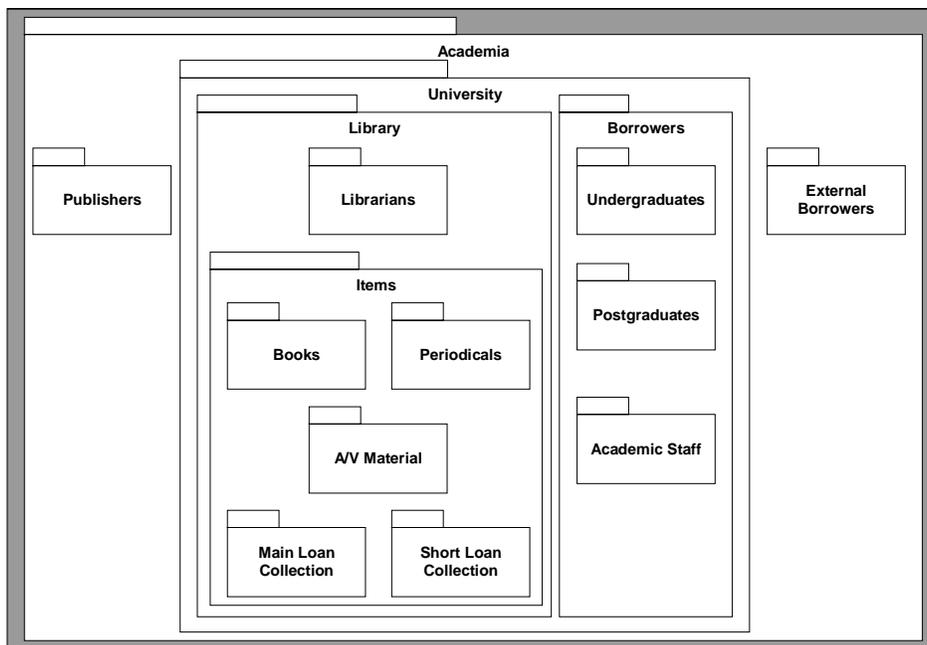
Items, except Short Loan and Part-Time collection loans [SLC renewal - PTC renewal] may be renewed via the Loan Desk, Web Catalogue, or telephone (01227) 827131 (internal 7131) provided they have not been reserved or requested by another user.

**Figure 6.3 Borrowing regulations of the Templeman Library**

Considering the highlighted text in Figure 6.3, we can refine our model of the Library by refining the *facilities* community. This community can now be seen as consisting of *items* that can be borrowed, *books, periodicals, audio visual material*. Since, in this study we are not interested in the rest of the facilities of the Library, such as rooms, borrowing desks etc., we remove the *facilities* community and replace it the *items* community. In Figure 6.4 we model these enterprises as being part of the Items community. The norms in Figure 6.3 sometime refer to the books, periodicals, etc, as material and sometimes as items. We use the term items in the rest of this section. Figure 6.4 also shows the Short

Term Collections and Main Loan Collection mentioned in Figure 6.3. The text in Figure 6.3 doesn't specify what items are included in one or the other collection or how the decision is made to place an item in one collection or the other. We therefore consider these collections as separate from the other types of items (books, periodicals and AV material).

In Figure 6.4 we have also added the *publishers* community. Note that the Library documentation doesn't mention how items are purchased by the Library. Knowing the rate at which academic items are produced, we can assume that such purchases form a substantial part of the Library's operations. For reasons of simplification, we placed the *publishers* community in the *academia* community even though some items may be purchased from outside the academia or be provided from inside the university.



**Figure 6.4 Refined relationship model of the Templeman Library**

Note that the set of norms in Figure 6.3 does not appear to be a consistent set. For example, rule 4.iv specifies that renewals can only be done in person, and that phone renewals are not accepted except for special cases. This contradicts the last rule under the Renewals heading, which specifies that renewals may be made in person, through the Web catalog, or by telephone. This gives the impression that the norms have evolved through time with no specific goal in mind.

## **6.2 Step 2: Analyzing how the relationships are regulated**

Considering the model in Figure 6.4 we can credit the *Library* community with the following maintenance goals:

- Maintain relationships with borrowers
- Maintain relationships with external borrowers
- Maintain relationships with publishers
- Maintain relationships with librarians
- Maintain relationships with items
- Maintain relationships with university

Since the Library documentation only specifies the relationships between the Library and the borrowers, we will focus on this relationship only. From the point of view of the borrowers, the

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Library's purpose can be stated as: Provide items on demand. However, the maintenance goals of the *Library* show that while it provides items to borrowers, it also regulates (restricts) the access of borrowers to items. These regulations seem to be contrary to the purpose of the Library from the borrowers' point of view. To understand why this is the case, we need to understand the problems the *Library* believes it is facing.

## 6.2.1 Maintaining Relationships with borrowers

### 6.2.1.1 Imposing borrowing restrictions (managing scarce resources)

An abstract view of the Library regulations in Figure 6.3 gives us the following business processes expressed as rules:

- If Borrower wants to borrow item then Borrower registers borrowed item
- If item borrowed then Borrower returns item before or at due date

In this section we analyze these rules to understand what and how they regulate.

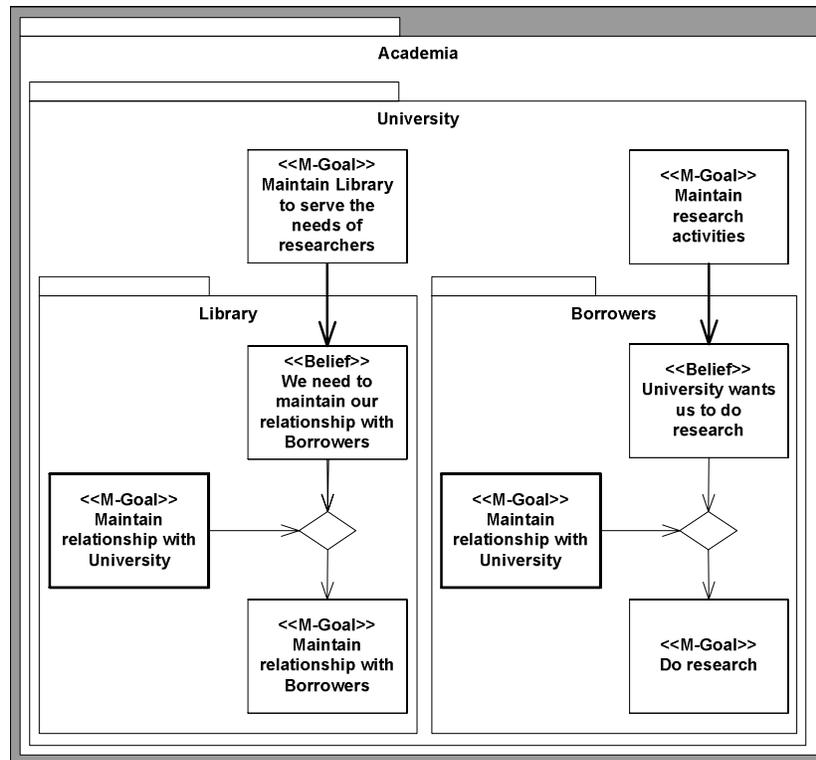
From the point of view of the borrowers, the purpose of the Library is to provide them with items whenever they need them. However, these items do not exist in sufficient quantity to be available to all borrowers at the same time. The basic assumptions underlying the regulations are that:

- If a borrower takes possession of an item, the item is not available to other borrowers.
- There are many borrowers who may want to borrow items at the same time

If the Library could purchase duplicate copies of items or create them on demand and distribute them to borrowers, the whole concept of borrower may disappear since it is based on the notion of sharing a scarce resource. In other words, if the number of borrowers was small with respect to the capability of the Library to provide them with individual copies, or if the borrowers were guaranteed to not request the same item at the same time, the Library may not need to regulate access to items. Thus, whereas the Library has certainly some duplicates of items, like any Library, having numerous duplicates of every item is probably overly expensive and legally prohibited.

Thus, the access to these scarce items is regulated so that all borrowers can obtain reasonable but not total access to these items. The Library faces the same dilemma as most other systems, the borrowers are the source of opportunities and threats at the same time. The relationship with borrowers needs to be regulated so that the borrowers receive a quality of service they can accept but their actions are constrained so that they don't threaten the service that the Library provides to these same borrowers in ways that are unacceptable to the Library and the borrowers themselves.

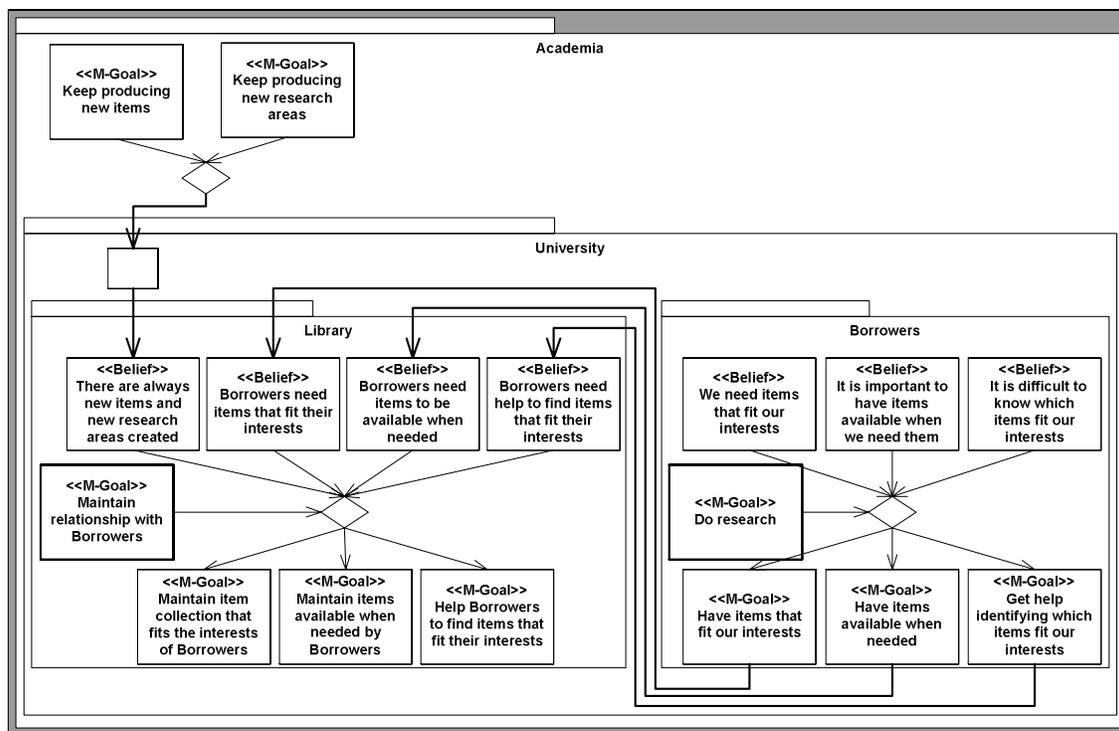
The regulation implemented by the Templeman Library and similar to most libraries is based on a strategy known to software engineers as time sharing. Access to a given item is granted to a given borrower for a limited period of time so that the item will always return the Library eventually so that other borrowers can have access to it. This is the basic idea behind the borrowing system.



**Figure 6.5 Maintaining relationships with university**

In Figure 6.5 we begin by modeling the relationships of the library and the borrowers with the university. In this model the *borrowers* maintain their relationship with the *university* by doing research, i.e. their belief that they need to do research is connected to the *university's* maintenance goal of maintaining research activities. This maintenance goal can also be linked to a maintenance goal of the *academia* community, to maintain research activities. However, this is not shown in Figure 6.5.

The *library* also needs to maintain its relationships with the *university*. The *university's* goal in maintaining a *library* is to serve the needs of its *researchers*. In Figure 6.5 we represent that this maintenance goal of the *university* is linked to the belief of the *library* “we need to maintain our relationship with Borrowers.” The associated subgoal of the *library* is to “maintain relationship with Borrowers”. The focus on borrowers rather than on researchers in Figure 6.5 derives from the library’s regulation in Figure 6.3 where the focus is on borrowers and borrowing rather than on researchers. We thus model that even though the university and the researchers are primarily interested in doing research, the library is mainly (at least as far as its regulations enable us to see) interested in its borrowing relationships.



**Figure 6.6 Helping borrowers to do research**

We can now further analyze the relationship between the borrowers and the library by reducing the goals obtained in Figure 6.5. The resulting model is shown in Figure 6.6. We refine the *borrowers'* goal “Do Research” into subgoals by considering three beliefs held by the *library's borrowers* (who as we have seen can be seen as researchers):

- We need items that fit our needs
- It is important to have items available when we need them
- It is difficult to know which items fit our interests

We use these beliefs to specify the following subgoals for the *borrowers*:

- Have items that fit our interests
- Have items available when needed
- Get help identifying which items fit our needs

These goals connect to three of the *Library's* beliefs respectively:

- Borrowers need items that fit their interests
- Borrowers need items to be available when needed
- Borrowers need help to find items that fit their needs

A fourth belief of the *Library* “there are always new items and new research areas created” is connected to maintenance goals of the *academia* community that keeps producing new items and new research areas. This belief shows that the *library* cannot achieve a state where its collection of items ultimately fits the needs of *borrowers* but rather that having a collection of items that fits the needs of its *borrowers* is, for the *library*, an on-going, never ending activity, i.e. that it cannot be modeled with an achievement goal but rather with a maintenance goal. Continuously maintaining the fit of the collection of items to the needs of *borrowers* means that making this ever changing collection of items available to *borrowers* and helping *borrowers* to find the items they need are also on-going activities.

These activities need to be modeled as maintenance goals. We use the *library's* four beliefs to motivate the *Library's* reduction of the goal “maintain relationship with Borrowers” into three maintenance goals:

- Maintain item collection that fits the interests of Borrowers
- Maintain items available when needed by Borrowers
- Help Borrowers to find items that fit their interests

This means that the *library* provides three basic services to *borrowers*, it maintains a collection of item that enables *borrowers* to do research; it maintains its capability to share this collection among *borrowers*, and it helps *borrowers* to find the items they need.

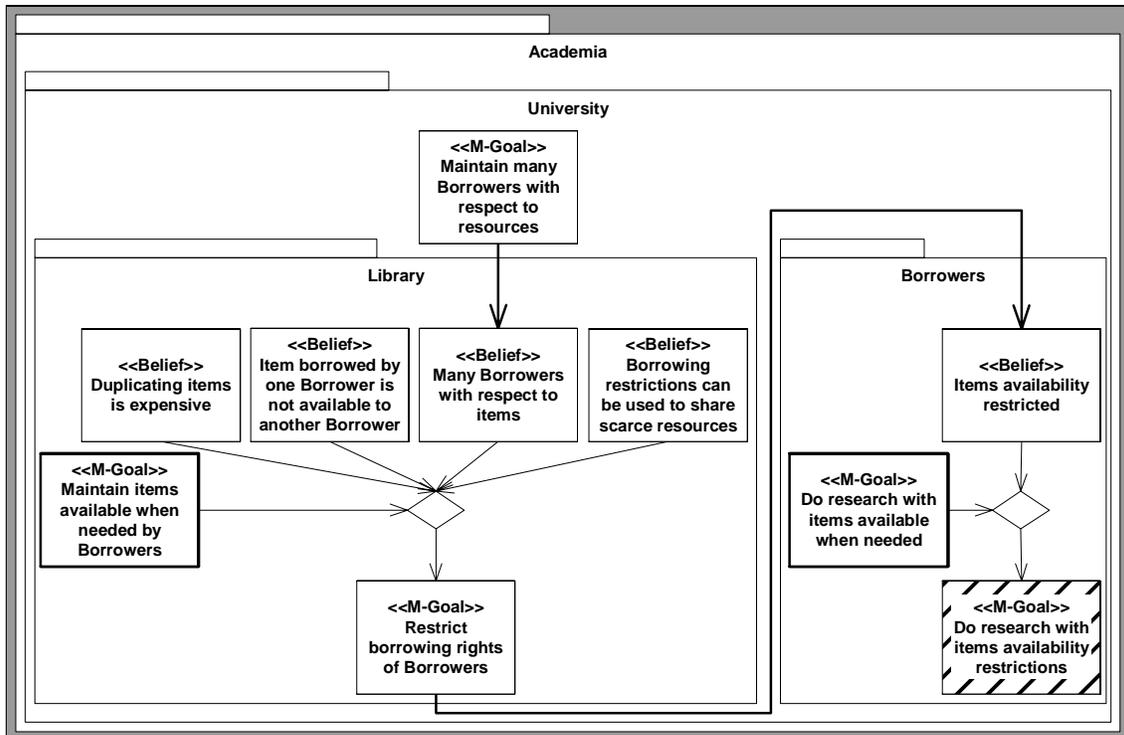


Figure 6.7 Maintain items available when needed by borrowers

In Figure 6.7 the goal of the *Library* “Maintain items available when needed by Borrowers” is further reduced to the goal “Restrict borrowing rights of Borrowers” by taking into account two beliefs of the *Library*: “Many Borrowers with respect to items” and “Borrowing restrictions can be used to share scarce resources.” The restriction of borrowing rights influences the *borrowers* into doing research with these restrictions. This goal is highlighted in Figure 6.7. This shows that the borrowing restrictions are not what *borrowers* would want to have but that they accept the situation even though it is not perfect from their point of view.

Table 6.1 reviews the maintenance goals and possible beliefs justifying the borrowing restrictions and information services provided to *borrowers*.

Maintenance Goals	Beliefs
Maintain collection of items comprising books, periodicals and other items	Borrowers need items that they do not wish or cannot afford to own  The collection of items matches the expectations of the borrowers

Maintain a limited number of copies per item	The Library has limited resources to purchase books and periodicals The Library has limited resources for maintaining and storing its inventory
Maintain some of the items available for borrowing	These items can be replaced if lost or it may be unimportant if they are lost
Maintain some of the items not available for borrowing	These items cannot be replaced or are too expensive to replace
Impose borrowing restrictions on Borrowers	When an item is borrowed by one person, it is not available to another person Only a limited number of copies of each item are available
Offer a reservation service for borrowed items with the possibility of recall	When a borrower requests an item they may not be able to wait for the borrowing period to expire
Maintain information services available to all borrowers	Borrowers need information services to find items The information services provided match the expectations of borrowers
Provide information and borrowing services to (internal) borrowers free of charge	The university insures the financing of the Library
Provide information and borrowing services to external borrowers for a fee	External borrowers don't pay tuition, they need to participate in financing the Library

**Table 6.1 Maintenance goals and beliefs justifying the borrowing restrictions and information services provided to borrowers**

### 6.2.1.2 Separating kinds of borrowers (customer specialization)

The basic borrowing system can be augmented, as is the case with the Templeman Library, with additional regulations that grant more or less access rights to some borrowers.

We have seen that the Library separates the borrowers into 4 broad categories: undergraduates, postgraduates, academic staff, and external borrowers. We can group the undergraduates and postgraduates into the category of students to broadly distinguish them from academic staff.

The maintenance goal that grants the *academic staff* more borrowing power than it grants to *students* can be understood as the *Library's* need to insure that what it believes are its main clients, i.e. *academic staff*, can have reasonable access to items even though there are far more *students*, *undergraduates* and *postgraduates*, than there are *academic staff*<sup>1</sup>. The regulation mechanism can be seen as limiting the number of items students can borrow and the time limit for borrowing so as to

<sup>1</sup> The ratio is probably about 12000 students and 1600 university staff not all of which are academic staff (Peter Linington, private communication).

limit the overall number of items borrowed by *students* at any given time. This, in principle, gives the *academic staff* more access to items. Not only do individual members of the *academic staff* enjoy more borrowing power, i.e. more items for longer periods of time, but they are also more likely to have the item they are looking for available for borrowing. However, it could also be that the *Library* simply believes that *students* cannot be trusted to return items as much as the *academic staff* can. Thus imposing more stringent borrowing restrictions on *students* can be understood as limiting the risk from non trustworthy *borrowers*.

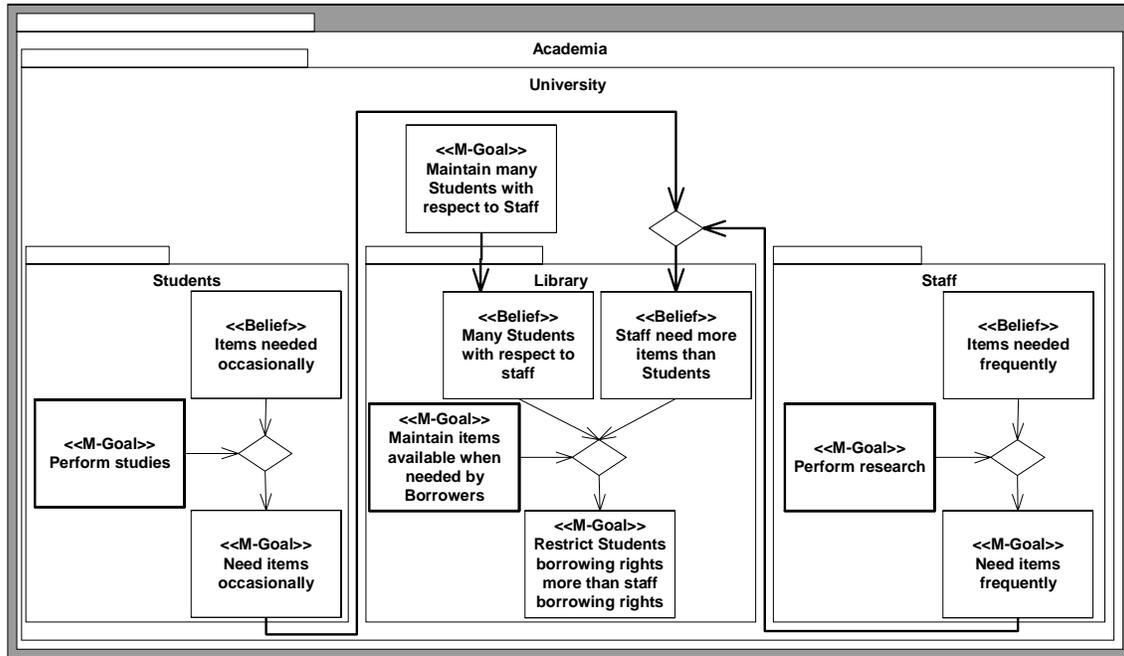


Figure 6.8 Separation of variables between Students and Staff

Figure 6.8 models the situation where the *Library* believes that the students need items less frequently than Staff.

Within the student community another such separation is performed. The Library authorizes postgraduates to borrow more items for a longer time than undergraduates. This separation can be understood by inspecting the number of undergrads and postgraduates the Library serves. According to official university figures (<http://www.ukc.ac.uk/about/statistics.php>), the university had, as of 1.12.2001 eight times more undergraduates than postgraduates. Thus undergraduates pose a much greater threat to the Library items and academic staff than postgraduates. Also, the university may try to give postgraduates a chance to get better access to items than undergraduates in the same style as for academic staff. Thus, the likelihood that postgraduates and academic staff may find the item they want to borrow unavailable is reduced.

The Library also protects some items more than others. Undergraduates, for example, are not allowed to borrow periodicals:

- (viii) Periodicals may not be borrowed by undergraduates except with the written authorisation of their Tutor or the member of the academic staff for whose course the periodical is needed, or the special permission of the Librarian.

We can say that it seems as though periodicals are more important than books or that they are more vulnerable. The access to “current periodicals” and other unspecified material is regulated even more; these items may not leave the Library premises. The most highly protected items, though, are those in the special collection and cartoons. Special collection items are only accessible through Library staff by appointment, can only be consulted in an “appropriate reading room” and only to “the user [who] is familiar with the Library’s rules for the handling of Special Collections items and agrees to observe them.”

Table 6.2 reviews the maintenance goals and possible beliefs justifying the separation of kinds of *borrowers*.

Maintenance Goals	Beliefs
Restrict borrowing by undergraduates more than postgraduates and postgraduates more than academic staff	<p>The university has many more undergraduates than postgraduates and academic staff. If undergraduates are allowed to borrow more items for more time. There may be not enough items available to the other kinds of borrowers</p> <p>undergraduates do not need as many items as postgraduates and academic staff</p> <p>undergraduates can be trusted less than postgraduates</p> <p>postgraduates can be trusted less than academic staff</p>

**Table 6.2 Maintenance goals and beliefs justifying the separation of kinds of borrowers**

The norms we have analyzed so far can be seen as **unconditional** regulation mechanisms. They are in place regardless of any condition. We will now analyze some of the norms that specify conditional regulation mechanisms.

### 6.2.1.3 Conditional regulation mechanisms

One of the conditional mechanisms (Heuristic H11) used by the Library is the possibility it offers borrowers to recall items from other borrowers:

(ix) After a main loan collection item has been in the possession of any borrower for a week it may be recalled if required by another user.

This norm can be expressed as the following rule:

- If item has been in possession of borrower for a week and item is required by another borrower then Library can recall item

This norm defines a backup mechanism that complements the borrowing limits and time limits. This mechanism enables a borrower to “extract” an item from another borrower. The recall mechanism is a good example of a conditional regulative mechanism that gets into action only if needed.

However, it may have some side effects that may not be desirable by borrowers. Indeed, this norm renders the borrowing time unpredictable. A borrower who borrows an item for a month may be requested to return it after a week or two.

#### Return of materials

(xi) Borrowers who, without good cause, fail to return an item or to renew the loan when it is due, will become liable to a charge at the rates prescribed until the book or periodical is returned to the Library and may have borrowing rights suspended.

