UML for Early Requirements Elicitation: A Regulation based Approach

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Early requirements of information systems are often understood in terms of the elicitation of stakeholders' high-level goals to be supported by the system under discussion. Stakeholders' goals are considered as the ultimate explanation of requirements. It is assumed that the notion of a high-level goal is natural and that high-level goals need no explanation with regard to their origins. We believe that these assumptions result in the definition of inadequate goals. We propose an organizational model where regulation provides an explanation for high-level goals. We will show that the goals of an organization can be seen as originating from its need to maintain its stability with regard to multiple opportunities and threats it identifies in its environment. Understanding the origins of goals enables stakeholders to change and expand the set of high-level goals envisioned for the system under discussion. In this paper we show how this framework can be used with UML in order to construct models for early requirements.

1 Introduction

The early requirements activity in information systems is concerned with understanding the problems faced by an organization and how an information system can help "solve" these problems. Early requirements usually begin when the organization identifies some problem and mandates a person or a group of people to investigate possible solutions for this problem. Early requirements are usually approached through the following steps:

- Define what is needed or wanted by the organization
- Specify as many optional ways as possible for doing what needs to be done
- Specify the potential influence of each option on the other options
- Select among the most interesting or acceptable set of options

Problems, however, are multi-faceted constructs that don't yield to easy analysis. Some of the problems faced by requirements engineers are the following:

1. What is needed or wanted is not clear. Among a set of stakeholders there's rarely an agreement on what is needed or wanted.
2. Specifying options is not easy
3. Selecting, among the options those to implement is even more difficult

The problem of understanding what is needed has been known for many years. Many methods have been proposed to address this problem. The main point of most, if not all, of these methods is the creation of discussions among stakeholders, including developers. The purpose of these discussions is to help stakeholders to understand what is needed and what is technologically feasible. Rapid prototyping, stakeholder workshops, eXtreme Programming, Agile Development etc. have all been developed with the goal of understanding what is needed and what is feasible. The main tool provided for this purpose in UML is the use case. Initially, use cases were used by developers to define how a potential user will interact with the system being defined [7]. However, in recent years the understanding has developed that during early requirements investigation, it is not good practice to think in terms of interactions of users with a system to be built. Doing so, may prevent the stakeholders from specifying optional ways of reaching the same expected result. Thus, goal-oriented use cases have been proposed by Cockburn and Constantine [4, 5, 6].

Goal-Directed Requirements Engineering (GDRE) methods also propose to solve problem 1 by moving beyond the user-system interaction. GDRE methods offer more formal models of goals and ways to structure the requirements in order to satisfy these goals. But, they have a bias towards an organizational model based on goals as ends to be met. In this model, goals are considered as the ultimate concept explaining human and organizational behavior. This bias prevents Goal-Directed techniques from understanding the source of goals themselves. Thus, instead of encouraging a discussion that focuses on what is needed or wanted, they specify alternatives for needs and wants that they assume being unquestionable.

When we don't actively question what is needed or wanted, we tend to think that we know what the goals of the stakeholders are. For simple systems, this may be true. Consider the classical example given in requirements text books and articles, the Automatic Teller Machine (ATM) [4, 5, 12]. It is clear that the customer's goal with respect to the ATM is to obtain cash, make transfers between accounts, obtain the balance of an account etc. For more complex systems the goals maybe less clear, even when we think that they are clear. Some of the reasons for this are:

- What is needed is not always wanted
- What is wanted is not always needed
- What is needed or wanted most often cannot be implemented
- What is initially felt as needed is generally not what would be the most effective

Consider the other classic problem of the meeting scheduler. It is almost universally acknowledged in academic papers that one of the main goals of a meeting support system is to schedule meetings. We thus find goals such as "ensure that all invited people can attend the meeting, find free slots in peoples' agendas" etc. Obviously, these goals can only be achieved by the system if people keep their agendas up to date. However, it is also known that when an automated system attempts to impose an agenda on people, people may balk and manage their time in a way that will prevent the system from doing its job (such as, not keeping their agendas up to date) [17]. This may be caused by the developers "knowing" the goals of the users but failing to appreciate the complexity of the situation. What if the users' goal was not to attend meetings as it is implicitly or explicitly defined in the meeting scheduler example? What if their goals were of a different order, such as "collaborate to solve problems, socialize," etc? How would we design the meeting support system if those were the stated goals? What if even these goals were not the right ones? How would we define the right goals? Obviously, defining a different set of goals for the system usually leads to a rethinking of what the system is. Thus instead of thinking about a meeting support system, we may propose to build a knowledge management system or a collaboration support system etc. But how do we know when to stop redefining what the system should be or do?

If we think only in terms of goals then we can redefine the system at will because there seems to be an everlasting hierarchy of goals. Each time we think we have found a high-level goal, somebody else finds a higher-level goal. Thus Zave and Jackson [18] state that goals alone are not sufficient for defining a system, arguing that reasoning only about goals, may well lead requirements engineers to propose inadequate goals by simply moving up the goal hierarchy without knowing when to stop. Zave and Jackson illustrate their argument with the example of a zoo where engineers may move up the goal hierarchy and propose to sell a zoo when they were asked to simply build a system to control the entrance to the zoo. Thus, even if UML were to adopt GDRE concepts it would still lack a good basis for understanding what system to build. GDRE methods are implicitly based on the notion that the best way to understand people and organizational behavior is by way of goals.

This, however, is not the only way to understand behavior. An alternative school of thought is represented by people more interested in understanding regulation than in understanding goals. For these people, goals are the "by product" of regulation. Goals are the tip of the iceberg that we "easily" observe but underneath this tip lies the huge, unsuspected part of the iceberg that is regulation. Regulation is defined as the set of mechanisms a system (organism, person, organization) has or builds in order to remain stable. "Regulationists" such as Weinberg and Weinberg [17] argue that we are so much accustomed to stable systems that we fail to notice their stability and only notice change. We thus overly emphasize the role played by goals in human affairs. To understand regulation, we have to understand what a given system defines as important and how it regulates these important things.

Thus, going back to the example of the zoo, we can prevent the goal abstraction from moving to a point where we specify selling the zoo because we understand that the zoo itself is important to its stakeholders and because we understand that the relationships of the zoo with its customers, animals, managers, employees etc. are of high importance. Thus, selling the zoo to make a profit is not within the realm of possibilities that the stakeholders will agree to. On the other hand, we may be able to expand the goals of the zoo entrance system by understanding that this system participates in the maintenance of the relationships between the zoo and its customers. The additional goals for the entrance system can be, "enable quick entry of groups," "enable free entry of children," "inform visitors about special events," etc.

In our models we use standard UML constructs with stereotypes in order to distinguishing between the different entities that our models specify such as maintenance goals, constraints, rules etc. This use of stereotypes has the advantage of not adding more symbols to UML therefore reducing the modeler's cognitive load.

In this paper we will use the case study of a video store (appendix 2) as an example for our proposals. The Video Queen Point of Rental Terminal (PORT) system requirements document shows a fairly realistic description of a simplified information system to be built for a franchised video store business. This document was written by a small team of academics and IT consultants to serve as the point of departure for an undergraduate course in software engineering.

Section 2 discusses early requirements support in UML and Goal-Directed Requirements Engineering. Section 3 describes some principles of regulation. Section 4 describes how goals defined during requirements elicitation can enable engineers to model the regulation of the organization and how goals can be redefined for a prospective IT system by using the regulation models.

2 State of the Art in Early Requirements

2.1 Early Requirements in UML

In UML the main modeling artifact used for early requirements is the use case. Cockburn defines a use case as [4, p. 1] "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." This definition is an extension of the original definition of a use case which only described the interactions between one actor and the system. Furthermore, the notion of "the system" has been extended to mean more than just the IT system to be developed. Thus, Cockburn states the following [4, p. 2] "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." In this model, use cases as seen as a way of stimulating the discussion among stakeholders about the system being designed [4, p. 1]. From the above definitions we see that use cases are primarily goal-oriented. To define a use case we need to know what the goal of the primary actor is and what are the goals (called interests by Cockburn) of the other stakeholders are. Thus, the discussion that use cases stimulate among stakeholders is mainly a discussion about the goals of these stakeholders. Goals are implicitly defined as achievement goals, i.e. ends to be achieved.

When working from a requirements statement such as the one we have for the Video Queen organization (appendix 2), we can identify the following stakeholders and their respective goals:

- Member
  - Loan Video
  - Return Video
- Clerk
  - Add new video
  - Add new member
  - Remove video
  - Remove member
  - Change loan Policy
  - Check which member has loaned which video
- PORT
- Video Queen Owner
  - Manage Video Business
  - Develop PORT
- Video Franchise Owner
  - Manage Video Store

Goals are acknowledged to constitute a hierarchy. Higher level goals can be implemented by lower level goals. For instance, to loan a video a customer may need to select the video from some catalog. To select the video from the catalog, the customer needs open the catalog, browse the videos or search the catalog etc. In this example, the "Loan Video" goal is usually considered a high level goal while the "search catalog" goal is usually considered a lower level goal. Cockburn defines a set of levels for goals using colors to differentiate them with reference to a sea level metaphor. The colors range from white, cloud (summary goal), blue, sea level (user goal), and indigo, underwater (detailed functional goal).