(xii) Items recalled under (ix) or (x) from any category of borrower must be returned immediately. A borrower who, without good cause, fails to return an item that is so recalled within **5** working days after that on which the recall card was issued, will become liable to the prescribed overdue charges and suspension of borrowing rights, continuing until the item is returned.

(xiii) Borrowers returning items must hand them in at the return point of the Main Loan Desk, Short Loan Collection desk or Document Delivery office as appropriate.

- Any charges due on overdue items must be paid at this time.
- (xiv) Items returned to the Library by post must be returned by registered post or recorded delivery.
- (xv) Failure to pay charges may result in suspension by the Librarian of borrowing facilities.

**Figure 6.9 Escalating measures for not returning items**

Figure 6.9 shows another set of conditional mechanisms designed to prevent a *borrower* from keeping an item indefinitely. We can express them as the following rule:

- If item not returned at due date Library fines borrower

In general the Library considers borrowers to be unreliable. The Library cannot trust them to return the items they have borrowed when the borrowing period has expired. Thus, it has a norm that imposes penalties on borrowers who fail to return an item by its due date. The penalties range from fines to suspension of borrowing rights to legal action. These penalties can be seen as an escalation of regulative mechanisms, if a borrower keeps an item past the due date, he will be fined. To make sure he pays the fine, his borrowing rights will be suspended. When he comes back to borrow an item he will have to return the item and pay the fine. Thus, the Library defines a set of conditional mechanisms designed to further protect the Library items by specifying escalating measures in case of breaches of the regulations. This is in line with Cannon's Homeostatic principles of bringing into play multiple mechanisms successively or simultaneously. A somewhat hidden aspect of these protection mechanisms is their interdependence. Disciplinary action seems to be the most powerful measure since it is much cheaper than an action in court but it can only be applied towards members of the university. Disciplinary action is quite harmless against people outside the university. This may be the reason for preventing outsiders from borrowing items unless they are registered and have paid dues that can be used in case of loss of items. These two norms (who is allowed to borrow items and what are the penalties for non conformance to regulations) are interlinked and are only efficient when applied simultaneously.

Table 6.3 summarizes the maintenance goals and possible beliefs justifying the separation of kinds of borrowers.

Maintenance Goals	Beliefs
Impose penalties on borrowers in case of non compliance with the norms.	Borrowers cannot be trusted to return items on time  The penalties are effective against threats from borrowers
Maintain Librarians' power to exercise judgment and overrule norms when judged necessary	The restrictions imposed by the Library may be too limiting, some judgment is necessary in their application

**Table 6.3 Maintenance goals and beliefs justifying the conditional regulation mechanisms**

### **6.3 Step 3: Identifying changing conditions**

#### **6.3.1 Addressing borrowers' dissatisfactions**

In Section 6.2.1 we have identified that the Library regulates its relationships with borrowers by imposing borrowing restriction on the borrowers. We have seen that borrowers may not like these restrictions and that these restrictions may prevent them from having the items that they need when they need them. Individual borrowers have to accept these restrictions for the better good of all borrowers. Changing conditions in the capabilities of IT systems, however, may help the Library to

ease some of these restrictions. Moreover, the Library may be facing competition from other libraries and sources of information in a way that was not possible before. A university library used to be the sole provider of items to the faculty and students. If the Library doesn't address these and other dissatisfactions it may become irrelevant to its potential borrowers who may prefer to other sources for the information they need.

### 6.3.2 The rise of digital libraries

The borrowing restrictions analyzed in Section 6.2.1 were based on the assumption that the items in the Library are considered as scarce resources. IT systems developments in the publishing sector, however, are challenging this assumption (heuristic H6). These developments are inspiring the creation by publishers and universities of so called digital libraries. Digital libraries typically contain traditional library items such as books, journals, conference proceedings, etc. in electronic form, as computer files (see the IEEE ([www.ieee.org](http://www.ieee.org)) and the ACM ([www.acm.org](http://www.acm.org)) for examples of such digital libraries. Since the cost of duplication of a computer file is currently very low, it is possible to create a copy each time an item is borrowed. The cost of "physical duplication" of an item is not the only constraint of item duplication, though. Another constraint is the legal copyright, however, in many cases this is but a fraction of the cost of a copy. Therefore, some digital libraries offer very low prices on individual or institutional subscriptions. An institutional subscription enables a university library, for example, to provide access to a quasi unlimited number of copies per item. The scarce resource has become abundant. The whole scheme of borrowing restrictions becomes inoperative when borrowers can download items from servers and thus create their own copies (electronic or printed). The IEEE and ACM digital libraries, for example, already make it superfluous to subscribe to the journals published by these organizations. Thus, the norm that prevents Undergraduates from borrowing periodicals is becoming obsolete. There is a danger, though, that such a norm may be implemented in the IT system giving borrowers access to digital periodicals, if its reason of existence (as we have discussed above) is not clearly understood.

Similarly, the borrowing scheme may be perpetuated regardless of the need to share scarce resources but as a way of limiting the cost of owning an item for an unlimited time. Borrowing restrictions may then be embedded in the items themselves, which will expire and become unreadable when the due date is reached unless the item is renewed. This kind of scheme exists today in software applications. If this scheme doesn't survive, however, it may not make sense to refer to the Library's clients as borrowers because they may not borrow anything.

The scarce resources of the Library, the items, will not become abundant overnight. The existing items will remain scarce but it is probable that they will be gradually supplemented and, to some extent, replaced by electronic copies.

## 6.4 Step 4: Identifying, evaluating, selecting options and corresponding IT system goals

Having understood how the Library regulates its relationships and having outlined a few future trends the Library should be aware of, we can initially define goals for the IT system of the Library by analyzing the needs of the users of the IT system. We will focus mainly on the librarians and borrowers as users of the IT system. Thus, we only consider here a small part of the Library services because we do not consider the financial needs of the Library, the maintenance of its facilities. We do consider, however, some aspects of the Library's relationship with publishers as they may help to better regulate the relationship with borrowers. We will show how "high-level" goals for the *Library* IT system can be defined by examining the *Library's* goal: "Maintain relationship with Borrowers." This goal was reduced in the model in Figure 6.6 into the following goals:

- *Library* goals
  - Maintain item collection that fits the needs of Borrowers
  - Maintain items available when needed by Borrowers

- Help Borrowers to find needed items
- *Borrowers* goals
  - Do research with items available when needed
  - Know which items are needed

In the following sections we will analyze these goals to produce high-level goals for the *Library* IT system.

### 6.4.1 Helping Librarians to impose borrowing restrictions

To understand how the IT system could help the *Librarians* in imposing borrowing restrictions we begin our analysis from the goals “Maintain items available when needed by Borrowers” and “Do research with items available when needed.” These goals have already been reduced in Figure 6.7 to the goals: “Restrict borrowing rights of Borrowers” for the *Library* and “Do research with items availability restrictions” for the borrowers. Figure 6.10, Figure 6.11, and Figure 6.12 define a further reduction of these goals, resulting in goals for the IT system. This goal reduction is performed with the beliefs of the *borrowers* and *Library* influencing each other. The result of this goal-reduction, shown in Figure 6.12 is two high-level goals for the *Library*’s IT system: “Help Borrowers to know loan due dates” and “Help Borrowers to easily renew loan.” This analysis shows that, even though the *Library* imposes restrictions on *borrowers*, it can help *borrowers* to accept these restrictions by offering tools that enable *borrowers* to know what restrictions apply to them and help *borrowers* to apply these restrictions.

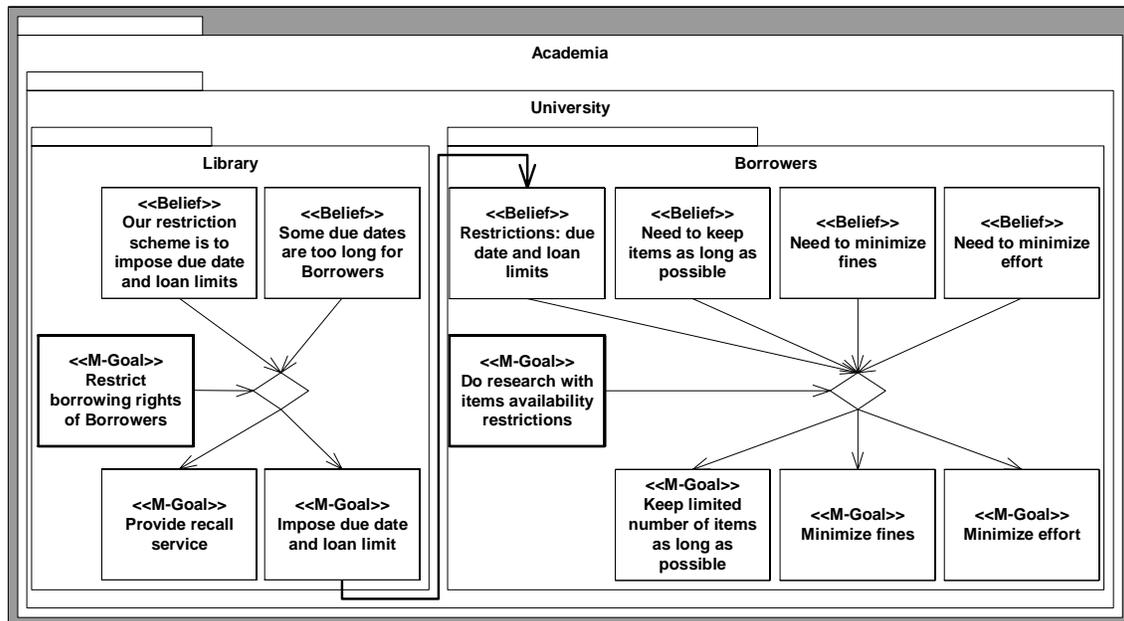


Figure 6.10 Goal reduction for “Restrict borrowing rights of borrowers”

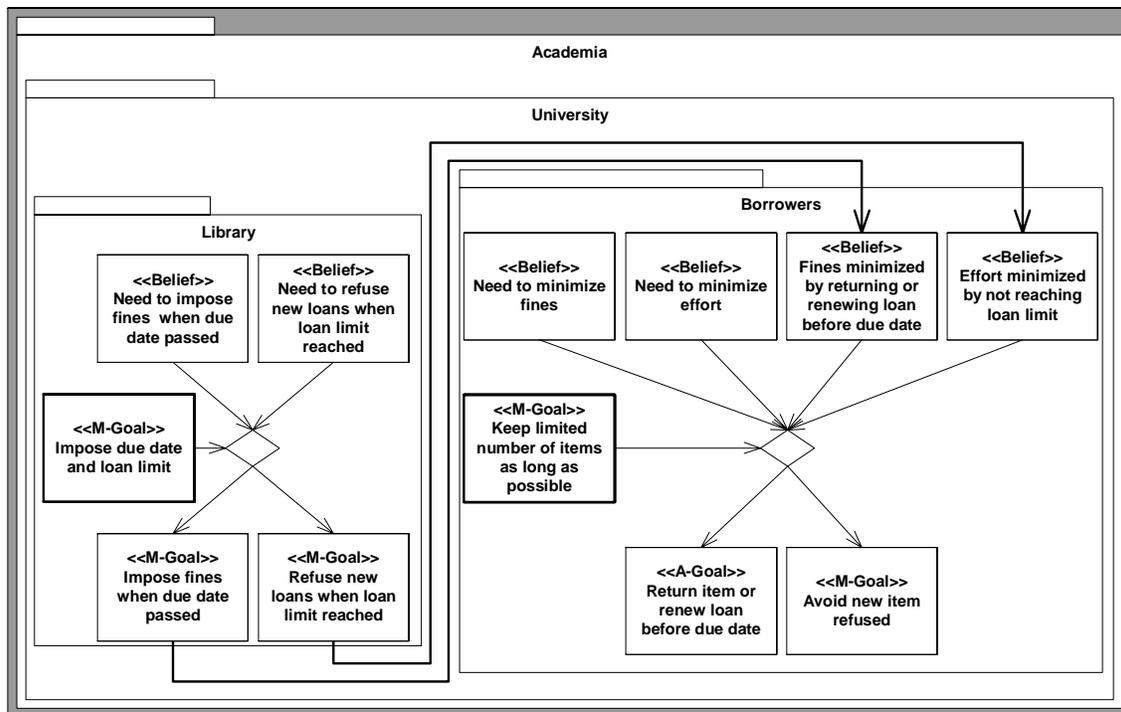


Figure 6.11 Goal reduction for “Impose due date and loan limit”

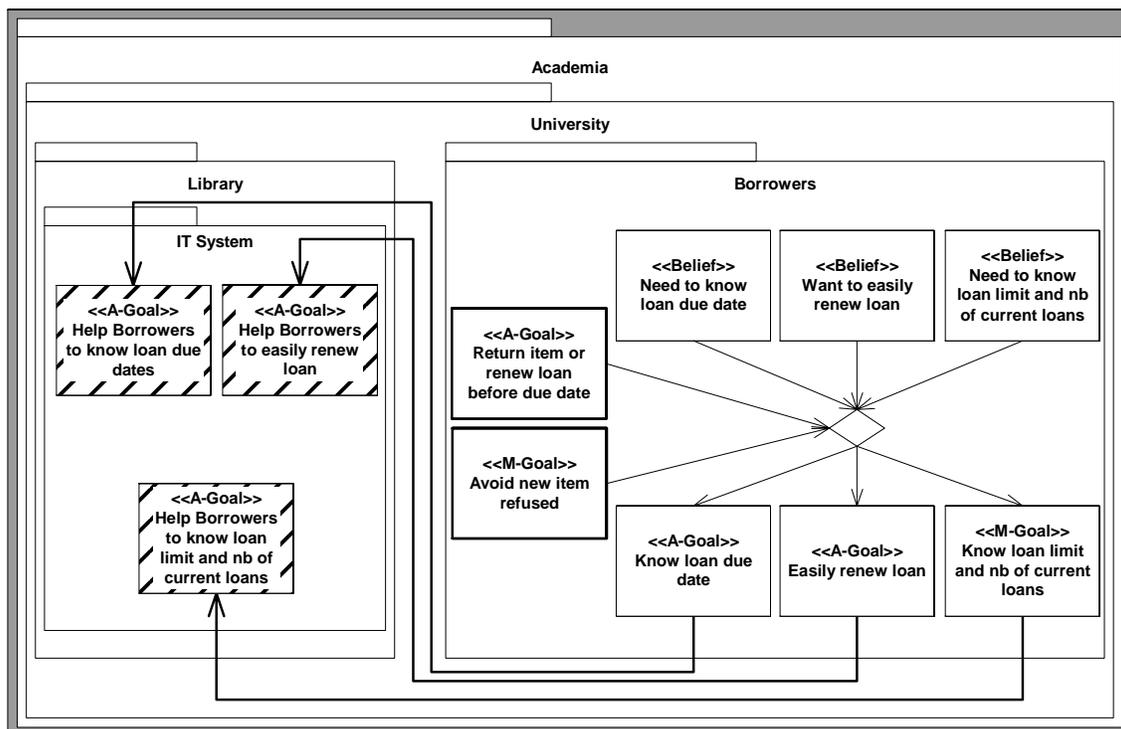


Figure 6.12 Goal reduction for “Help Borrowers to know loan due dates”

Taking the perspective of the Librarians with respect to the goal of the *Library* identified in Figure 6.7: “Restrict borrowing rights of Borrowers” we can define the following beliefs for the *Library*:

- Goal: Restrict borrowing rights of Borrowers
- Beliefs:

- Our restriction scheme is to impose due date and loan limits
- Due dates and loan limits are different for undergraduates, postgraduates, academic staff and external borrowers
- More restrictions can be imposed on “bad” borrowers

These beliefs give us the following IT system goals:

- Help Librarians to set and impose due dates and loan limits
- Help Librarians to distinguish between undergraduates, postgraduates, academic staff and external borrowers
- Help Librarians to distinguish between “good” and “bad” borrowers

## 6.4.2 Relaxing borrowing restrictions

We can define more IT system goals by further analyzing the effects of the borrowing restrictions on borrowers. More specifically, the goal we have identified in Figure 6.10: “Provide recall service.” This goal is due to a belief of the *Library* that “Some due dates are too long.” This means that a *borrower* who needs an item that is currently on loan (we will call her the *requestor*) may want to have access to the item before the *current borrower* is obligated to return the item. Remember that Academic Staff can borrow an item for a year. This seems to be too long a time to wait.

When the recall mechanism is put into action, the *current borrower* needs to return the item within 5 days or face penalties. A recall can only be triggered when the *current borrower* has had the item for at least one week.

The recall service solves the problem of the *requestor* but presents problems for the *current borrower*. The recall service makes it difficult for the *current borrower* to anticipate how much time they may keep an item. It also may not be efficient if the *Requestor* changes her mind and doesn’t bother to retrieve the item when the *current borrower* has returned it. The *requestor* may also only want to briefly look at the item and may promptly return it to the *Library* without the *current borrower* knowing that the item has become available. With no other control mechanisms, two borrowers may force each other to return an item within a week of having borrowed it, and do it indefinitely. We presume that in practice, the *librarians* will prevent such a case from occurring.

We can compare this Library norm to the norm of the Library of the University of Lausanne, Switzerland (BCU, <http://virtuavd.unil.ch/>). At the BCU, the effect of reserving a currently borrowed item is to prevent the current borrower from extending the borrowing period. The requestor is notified by the Library when the item has been returned by the current borrower. The BCU doesn’t have the same norm of recalling an item when it has been reserved. It thus uses a strategy that resembles what software engineers know as cooperative multitasking (it is only semi cooperative since there is a limit on how much time the item can be kept by the current borrower) versus the Templeman Library’s strategy of preemptive multitasking. This means that the requestor is likely to wait until the end of the borrowing period of the current borrower. The standard borrowing period is 4 weeks. The BCU’s norm is that this is a reasonable time to wait for a reserved item. In the case of the Templeman Library, Academic Staff enjoy a longer borrowing period (six months). This period of time is considered by the BCU to be too long for a requestor to wait. It thus has the norm of giving the identity of the current borrower to the requestor when the current borrower is an Academic Staff. This enables, the requestor obtain access to the item by directly contacting the current borrower.

This norm of the BCU may not be effective if the requestor is a student and the current borrower a professor. The student may be reluctant to get into direct contact with a professor for the purpose of requesting an item. Also, maybe the academic staff don’t want their identity to be given to the requestor. Maybe a mixed solution giving academic staff the choice of returning the item or divulging their identity would give better results while protecting the identity of the requestor could be designed.

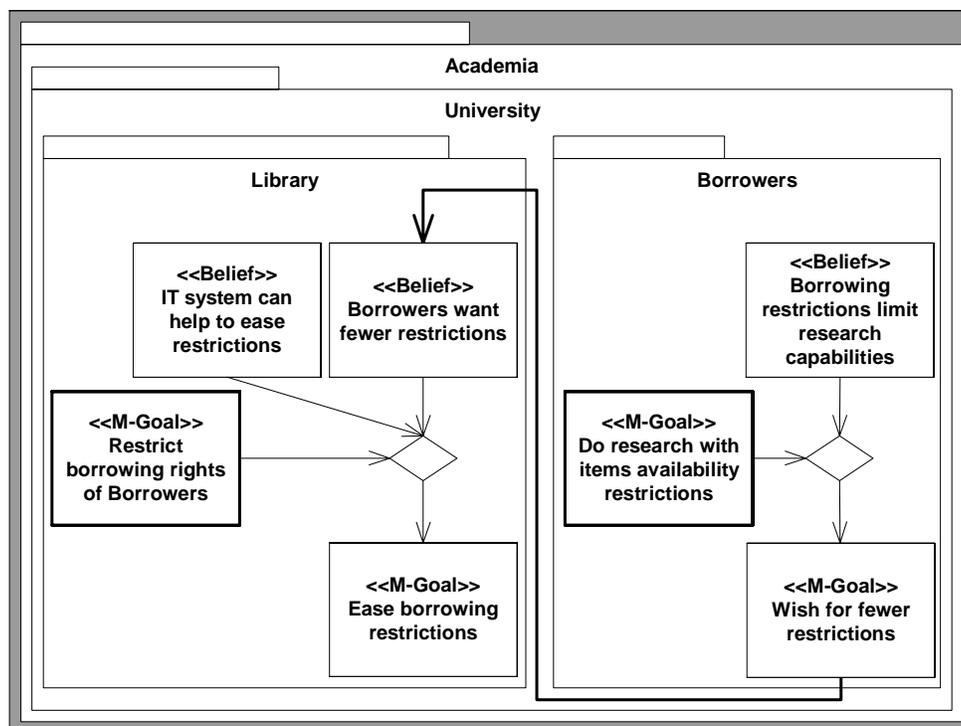
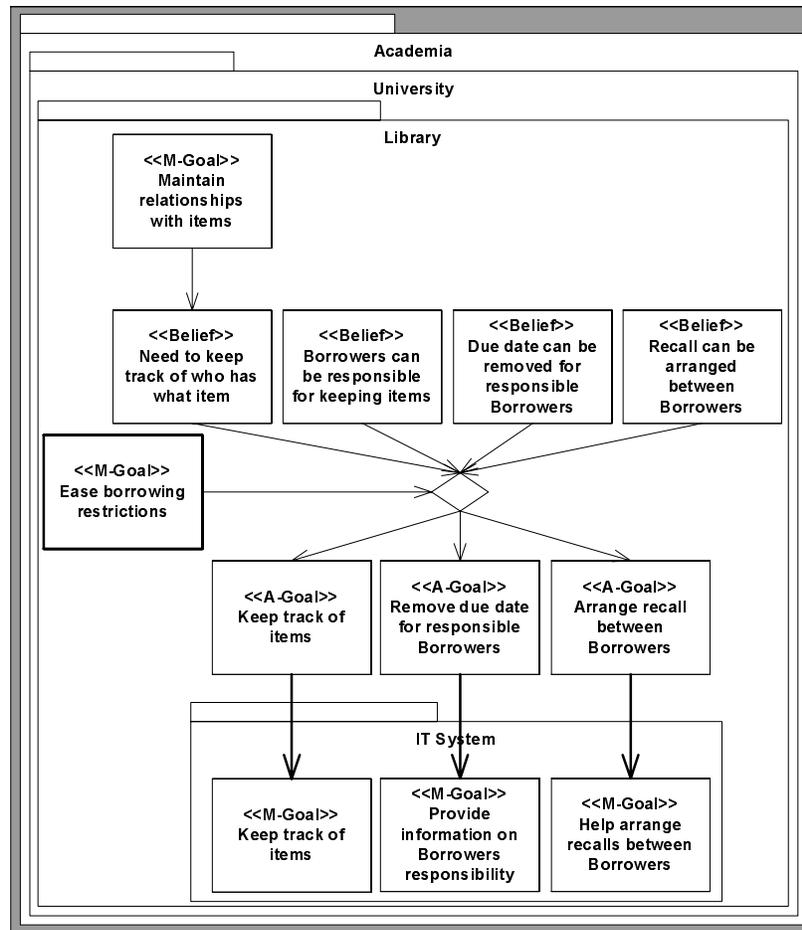


Figure 6.13 The need to ease borrowing restrictions

Figure 6.13 shows the case where the Templeman *Library* realizes that borrowing restrictions need to be eased. This realization is influenced by a belief that *borrowers* want fewer restrictions and by a belief that an IT system can help to ease restrictions.

Figure 6.14 shows the case where the *Library* eases borrowing restrictions by removing the due date restrictions on *borrowers* that it considers as responsible enough and arranging for recalls to be negotiated between *borrowers*. Since the *Library* still needs to maintain its relationship with its items, it has the goal of keeping track of items. This can be seen as a backup regulation mechanism (heuristic H8) that maintains the borrowers' responsibility for the items. Of course, to be effective, this mechanism needs to be coupled with some penalty on lost items imposed on *borrowers* (not shown in Figure 6.14).



**Figure 6.14 IT system goals for easing borrowing restrictions**

Since the *Library* needs to know who is in possession of its books, the *Library's* IT system would have the goal of tracking whether the exchange of items in case of a recall has been performed and when. This can be done by requesting that the *current borrower* and *requestor* both signal the exchange on the *Library's* web site. Down the line the *Library* may decide to build personal web pages for *borrowers* where they would have the list of books they hold and from where they will be able to request other books, negotiate the exchange with other *borrowers*, and signal that they are in possession of an exchanged book. Since the *current borrower* who hands a book to a *requestor* is responsible for the book until the exchange is made, the latter has the right incentive for signaling the exchange. If the *requestor* doesn't signal the exchange and the *current borrower* does, the IT system can detect the inconsistency and prompt *current borrower* and *requestor* to solve the issue.

The additional goals for the IT system, based on the above discussion, are:

- Propose negotiation of transfer of item to Borrower and Requestor
- Help Borrower and Requestor to Negotiate transfer of item (maintain anonymity if necessary)
- Memorize negotiation result (who finally holds the book)
- Alert Library staff if negotiation result is inconsistent (borrower and requestor logged inconsistent results)

This new way of recalling items does place more responsibility on the part of the *borrowers* but at the advantage of more flexible borrowing restrictions. However, some *borrowers* may not believe that the added services offered by the *Library* are useful. Some others may like the new services and use them.

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The question is to what extent the new services will be used. Also, it may be that the belief that *borrowers* want eased restrictions doesn't hold.

The result of the eased restrictions may be a truly distributed *library*. We can even imagine that people in the university may add their own books to the *Library* catalog, and negotiate their borrowing.

One of the effects of the revised recall service may be to trigger discussions between *requestor* and *current borrower*. Indeed, the *requestor* may ask the *current borrower* for his opinion about the item and decide to borrow it or not depending on this opinion. *Requestor* and *current borrower* realizing that they may have the same research interests because they are interested in the same item may discuss the item or their research interests, thus enriching the knowledge of both. The *Library* IT system's goals could thus be augmented with the following goal: "Help Requestor and current borrower to discuss item."