2.2 Early Requirements with Goal-Directed Requirements Engineering

Requirements engineering (RE) takes the view that requirements derive from stakeholders' goals. This can be seen from the Requirements Engineering Conference 2002 Call for Papers [11], which describes Requirements Engineering as "the branch of systems engineering concerned with the real-world goals for, functions of, and constraints on software-intensive systems. It is also concerned with how these factors are taken into account during the implementation and maintenance of the system, from software specifications and architectures up to final test cases." Thus, RE already assumes the view that "real-world goals, functions and constraints" are the source of the requirements for software systems. Goal-Directed Requirements Engineering (GDRE) is a branch of RE, which is concerned with the definition of methods for defining the complete requirements for a software system starting from goals stated by stakeholders. GDRE methods generally define a Goal to be [10] "condition or state of affairs in the world that the stakeholders would like to achieve." Several GDRE methods have been developed in the last years. Examples of such methods are KAOS [13, 14], Goal-Based Requirements Analysis Method GBRAM [1, 2], ESPRIT CREWS [12], and NFR [9]. Most of the GDRE methods consider goals to be only ends to be met, i.e. achievement goals. GBRAM and KAOS distinguish between maintenance goals and achievement goals. GBRAM in particular distinguishes between the two kinds of goals as follows [2]: "information systems: that such goals imply "An achievement goal is satisfied when the target condition is attained. A maintenance goal is satisfied as long as its target condition remains true." GBRAM further states that [2]: "Maintenance goals are usually high-level goals with which associated achievement goals should comply."

More recently, NFR has been developed into an array of languages and methods named Tropos, I*, GRL. Tropos in particular was proposed as a basis for UML extensions for agent-oriented software development [10]. The Goal-oriented Requirement Language (GRL) is part of an ITU-T URN standard draft. The main modeling elements in Tropos are: Actor, Goal, Softgoal, task and resource. Softgoals are defined as goals, which [10] "fulfillment cannot be defined precisely (for instance, the appreciation is subjective, or the fulfillment can occur only to a given extent)." Softgoals capture such fuzzy concepts as customer satisfaction, increase of market share, availability, security, adaptability etc. Tasks are defined as [10] "A task specifies a particular way of doing something." A resource is an artifact shared by actors. Figure 1 shows a model of the Video Store in Tropos.

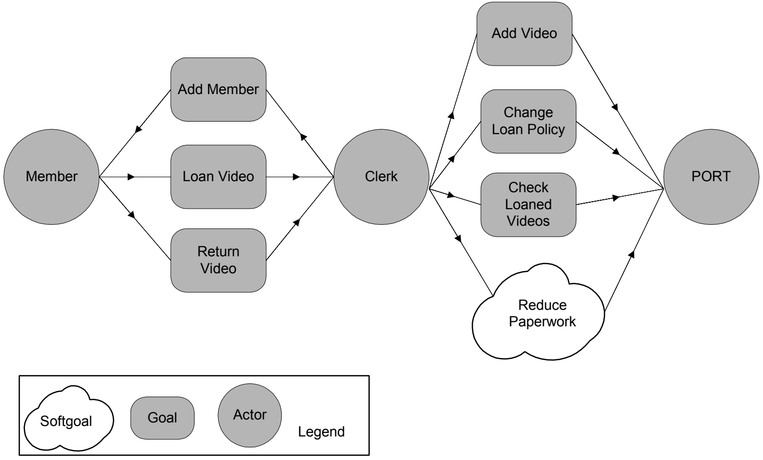

Figure 1. Tropos Model of Video Store

Tropos encourages the modeler to make a distinction between goals, softgoals, tasks, and resources. In our model of the Video Store we find it difficult to decide whether "Add Member", for instance, is a task or a goal. As in the case of use cases, Tropos encourages a discussion about the goals among stakeholders. It is possible that one stakeholder (the Clerk for example) will see "Add Member" as a goal while for other stakeholders (customer for instance) this same action is viewed as a task subordinate to the goal of loaning a video.

As we can see from the examples above, the discussion about the possible goals of stakeholders in GDRE, and goal-oriented use cases is fairly limited. The discussion usually centers around higher level or lower level goals to be achieved but not about why certain goals are even desirable. In order to orchestrate a discussion about what goals to achieve, we need some other concept than goals as ends to be met. We will now introduce regulation as a way to explain why certain goals are desired.

3 Regulation as a Central Mechanism for System Analysis

3.1 The Principles of Regulation

Goal-directed techniques for early requirements elicitation such as the ones we have described above, assume that goals are the primary way by which people and organizations specify their needs and desires. For the most part, goals are defined or are assumed to be Achievement Goals with the notable exceptions of GBRAM and KAOS. Most of the discussion during early requirements is centered on whose goals the system needs to support and what are the relative importance of these goals in terms of higher-level or lower-level goals. Thus, Cockburn states that the right goals the system should support are users' goals, high-level user goals are "defined" as goals, which once achieved, the user is satisfied and can take a break [4, p. 68]. This view leads to a very short term view of what goals to achieve. In general, the discussion about goals, even in more formal GDRE publication is missing the question of why would the user want this or that goal. Thus, in [10] it is assumed from the beginning of the requirement process that the main goal of the customer is to buy media items. How do we know that searching the media catalog is a task while buying a media item is a goal? Aren't we assuming the Media Shop's point of view because selling an item brings money while searching the catalog does not? If a total customer satisfaction strategy is applied then searching the catalog may viewed as an important service to be provided to customers. Even if we can't ask customers to pay for such a service, a good searching service may be the way to attract more customers and thus participate in our overall strategy in ways that we didn't imagine at first. In this respect early separation between goals, softgoals, and tasks may prove to be harmful.

This view of the world as consisting of achievement goals that people are seeking to achieve and where the reasons for the goals themselves are not discussed is defined by Checkland and Holwell [3] as coming from H.A. Simon's work. An alternative strand in the system sciences says very little about goals. This strand sees regulation in general and the regulation of relationships in particular as a more accurate model of human and organizational behavior. In the following paragraphs we will briefly introduce this strand by drawing from the works of Maturana and Varela, Weinberg and Weinberg, and Vickers. From the principles enunciated by these works we will define a framework that enables us to discuss goals as they appear in early requirements.

Studying regulation implies understanding how systems become stable, what is important to them in the long term and how they protect what is important to them in relation to perturbations they see in their environment. This means modeling the environment (or context) of every system together with its competitors, customers etc.

Maturana and Varela [8], define a model where living beings and organizations are viewed as autonomous entities. These autonomous entities interact through "structural coupling." The actions of one entity create perturbations that other entities may choose to view and act upon. Entities co-evolve through their structural coupling. Thus, an entity is influenced by its environment but it also influences its environment. Each entity is operationally closed, its actions are influenced by its own internal state. These actions are performed in order to achieve a balance of the internal relationships between the components of the entity. Maturana and Varela define the notion of behavior as [8, p. 136], "the changes of a living being's position or attitude, which an observer describes as movements or actions in relation to a certain environment." Thus, the notion of a goal comes from an observer's account of the actions of an entity within an environment selected by the observer.

Daniela and Gerald Weinberg[1] discuss the general principles of regulation in their book "General Principles of Systems Design." [17]. The principles defined by Weinberg apply to a very broad range of systems. Weinberg's initial argument is that it is not "change" that needs explanation but rather "stability". Stable systems are systems that we can observe. If these systems were not stable, we would not be able to observe them. If a system is to be seen, it must survive. If it is to survive, it must be stable. Weinberg assert that stable systems maintain their stability by regulating a set of essential or identifying variables. For Weinberg, the identity of a system is defined by the maintenance of some "variables within limits set by some observer." The main idea of stability is then to protect "identifying variables" or those system variables that define the identity of the system from being affected by environmental threats. This leads to the regulation of these variables with respect to environmental threats rather than these variables being regulated directly by the environment. In the Video Store example, an identifying variable could be its ability to provide a good service to its customers. To do that it needs to protect its collection of videos from disappearing. It thus needs to protect the access of

[1] For the sake of brevity we will refer to the Weinbergs collectively as Weinberg in the remainder of this document

the environment (the customers) to these videos. It does this by having clerks who "guard" the videos and who let a customer remove a video from the store only when they are reasonably certain that the customer will bring the video back.