Thus, a recall can be seen as an opportunity for collaboration rather than a hassle and one of the *Library*'s purposes could be seen as: *Offer support for collaborative and individual research* rather than sharing books and periodicals as fairly as possible among Students and Academic Staff.

### 6.4.3 Helping borrowers to find items

We can now reduce the two other goals identified in Figure 6.6: "Help Borrowers to find needed items" and "Know which items are needed." Figure 6.15 shows a possible reduction of these goals. The *borrowers*' goal is reduced to two goals: "Define research area" and "Find relevant items in research area." The latter influences the belief of the *Library* "Need to provide information about relevant items in research area." This belief is combined with the belief of the *Library* that the expertise of other *borrowers* in the university could be used to provide this information, namely: "use Borrowers expertise." This belief is influenced by the maintenance goal of the university itself which is expressed as: "Borrowers build expertise in research area."

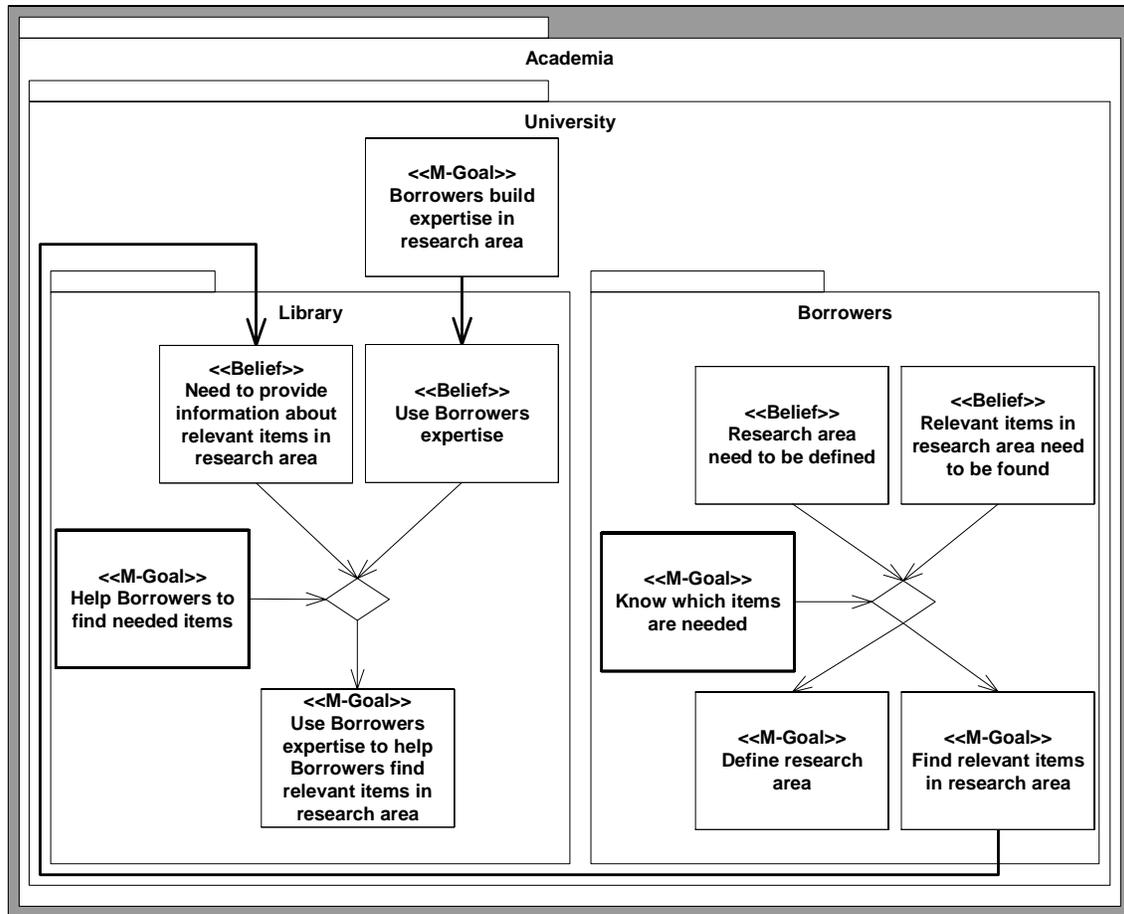


Figure 6.15 Goal reduction for “Help Borrowers to find needed items”

Satisfying the resultant goal: “Use Borrowers expertise to help Borrowers find relevant items in research area” could be done by linking *borrowers* together so that *borrowers* who are inexperienced in a research area could use the expertise of those who are more experienced. More specifically, this goal could be reduced with the following beliefs:

- An item browse and search tool could be useful to Borrowers
- for each item the following information can be recorded:
  - the research units whose members have loaned the item
  - loan frequency
  - commentaries by past Borrowers
  - If authorized, the individual Borrowers who loaned the item

This will enable the IT system to offer a browse and search tool that will list the information recorded for each item. This tool will help *borrowers* to understand what research unit borrows what item, thus linking items with research areas. The loan frequency, i.e., number of times an item was loaned, gives some measure of the relevance of the item. Commentaries by past *borrowers* help to further understand the item. Linking to a list of past or *current borrowers* of an item, enables a *borrower* to ask other *borrowers* direct questions about an item. This, however, can only be done if each individual agrees for his or her name to be published.

This gives us the following high-level goals for the IT system:

- Provide item browse and search tool

- For each item provide the following information:
  - the research units whose members have loaned the item
  - research areas concerned by the item
  - loan frequency
  - commentaries by past Borrowers
  - If authorized, the individual Borrowers who loaned the item

#### 6.4.4 Maintaining the collection of items

Up till now we have supposed that the collection of items is static and that the Library does nothing but regulate the access of Borrowers to this collection. However, as we have seen in Figure 6.6, the *academia* community keeps producing new items that may be needed by *borrowers* and new research areas that shape the needs of the *borrowers* in terms of items. This influences the *Library* to have the goal: “Maintain item collection that fits the needs of Borrowers.” We can reduce this goal by considering the following beliefs:

- Research areas change constantly
- New items become available all the time.
- Cannot purchase all new items.
- Necessary to know which items become available
- Necessary to know which items are needed by Borrowers.
- Necessary to know how many copies of each item to purchase.
- Necessary to know how many Borrowers may be interested in each item at the same time.

This goal reduction shows that the *Library* cannot purchase all new items that become available. It needs to know which items become available and purchase only those that it believes will be needed by *borrowers*. Similarly, the research areas of *borrowers* are changing and the *Library* needs to track these areas, respond to the emergence and disappearance of research areas, and if possible anticipate the needs of new research areas. The *Library* also needs to know how many copies of each item to purchase. For that it needs to know the popularity of items, i.e., how many *borrowers* will be interested in a given item at the same time. The resulting goals for the *Library* are:

- Track research areas of Borrowers
- Track new items
- Purchase items that match research areas of Borrowers
- Predict number of copies needed for each item
- Improve purchase decisions

The goals listed above suggest that the *Library* might partner with *publishers* so that it can better track new items and order them on time to be relevant to the *borrowers*. This could be done by linking the *publishers’* and *Library* IT systems so that new item information is automatically available to the *Library*. The tracking of new research areas could be partially performed through this partnership but also through information gathered from other sources such as conferences, workshops, keywords analysis in conference and workshop proceedings, and in journals. The IT system could also be used to identify *borrowers’* borrowing patterns and thereby improve the *Library’s* ability to order the items they desire in the appropriate quantity. The resulting goals for the IT system are:

- Provide information on emerging new research areas and those that are fading out
- Provide new item information from Publishers

- Match new item information to research areas of Borrowers
- Track purchased items usage and provide information on past purchase decisions
- Provide information on Borrowers' borrowing patterns
- Provide information on items that Borrowers didn't borrow because they were not available

### 6.4.5 Providing digital library services

If the belief of the rise of digital libraries holds, then an interesting question is what would be the role of the Templeman library. Digital libraries enable not only the relatively cheap distribution of electronic items. This would simply be an automation of an existing scheme. Digital libraries give the possibility of better serving the clients of the library by providing them with services that they didn't have before. We can reduce each of the three goals identified in Figure 6.6: "Maintain item collection that fits the needs of Borrowers," "Maintain items available when needed by Borrowers" and "Help Borrowers to find needed items" and identify how a digital library may help with their satisfaction by considering the following beliefs that now stem for our interpretations (as designers) of digital libraries:

- Maintain item collection that fits the needs of Borrowers
  - Beliefs
    - Other libraries have interesting items for our Borrowers
  - Subgoals
    - Maintain relationships with other digital libraries
- Maintain items available when needed by Borrowers
  - Beliefs
    - Items are needed by Borrowers without interruption
  - Subgoals
    - Maintain IT systems functioning without interruption
- Help Borrowers to find needed items
  - Beliefs
    - Useful statistics can be constructed about Borrowers borrowing patterns
    - Borrowing patterns can provide useful information on items to consult
    - Digital libraries facilitate collaboration between interested Borrowers
    - Digital libraries facilitate cross pollination between researchers with same or different interests
    - Digital libraries enable Borrowers to keep track of the items they have borrowed or would like to borrow
    - Digital libraries enable Borrowers to maintain notes about the items they have borrowed or would like to borrow and share them with other borrowers
  - Subgoals
    - Construct statistics about Borrowers borrowing patterns
    - Provide borrowing patterns to borrowers
    - Provide tools for collaboration between interested Borrowers

- Provide tools for cross pollination between researchers with same or different interests
- Provide Borrowers information about the items they have or would like to borrow
- Provide Borrowers personal spaces where they can maintain notes about the items they have borrowed or would like to borrow and share them with other borrowers

The resulting IT system goals reflect the goals of the *Library* identified above:

- Help library to maintain relationships with other digital libraries
- Function without interruptions
- Construct statistics about Borrowers borrowing patterns
- Provide borrowing patterns to borrowers
- Provide tools for collaboration between interested Borrowers
- Provide tools for cross pollination between researchers with same or different interests
- Provide Borrowers information about the items they have or would like to borrow
- Provide Borrowers personal spaces where they can maintain notes about the items they have borrowed and share them with other borrowers

Among the possible effects of providing a digital library compared with a traditional one, we can list the following:

- There may be an increase in printing needs by borrowers leading to increased cost for the departments of the university and a decrease in the cost of buying some items for the library
- Increase in storage needs by borrowers for saving digital files and a decrease in shelf space for the library
- An increase in the need for on-line help for borrowers

Gradually we can expect the borrowing restrictions part of the Library IT system to become less important compared to the information services, such as help to find relevant items, provided by the Library. Hence, the Library's IT system may be better thought of as an information portal helping researchers with their research activities rather than as helping the Library to fairly and efficiently share items among borrowers.

In such a view, collaboration among researchers (with the help of the Library) takes on much more importance than before (de Haan et al. 1999). The library doesn't simply transform into a digital version of a traditional library. It takes on a whole new set of responsibilities. However, the digital library may prove to be a passing mode. It is possible that the digital library concept will not materialize except for limited areas such as periodicals in which it is already a reality. Thus, the current maintenance goals of traditional libraries may prevail.

## 6.5 Summary

In this chapter, we have analyzed the regulation of relationships performed by the Templeman Library. We have followed the Lightswitch method defined in 5.2.3. This analysis enabled us to provide a plausible explanation to the reason of existence of the norms of the Library, such as the borrowing restrictions, the separation between different kinds of borrowers etc.). Analyzing these norms and their possible interpretations by the Library and its stakeholders, we analyzed some of the effects of the regulation of the Library on its Borrowers. We have identified current possible dissatisfactions with this regulation and current trends in digital libraries that may render this regulation obsolete. This enabled us to define high-level goals for a possible IT system for the Library that takes these

conditions into account. These goals were designed so that the Library can provide more services to its Borrowers and relax the restrictions imposed on them. Thus, by focusing on the regulation of relationships and the needs of protection of both the Library and its clients we were able to define IT system goals that take into account current and future conditions that may relegate the Library to a secondary role if it doesn't address them. These goals go beyond simply those that apply borrowing restrictions on borrowers as done in the ODP-EL literature. The complete list of goals is summarized in Table 6.4

The part of the analysis that corresponds to borrowing restrictions was based on the assumption that items are a scarce resource. If electronic books and periodicals become available as is already the case from some academic publishers such as IEEE and ACM, it may change the status of items from scarce to abundant. We have identified the opportunity for a collaborative application where the result is a distributed system where the librarian has a role of an off-hand regulator rather than a gate keeper.

With the goals identified for the IT system, the strategy of the Templeman Library, implicitly based on the protection of a central collection of items, can now be thought of as actively supporting the research performed by the University.

However, applying the Homeostasis principles to this change, we need to note that modifying the Library's purpose in this way may require major change on the part of the Library personnel, its Borrowers and Suppliers. Such a change may not be easy to implement. We can identify the following factors that may act against or in favor of the design of the IT system as envisioned above:

- The University or Library management may be unwilling to invest in such an IT system.
- Some of the Library personnel may feel threatened by the envisioned change and may wish to block such an initiative. Some others may find new opportunities in this newly envisioned Library.
- The current, highly specialized structure of the Library may prove to be difficult to change.

- Help Librarians to set and impose due dates and loan limits
- Help Librarians to distinguish between undergraduates, postgraduates, academic staff and external borrowers
- Help Librarians to distinguish between “good” and “bad” borrowers
- Propose negotiation of transfer of item to Borrower and Requestor
- Help Borrower and Requestor to Negotiate transfer of item (maintain anonymity if necessary)
- Memorize negotiation result (who finally holds the book)
- Alert Library staff if negotiation result is inconsistent (borrower and requestor logged inconsistent results)
- Provide item browse and search tool
- For each item provide the following information:
  - the research units whose members have loaned the item
  - research areas concerned by the item
  - loan frequency
  - commentaries by past Borrowers
  - If authorized, the individual Borrowers who loaned the item
- Provide information on emerging new research areas and those that are fading out
- Provide new item information from Publishers
- Match new item information to research areas of Borrowers
- Track purchased items usage and provide information on past purchase decisions
- Provide information on Borrowers’ borrowing patterns
- Provide information on items that Borrowers didn’t borrow because they were not available
- Help Library to maintain relationships with other digital libraries
- Function without interruptions
- Construct statistics about Borrowers borrowing patterns
- Provide borrowing patterns to borrowers
- Provide tools for collaboration between interested Borrowers
- Provide tools for cross pollination between researchers with same or different interests
- Provide Borrowers information about the items they have or would like to borrow
- Provide Borrowers personal spaces where they can maintain notes about the items they have borrowed and share them with other borrowers

**Table 6.4 Summary of the IT system goals for the Library**

## 7 The CHUV's Central Sterilization Department Case Study

The CHUV (Centre Hospitalier Universitaire Vaudois) is the main hospital in the Canton of Vaud, Switzerland. A particular preoccupation in every hospital is the absence of germs of any kind in the medical equipment that is used to care for patients. This medical equipment consists of anything that comes into contact with patients, bandages, needles used for injections, instruments used in operations, implants such as screws, etc. The CHUV, as most hospitals, has a so-called sterilization service. The sterilization service sterilizes medical equipment for the different services of the hospital. The Sterilization service uses an Information Technology (IT) application called Mikros to help it with some of its operations. Mikros is currently used for:

- Identifying all the nursing and surgical devices and equipment sterilized by the sterilization department
- Defining the treatment and the sterilization process for the different equipments that are sterilized by the sterilization department.
- Calculating production costs
- Registering the equipment and devices delivered to internal and external clients
- Generating monthly and yearly statistics

Mikros has been in use for about 15 years. It uses a character based user interface. It was developed on top of an obsolete software platform. It has been decided that Mikros can no longer be maintained and that it needs to be changed. A team of 3 people, the director of the sterilization service, a software project manager and a software team manager from the SIG (Système d'Information de Gestion, Management IT systems) were asked to conduct an "opportunity study" whose aim was to define the "needs of the sterilization department in terms of IT systems for the 2002-2005 timeframe" (CHUV 2002). These needs should be used for the initial specifications for a replacement for Mikros. The study was conducted from April to July 2002. The study involved:

- the interviews of several people in high management positions within the CHUV in order to understand their viewpoints on the sterilization service. The positions of the interviewees were: Medical Manager, Finance Manager, Purchasing Manager, Bio-Medical Engineer, Nursing Manager, Inventory Manager
- several debriefing sessions
- visits to the sterilization service to understand how it functions
- a visit to the sterilization service of a French hospital in Paris organized by Optim (<http://www.optim.fr>), a vendor of sterilization IT systems, in order to understand how a newly created service functions with a state of the art IT system

The way the study was organized, showed that the problem of the replacement of Mikros was not only analyzed from the point of view of what Mikros does today and how to replace it but included an analysis of the global context, i.e., of the strategic changes expected in the Swiss healthcare landscape and the needs of the clients of the sterilization department. This is reflected in the structure of this Chapter. In the first part of the chapter we analyze the relevant aspects of the Swiss healthcare landscape. In the second part we analyze the specific needs of the sterilization department.

The study team produced an internal CHUV document that summarizes its findings and recommendations (CHUV 2002). Some of the elements in this chapter have been borrowed from this document. The results of the study and its recommendation were presented to top managers in the CHUV. The presentation was followed by a discussion with the managers in which the initial recommendations were changed in ways that we will explain later. In March 2003 the general management of the CHUV agreed to fund the "replacement of Mikros" project based on the recommendations of the study team.

The author of this thesis was privileged to participate in this study from the beginning of the interviews to the first presentation of the results. This chapter contains the results of the author's participation and the application of the Lightswitch framework to the problem of the replacement of Mikros. This chapter contains the author's own views on the study and the needs of the sterilization department. The author endorses full responsibility for these views. The use of the term *we* in this chapter does not imply an endorsement of the author's ideas by the other participants in the study or any other member of the CHUV. However, the chapter was reviewed by the CHUV's study team. Their comments enabled the author to refine the models and to propose more realistic options.

In this chapter we will use the following terms and their definitions:

- Hospices group refers to the administrative and financial entity of which the CHUV is part.
- CHUV refers to the set of nursing units and operating theaters that the Sterilization department serves.
- Affiliates refers to the other units dispensing care to patients and which are part of the Hospices group
- *Ster* refers to the CHUV's central sterilization department.
- *SIG* when refers to the Hospices IT systems department
- *Operating theater* refers to the CHUV's set of operating rooms
- *Nursing units* when referring to the units of the CHUV that provide care to patients
- *Medical material* or sometime *material* refers to equipment that the Ster decontaminates, produces, sterilizes and distributes
- *Specific material* when referring to material that is specific to a *nursing unit*
- *Generic material* when referring to material that is generic to all *nursing units*
- *Surgical tray* or sometime *tray* when referring to a box that encloses medical material used during surgery and the medical material included in the tray.
- *Implants* when referring to medical material that may be implanted in patients during surgery.
- *Instruments* when referring more specifically to medical instruments.

In this chapter we follow the Lightswitch design process as defined in 5.2.3. In Section 7.1 we identify the sterilization department and its stakeholders. This corresponds to step 1 of the Lightswitch process. In Section 7.2 we analyze the CHUV's relationships with some of its stakeholders, i.e. we identify some of the current norms in the Swiss healthcare landscape and the CHUV's responses to them. These responses have an impact on the Ster. This corresponds to Step 2 of the Lightswitch process, applied to the CHUV. In Section 7.3 we analyze the current regulation of the Ster's relationships with some of its internal clients. We focus on the relationships between the Ster and the nursing units. We identify the main services provided by the Ster to the nursing units, i.e. the distribution of generic and specific material. This corresponds to step 2 of the Lightswitch process applied to the Ster and its stakeholders. In Section 7.4 we analyze the distribution of generic material to the nursing units. With this analysis we identify dissatisfactions with the current state of this distribution. We then evaluate several options for addressing these dissatisfactions. For each of these options we propose a set of IT system goals. This corresponds to steps 2, 3, 4 and 5 of the Lightswitch process applied to the Ster and the nursing units. In Section 7.5 we perform the same analysis of the distribution of specific material albeit in less detail due to time and space constraints in the thesis.

In this chapter we limit our detailed analysis to the distribution of generic medical material to the nursing units. The distribution of specific material is analyzed in less detail. The relationships with the operating theater and the control of the sterilization process are not described in this chapter. Both these aspects were analyzed during the study, but it was decided to leave them out of this chapter for time and space reasons.

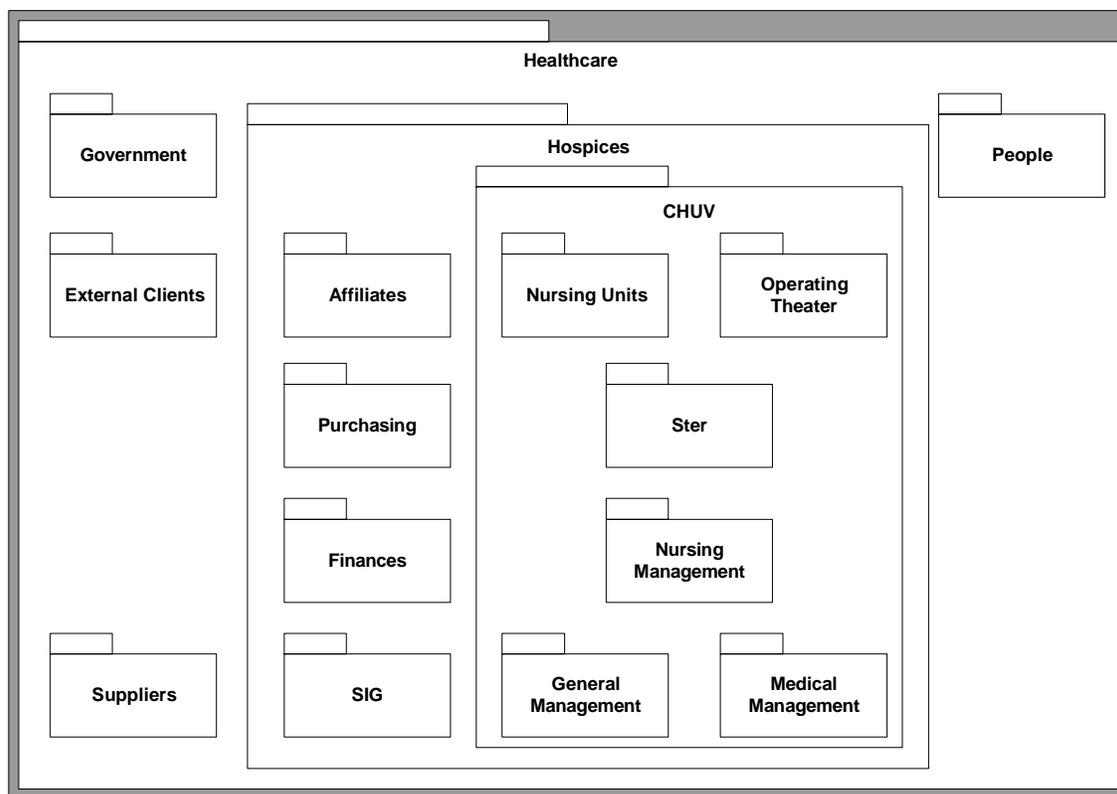
## 7.1 *The Ster and its relationships*

In Figure 7.1<sup>1</sup> we model the main enterprises to which the *Ster* is directly or indirectly related, as communities. Proceeding from the inside out we find the following communities:

- The *nursing units* and *operating theater* are identified by the *Ster* as its main clients.
- Other clients are roughly distinguished as the *Affiliates* and *External Clients*
- The other communities of interest within the *CHUV* are the *Medical Management*, the *Nursing Management* (of which the *Ster* depends hierarchically), and the *General Management*.
- The *CHUV* is part of a larger structure called the *Hospices* group. The *Hospices* group has a number of other healthcare facilities, called *Affiliates*. We represent those enterprises as the *Hospices*, *Affiliates*, and *CHUV* communities.
- Within the *Hospices* group, we also identify the *Purchasing* community, *Finance* communities, and the *SIG* community, which is driving the IT requirements project.
- Outside the *Hospices* we identify the *Suppliers* community that represents the enterprises supplying the *Ster* with raw material, instruments etc.
- Outside of the *Hospices* we placed the *External Clients* community that represents other hospitals, small clinics or institutes and independent doctor practices.
- The *Government* community represents the Swiss and cantonal governments, responsible for defining the laws and controlling their application.
- The *People* community represents all the people who may be concerned by the services of the *CHUV* or *Hospices*, in other words, the main clients of the hospital. The *People* are the ones who ultimately pay for hospital services, most often indirectly through health insurance.
- We call the supra community enclosing all of these communities, the *Healthcare* community.

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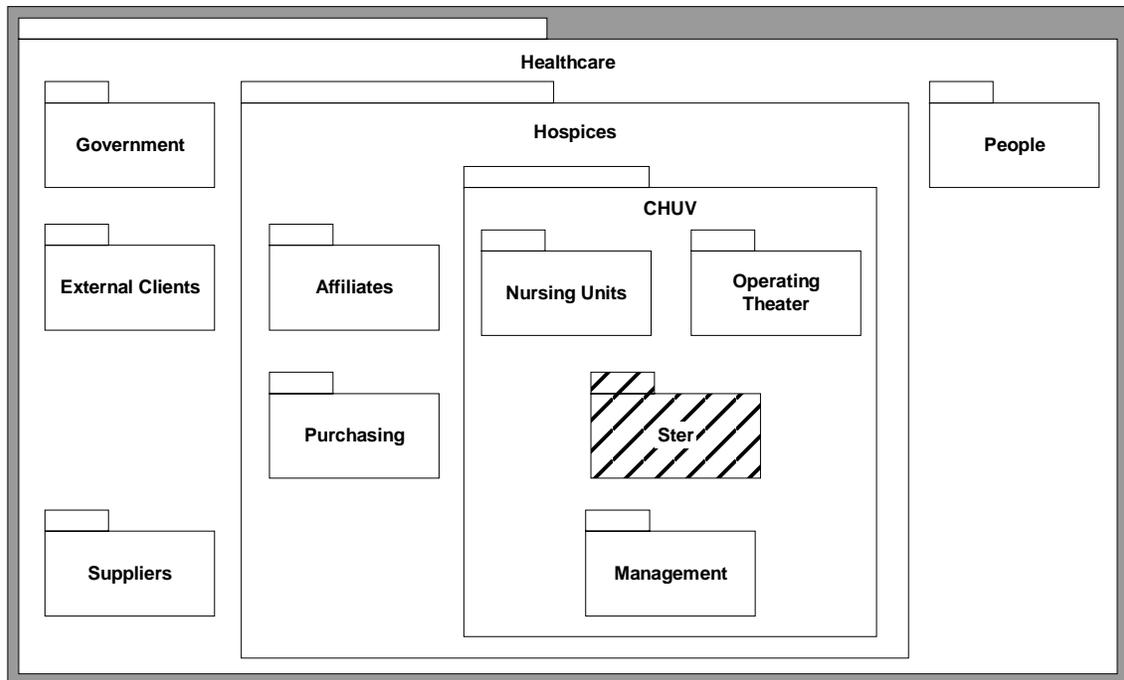
<sup>1</sup> The diagram doesn't show the reporting structure, i.e., the formal structure of the *CHUV* but rather the relationships between the identified communities.



**Figure 7.1 The Ster and its relationships as identified during the interviews**

Notice that we have made a large number of simplifications in this model. We didn't include any health insurance community; we have grouped many clients into kinds of communities as if they all had the same needs. For instance, we do not model individual nursing departments but group them all into one community.

The communities in Figure 7.1 represent most if not all the entities that intervened during the study or whose needs were evoked during the interviews and discussions. In the rest of the chapter we will focus on a smaller set of communities, which are modeled in Figure 7.2.



**Figure 7.2 The Ster and the communities used in the analysis**

This simplification will make our analysis much simpler while not removing any community that we perceive as essential for this study. In the list above we grouped several management communities into one Management community. We have also removed the SIG community, not wishing to do a meta analysis of the way the SIG analyzes the situation. This simplification is the consequence of our limited ability to analyze the complete complexity of the situation and our limited ability to collect and represent data about all the communities in Figure 7.1.

Within the Ster community we can distinguish the following communities (Figure 7.3):

- The *SterBOP* (for “Stérilisation du Block OPérateur”) community serves only the needs of the *Operating theater*. This community can be seen as a specialization of one of the *Ster*’s sub-communities to regulate the influences coming specifically from the *Operating theater*
- The *Personnel* community represents the people working in the *Ster*.
- The *Machines* community represents the decontamination, sterilization, packaging, and storing machines used by the *Ster*.
- The *IT systems* community represents the IT systems of the *Ster*.
- The *Management* community represents the management of the *Ster*.

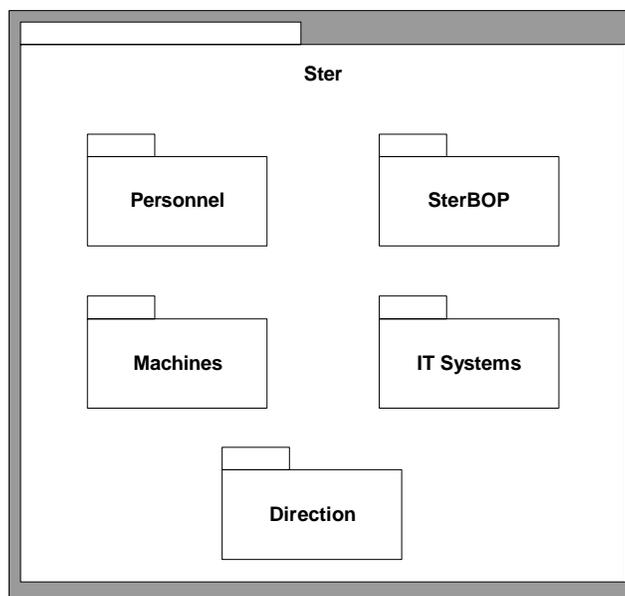


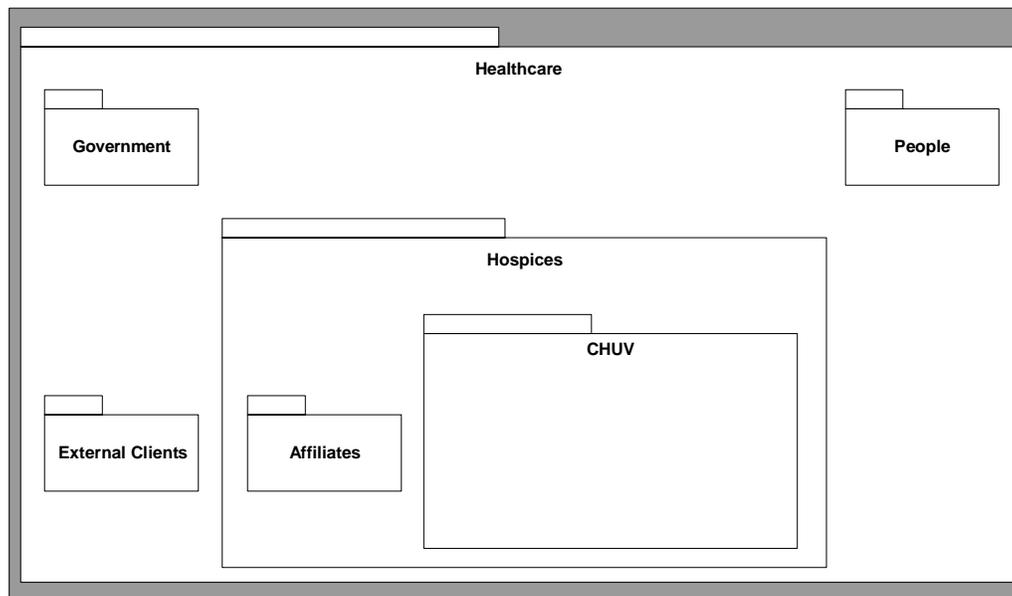
Figure 7.3 The sub-communities of the *Ster*

## 7.2 The CHUV's relationships with some of its stakeholders

To understand some of the influences affecting the *Ster*, we need to understand the global context in which it evolves. In this section we apply step 2 of the Lightswitch design process, the analysis of the regulation of the relationships of the enterprise and its stakeholders, to the CHUV. We first examine some of the norms of the Swiss health care landscape. This analysis will give us an understanding of the influences that affect the *Ster* through its relationship with the CHUV. For this analysis we use the model in Figure 7.4. This model only contains the communities that are essential for understanding the strategic influences operating on the CHUV from the outside<sup>1</sup>.

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<sup>1</sup>, for example, we do not take into account here the internal influences represented by the CHUV's personnel desire for a better work environment as described in the Hospices Group's strategic planning documents available on the Hospices group's Web site: [http://www.hospvd.ch/public/home/ind\\_struct\\_pl\\_strat.htm](http://www.hospvd.ch/public/home/ind_struct_pl_strat.htm)



**Figure 7.4 The context of the CHUV**

We can identify the goals of the different communities identified in Figure 7.4 by understanding some aspects of the Swiss healthcare landscape. Swiss people expect good quality health care. With time people have come to expect an ever increasing quality. For a host of reasons, the cost of healthcare in Switzerland is increasing every year. At the same time, people expect healthcare to be provided at a reasonable cost. This cost is beginning to exceed the cost that people agree to pay. This situation gives rise to a new norm, which is to reduce the health care cost. A third norm consists of requiring an ever greater medical and financial responsibility. This gives us three seemingly inconsistent norms that the government imposes on health care providers such as hospitals.

- expecting an ever increasing quality
- requiring a cap or even a decrease in cost
- Expecting an ever greater medical and financial responsibility

In terms of the regulation principles we have seen in Chapter 4, these norms can be seen as the regulative mechanisms of the healthcare landscape counterbalancing what is seen as unacceptable rises in healthcare cost. During the interviews, these norms showed through the following statements given by several interviewees (CHUV 2002):

- The Hospices group is gradually integrating its Affiliates, i.e., combining and eliminating redundant functions
- The canton of Vaud is expected to reduce its number of major public hospitals over the next few years.
- The new laws and government imposed norms concerning the sterilization of medical material will increase the cost and expertise necessary for maintaining a sterilization service within a hospital or other health care provider.

The same three norms also influence the Hospices and the CHUV into creating and maintaining a “Quality Program” (<http://www.hospvd.ch/qualite/>). This program in turn influences the Ster into running its own quality program, conforming to ISO 9002 and sending out satisfaction questionnaires to its clients. Moreover, as we will see later, specific quality measures brought by new norms and laws in the Swiss health care landscape influence the Ster into further action.



reduce its own costs, combined with the *CHUV*'s goals of maintaining its relationships with the *Hospices* and *External Clients* gives the *CHUV* the goals of serving *Affiliates* and *External Client's*.

### 7.2.1 Impact on the Ster

In line with the above analysis, the first version of the *CHUV* document (*CHUV* 2002) proposed to substantially increase the number of external clients the *Ster* would serve over the next few years. This scenario would have forced the *Ster* to become equipped with state of the art IT systems for managing billing, client payments, order tracking, order fulfillment, cost tracking etc.

When presented to the management, this option was discounted because it meant that the *Ster* would become a de facto commercial entity. This was not in line with the norm of the *CHUV* being a public hospital. It was felt that the *Ster* should better focus on the needs of its internal clients rather than catering to would be external clients. Note that the *Ster* already has some external clients and their number will necessarily increase as a result of the integration of affiliates (this may force the *Ster* to serve more clients without being able to say no) but the revenue they generate is believed to not justify the investment required to renovate the capabilities of the *Ster* described above.

In terms of regulation, the management's judgment to not expand the *Ster*'s external operations can be understood as a regulative action taken in order to regulate the number of external influences on the *Ster*, i.e., to avoid having a relationship with too many external clients so as to avoid the investment that such a move will require.

Thus, in the next section, we focus on the needs of the internal clients of the *Ster*.

## 7.3 The Ster's relationships with clients internal to the CHUV

In this section we apply step 2 of the Lightswitch design process, the analysis of the regulation of the relationships of the enterprise and its stakeholders, to the *Ster* and its clients that are internal to the *CHUV*. The norms that we have identified during the analysis of the *CHUV* will apply to the models we develop in this section. They will appear as beliefs about the need to reduce cost and increase quality.

### 7.3.1 Maintenance goals of the Ster

The following list shows the purposes that some of the communities in Figure 7.2 ascribe to the *Ster*. This illustrates heuristic H2 regarding the reliance of some enterprise on the norms of other enterprises. For example, the nursing units rely on the stable provision of medical material that the *Ster* offers them. Without this stability, their operations may be seriously disrupted and the quality of their care dispensed to patients will be reduced. They thus view the *Ster* as a supplier of sterilized medical material. As can be seen from this list, the purpose of the *Ster* can vary widely from one observing community to another.

- *Management*
  - *Ster* provides sterilized medical material to *nursing units* and *Operating theater*
- *Nursing units* and *External Clients*
  - *Ster* provides sterilized medical material
- *Operating theater*
  - *Ster* provides sterilized operation trays
- *Purchasing*

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<sup>1</sup> Notice that we could also model the affiliates integration separately because the *CHUV* may not receive much financial benefit from serving them in terms since they are part of the same financial structure and because the *CHUV* may be forced to serve them whereas it may not be forced to do so for external clients.

- *Ster* orders items to be purchased
- *Ster Personnel* and *Ster Management*
  - *Ster* provides a place of work
- *Suppliers*
  - *Ster* purchases medical material and machines

The *Ster* regulates its relationships with all of the communities above. However, it is protected from most direct influences from the communities outside of the CHUV by the internal environment provided to it by the *CHUV*. We can thus assign the following maintenance goals to the *Ster*:

- Maintain relationships with the *Nursing units*.
- Maintain relationships with the *Operating theater*.
- Maintain relationships with the *External Clients*.
- Maintain relationships with the *CHUV's Management*
- Maintain relationships with the *Ster's Personnel*
- Maintain relationships with the *Suppliers*

### 7.3.2 Norms and Interpretations that Influence the *Ster*

The following list gives some of the norms and interpretations that influence the *Ster* as they were identified during the interviews or in the CHUV document (CHUV 2002).

- The *Ster* is expected to control its costs, for example, optimize the use of materials, machines, and IT systems.
- The *Ster* is expected to deliver better quality to its clients
- New health care norms represent an opportunity to extend services outside of the CHUV. They also represent a threat of competition from outside the CHUV.
- Traceability of medical material, i.e., which material has been used on what patient and how this material was sterilized is expected to become a new norm within the Swiss healthcare landscape. The new machines purchased by the *Ster* and future IT systems can support this traceability to some degree
- The new machines purchased by the *Ster* can be connected to IT Systems, thus providing better control of the sterilization process
- Reported problems with current operations
  - Loss of material that belongs to the nursing units.
  - Insufficient tracking of material while it is in the *Ster*.
- Constraints on the IT systems in terms of what the personnel can handle
  - The need to train the *Ster's* personnel to use an envisioned IT system.
  - The user interface of these IT systems should be adapted to the personnel's abilities and to the working environment of the *Ster*.
- Deployment of IT systems
  - may require the inventory, naming, classification of all materials
  - may require the formalization of processes
- The *Ster's* personnel face a hard and requiring job. The new machines and IT systems are expected to ease their working conditions

In order to understand what kind of IT support the Ster needs, we will now analyze two of the maintenance goals defined in Section 7.3.1, i.e., the maintenance of the relationships with the *nursing units* and with the *operating theater*. The analysis of these relationships will yield several possible structural changes that distribute the responsibilities between the *Ster*, the *nursing units*, and the *operating theater*. These two maintenance goals will be subject to the influences described in the list above. As much as possible, the source of the influence will be identified. For example, the norm to reduce cost will appear as a maintenance goal of the *Healthcare* or *CHUV* that influences the *Ster*.

### 7.3.3 Analysis of the Ster's relationships with the nursing units

Maintaining the Ster's relationships with the nursing units means, for the Ster, that it has to deliver the service that the units require. The units themselves are delivering a service to their own clients, i.e., a patient. The patient requires quality treatment. This quality is defined by norms that exist in the healthcare discipline. The relationship between the Ster and the nursing units is also regulated by a number of norms that have evolved through time. In this section, we will examine those norms and their influences on the Ster and the nursing units.

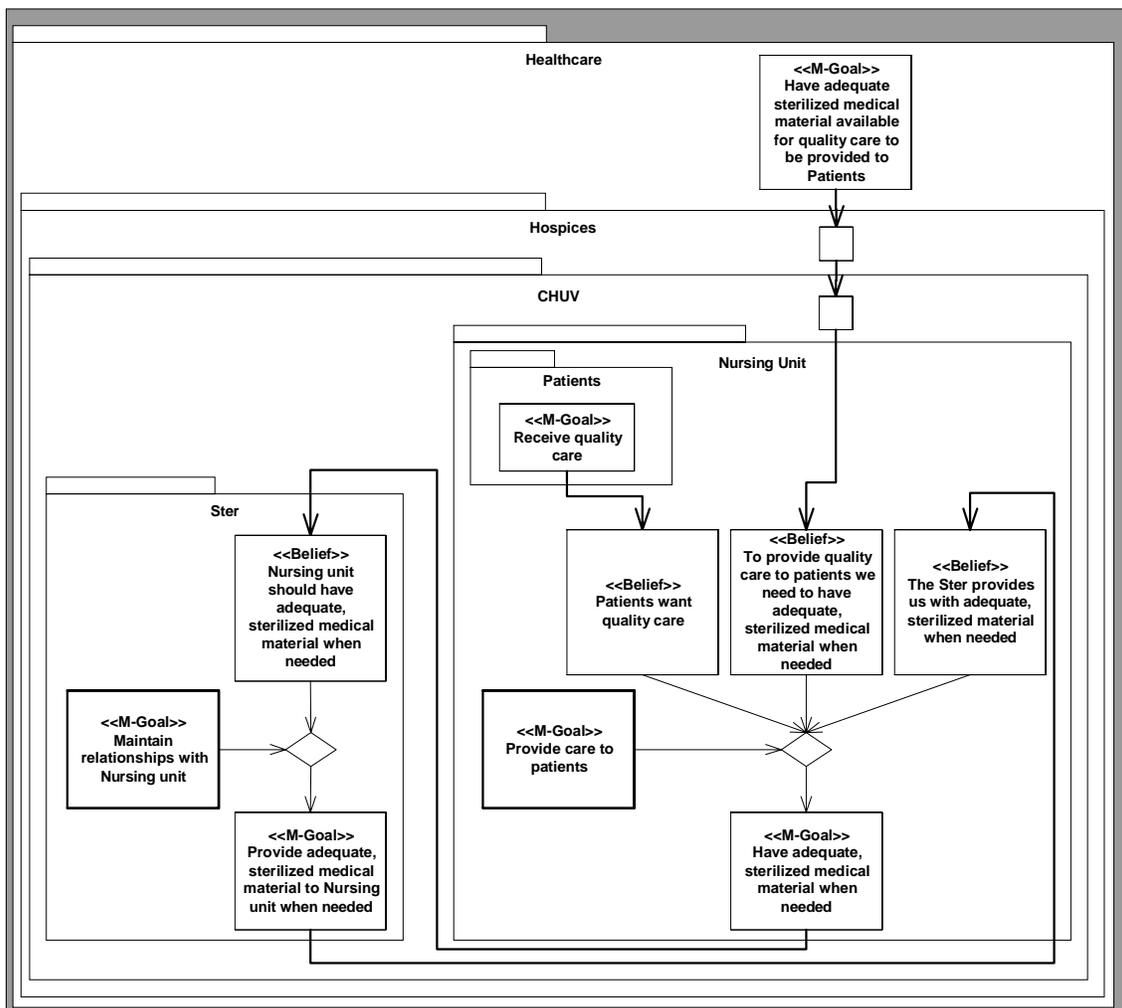


Figure 7.6 Provision of material to the Services

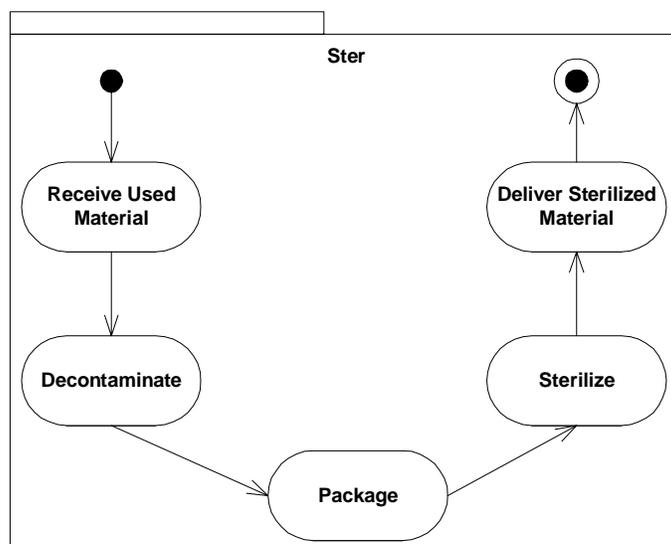
Figure 7.6 represents the typical nursing units as the *nursing unit* community. The *nursing unit* has a relationship with the *patients* community. *patients* have a maintenance goal: “Receive quality care”. The *healthcare* community has the maintenance goal: “Have adequate sterilized medical material

available for quality care to be provided to Patients”<sup>1</sup>. These two maintenance goals influence the *nursing unit’s* beliefs that, “patients want quality care” and that “To provide quality care to patients we need to have adequate<sup>2</sup>, sterilized medical material when needed”. As a consequence of these beliefs and the *nursing unit’s* goal, “Provide care to patients,” the *nursing unit* has the goal, “Have adequate, sterilized medical material when needed.” This goal influences the *Ster’s* belief, “Nursing unit should have adequate, sterilized medical material when needed.” This belief, coupled with the *Ster’s* goal, “Maintain relationships with Nursing unit”, means that the *Ster* has the goal, “Provide adequate, sterilized medical material to Nursing unit when needed”. This goal influences the *nursing unit’s* belief, “The Ster provides us with adequate, sterilized material when needed.” This reinforces the *nursing unit’s* goal of having this material and its ability to provide care to *Patients*.

This model shows the nursing unit’s reliance on the Ster’s stability of action. Without this stability, the nursing unit will not be able to function for long because they will run out of sterilized medical material without which patients can not be treated.

To understand how medical material is delivered to the nursing units we analyze how the Ster receives and delivers this material.

A typical sterilization department can be modeled as performing a cycle of activities as shown in Figure 7.7. The sterilization department receives used material that is partly decontaminated, decontaminates and washes the material, repackages the material, sterilizes it and delivers it. This is done for material that is reusable. Another class of material is disposable material that is used only one.



**Figure 7.7 A sterilization department’s basic activity diagram (UML)**

The cycle in Figure 7.7 is not applicable to the Ster. The Ster sterilizes some 3000 different articles. Of those 3000 articles, 200 are common to all the nursing units. We will call this kind of articles *generic material*. The remaining 2800 are specific to each nursing unit. We call those, *specific material*. The Ster and the nursing units have specialized treatment for generic material and for specific material. Both specific and generic materials are reusable. Once the material has been used, it can be sterilized and used again. Both specific and generic material has a limit to the number of times it can be

<sup>1</sup> We do not deal here with the other aspects of how care is delivered to patients and hence, we do not model the aspects of medical personnel know how, training, etc.

<sup>2</sup> The term adequate has two meanings in English. 1: sufficient for a specific requirement. 2: barely sufficient or satisfactory. (Merriam-Webster 2002). In this chapter we use the first meaning, which we interpret as fit for the required use.

sterilized. When this limit is reached, the material should be disposed of. Both kinds of material also need maintenance work when they are broken or worn out<sup>1</sup>. These aspects are not shown here.

Hence, the basic cycle of Figure 7.7 can be refined by observing that the Ster has two distinct modes of operation. The Ster gets used material that is either specific or generic. Generic material is stored in the Ster's inventory after sterilization. When a nursing unit needs some generic material, it orders it from the Ster. The Ster also uses raw material to build new generic material. Material that is specific to a nursing unit is sterilized and returned to the nursing units within 24 hours (CHUV 2002). This means that the nursing units probably have some inventory of both generic and specific material so that they can continue to provide care in the absence of the material being sterilized (Heuristic H5). Figure 7.8 shows a model of the Ster's activity cycle. In this cycle, we see that after sterilization, generic material is stored whereas specific material is delivered (to clients). A second entry point was added in the diagram to show that generic material is provided to clients when they demand it.