There is a very wide range of strategies which systems can apply to protect their identifying variables. These strategies are mainly based on aggregation and the separation of variables in the environment. Thus, for Weinberg, systems use aggregation as a strategy for becoming less vulnerable to unknown threats and separation of variables as a strategy for dealing with known threats. A system made of aggregates is not a simple summation of its parts. The system applies multiple constraints to keep its aggregates within some bounds to as to maintain the stability of its identifying variables. Thus, Weinberg state that [17, p. 165]: "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." Separation of variables functions in unison with the regulation of aggregates. Separation of variables can be seen as a specialization, i.e. the specification of specific protection mechanisms for each threat. Weinberg specify that regulation is always a compromise between specialization and aggregation. The Video Store for example, specializes in two ways, it the loan of videos, and in serving members only. This specialization has the contrary effect counting totally on aggregation which would have the video store loan and sell just about anything to anybody. Neither total specialization nor total aggregation provides for a good strategy but rather a good balance between the two.

For Weinberg, stability always involves the regulation of several variables against multiple threats at the same time. It is thus dangerous to simplify a problem to the regulation of only one variable. For example, to name just a few of the things we regulate when we want to loan a video: regulating the amount of time it will take us to do search and loan the video with regard to the amount of money the loan will cost, and the number of relationships with video stores we want to explore or maintain.

Weinberg devote much of their discussion to the question of set points, or norms. Weinberg note that many systems don't have an explicit set point but settle in a set point that can be defined by an observer because this set point happens to be a point of equilibrium which emerged from the system's interactions with its environment. This explanation goes back again to the role of the observer as the entity defining the set point. Body weight, pulse rate and body temperature are examples of such set points which an observer can define that a human being regulates but these set points are not found explicitly within a human body In human organizations, it is believed that set points, called norms, or purposes, exist as we will see from out discussion of Vickers, below. It is important to keep in mind that these norms are defined by an observer and that the organization may be oblivious to itself as imposing these norms.

Sir Geoffrey Vickers [15] applied system science principles to the study of social systems. Vickers, like Weinberg, and Maturana and Varela offers a view where goals have a secondary role. Weinberg and Vickers arrive at the same conclusion: systems in general and social systems in particular are better approached by studying how they regulate themselves than by ascribing to them a set of goals. As noted by Checkland and Holwell [3, p. 47]:

> In Simon's model, goal definition does not get much attention, but in Vickers' 'appreciative system', the core of the activity concerns debate about possible courses which might be followed and the relationships they will affect. For Vickers, in contrast to Simon, managers set standards or norms rather than goals, and the focus on goals is replaced by one on managing relationships according to standards generated by previous history. Furthermore, the discussion and debate which leads to action is one in which those taking part make judgements about both 'what is the case' (Vickers' reality judgements) and about its evaluation as 'good' or 'bad', 'satisfactory' or 'unsatisfactory' – what Vickers calls 'appreciative judgements'.

Thus, in Vickers' model the regulation (or management) of relationships is the most important activity. We can understand this point by noting that in a liberal market, a commercial enterprise would not survive for long if it neglected its relationships with its customers. More generally, members of any organizations will be threatened if they didn't manage their relationship with their co-members. This is the case for commercial enterprises but also for families, public sector organizations etc. The management of relationships is rendered complex by the observation that every relationship between entities offers a capability to do more than each entity can do by itself and a potential threat to the existence of the entities involved in the relationship. In other words, organizations need internal and external relationships but have to protect themselves from these same relationships. In doing so, organizations define what is generally called policies or set of rules. By examining the rules of an organization, we can identify what it regulates and thus better understand its goals.

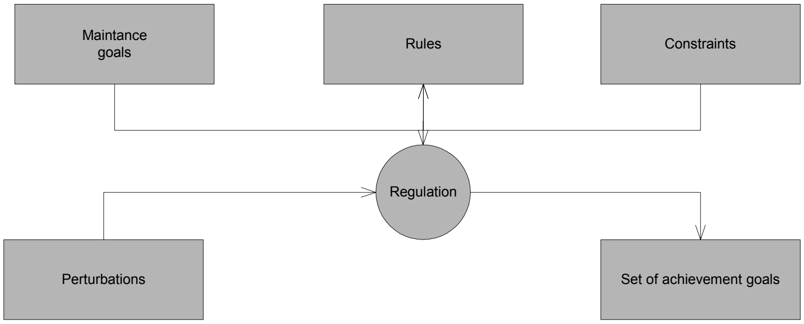

Figure 2. The Generation of achievement goals

Following Vickers model we see that plans of action are generated when the appreciative judgements point to a sufficiently large gap between the reality judgements and the way we want things to be. This is expressed as a perturbation in figure 2. However, Vickers also makes the point that observable action is not always taken. Rather, it is very often the case that the appreciative judgements and/or reality judgements are modified. This is also an action but it usually goes unnoticed to an observer. It does have the capacity to change all subsequent actions.