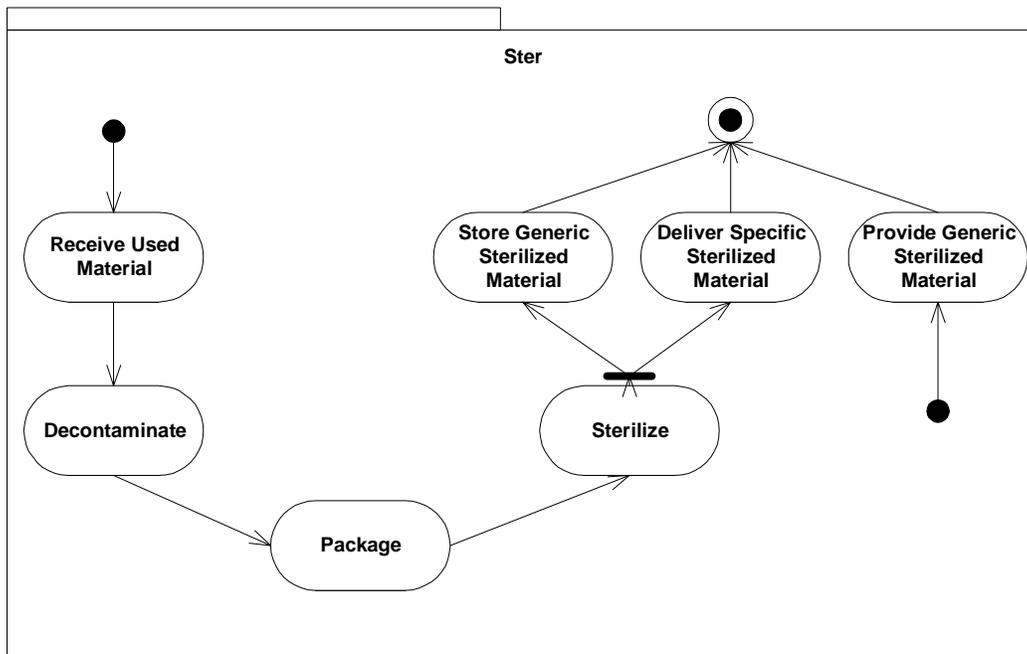


Figure 7.8 The Ster's activity diagram (UML)

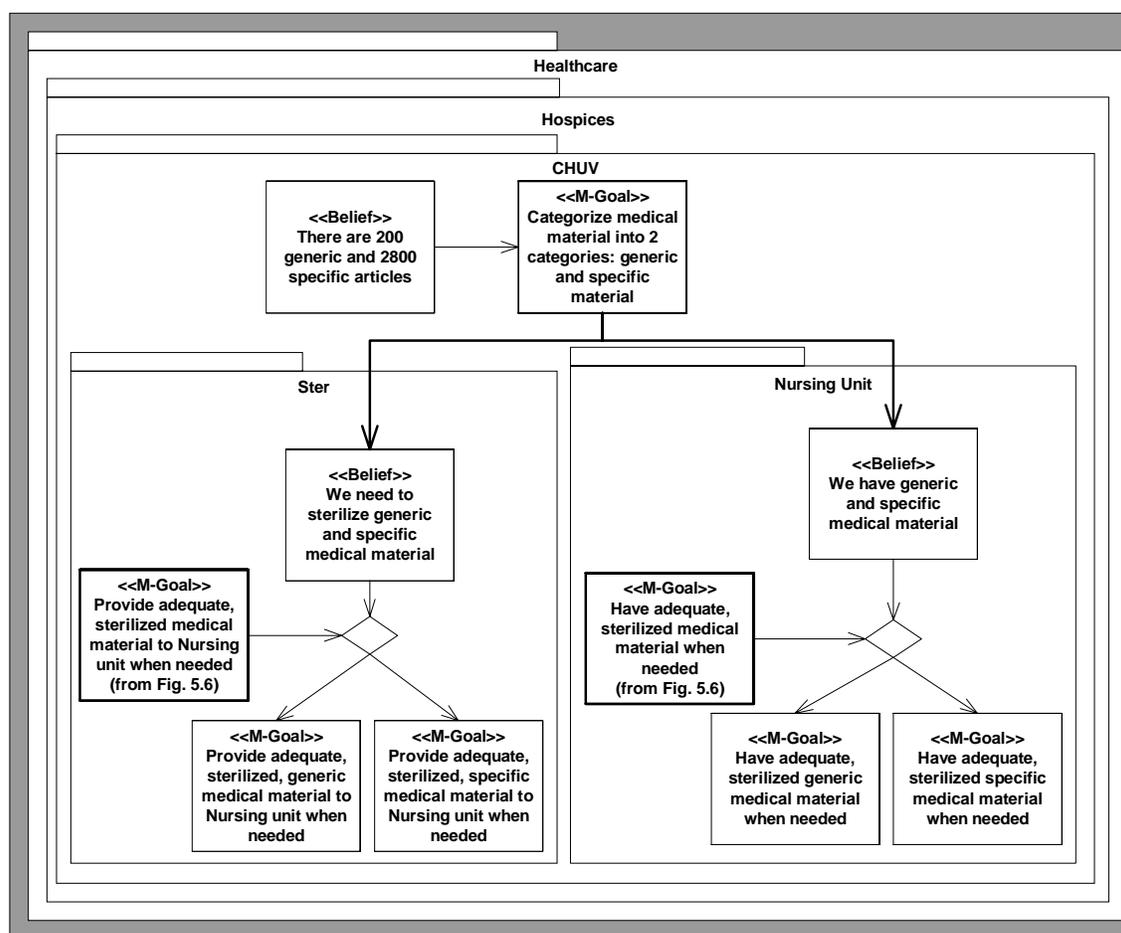
The separation between generic and specific material is important because not all hospitals make this distinction as we have seen during our visit to Paris. Indeed, the sterilization service of the Paris hospital only sterilizes material that is considered as specific to each Service. Each service deposits its used material in a container and picks the same container up with its specific material when it has been sterilized. The Paris hospital is only a couple of years old and during its conception, the decision was made to rely on the use of disposable generic material rather than reusable material as the Ster does. Thus, the sterilization service of the Paris hospital doesn't have the responsibility of distributing generic material to services. The sterilization service of the Paris hospital specializes in one function only. The Ster, on the other hand, has two specialized functions (heuristic H4): Delivering generic material and delivering specific material. This particularity may be common in older hospitals that have evolved before the widespread availability of disposable material. It seems to be a common practice in Switzerland. Moreover, whereas specific material is the property of each nursing unit, generic material is the property of the Ster.

From the point of view of the *nursing unit*, the *Ster* performs the following activities:

<sup>1</sup> One source of dissatisfaction is that currently many articles are believed to be discarded before they reached their prescribed maximum number of sterilizations. Also, it is not always clear when items need maintenance and which items are currently in maintenance.

- Delivery of sterilized generic material
- Removal of used generic material
- Delivery of sterilized specific material
- Removal of used specific material

We model this in Figure 7.9 where we have a belief of the *CHUV* that it has 200 generic articles and 2800 specific ones. This belief influences the maintenance goal that specifies that these articles are categorized into two separate categories of generic and specific material. This maintenance goal influences both the *nursing unit* and the *Ster*'s goals identified in Figure 7.6 (“Have adequate, sterilized medical material when needed” and “Provide adequate, sterilized medical material when needed”) into handling these two categories differently. We end up with two maintenance goals for the *nursing unit*: “Have adequate, sterilized generic medical material when needed;” “Have adequate, sterilized specific medical material when needed.” The *Ster* has the corresponding maintenance goals of: “Provide adequate, sterilized, generic medical material to Nursing unit when needed;” “Provide adequate, sterilized, specific medical material to Nursing unit when needed.”



**Figure 7.9** The split between specific and generic material

We can separate the needs of the *Ster* into three main areas:

- Decontamination and sterilization of material
- Distribution of material to the *nursing units*
- Removal of material from *nursing units*

For the decontamination and sterilization of material, the *Ster* needs an IT system capable of tracking and imposing the prescribed decontamination and sterilization cycles. The CHUV document (CHUV 2002) dealt with the question of what IT system to purchase for this need. We do not analyze this need in this chapter. In the following sections we focus on the distribution of generic and specific material to the nursing units. The removal of material is only analyzed in connection with the distribution of material and may benefit from a more detailed analysis.

## **7.4 Distribution of generic material**

In this section we first analyze the goals and beliefs that influence the current distribution of generic material to the nursing units. This analysis will result in a model that will show the dissatisfactions of some of the stakeholders with the current situation. This analysis corresponds to steps 2 and 3 of the Lightswitch design process. We then identify and evaluate several options that may address these dissatisfactions as proposed in step 4 of the Lightswitch design process.

### **7.4.1 Current distribution of generic material**

Figure 7.10 shows the model of the distribution of generic material to the nursing units. It shows that the *Ster* is responsible for the distribution of generic material to the nursing units and the verification of the adequacy of the medical material. It instructs the nursing unit to sterilize medical material after use. This results in the *Ster* having the following goals:

- Sterilize and verify adequacy of medical material
- Manage inventory of generic material
- Take and fulfill Nursing unit's orders for generic material

The nursing unit has the corresponding goals:

- Order generic medical material when inventory too low
- Send used generic medical material to the *Ster*.

The nursing unit has a third goal: "Maintain inventory of generic, sterilized medical material." The corresponding belief is "We can't function without medical material."

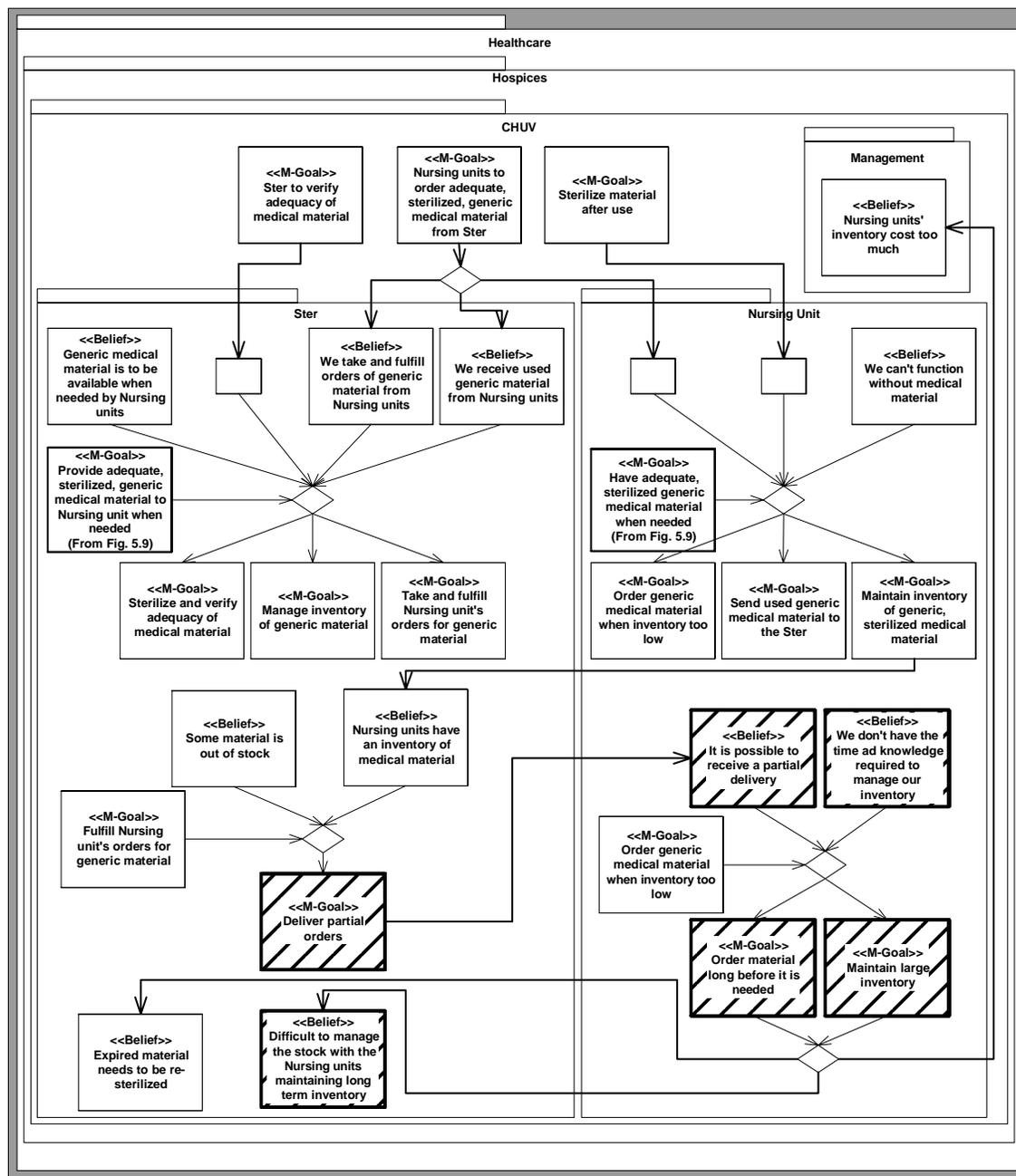


Figure 7.10 Distribution of generic material

The maintenance of a minimum of inventory by the *nursing unit* is necessary for it to maintain its capability to deliver care to patients. Indeed, the nursing unit is physically distant from the Ster, and faces unpredictable situations with patients. It thus cannot count on the Ster's inventory for its day to day operations but needs to maintain its own inventory. The existence of the nursing unit inventory, however, creates a situation where the Ster can make partial deliveries. A partial delivery is made when the Ster's inventory is out of stock. The existence of the concept of partial delivery and the existence of the *nursing unit's* inventory are interdependent. The Maintenance of inventory by the *nursing unit* is interpreted by the Ster as relieving itself from managing its inventory too closely while the occurrences of partial deliveries encourage the *nursing unit* to protect its ability to deliver care to patients by maintaining a relatively large inventory and by ordering medical material preventively.

Thus, this situation probably leads to large quantities of inventory in the *nursing unit* that anticipate on the *Ster*'s inability to deliver complete orders and protect themselves from partial deliveries (heuristic H10). Another influence shown in Figure 7.10 that contributes to large *nursing unit* inventory is the *nursing Unit's* belief: "We don't have the time and knowledge required to manage our inventory." This may be caused by high turnaround rate of personnel in nursing units, the nursing units' personnel being preoccupied with more urgent tasks such as caring for patients, and nursing units' lack of inventory management tools.

The beliefs about this situation by the different communities involved are the following:

- The *Ster* believes that this leads to waste due to expiry dates on sterilized material which leads to either throwing away of material or re-sterilization of material.
- The *Ster* believes that it cannot correctly manage its inventory, i.e., due to the accumulation of material in the *nursing units*, the *Ster* cannot predict what levels of inventory it needs to have. Thus, for the *Ster*, partial deliveries may happen because of the large *nursing units* inventories. We are in a self perpetuating cycle.
- Each *nursing unit* probably spends some of its time on managing its inventory, which can be seen as not being one of its primary duties.
- Management thinks that this is an unsatisfactory situation with respect to quality of care and cost.

The people we have interviewed in the *Ster* believe that the issue of partial deliveries was relevant a few years ago but that now they manage their inventory in a way that insures complete deliveries. If this is the case, then we can see that the nursing units are probably anticipating on an influence that does not exist anymore. However, since being out of stock represents a much more important threat to their ability to provide care than the existence of too much inventory, they are willing to sacrifice some inefficiency in but not lose the ability to carry out their core mission. This is a direct application of heuristic H12 where we hypothesize that current norms compensate for past influences.

#### **7.4.2 Options for distributing generic material and resulting IT system goals**

We can think of several optional courses of action that may improve the situation described in the previous section. In the following we list these options and explain some of their implications:

**Option 1:** Maintain the *nursing unit's* inventories but make the *Ster* responsible for managing it.

- The *Ster* will have the goal of maintain adequate inventory levels in *nursing unit*
- Offer a backup mechanism, i.e., an emergency delivery service to nursing unit in case that they are out of stock due to unanticipated surge in its activities.
- This would require the *Ster* to build statistics on which *nursing unit* uses what material and at what rate, and use these statistics to predict the needs of each *nursing unit* in order to maintain its stock.
- Will remove the responsibility of the *nursing unit* to manage its inventory, thus freeing it to focus on the provision of care to patients.
- The *nursing unit* will depend even more on the *Ster's* ability to manage the inventory, i.e., the *nursing unit* will lose some of its autonomy, which may cause organizational problems. For example, several forces may get into action to prevent this reorganization, as anticipated in Cannon's homeostasis principles.
- The *Ster* will need to have more personnel and train them to manage the *nursing unit* inventory.

**Option 2:** Require the *nursing unit* to reduce its inventory to a minimum and rely on the *Ster's* ability to do fast and complete deliveries

- The *Ster* will have the following goals:
  - Maintaining its inventory level so as not to run out of stock
  - Insure delivery of orders before *nursing units* run out of their minimal inventory
- This would require statistics on aggregate consumption of material, no need to track individual *nursing unit*.
- Train *nursing unit* to manage their inventory and maybe install an IT system that enables *nursing unit* to better manage their inventory
- The *nursing unit* will retain their autonomy, i.e., the responsibility and capability of managing their inventory. On the other hand, it will be taking responsibilities that may be out of its scope of providing care to patients. So in situations of stress, the quality of the inventory management may drop. This option may also cost more (at least for the short term) than option 1 because it may cost more to train all the *nursing units*' personnel than to train the *Ster's* personnel. Also,

**Option 3:** Eliminate the *Ster's* inventory and use disposable material wherever possible as in the Paris hospital

- This means letting each *nursing unit* manage its own inventory of disposable material. Non disposable material becomes specific material. The question of the timely provision of sterilized material to the *nursing units* remains open.
- The nursing unit may believe that the quality of disposable material is not as good as that of reusable material.
- The cost of change should be calculated

**Option 4:** Make no change and accept the cost associated with the status quo

The first version of this document proposed one more option that consisted in a better management of the *Ster's* inventory and a voluntary effort made by the *nursing unit's* to maintain the inventory levels as low as possible. This would have permitted an auto-organization of the inventory levels. Following a review of the document by the *Ster*, we added the additional belief of the *nursing unit* that they don't have the time and knowledge to maintain their inventory. This belief makes the auto-regulated option seem unreasonable. We have thus removed it from the list.

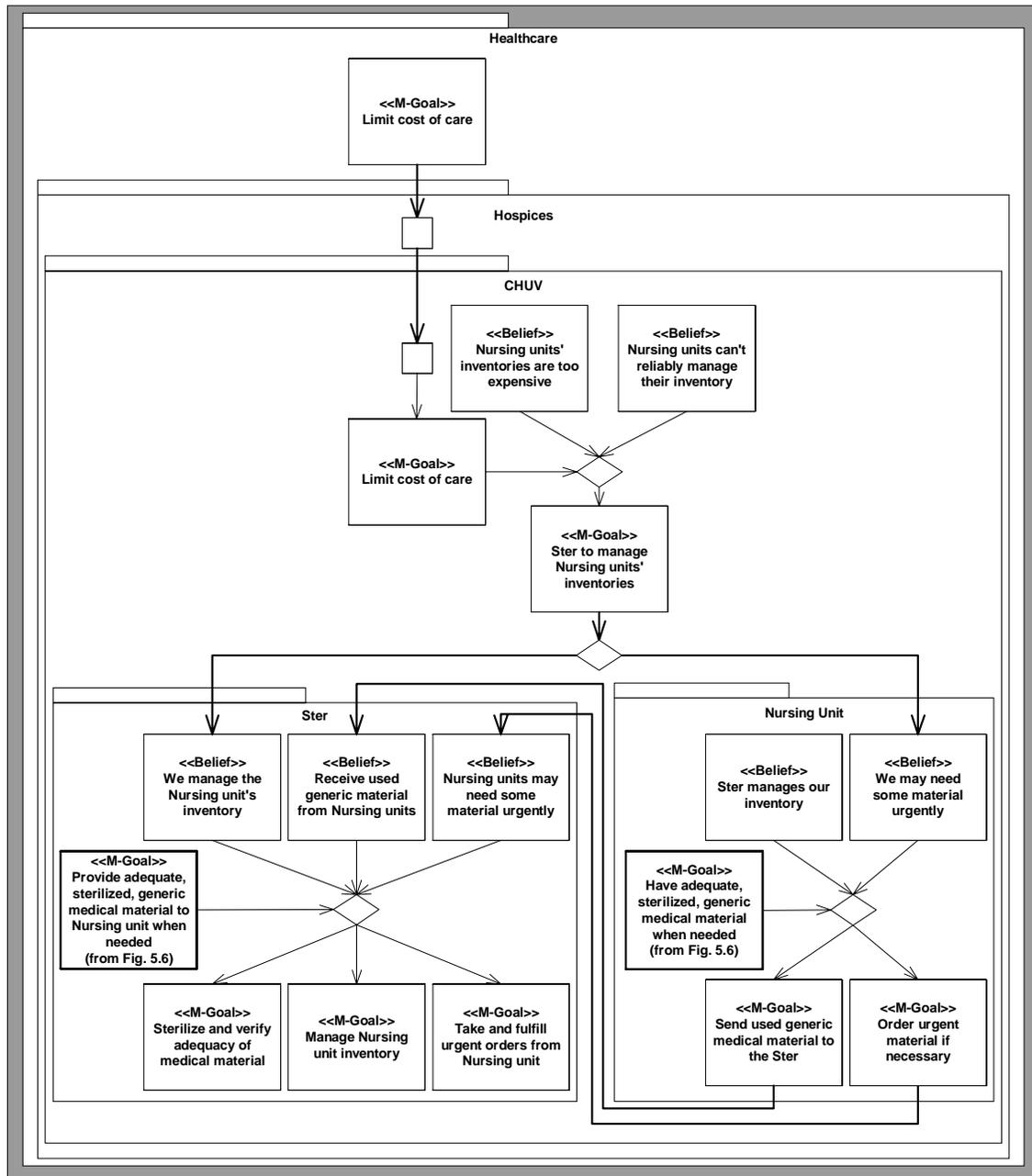


Figure 7.11 Inventory management for option 1

Figure 7.11 shows the situation for option 1. The belief of *Management* that the *nursing unit* inventory is too expensive and the belief that the nursing units cannot reliably manage their inventory now result in a maintenance goal that instructs the *Ster* to manage the *nursing units'* inventories. By placing these beliefs and maintenance goal in the *CHUV*, we wish to show that it is not just *Management* that is preoccupied with this issue but the rest of the community. This maintenance goal influences both the *nursing unit* and the *Ster*. The *nursing unit* now relies on the *Ster's* ability to manage its inventory. A backup mechanism for urgent orders is provided to handle unexpected events in the *nursing units*. Notice that compared to the model in Figure 7.10 the *nursing unit* has one less goal, i.e., managing their inventory while the *Ster's* goal has changed from managing its inventory to managing the *nursing unit's* inventory. This means a definite shift in the mission of the *Ster* which may now focus more on its clients needs.

We now want to analyze what the goals of the IT system should be for option 1. Figure 7.12 shows a further decomposition of the maintenance goal of the *Ster*, “Manage Nursing unit inventory” and the resulting IT system goals.

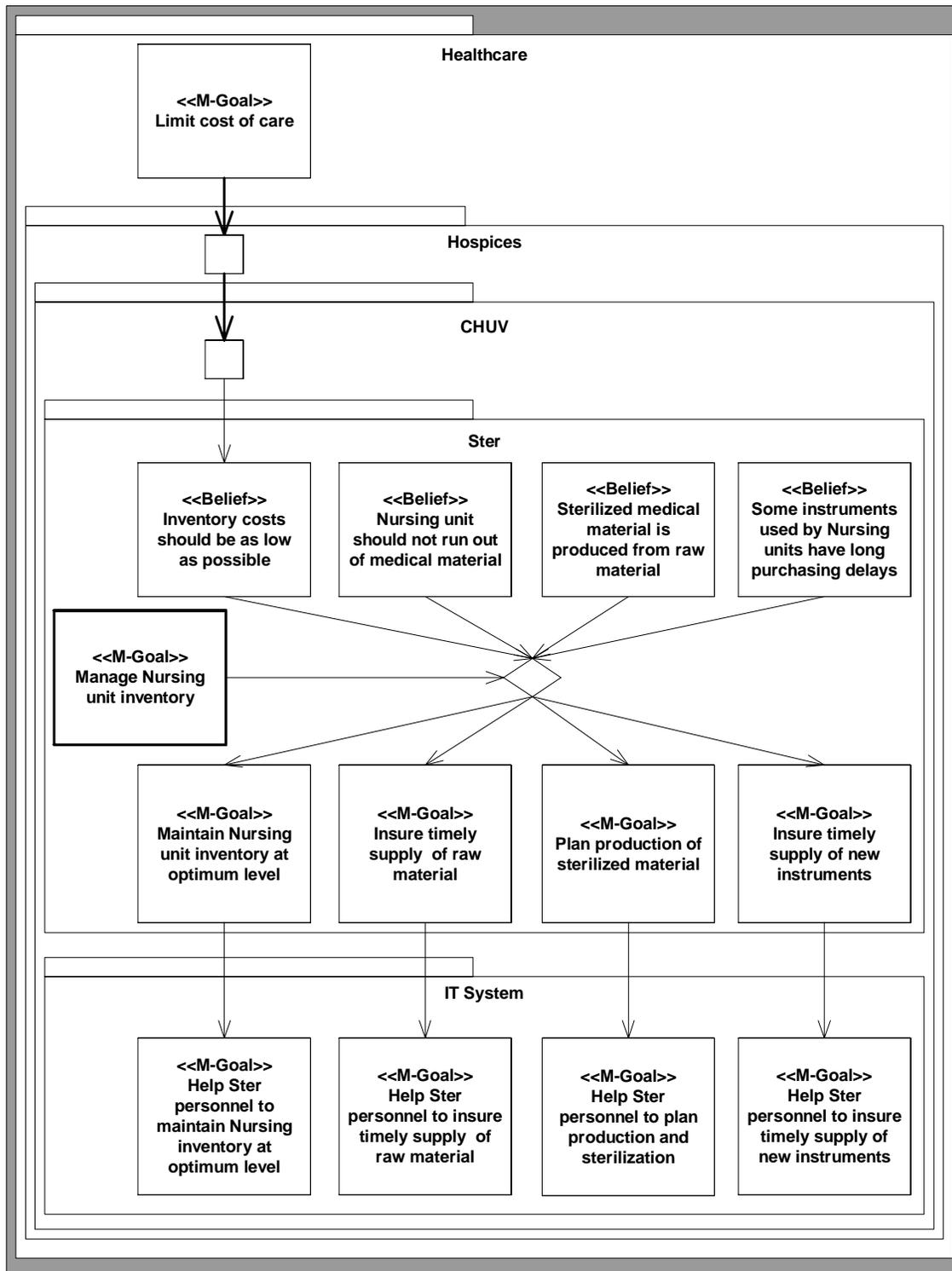


Figure 7.12 IT system goals for option 1

The *Healthcare* maintenance goal of limiting the cost of care and the need to insure that *nursing units* not run out of medical material are shown as influencing the *Ster* into maintaining optimum levels of

*nursing unit* inventory. The *Ster* produces sterilized material from raw material. We thus assign the maintenance goals of maintaining optimum levels of raw material and plan the production of sterilized material.

The CHUV document (CHUV 2002) also mentions that the *Ster* manages the inventory of new instruments which may take up to 6 months to be delivered by suppliers. This inventory is managed with the help of an existing IT application. In Figure 7.12 we have added the corresponding goal to the *Ster* because the goal of maintaining the new instruments inventory seems to be similar, if not identical in nature to the maintenance of the other two inventories.

The *IT system's* main goals are shown at the bottom of Figure 7.12. They are stated as goals that help the *Ster's* personnel to achieve the goals identified above. The identification of the IT system goals as helping the *Ster's* personnel to achieve its goals can be helpful in helping the *Ster* to offer better working conditions for its employees. This is one of the issues that were raised during the interviews as being an important result of the study.

Another issue that came up during the interviews was the issue of statistics gathering. It was not clear what statistics could be useful and what statistics are superfluous. The goals of the *Ster* and the IT system identified above can give a hint into the statistics that may be needed. Indeed, the need to keep optimum levels of inventory suggest that statistics should be gathered about

- the rate of consumption of medical material by each nursing unit
- the delays in receiving raw material
- the rate of consumption of new instruments by each nursing unit
- the delays in receiving new instruments
- the size and cost of the inventory of each service

Not included in the above analysis are the goals related to:

- Payments by nursing units. Payments are not currently required from nursing units. However, payments are requested of external clients. For payments to be correctly calculated, the cost of raw material, production and sterilization, packaging and delivery should be known. Mikros does part of these calculations. If it is to be replaced, these goals should be added to the new IT system.
- Integrating the *Ster's* IT system with the nursing units' ordering IT system.
- Integrating the *Ster's* IT system with the purchasing IT system in order to facilitate order taking and payments to suppliers.

## **7.5 Distribution of specific material**

In this section we analyze the distribution of specific material to the nursing units. The *nursing unit* in Figure 7.9 has the maintenance goal "Have adequate, sterilized specific medical material when needed." In Figure 7.9 we also identified the *Ster's* corresponding maintenance goals: "Provide adequate, sterilized, specific medical material to Nursing unit when needed." Unlike the case of generic material, specific material is removed by the *Ster* and returned to the nursing units without the nursing units needing to order this material.

The qualification "when needed" requires some refinement. In practice, the *Ster* only guarantees the return of specific material to the nursing units within 24 hours. Thus, the goal of the *Ster* in Figure 7.9 should be refined into: "Insure delivery of adequate sterile specific material to the nursing unit within 24 hours." This suggests that the nursing units are able to function without the material that was removed for at least 24 hours. Thus, they probably have an inventory of specific material (heuristic H5).

Specific material is the property of each nursing unit. The nursing unit purchases the material and sends it to the *Ster* for sterilization. In principle the material should be accompanied by sterilization

instructions but many times it isn't. The Ster then needs to obtain this information from the supplier. A standardization effort is under way to force suppliers to issue standard instructions. While the specific material is in the Ster, it is verified for adequacy just like generic material.

The nursing units appear to believe that material that is removed by the Ster often fails to return to the nursing units. This was found to be the major problem reported by nursing units in response to the satisfaction questionnaire sent to the Ster's clients. The Ster removes the specific material in containers that have a different color from the containers of generic material. The material is deposited in the containers by each nursing unit. The Ster doesn't know which material was actually deposited in the containers. It also cannot know what the nursing unit personnel thinks they have put in the container but didn't. The Ster only knows which material was found in the container when it is in the Ster.

Some generic material is sometimes added by the nursing units to the specific material containers. When this happens, the Ster has difficulties in separating the generic material from the specific and to handle them accordingly. Some of the specific material represents a set but the elements of the set are deposited in the containers without being properly labeled as being part of the set. The Ster doesn't know that the nursing unit wants this material back as a set nor does it know what elements constitute the set, since the individual elements are not labeled as such. As a result, the Ster may fail to return specific material to the nursing unit, thinking that it is generic and it may return only some elements of a set or all the elements but in several batches.

Hence, the Ster attempts to separate generic and specific material to be able to provide specialized handling for these different kinds of material. Nursing units don't always cooperate in this separation because their most important norms are to provide care to patients, not to sort material. When the nursing unit is under stress, the sorting gets less attention. The Ster is then incapable of sorting out the specific from the generic and cannot reconstruct the sets of specific material that the nursing units expect. The nursing units then see the Ster as losing their material, leading to mounting dissatisfactions.

It can be said that the goal of having different buckets for the Ster is to separate generic material from specific material. The goal of buckets (any bucket) for some nursing units is to transfer material (any material) to the Ster regardless of what material it is.

Resolving the conflict of whether the material returned to the nursing units corresponds to what the nursing units believes it has put in the containers can be resolved by requiring the nursing units to record the material that they deposit in the container. This could be done with a paper form that the nursing units fill up and attach to the container. However, the nursing unit personnel is often incapable of correctly identifying the material that is deposited in the specific material containers. The nursing unit personnel also has little time to allocate to the identification of the material.

Tracing of the specific material could also be done with the help of an IT system by having a mini bar code inscribed on each article so that it can be uniquely identified. The nursing units would then use a bar code reader to record the material they deposit in the container. However, the bar code technology to be inscribed on medical material is believed by the different parties involved in this study to be unreliable and too complicated to use by Ster personnel. The bar code is believed to be erased when the material is decontaminated and sterilized. The Ster personnel have difficulties in reading the mini bar code. Also, it is believed that inscribing the bar code on all existing material may be overly expensive for the hospital. Indeed it is believed that the material needs to be shipped to a factory to be inscribed. The cost of inscription includes the direct cost associated with the inscriptions and in terms of the surpluses needed while the material is being inscribed.

These constraints only represent the beliefs of the interviewees and it may be that new technical solutions exist that permit the unique identification of material without it being erased during the sterilization process and without it being difficult to read by the Ster personnel and without the need to send it to a factory.

Even with this unique identification of material, discrepancies can still occur between what the Ster finds in the container and what the nursing units reported as placing in it. An article could be passed in

front of the bar code reader and then be placed elsewhere, or articles could be placed in the container without having been passed through the bar code especially in times of stress. Also, the nursing units personnel may feel that this is an unbearable surplus of work.

However, unique identification of material can help avoid the throwing away of material before it has reached its prescribed maximum number of sterilizations (see Section 7.3.3). Unique identification can also help with the maintenance of material, enabling the recording of which material is due for maintenance and which is in maintenance and therefore not available for use. The cost of unique identification needs to be weighed against the potential savings from the prolonged life and better control over the maintenance and location of material.

Thus, further analysis is needed to understand the importance of this problem in terms of dissatisfaction of the nursing units but also in terms of the quality of care that they offer to patients, and how much effort is acceptable in resolving it.

The treatment of both generic and specific material by the Ster creates problems that would not arise if the Ster treated only one kind of material or if each nursing unit used only one kind of material. Since nursing units tend to mix these two kinds of material, the Ster cannot achieve a perfect separation. Especially from the point of view of the nursing units who require this separation from the Ster even though they do not implement it themselves. Thus, the problem of tracking specific material is neither a problem of the Ster alone or of the nursing units alone. It is a problem that arises from the relationship between them both.

A possible IT solution, given these beliefs, may reside in the use of an IT system to record the specific material used by each service. These records could help the Ster personnel to separate the generic material from the specific material and to assemble the sets. To achieve this goal, in the absence of individual marking of each instrument, the records could contain a textual description and one or more pictures of the material. This information will be fed into the IT system when an item is purchased or is sterilized for the first time.

## **7.6 Summary**

In this chapter we have shown the application of the Lightswitch modeling framework to the case of the Sterilization department of the CHUV. We have shown that the framework is applicable and useful in “real world” projects. We used the framework to analyze both the strategic needs of the Ster and its IT system needs. This analysis was performed by:

- Analyzing the relationships between the CHUV and its stakeholders and understanding how these relationships affect the Ster.
- Identifying the major relationships regulated by the Ster with its stakeholders.
- Analyzing the maintenance goals and beliefs of the Ster and its stakeholders, modeling dissatisfactions with the current state of affairs as they were expressed during the interviews.
- Proposing and evaluating several options for addressing these dissatisfactions and proposing IT system goals for each option.

We have shown that there was not a single cause for these dissatisfactions but that they are, to a large extent, due to the way the Ster and the nursing units have evolved over the years within the context of the CHUV. These dissatisfactions are not new but they may have passed the threshold of acceptability, described in chapter 4, and may now lead to action. This threshold may have been reached by the cumulative effect of:

- More stringent norms regarding cost, quality and responsibility that are emerging in the Swiss healthcare landscape
- The obsolescence of the current IT system used by the Ster
- The belief that new IT systems may help satisfy the more stringent norms

We have shown that the relationships of the Ster with the nursing units follow some of the regulation principles described in Chapter 4. In particular, that the nursing units may be protecting themselves against the past norms of the Ster. Since this behavior may have changed, the nursing units may be continuing to protect themselves against an unlikely influence. We have shown that this protection coupled with some changing norms leads to a situation that is judged as unsatisfactory by some stakeholders.

We were able to propose several courses of action in this situation (including not doing anything), and analyzed the one that has the most probability of being implemented. This analysis modeled the changes that may be necessary in the relationships between the Ster and the nursing units. The models show the changes in some of the *Ster and nursing units'* goals and proposed goals for an IT system that should help them to assume these new goals.

This chapter was reviewed by the participants of the study team. Their comments are reflected in this version of the chapter. The feedback from the SIG people was that they better understood the rationale for some of the objectives of the Ster. They felt that this will help them to present their vision to management and to the project managers who may implement the different IT projects. They would have liked for this chapter to include the integration of the Ster's IT system goals with the strategic goals of the CHUV's information systems. However, the scope of the project didn't enable us to analyze this integration. To do this, more interviews are needed to understand these strategic goals.

The feedback from the people responsible for the Ster was that the models produced and the descriptions in this chapter correspond to the reality that they perceive. Initially, this chapter proposed an IT system to manage the central inventory of the Ster. This, they felt, was not really useful since the number of items in the inventory didn't justify such a system. However, they did note that if they needed to manage the nursing units' inventory, they would need more resources than they have today. This feedback allowed us to correct the document and to propose IT system goals that may better help the Ster.

From our point of view, we have shown that the Ster's needs cannot be compared to the needs of other sterilization departments, such as the one we visited in Paris. A sterilization IT system can help the Ster to better control the sterilization process and to enable the traceability of medical material but it cannot help the Ster to better deliver medical material to the nursing units. Thus, the use of the Lightswitch approach enables us to state that from the point of view of its clients, the purpose of the Ster should be seen as "Provide adequate, sterilized medical material" rather than "sterilize medical material." This change of perspective enables us to propose high-level goals for the IT system that are better suited to the needs of the Ster.

We have also seen that the study itself as it was conducted by the CHUV's study team propagated from the local problem of replacing the Ster's IT system to a reflection about the strategic directions of the CHUV. However, no strategic objectives were given to the team. The team had to identify the strategic goals through multiple interviews. These goals were then discussed and changed. There was disagreement about what those goals should be. This confirms the point we have made in Chapters 1 and 2 that designers cannot count on given goals.

## 8 The ABB Sécheron Case Study

The ABB Sécheron case study was performed by Matin Zebad (hereafter referred to as “the student”), as his software engineering diploma project. ABB Sécheron is an independent company belonging to ABB Switzerland, itself a unit of the ABB group. ABB Sécheron designs, manufactures, sells and services electrical transformers, mainly for railway uses. The project (Zebad 2003) consisted of studying the adequacy between the business processes of ABB Sécheron and the software tools used to support these processes. The Lightswitch conceptualization and modeling method were used as the main theoretical tools in this project. The project was performed over a period of four months with the student working full time on the project, the managers at ABB Sécheron and the author of the thesis conducted separate review meetings about every two weeks. In this chapter we summarize the major findings of the project.

### 8.1 *Methods used*

The research method used during this project was to gather information about ABB Sécheron’s mission from documents available on the Intranet and internet sites of ABB Sécheron. To understand the broad structure and activities of ABB Sécheron from a Porter diagram provided by ABB Sécheron showing, at a very high-level, its structure and activities. This initial analysis helped to identify the key stakeholders that were to be interviewed and served as input to the first Lightswitch models.

The interviews were conducted with the guidelines of Contextual Inquiry (Holtzblatt and Jones 1993). For practical reasons it was not possible to conduct real contextual interviews (done while the interviewees perform their actual work tasks). However, Contextual Inquiry was used to define a questionnaire prior to each interview so as to set the focus of the interview, and to set the interview so that an apprentice-master relationship is established between interviewer and interviewee.

After each interview, the student updated the Lightswitch models. Regular review meetings were scheduled at ABB Sécheron and EPFL to review these models and define future directions. The student also used the Lightswitch models in repeat meetings with interviewees as a means to discuss his understanding of the situation described during the interviews.

### 8.2 *Scope of the project*

ABB Sécheron can be seen as having a matrix structure where functional departments such as Operations, Marketing, Finance, R&D, Human Resources support business units that focus on specific product lines. ABB Sécheron has four such business units: Traction (transport) Transformers (TT), Middle Voltage Transformers (MT for Moyenne Tension in French), Services (SS), and Compact Power Stations. The Compact Power Stations business unit is separated physically from the other units and was not considered in this study.

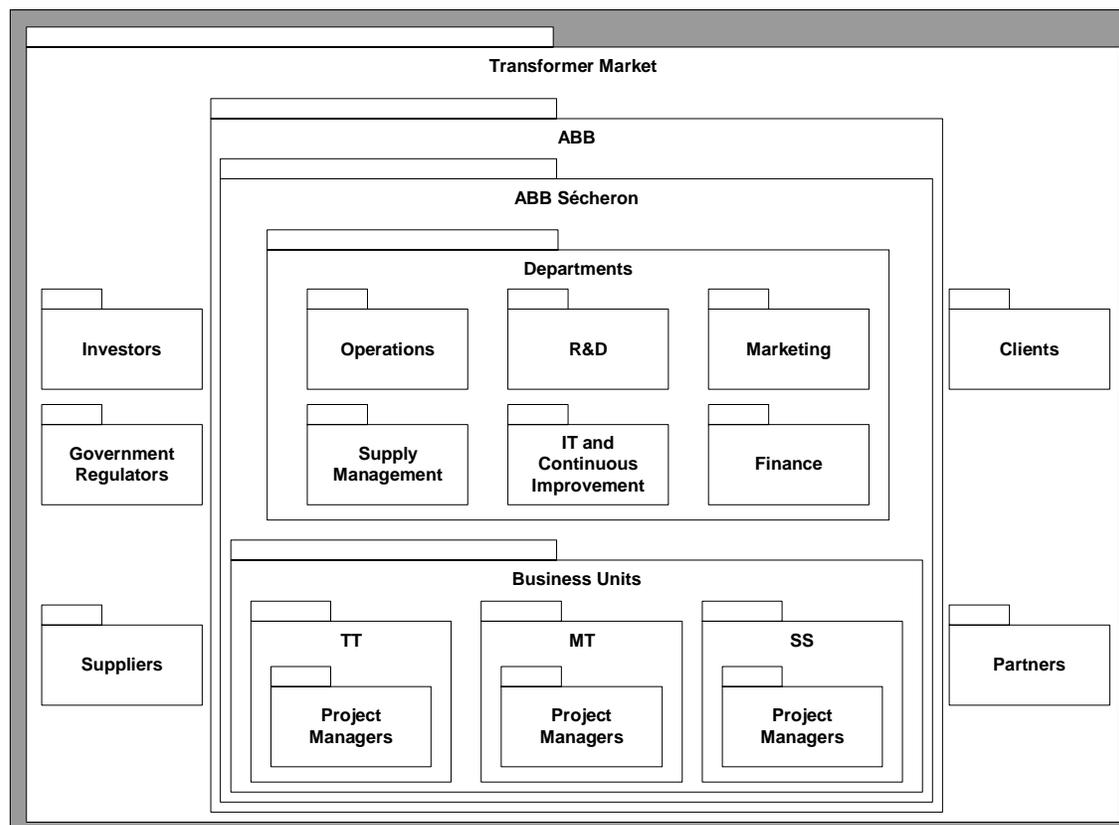
The project was conducted in two main phases:

1. Initially, it was agreed upon with the IT manager of ABB that the scope of the project will be stated in relatively large terms: The study of the adequacy between processes and IT systems of the operations department for the three main business units: TT, MT, and SS. The scope was narrowed down regularly during the project to “manage” the complexity of modeling this large set of processes. The scope was reduced to the analysis of the TT Engineering processes and the related IT systems after an initial set of interviews with the Operations department manager, the SS business unit manager, and the TT engineering manager. A model representing a global view of the TT engineering business processes and their relationships with IT systems was created. Next, the scope was further reduced to focus more on the mechanical design rather than on the electrical design or on their interface.
2. After a sufficient level of description has been attained and several relationships between processes and IT systems that were considered important have been identified, the project scope was set to the analysis of stakeholders that could benefit from an internally developed IT application named LightFlame (no connection with Lightswitch).

The structure of this chapter follows the structure of the analysis performed by the student.

Note that even though the initial focus can be judged as relatively large from the point of view of the analysis of the adequacy between business processes and IT systems, from the point of view of ABB Sécheron as a whole, this scope is relatively limited. For example, no mention is made in this analysis of the product strategy of ABB Sécheron and how this strategy influences the business processes and IT systems used.

### 8.3 Identifying relationships



**Figure 8.1 ABB and its main stakeholders**

Figure 8.1 represents a partial model of ABB Sécheron and some of its stakeholders. ABB Sécheron is represented as a community within the *ABB*<sup>1</sup> community. For simplification purposes, the *ABB* community represents both ABB Switzerland and the ABB group. The *ABB* community is contained within a community that we call the *Transformer Market*. The *Transformer Market* community is the supra-community of the *ABB* community and the stakeholders of ABB Sécheron which are represented by: The *investors*, *government regulators*, *suppliers*, *clients*, and *partners* communities. The *ABB Sécheron* community contains two sub-communities: the *departments* and *business units*. The *departments* community contains communities that represent some of the departments of ABB Sécheron identified during the project. The *business units* community contains communities representing the three business units: TT, MT, and SS. Each business unit contains a *project managers* community.

<sup>1</sup> Note that we use the convention where communities in the model appear in italics to differentiate them from the systems that we see in the perceived reality.

## 8.4 Analyzing how the relationships are regulated

In regulation terms the matrix configuration of *ABB Sécheron* shows the balance that is sought between specialization and aggregation. The *business units* can be considered as specializations (heuristic H4) towards specific influences from different client needs, i.e. different customer segments. Their *project managers* are specialized for the specific product or service that the *business unit* provides to its *clients*. The *TT project managers*, for example, specialize in managing traction transformers projects. The *departments*, on the other hand can be considered as aggregations (heuristic H3) that maintain a more or less general availability for the *business units*. They can thus provide services to the different *business units* depending on the demand. The *operations* department can, for example, provide more engineering services to a *business unit* that experiences more work load than other *business units* without changing the configuration of the enterprise. In this model, *ABB Sécheron* is attempting to minimize the use of the scarce resources (heuristic H6) represented by time and money while maintaining its capacity to deliver products and services to its clients, and value to its shareholders and employees. The result is an optimizing-balancing act. Optimization of the products and services rendered to the different stakeholders and a balancing of the resources allocated to the development of these products and performance of these services.

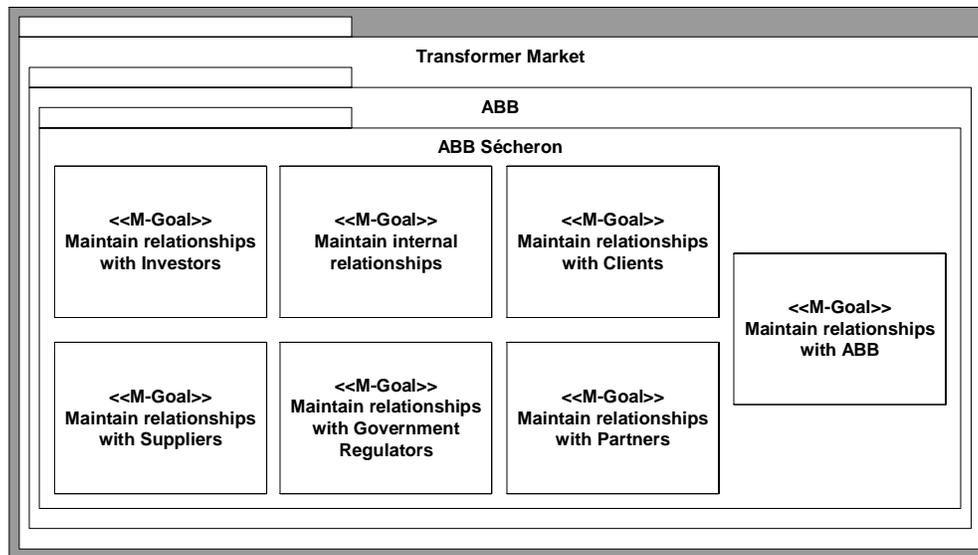


Figure 8.2 ABB Sécheron's maintenance goals

Figure 8.2 represents some of the maintenance goals of *ABB Sécheron* deduced from the model in Figure 8.1. A maintenance goal is defined for each of the external stakeholders identified in Figure 8.1. Two additional maintenance goals, “Maintain internal relationships” and “Maintain relationships with ABB” are added to model *ABB Sécheron*'s need to regulate its relationships with internal stakeholders and with ABB. The goal “Maintain relationships with investors” is probably only satisfied indirectly through the management of *ABB* since *ABB Sécheron* is not a financially independent community and doesn't deal directly with investors.

### 8.4.1 Maintaining relationships with clients and suppliers

Figure 8.3 shows the way *ABB Sécheron* maintains relationships with its *clients*. *ABB Sécheron* responds to its *clients*' need for transformers by having the goal “Sell, build and deliver transformers.” Since the transformers are used by its *clients*, *ABB Sécheron* also has the goal to service the transformers that it sells. *ABB Sécheron* is constrained in the maintenance of this relationships by its belief that it needs to insure a continuous flow of orders from *clients* which results in the corresponding maintenance goal. This belief is influenced by *ABB Sécheron*'s *investors*' maintenance goal of maintaining their Return On Investment (ROI) and *ABB Sécheron*'s *employees*' maintenance

goal to maintain work. The resulting goal for *ABB Sécheron* to insure continuous flow of orders from *clients* justifies the research and development, and marketing efforts.

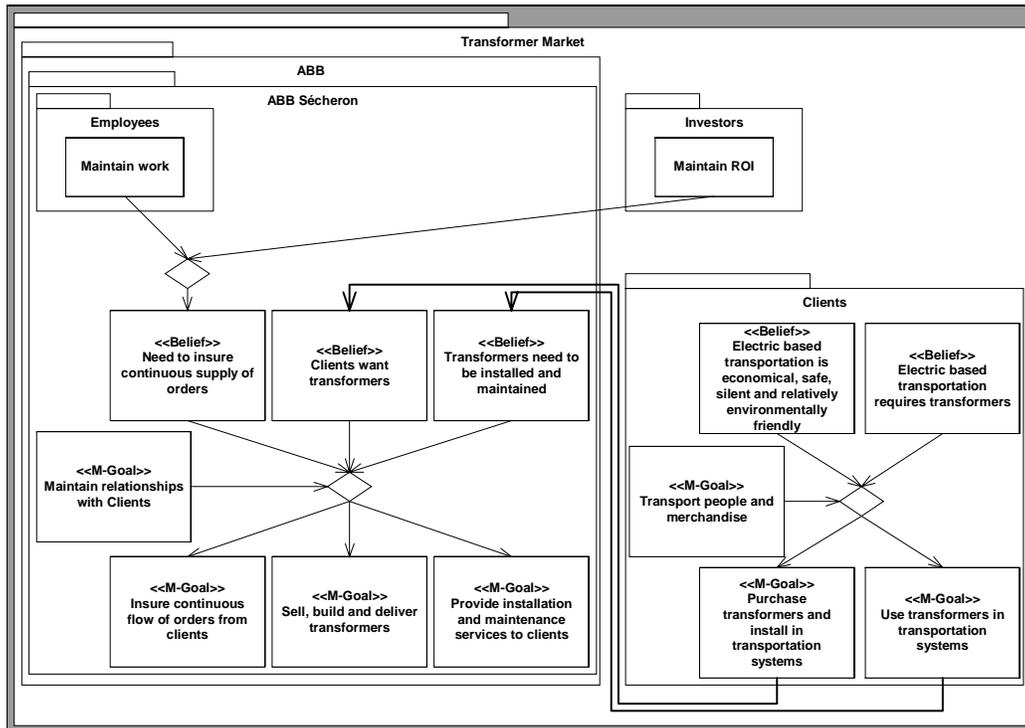


Figure 8.3 Maintaining relationships with clients

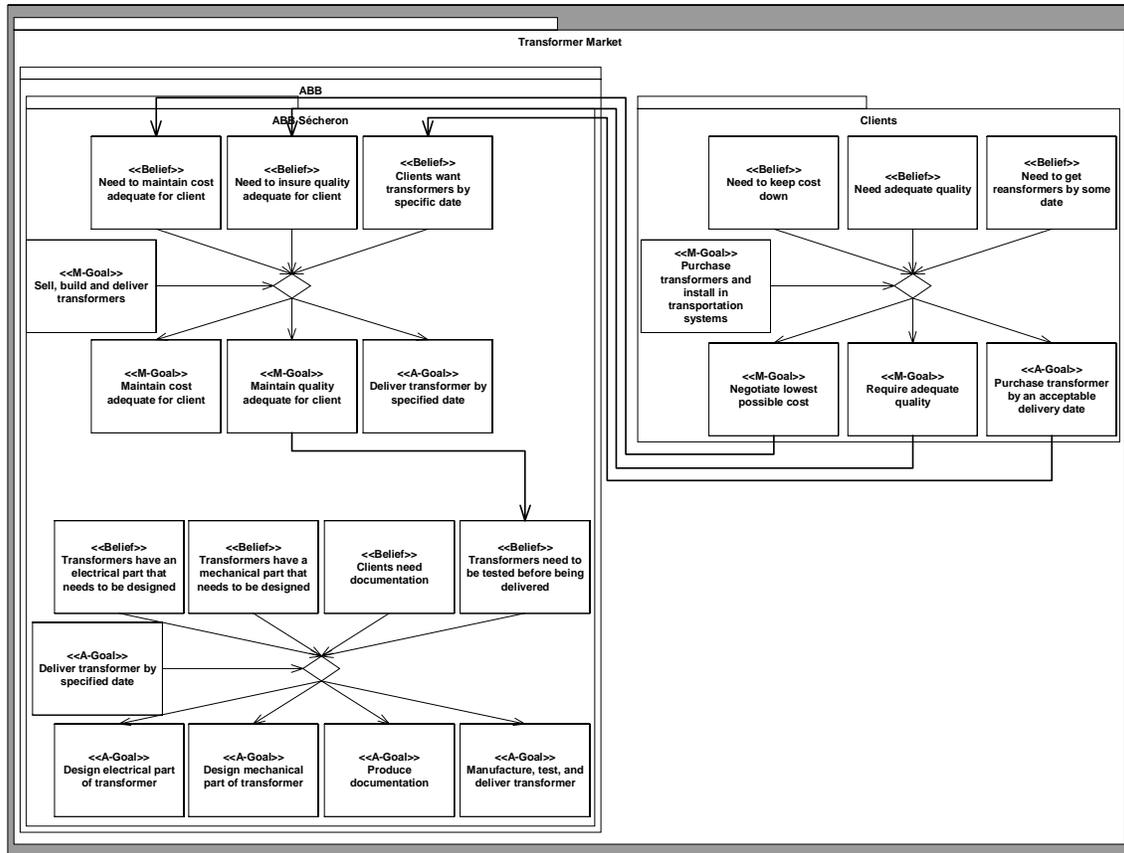


Figure 8.4 Selling transformers

Figure 8.4 shows the model for *ABB Sécheron*'s goal "Sell, build and deliver transformers." The satisfaction of this goal is dependent on the *ABB Sécheron*'s understanding of its customers' needs, reflected by *ABB Sécheron*'s beliefs about the customers. This results in the following three goals for *ABB Sécheron*:

- "Maintain cost adequate for client,"
- "Maintain quality adequate for client,"
- "Deliver transformer by specified date."