When action is taken, an observer can make an account of it in terms of a plan of actions (set of achievement goals in figure 2). The observer cannot know whether the entity she is studying actually has a plan, only that it looks as if there is (this notion is used extensively in SSM [3]). If the observer detects the “presence” of a plan then the notion of goal emerges for the observer who speculates that there is a goal for the actions that she observed. The plan contains rules such as “if this is the case then do this.” What follows the “then” can take the form “do this”, “don’t do this”, “avoid this”, “encourage this”, or in general any verb. These verbs point to sub-goals of the goal identified for the plan. The rules constituting the plan are sometimes called business rules or policies. Policies are usually defined as “set of rules for a particular purpose.” An observer of the plan can put together a subset of the rules and say that they constitute a policy for some purpose that is also defined by the observer. In the Video Store example, we can define that the rules specifying that only members can loan videos and that there is a limit on the number of videos a member can loan simultaneously, constitute the Video Store’s “loan policy.” As observers of the plan we can define the loan policy’s purpose as “insure adequate supply of videos to all members,” or “reduce risk related to customers’ losing videos,” or “Making customers’ life complicated.” The observers have many choices in the purposes that they attribute to a plan or sub plan and these purposes may differ to a large extent depending on the point of view taken by the observers. The set of achievement goals is very often internalized by the organization and becomes a set if rules (rules in figure 2) that the organization uses to regulate its relationships.

Whatever the purpose we attribute to a set of rules, we can be sure that the set of rules are interlinked and that they rely on each other for the success of the plan [17, p. 206]. Thus, in the Video Store example, the loan limit rule only applies if we have members. It depends on the rule saying that only members can loan videos. Thus, the set of rules may have no purpose or as many purposes as the observers care to specify but it does have coherence. The coherence of the set of rules is usually both internal and external to the system of interest. There’s internal coherence because one rule depends on another. There’s also external coherence if the set of rules has been in operation for a while because it has then proved itself to be effective which means that it is adapted to its environment. If, for example, the rules specify that only members can loan videos it is more than probable that customers accept or even like to become members of a video store. If it wouldn’t, the Video Store would not have survived to this point. Both the internal and external coherence may be broken by an inconsiderate change to one or more rules or by a change in the environment such as customers don’t want to become members anymore. It is thus important to understand how these rules are interdependent and how they are adapted to the environment. This is the subject of our next section.

4 Regulation applied to early requirements in UML

In order to define an adequate set of goals for an IT system, we propose to first understand the source of the initial goals proposed during the requirements elicitation we establish relationships between these goals and the organization's understanding of its environment. To do this we need to understand what entities and constraints (obstacles and capabilities) the organization sees in its environment. We then analyze the rules that the organization has put in place in order to adapt to its relationships with these entities and constraints. These rules help us understand the patterns of behavior that the organization attributes to these entities.

In a second step, we redefine the goal set by assuming that the organization seeks to maintain a set of relationships with its environment. Stating this maintenance of relationships in broad terms and understanding what are the environmental forces acting on the organization, enables us to define a set of goals for the IT system. We will illustrate this method with the Video Store example.

We express our models in UML by defining an autonomous entity that we call a community. A community is represented as a UML package. A community can be made of sub-communities (aggregation). Each community has a number of maintenance goals by which it seeks to maintain the norms it has defined for itself. Each community has constraints which can be obstacles and capabilities. Constraints are internal "representations" of relationships that the community defines in its environment (separation of environmental variables). Constraints express the concepts we called threats and opportunities but can be stated in more general terms. Each community has rules of behavior that can be seen as plans that have been elevated to the status of norms. From these rules an observer can identify goals, both maintenance and achievement goals. Maintenance goals, achievement goals, constraints and rules are represented as classes with the corresponding stereotype. Appendix 1 gives the definitions of all the terms we use.

While performing this analysis we should not forget that the model we build is our (an observer's) description of the behavior of the organization. The model is therefore but one plausible explanation of what we as observers want to see in the organization's behavior with regard to an environment chosen by us. The model needs to be confronted with the organization's stakeholders to make it more plausible but it will remain just one plausible model. It can be very useful to create several models which give different plausible explanations and compare these models.