Using four beliefs about what is needed in order to deliver a transformer, the goal "Deliver transformer by specified date" is then reduced into the four following goals:

- Design electrical part of transformer
- Design mechanical part of transformer
- Produce documentation
- Manufacture, test, and deliver transformer

We can identify constraints (that could be shown as beliefs) between the needs to satisfy the different maintenance goals in Figure 8.4. For example, a mobile transformer should have a size/weight/performance ratio which is quite specific as it is used aboard trains and other mobile equipment. These constraints will influence the satisfaction of the goals "Design electrical part of transformer" "Design mechanical part of transformer," and "Manufacture, test, and deliver transformer." These constraints should appear in later models as the analysis continues. However, due to space and time constraints we will not analyze these constraints in the next models. Rather, we will

focus on the aspects of information production and sharing within the activity of designing, manufacturing, and marketing the mobile transformers.

Notice that we don't connect the *ABB Sécheron's* beliefs about *clients'* needs for documentation or that transformers have an electrical and a mechanical part to some maintenance goal. It is possible to do so but it is practically complicated in these models. Hence, for practical reasons we don't include these relationships.

Figure 8.5 represents a further reduction of *ABB Sécheron's* goal: "Manufacture, test, and deliver transformer." The most interesting results for our discussion is the need to "purchase components from suppliers" justified by the belief that "It is more cost effective to purchase components from suppliers than to manufacture them." The model in Figure 8.5 gives a reason for establishing relationships with *suppliers*. After some time from establishing such a relationship, the enterprise becomes dependent on its relationships with its suppliers and needs to maintain these relationships.

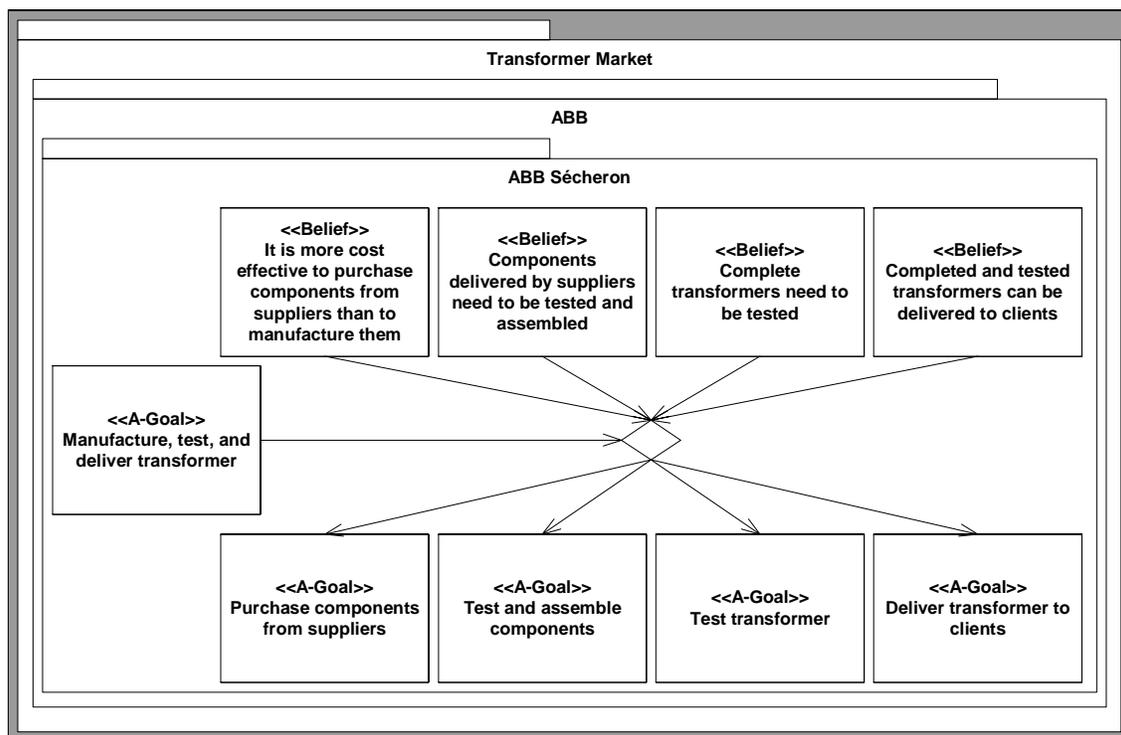


Figure 8.5 Manufacturing, testing, and delivering transformers

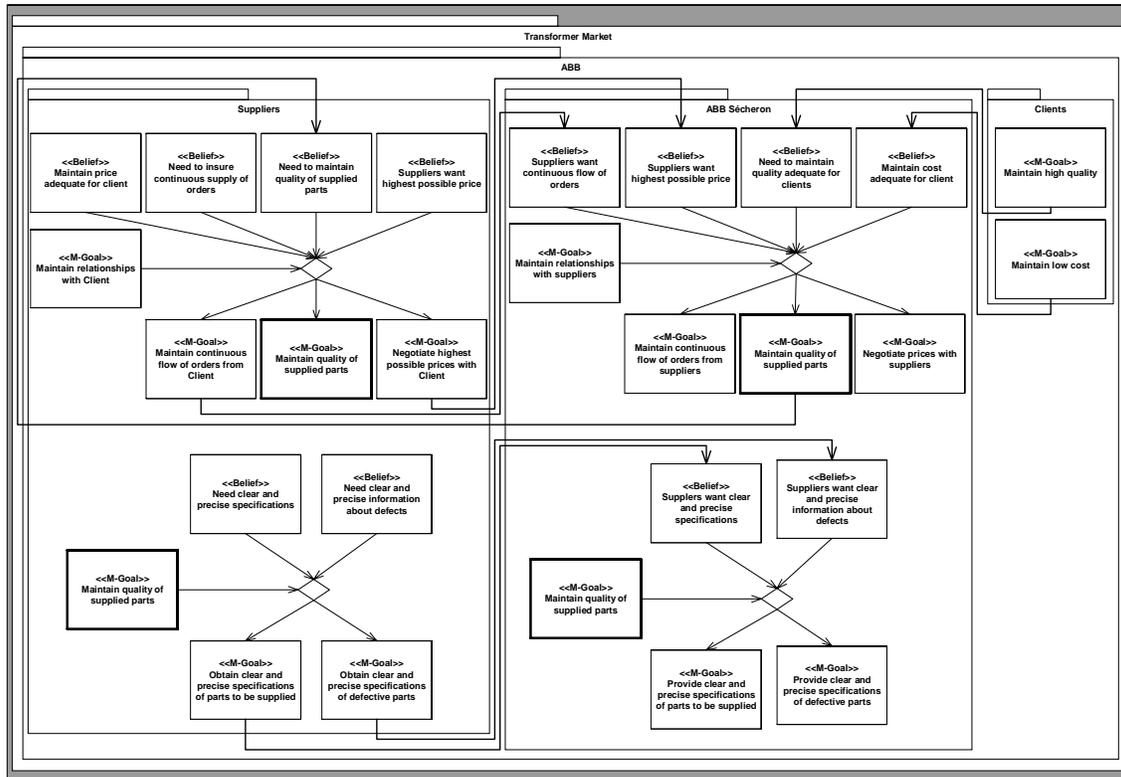


Figure 8.6 Maintaining relationships with suppliers

Figure 8.6 shows what is implied by *ABB Sécheron's* need to maintain its relationships with its *suppliers*. We can see that this relationship is symmetrical to *ABB Sécheron's* need to maintain its relationships with its *clients*. Indeed, *ABB Sécheron* is also seen by its *clients* as a supplier, and hence the nature of these relationships is very similar. What we show in Figure 8.6 is that *ABB Sécheron* is influenced by its *clients* into delivering transformers at a quality and price that are adequate for the *client*. This in turn influences *ABB Sécheron's* relationship with its suppliers. *ABB Sécheron* expects a given quality and cost of the supplied parts. A negotiation over the price of the supplied parts is engaged. The *suppliers* expect a continuous flow of orders from *ABB Sécheron*. The maintenance of the quality of the supplied parts results in the provision by *ABB Sécheron* to the *suppliers* of clear and precise specifications for the parts to be supplied and clear and precise descriptions of defects found in supplied parts.

## 8.4.2 TT engineering business processes and IT systems

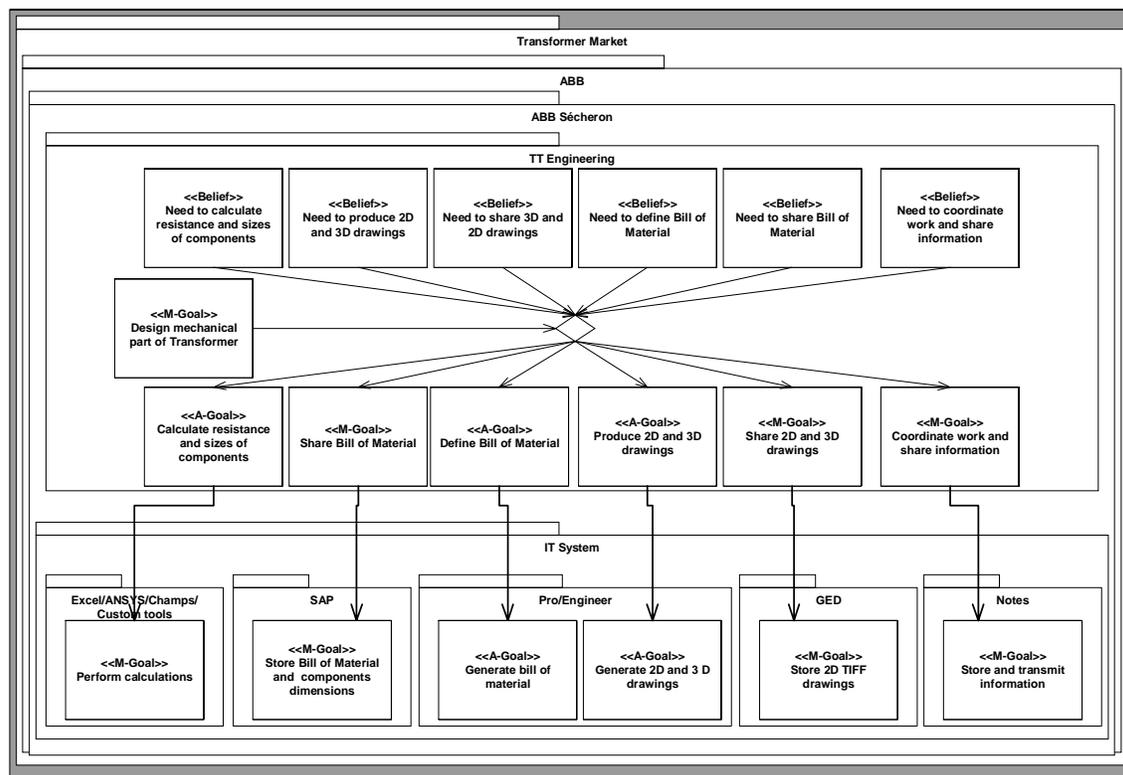


Figure 8.7 Mechanical engineering processes

Figure 8.7 shows the mechanical engineering process as a consequence of the achievement goal “Design mechanical part of transformer” identified in Figure 8.4. In this model we identify the different activities that they are performed by the mechanical engineers and the way these activities are supported by the IT system. The IT system is modeled as composed of five communities. *SAP*, *Pro/Engineer*<sup>1</sup>, *GED*, and *Notes* represent individual IT applications. The fifth community represents a group of applications that are used to calculate the different components of a transformer.

Within the TT Engineering department a need is felt, not represented in Figure 8.7, that the sharing of 3D and 2D drawings among engineers can be improved by making an application available that acts as a front end, integrating the 3D drawings of a transformer and making it available to engineers. Development of such an application, called LightFlame, has started prior to the undertaking of the study described in this chapter. The first version of LightFlame, LightFlame I, is nearing completion and deployment in the engineering department is expected proceed in the next months.

Interestingly, the LightFlame capabilities are interesting from the point of view of other departments than the TT Engineering department who also have a need to share 3D and 2D drawings. We will give the examples of two such departments, marketing and manufacturing, in the following sections. These examples will show that by extending the scope to other departments’ needs, the high-level goals of LightFlame need to be changed.

<sup>1</sup> A few applications serve as alternatives to the use of Pro/Engineer. These are LogoCAD and EloCAD. These two applications are used for some engineering tasks where they are believed to be more efficient than Pro/Engineer. However, some people in the Enterprise would want to standardize the use of Pro/Engineer so that fewer applications need to be supported and maintained.

### 8.4.3 Marketing needs

The marketing manager stated in the interview that the marketing department was responsible, among other things, of the sale strategy and the client relationship. The issues raised during the interview were:

- The need to help clients by giving them information
- It should be simple and easy for clients to make a purchase
- Clients need to have a direct access to information
- Currently, information is mainly sent to clients by email
- It very difficult to send images to clients
- The need to understand and measure the transformer market

Based on this interview we have inferred the model in Figure 8.8. Note that we do not address the last point pertaining to the need to understand the transformer market.

The model in Figure 8.8 shows a partial view of what the marketing manager believes the clients want as information about a transformer before and after they have made their mind about the purchase. The goal of the *clients* to “Purchase transformers and install in transportation systems” was specified in the model in Figure 8.3. The model in Figure 8.8 shows that *clients* need to make a choice between several optional transformers and need to understand the characteristics of these transformers. This leads *marketing* to want to share 3D and 2D drawings of possible transformers with *clients*. These drawings are generated by the engineers as we have seen in Figure 8.7.

Note that the goal attributed to the *clients*: “Understand characteristics of possible transformers” was inferred from the interview of the marketing manager. This goal was not stated explicitly during the interview. We don’t have further information about the characteristics that clients would want to have but we could infer that these are related to their need to understand the structure, dimensions, weight, price and electrical performance of a transformer?

The situation today is such that 2D drawings are sent to clients on demand by email or are made available in brochures. There is no current solution for sharing 3D drawings with clients. Moreover, the belief, shown in Figure 8.8, that customers want an easy access to information, drives the marketing manager to want a better way of sharing 2D drawings, and a way of sharing 3D drawings with clients.

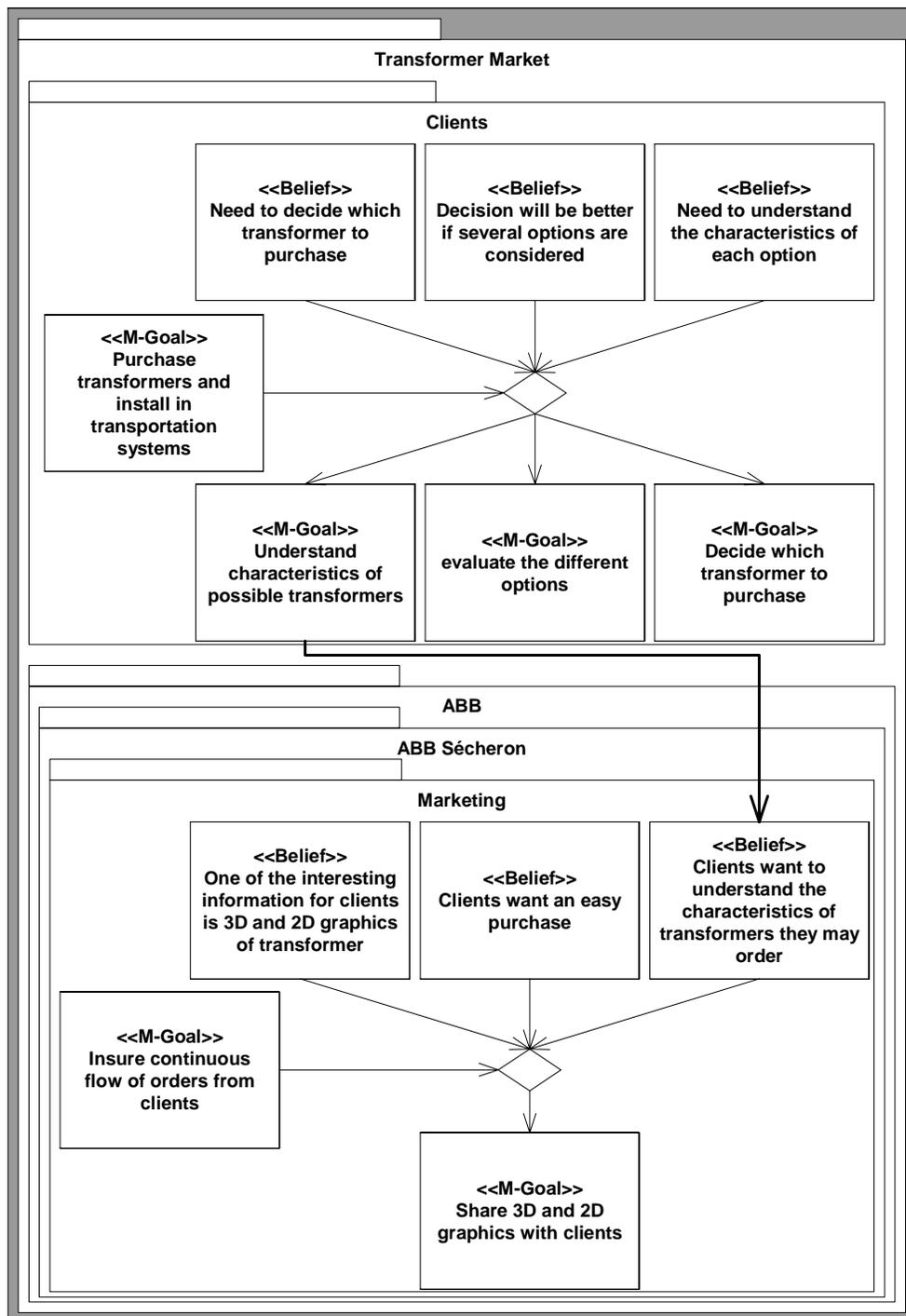


Figure 8.8 Sharing information with clients

#### 8.4.4 Manufacturing needs

The manufacturing department is responsible for the manufacturing of the transformer. The interview with the manufacturing manager exposed the following issues:

- There is a problem of coordination between the engineering department and manufacturing. Changes made to parts by the engineering department are manually transmitted to manufacturing. This causes a disconnect which means a waste of time. Automatically

transmitting the changes and making them visible directly in the 3D drawings is expected to make an improvement.

- Some dimensions may be missing from the 2D drawings given by the engineering department. These dimensions are usually not included in drawings because they clutter them. They could be read directly from 3D drawings
- Creating a defect notice for a defective part is a complicated process involving too many steps. This process could be made simpler.

In this section we only discuss this last problem only.

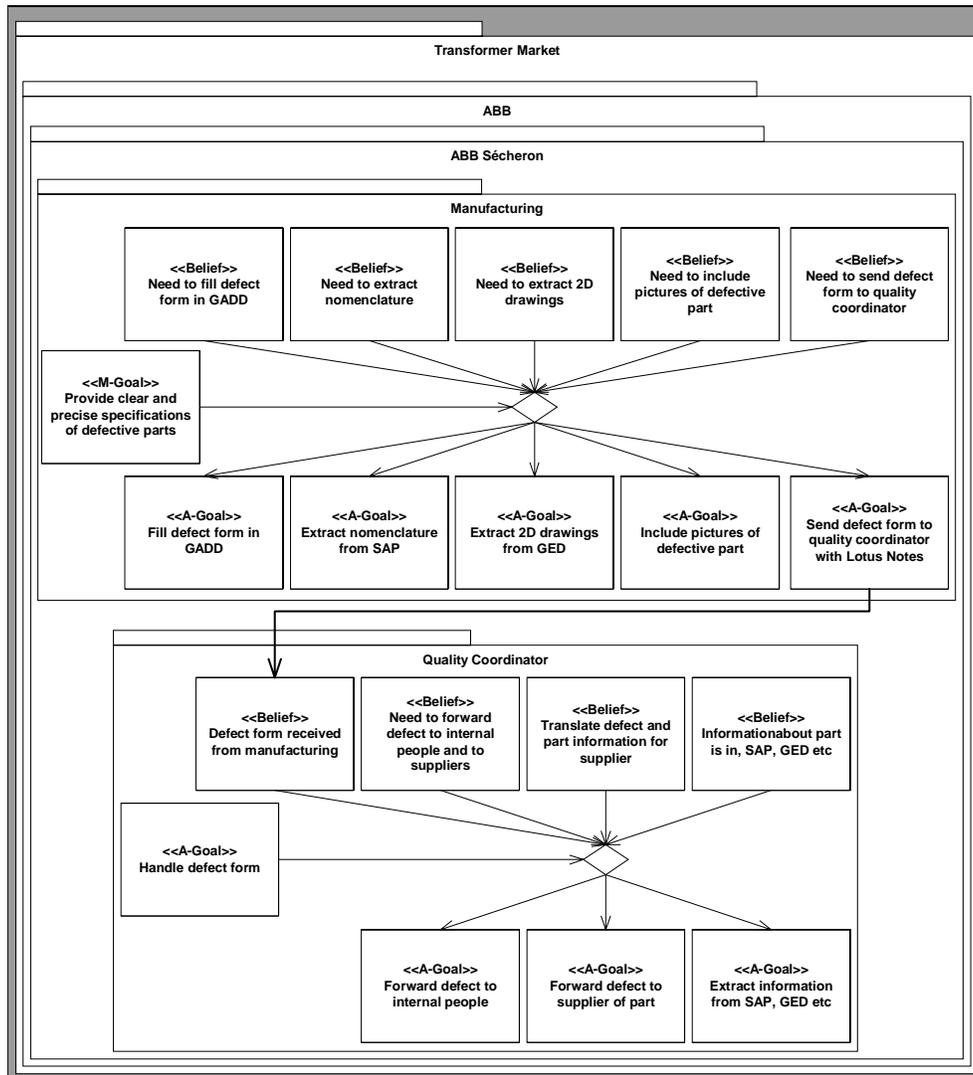


Figure 8.9 Current defect notice process

Figure 8.9 shows a summary of the defect notice process issued by *manufacturing* when a defective part is detected. The *manufacturing* goal: “Provide clear and precise specifications of defective parts” was identified in Figure 8.6. The model in Figure 8.9 shows the many IT applications needed to fill and send a defect notice. GADD is a Lotus Notes based tool where the defect form is filled. *Manufacturing* also needs to extract the nomenclature from *SAP*, extract 2D drawings from *GED*, include pictures of the defective part, and send the form to the quality coordinator. The quality coordinator extracts necessary information from the form and sends it to internal people and to the

*supplier*<sup>1</sup>. The *supplier*, not shown in Figure 8.9, will extract the information from the form and act upon it. Notice that 3D drawings are not sent to the *supplier*.

## 8.5 Identify, evaluate, select options and IT system goals

Figure 8.10 shows an example of how the defect notice process will be changed with the use of LightFlame II by the *manufacturing*, *quality*, and *suppliers* communities. The idea in this model is that *manufacturing* embeds a link to the specification of the defective part in the defect form together with an explanation of the defect and a picture of the defective part. The defect form is then sent to the *quality coordinator*. The *quality coordinator* forwards the defect form to the *supplier*. The *supplier* has a direct access to LightFlame II and can thus inspect the form and take corrective action. This process can be contrasted with the model of the present process in Figure 8.9 where several applications are used by *manufacturing* and the *quality coordinator* and no direct access to the information is available to the *supplier*.