4.1 Understanding the Source of Goals

The Video Store requirements document names the following entities: The Owner of the Video Queen business, The Video Queen business, Video Stores, Owner of store, Clerks, Customers, Members, Videos, PORT, Loan Policy.

For our convenience, we can sort these entities in the following hierarchy but we need to keep in mind that this hierarchy is just one possible view:

- The Owner of the Video Queen business
- The Video Queen business composed of
  - Video Stores composed of
    - Owner of store
    - Clerks
    - Customers
    - Members
    - Videos
    - PORT
    - Loan Policy

The entities above form a web of relationships, which is purely internal to the video business. From the principles of regulation we know that this web of relationships is maintained stable with regard to external and internal threats and opportunities as they are viewed and understood by the video business. The set of external threats and opportunities can be thought of in this case as the Video Market. Figure 3 represents a simplified UML model of this market.

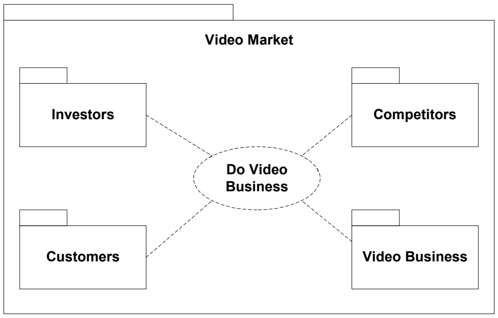

Figure 3. The Video Business's position in the Video Market

The web of relationships has this particularity that it maintains the stability of the market as a whole. Thus, there is a tension between competitors placing a cap on the number of customers the video business may have and the investors who inject funds into the video business therefore adding to its capabilities, want a return on investment. This necessity of creating shareholders value prevents the video business from being too generous with its customers so as to give away videos for free, for instance. The Video business seeks to maintain a balance between these relationships with rules it has created and perfected over the years in order to counter balance the threats and opportunities in the market. Examining the Video Store requirements document we can find the following rules:

1. Anybody can open a Video Store
2. Only customers who are members are allowed to loan videos
3. Members are not allowed to loan more than a certain number of videos
4. Members are not required to return loaned videos after a certain time limit
5. Members can return videos to the store (but are not required to)
6. Members are not allowed to operate the PORT directly
7. PORT should comply with Windows User Interface guidelines
8. PORT should have a high-tech look and feel.

These rules emerged through the experience of the Video Store stakeholders and embody the Video Store's knowledge of the threats to the relationships it attempts to maintain. Some of the threats we can identify are:

1. Videos may be lost or stolen by customers
2. Members may damage PORT information (incorrectly registering loans and returns)
3. Members may move to a competitor
4. Investors want return on investments

These rules also embody assumptions on the behavior of the threats, such as:

1. There are enough customers who will agree to become members to insure the Video Store's survival
2. Members continually want to loan videos therefore a loan policy based on the number of outstanding loans is effective

The separation between members and non members can be understood as the Video Store's desire to separate between customers it can trust and customers it cannot trust or doesn't want to trust. Members are customers who have identified themselves to the Video Store. The Video Store can then trust them more than unidentified customers because it can apply pressure on members to return videos to the store. The concept of a member can also be understood as the Video Store's desire to maintain long term relationships with "good" customers. It probably doesn't make sense for a customer to become a member to loan just one video. By becoming members, customers in principle accept a long term relationship and thus may return more often to the Video Store. Since no regulation is perfect, it also implies that customers need to go through some form of registration to become members. This registration can be seen as an obstacle by some customers who may not use the store services because of this obligation to become members.

The rules, threats, and assumptions form a system where a change in each part of the system influences the others. The rule on the maximum number of outstanding loans can only work with the rule that says that only members can loan videos. If the Video Store accepts that each customer can loan videos regardless of their status as members, how would it know how many outstanding loans a customer has? Obviously, if the rule saying that only members can loan videos is removed, some other mechanism will need to be put in place to compensate for its loss of regulation. Some of these relationships are shown in figure 4. Note that some relationships between constraints and rules are n-ary relationships that cannot be reduced to binary relationships.