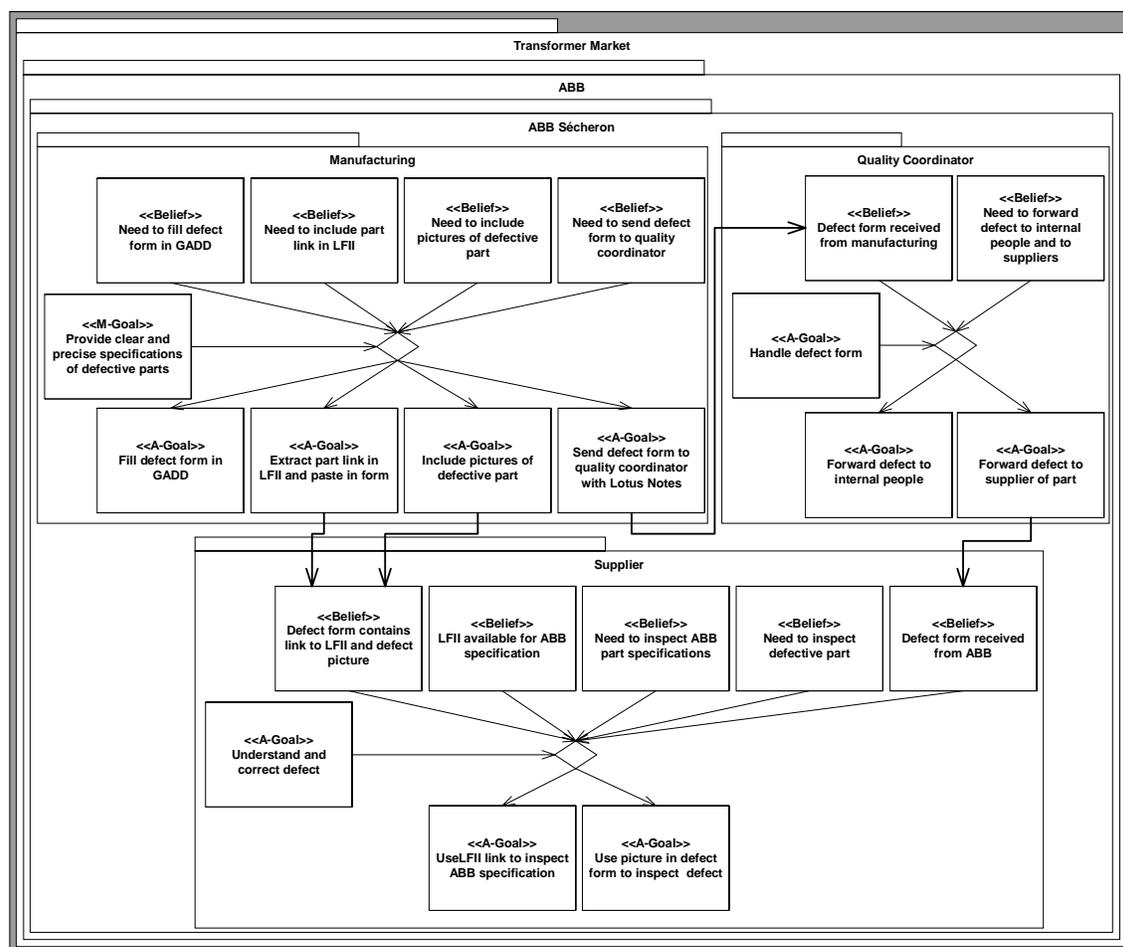
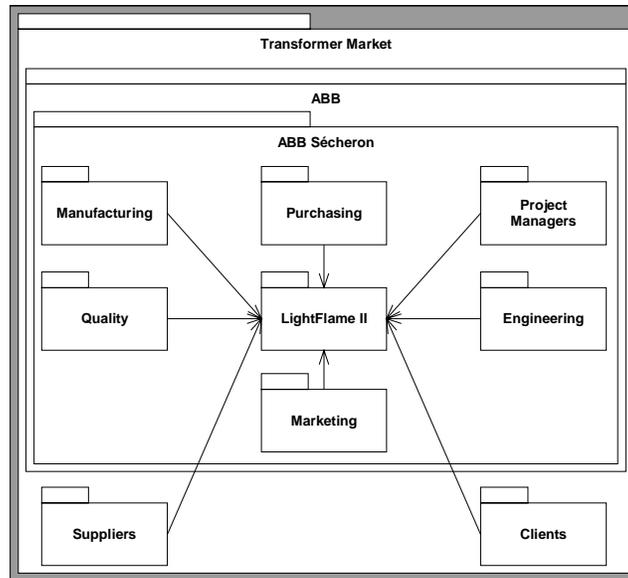


Figure 8.10 To be defect notice

<sup>1</sup> In practice it is probable that the supplier only forwards the defect notice to internal people who forward it to the supplier. However, the interviews didn't expose clearly who sends the notice to the supplier. We thus assume here that it is the coordinator.



**Figure 8.11 LightFlame II in context**

Based on the analysis in the previous sections, we can construct a model of the context of use of LightFlame II as shown in Figure 8.11.

In this model, *LightFlame II* is used by *manufacturing, quality, purchasing, marketing, project managers, and engineering* inside *ABB Sécheron*, and by the *suppliers and clients* from outside *ABB Sécheron*. Whereas the original version of *LightFlame* is destined mainly to be used within the engineering, the study has revealed that *ABB Sécheron* would benefit from an expanded *LightFlame*. *LightFlame II* can take the form of a World Wide Web portal available to both internal and external users. The goals that these stakeholders could have with respect to *LightFlame II* are:

Manufacturing:

- Share 3D, 2D, and bill of material with engineering, project managers and suppliers
- Prepare, share and track defect notices

Quality:

- Prepare, share and track defect notices

Purchasing:

- Get better understanding of the structure of a transformer
- Share 3D and 2D drawings with suppliers

Marketing:

- Help clients to understand the characteristics of a transformer

Project Managers:

- Share 3D, 2D, and bill of material with engineering, manufacturing and suppliers.
- Track manufacturing status of transformer and share with clients
- Reuse 3D and 2D drawings in new projects

Engineering:

- Share 3D, 2D, and bill of material inside engineering.
- Share part changes with manufacturing

- Share 3D and 2D drawings with suppliers

Suppliers:

- Access 3D and 2D drawings of parts
- Share and respond to defect notices

Clients:

- Access 3D and 2D drawings of parts

Other departments within ABB Sécheron could use LightFlame II as well. However, the analysis presented in this chapter didn't investigate these departments.

The Implications of this list of goals are:

- LightFlame II will need to offer more than simply a hierarchical view of 3D and 2D drawings. It will need to integrate the bill of material with the 2D drawings and 3D drawings in a coherent navigation of a transformer. This coherence should be understood for each stakeholder, i.e. clients may not navigate a transformer in the same way as engineers would.
- Suppliers and clients will have to have ProductView (a 3D and 2D Web based image viewer) to be able to view 2D and 3D drawings.

## **8.6 Results and lessons learned**

In this chapter we have presented a summary of a project conducted by a student using the Lightswitch approach to understand some of the business processes of ABB Sécheron and their support by IT applications. The details of the potential use of an IT application (LightFlame II) were identified by interviewing potential users and understanding their needs. These needs were identified by understanding the relationships that were regulated within ABB Sécheron and the relationships that ABB Sécheron regulates with its external stakeholders, clients, investors, and suppliers. The Lightswitch approach was used to:

- Model the large scope and as an aid in deciding how to narrow the scope.
- Model both the present situation and the potential future uses of the LightFlame II.

Concrete recommendations of the change necessary in some business processes and the related high-level goals for LightFlame II were made.

The student performed the project with successive drafts of the present document as guidelines. The feedback from the student confirmed that it is difficult to define goals and beliefs. We may add that an additional issue was the separation of goals and beliefs, i.e. knowing what aspect to model as a goal and what aspect to model as a belief. However, we have shown that it is possible, but difficult, for a person who did not participate in the elaboration of Lightswitch to use the approach. Namely, it is difficult to define (and distinguish between) goals and beliefs; difficult to handle the numerous models needed to represent a given problem.

As for the analysis presented in this chapter, two continuation projects are possible:

- Help with the deployment of LightFlame I by understanding users' needs through contextual interviews and LS modeling.
- A continuation of the definition of the high-level goals for LightFlame II based on the work completed during the diploma project and the lessons learned during the LightFlame I deployment.

## Part 3 Summary

In this part we presented the validation of the Lightswitch approach. We showed that it can be used in practice to identify high-level goals, or early requirements, for an IT system envisioned for an enterprise.

The first case we presented was a theoretical case. It did not involve interviews of people in the enterprise. It was based on careful analysis of the customer documentation defined by the Templeman Library itself. As designers, we provided an external view on this documentation. We analyzed this documentation with the help of the heuristics defined in Part 2 and created goal-directed, Lightswitch models. These models enabled us to define a set of high-level goals for a future IT system for the Templeman Library. These goals were defined by taking into account both the current state of the Library and what we defined as future trends that may affect any university library such as the Templeman Library.

The second and third cases were practical cases that involved the analysis of interviews rather than enterprise documentation. Indeed, in both cases some documentation existed and was used but most of the useful information came from what the people within the enterprises said they believed their situation was. In both cases we provided an analysis of some of the past, current, and foreseeable conditions in which these enterprises find themselves. These conditions and their analysis were based on the beliefs of the people interviewed and on our beliefs as designers. Through these case studies we showed that it was possible to use the Lightswitch approach to define high-level goals in a non theoretical setting.

In the sterilization department case we were able to show that different structures in the enterprise should result in different high-level goals for the IT system. We presented several options that coupled possible structures and goals.

In the ABB Sécheron case we showed how different goals for an envisioned IT system influenced the relationships between the enterprise, its clients, and its suppliers as well as among the different departments within the enterprise.

## 9 Conclusions

In this thesis we have sought to improve the state of the art in Requirements Engineering by focusing on the use of goals in Enterprise Architecture (EA) and Goal-Directed Requirements Engineering (GDRE) methods. We have seen that current methods propose useful concepts such as context diagrams, maintenance goals, achievement goals, softgoals, beliefs etc. These methods also propose techniques for using these concepts to produce requirements for IT systems. However, they can be improved in the area of early requirements.

Defining the requirements for an enterprise IT system is a complicated task. The requirements explain what the IT system should be so that it can be built and used. IT systems are built for enterprises and enterprises attempt to survive in a changing and often hostile environment. An IT system should help the enterprise for which it is built to maintain success in its changing environment. The enterprise and its environment, therefore, should not be seen as static entities but as dynamic entities with a past that determines their current structure and a future in which they will need to survive. Both the past and the future need to be understood by the designers who define IT system requirements, the past because it explains the present and the future because it contains the conditions of survival. However, we cannot know for certain what the past was and what the future might be. There are even disagreements among people about what the present is. Designers have no choice but to define requirements in such an uncertain situation. Considering these conditions, we identified a number of missing elements in the EA and GDRE methods we have surveyed. These missing elements are:

- an evolutionary perspective
- an appreciation for the factors that contribute to the survival of the enterprise
- a theoretical perspective on goal-directed behavior

We argued that as a result of these missing elements, EA and GDRE methods are ill adapted to reflect on the strategic nature of IT systems.

GST and Cybernetics provide a general purpose evolutionary perspective that also explains goal-directed behavior.

### 9.1 Contributions

We have used GST and Cybernetics to propose a conceptualization of the subject matter of enterprises. This conceptualization provides an explanation of the ways by which enterprises maintain their stability in an unstable environment. The result is a threefold contribution to EA and GDRE:

- A theoretical explanation for some of the modeling concepts used in EA and GDRE, such as achievement goal, maintenance goal, softgoal, and belief (see Chapter 4)
- An augmentation of these methods with proposals to focus more on maintenance goals and beliefs. Maintenance goals are the modeling elements of norms. Beliefs are the modeling elements of an enterprise's interpretations of itself and its environment (see chapter 5).
- A modeling framework that uses maintenance goals, achievement goals, and beliefs. This framework enables designers to reflect on the ways by which enterprises regulate relationships with their environment and define early requirements for IT systems in the form of high-level goals (see chapter 5).

The modeling framework that we propose consists of a four steps process:

1. Identify relationships
2. Analyze how the relationships are regulated
3. Identify changing conditions
4. Identify, evaluate, select options and corresponding IT system goals

In this process goal-directed models are built by designers. In these models, enterprises are modeled as interacting communities that have maintenance and achievement goals. In a given community goals are reduced into lower level goals by the use of beliefs. Beliefs represent what the community knows of its goals and the goals of other communities.

Regulation-directed heuristics are used in each one of the above steps in order to help the designers to analyze how the enterprise and its environment maintain their stability.

The point of departure of the design process consists in considering the survival of the enterprise as reflected by the norms that it maintains and the relationships that it regulates in order to maintain these norms. The Lightswitch modeling framework, therefore, offers a higher level of abstraction than the one proposed today by GDRE and EA methods, where goals are considered as the point of departure without an understanding of their connection to the norms and the regulated relationships.

The context of use of the Lightswitch modeling framework is the early stage of the development of an IT system when it is not yet clear what IT system to build nor whether it makes sense to build any at all. This is the case of the sterilization department described in Part 3. However when the strategy of the enterprise and the high-level goals of the IT system are known beyond doubt, an approach such as Lightswitch is not needed. Caution is needed though because many times it appears that the goals are known and shared by all members of an enterprise when in fact they are not as our example of the meeting scheduler in Chapter 3 shows. This means that good judgment needs to be exercised when deciding whether to use Lightswitch or not.

The explanation of the method as described above is quite short and simple. Its implementation, on the other hand, is quite complicated because it requires that implicit aspects of several enterprises be made explicit. This is a property that is apparently common to most if not all systemic methods (Malarewicz 2000 p. 13). They are relatively easy to understand but difficult to apply.

We have presented an evaluation of the Lightswitch modeling framework. This evaluation involved two practical field studies in enterprises and one theoretical case. This evaluation shows that Lightswitch is usable and useful in practice. Used prior to the application of a traditional EA or GDRE method, a Lightswitch style inquiry can help identify the main issues to be dealt with, what may change and what stakeholders would not want to change, as well as the appropriate IT system high-level goals for the envisioned change.

## **9.2 Future work**

Since much of the Lightswitch approach is based on interpretations of the world, we would like to further study how interpretations are explained in Hermeneutics (Winograd and Flores 1986) and Organizational Semiotics.

It should also be useful to link the Lightswitch approach with AI and computational logic describing social networks of agents.

Both the author and others who have applied the Lightswitch modeling framework conclude that it is long and difficult to create, maintain, and modify the Lightswitch models. The support of a tool (an IT system) would be very welcome if the Lightswitch modeling framework is to be used by other people. The modeling tool derived from the Knoware project, currently under development at EPFL-LAMS, provides a promising start.

We wish to create an executive version of the Lightswitch method that can be explained very briefly and used in brainstorming sessions in order to create a shared understanding within a team of the strategic issues concerning some particular question. These questions may be completely unrelated to requirements engineering, for example, how to design the interior of EPFL's new Information and Communication faculty building, or how to design a potential collaboration between two or more professors working in different academic institutions.

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## Appendix A: Supplemental reading

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## Appendix B: Templeman Library Documentation

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### Library Regulations

#### **REGULATIONS FOR THE USE OF THE TEMPLEMAN LIBRARY**

##### **(1) Terms Used in these Regulations**

The term "academic and related staff" means those members of the staff of the University who are paid on academic and academic-related salary scales and also academic staff who have formal Visiting or Honorary status.

The term "undergraduate" means a student registered for part or all of the course of study leading to a first degree, diploma (except a postgraduate diploma) or certificate of the University.

The term "postgraduate" means a student registered as a candidate for a higher degree, postgraduate diploma or postgraduate certificate of the University.

The phrase "facilities of the Library" includes access to materials, staff time, services, and space provided for users. The use of such facilities may require the payment of a prescribed charge and may be restricted or withdrawn at the discretion of the Librarian. The additional regulations which apply to campus computing services are set out in the separate Regulations for the use of Computing Services.

##### **(2) Library Users**

(i) The facilities of the Library including borrowing rights are available to all academic and related staff, all other staff, and registered postgraduate and undergraduate students of the University who comply with the Regulations set out below.

(ii) The facilities of the Library including borrowing rights are also available to postgraduate research students of the University who have completed the period of registration and who have paid the charge prescribed for the use of University facilities while writing up their theses.

(iii) The facilities of the Library may also be made available by special permission of the Librarian to other persons.

(iv) Users must carry a valid Library card which will serve as a form of identification and a means of access to facilities. The card is not transferable and must be shown to Library staff on request.

##### **(3) Subscription charges**

The facilities of the Library are available to users specially admitted under 2(iii) on payment of the prescribed charges in force at the time of application. Such charges may be altered or waived at the discretion of the Librarian.

##### **(4) Borrowing**

(i) Material may be removed from the Library only after the relevant borrowing procedure has been followed. Any removal or attempted removal of an item without complying with

this procedure constitutes an offence and renders the borrower liable to disciplinary action.

(ii) The borrower must hand items with bar-coded labels from the main loan collection together with a valid Library card to an assistant at the Main Loan Desk. To borrow all periodicals, the borrower must fill in and sign a separate loan voucher for each item and hand periodicals and vouchers to an assistant at the Main Loan Desk. To borrow material from the Short Loan Collection, the borrower must hand to an assistant at the Short Loan Collection desk details of the item to be borrowed together with a valid Library card. To borrow material from the Audio-Visual Materials Collection the borrower must comply with the loan procedure in force.

(iii) There are prescribed periods of loan for material not specifically confined to the Library and limits on the numbers of items allowed on loan to a borrower at any one time. Details of the current arrangements are available from the Main Loan Desk.

(iv) Loans may be renewed if the item is not required by another borrower. Telephone renewals are not permitted except in the case of part-time or disabled students.

#### Restrictions on Borrowing

(v) No current number of a periodical, or other material specifically confined to the Library may be removed from the Library except with special permission of the Librarian.

(vi) The borrowing of items from the Short Loan Collection is restricted in various ways which are specified at the time of borrowing. Details are available from the Short Loan Collection desk.

(vii) Items borrowed must be returned by the due day and time which is specified when the item is borrowed.

(viii) Periodicals may not be borrowed by undergraduates except with the written authorisation of their Tutor or the member of the academic staff for whose course the periodical is needed, or the special permission of the Librarian.

(ix) After a main loan collection item has been in the possession of any borrower for a week it may be recalled if required by another user.

(x) The Librarian may recall material at any time, if it is required for special purposes, and may withhold or restrict the circulation of any item.

#### Return of materials

(xi) Borrowers who, without good cause, fail to return an item or to renew the loan when it is due, will become liable to a charge at the rates prescribed until the book or periodical is returned to the Library and may have borrowing rights suspended.

(xii) Items recalled under (ix) or (x) from any category of borrower must be returned immediately. A borrower who, without good cause, fails to return an item that is so recalled within **5** working days after that on which the recall card was issued, will become liable to the prescribed overdue charges and suspension of borrowing rights, continuing until the item is returned.

(xiii) Borrowers returning items must hand them in at the return point of the Main Loan Desk, Short Loan Collection desk or Document Delivery office as appropriate. Any charges due on overdue items must be paid at this time.

(xiv) Items returned to the Library by post must be returned by registered post or recorded delivery.

(xv) Failure to pay charges may result in suspension by the Librarian of borrowing facilities.

### **(5) Special Collections and Cartoon Centre**

(i) The collections to which these regulations apply are shelved in the Special Collections Room, the Special Collections stores, the Maddison Collection Bookcases and the Centre for the Study of Cartoons and Caricature.

(ii) Users of these collections will be required to provide documentary proof of identity and the document(s) will be retained while material is being consulted.

(iii) Special Collections material may only be consulted by prior appointment and on completion in advance of a Special Collections Request Form. Material will be brought to users in the appropriate reading room. It is a condition of access that the user is familiar with the Library's rules for the handling of Special Collections items and agrees to observe them.

(iv) Details of user access to the Cartoon Centre's database of cartoons, its books, periodicals and videos are set out in the current issue of the Centre's guide available from the Library.

### **(6) General**

(i) Silence is to be observed in all public study areas except in areas specifically set aside for group study or discussion.

(ii) The reservation of seats in public reading areas is not permitted. Articles left unattended on chairs and tables may be removed by the Library staff.

(iii) Articles left in the public area at closing times will be cleared away. The Library accepts no responsibility for belongings left in the building.

(iv) A warning bell will be rung ten minutes before closing times, and all readers must vacate the Library by closing time. Refusal to leave will be regarded as a serious breach of the Regulations.

(v) Users may be required to show all Library materials to the attendant at the exit turnstile before leaving the Library, and must make available for inspection by the attendant any other objects in their possession.

(vi) Library material and property must not be marked or in any way defaced.

(vii) Users will be held responsible for, and will have to make good any loss of, or damage to, the Library material on loan to them, or being used by them in the Library.

(viii) Users may not bring into the Library anything which, in the judgement of the Librarian, could cause damage to Library materials, equipment, and furnishing, or which

could cause disturbance to other users. Items may be left with the gate supervisor for later collection. Such items found within the Library may be confiscated for return to the user on departure. The consumption of food and drink is forbidden in the Library. Mobile telephones and personal stereos must remain switched off in the Library.

(ix) Users are responsible for complying with copyright legislation.

(x) The Librarian may require any person who is guilty of disorderly or improper conduct or who is in breach of these Regulations to leave the Library forthwith.

(xi) Contravention of Library Regulations will render the person or persons responsible liable to disciplinary action. In the case of students, such disciplinary action will normally be taken under the provision of Ordinance XXIV (Of Discipline). The improper removal of all or any part of an item or the mutilation or defacement of Library materials or property will also render the user concerned liable to prosecution in the Courts and suspension of borrowing facilities.

(xii) The Librarian may delegate all or any powers under these Regulations to such member or members of the Library staff as may be appropriate.

March 1998

LPC97/11 revised 6.3.98

## **Borrowing Books and Journals**

### ***Undergraduates***

Undergraduates may borrow 8 books from the open shelves + 4 books from the Short Loan Collection. They may not borrow periodicals. Photocopies of articles on reading lists are usually available from the Short Loan Collection.

Books on the open shelves may be borrowed for four weeks unless they are in the following restricted loan categories:

### ***One Week Loan Books***

Books on the open shelves with a one week date label may be borrowed for one week only.

### ***Postgraduates***

Postgraduates may borrow 16 books or periodicals from the open shelves plus 4 books from the Short Loan Collection.

Periodicals not confined to the Library may be borrowed for one week.

Books on the open shelves (except those on one week loan: see above) may be borrowed for:

Taught postgraduates - 4 weeks  
Research postgraduates - 10 weeks

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## **Teaching Staff**

Teaching staff may borrow 24 books or periodicals from the open shelves plus 4 books from the Short Loan Collection.

Periodicals not confined to the Library may be borrowed for one week

Books on the open shelves (except those on overnight or one week loan: see above) may be borrowed for up to one year.

## **Part-Time Students**

Part-time students have the same borrowing rights as full-time students. In addition, students on part-time courses have their own Part-Time Collection of books and articles which can be obtained from the Short Loan Collection counter and taken out for a week. Special arrangements are available for telephone renewal from both the PTC and SLC.

## **Renewals**

Items, except Short Loan and Part-Time collection loans [SLC renewal - PTC renewal] may be renewed via the Loan Desk, Web Catalogue, or telephone (01227) 827131 (internal 7131) provided they have not been reserved or requested by another user.

## **Photocopying**

There are photocopiers on all levels of the Library. The charge is 5p per copy. None of the photocopiers take coins. To use them you must purchase a flexicard from the dispenser in the Loan Hall for £2 (non-refundable). Each card contains £1 of credits. Extra credits can be added to the flexicard using the Value Loader in the Loan Hall.

## **External Borrowers**

### ***Application***

Anyone wishing to be registered as an external borrower of the Templeman Library should apply in writing to:

The Director of Information Services and  
Librarian,  
Templeman Library,  
University of Kent at Canterbury,  
Canterbury,  
Kent CT2 7NU.



## Appendix C: Table of Abbreviations

AI	Artificial Intelligence
ATM	Automatic Teller Machine
BCG	Boston Consulting Group
BPR	Business Process Reengineering
CHUV	Centre Hospitalier Universitaire Vaudois
CSAM	Compaq Solution Architecture Methodology
CST	Critical Systems Thinking
DSS	Decision Support Systems
FR	Functional Requirements
EA	Enterprise Architecture
ESPRIT	European Union information technologies programme
ESPRIT CREWS	ESPRIT project: Cooperative Requirements Engineering With Scenarios
GBRAM	Goal-Based Requirements Analysis Method
GDRE	Goal-Directed Requirements Engineering
GRL	Goal-oriented Requirement Language
GST	General Systems Thinking
IS	Information System
ISA	Information Systems Architecture
ISO	International Organization for Standardization
IT System	Information Technology System
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
KAOS	Knowledge Acquisition in autOMated Specification
MIS	Management Information System

NFR	Non Functional Requirements
ODP	Open Distributed Processing
ODP-EL	ODP Enterprise Language
RE	Requirements Engineering
RM-ODP	Reference Model of Open Distributed Processing
SIS	Strategic Information System
SSM	Soft Systems Methodology
STS	Socio-Technical Systems
SuD	System under Discussion
SWOT	Strengths, Weaknesses, Opportunities, Threats
TPS	Transaction Processing System
TQM	Total Quality Management
UML	Unified Modeling Language
URN	User Requirements Notation
URN-FR	User Requirements Notation-Functional Requirements
URN-NFR	User Requirements Notation-Non Functional Requirements
XP	eXtreme Programming

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## Curriculum Vitae

### Gil Regev

<b>Academic Experience</b>	<b>Swiss Federal Institute of Technology</b> , Lausanne, Switzerland Researcher / PhD Student	1997-Present
<b>Industrial Experience</b>	<b>Logitech Inc</b> , Fremont, California Senior Software Project Leader	1995-1997
	<b>Logitech Inc</b> , Fremont, California Senior Software Engineer / Principal Engineer	1993-1995
	<b>Logitech SA</b> , Romanel sur Morges, Switzerland Macintosh Software Engineer	1989-1993
	<b>Logitech SA</b> , Romanel sur Morges, Switzerland Test Software Engineer	1988-1989
<b>Education</b>	<b>Swiss Federal Institute of Technology</b> , Lausanne, Switzerland Master of Science - Computer Science	1988