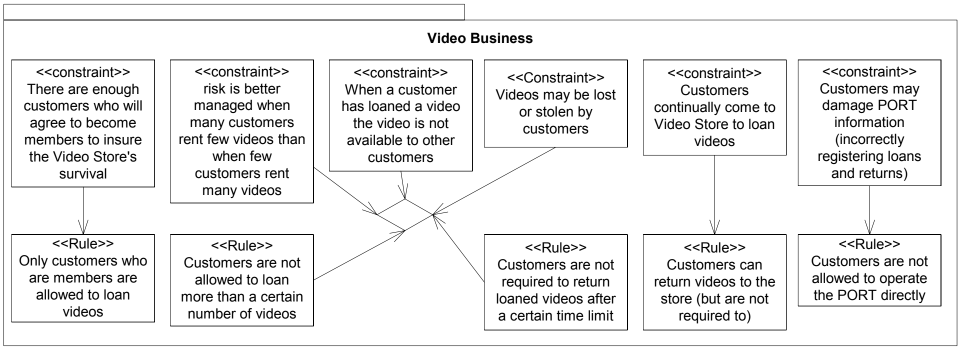
Video Business
<<constraint>> There are enough customers who will agree to become members to insure the Video Store's survival
<<constraint>> risk is better managed when many customers rent few videos than when few customers rent many videos
<<constraint>> When a customer has loaned a video the video is not available to other customers
<<Constraint>> Videos may be lost or stolen by customers
<<constraint>> Customers continually come to Video Store to loan videos
<<constraint>> Customers may damage PORT information (incorrectly registering loans and returns)
<<Rule>> Only customers who are members are allowed to loan videos
<<Rule>> Customers are not allowed to loan more than a certain number of videos
<<Rule>> Customers are not required to return loaned videos after a certain time limit
<<Rule>> Customers can return videos to the store (but are not required to)
<<Rule>> Customers are not allowed to operate the PORT directly

Figure 4. Video business constraints and rules

The model in Figure 4 enables us to better understand the source of the goals we have identified with the goal-oriented methods. It explains how these goals are linked with the interpretations of the reality of the different stakeholders. This understanding explains what needs to change in these interpretations for the goals to change or how changing the goals, imposes a change in the interpretations. Using the regulation principles, we can advance even further in our understanding of the different options that are open to the Video Store. This is the subject of the next section.

4.2 Expanding the Goals

We now assume that the Video Store seeks to maintain the relationships between the entities it identifies in its environment within some norm. These relationships are under constant threats from the different communities (Video Store owner, clerks, customers) and from competitors, technology changes etc. The Video Store needs to manage its relationships with these threats in mind and in a way that will insure its long term survival. Notice that some of the threats come from the very same entities that the Video Store was designed to serve. Actually, all of the threats identified in the Video Store requirements document point to threats identified from the store's relationships with its customers and Clerks. This case is very commonplace. Every relationship between entities harbors in it a source of advantages to the entities while also threatening these entities. Thus, the entities define rules to protect themselves from the threats they want to see in these relationships.

The Video Store needs to strike a balance between the protection it gives to each one of its relationships. Indeed, privileging one over the other may cause an imbalance which may threaten the efficiency and long term survival of the store. The Video Store could, for example, privilege its customer relationships in a way that would threaten its collection of videos (by removing the limit of outstanding loans) which may force it to acquire more copies of each video thus threatening its financial position. It could overly protect its video collection by imposing more restrictions on outstanding loans or add strict time limited loans but it could lose too many customers.

To understand how to keep this balance while expanding the set of options for the Video Store, we identify a set of maintenance goals that can apply to the Video Store.

- Maintain investor relationships
- Maintain customer relationships
- Maintain employee relationships
- Maintain video availability
- Maintain supply of new releases at a good rate for continuous member satisfaction
- Maintain service quality
- Maintain Member Supply at a good rate for maintaining a good loan rate
- Maintain Low Cost Structure in order to make profit
- Maintain and enhance self image as "modern and high tech" by requesting an IT system that is "more modern and high tech feel." *

Again, the above list can be grouped in a hierarchical order such as the following list. We should be very careful with this hierarchy because it implicitly defines what goal is more important than another. During early requirements we want to keep most of our options open and therefore play with several such hierarchies:

- Maintain investor relationships

  - Maintain Low Cost Structure in order to make profit
  - Expand revenues
  - Maintain and enhance self image as "modern and high tech" by requesting an IT system that is "more modern and high tech feel."
- Maintain customer relationships
  - Maintain Member Supply at a good rate for maintaining a good loan rate
  - Maintain service quality
  - Maintain video availability
  - Maintain supply of new releases at a good rate for continuous member satisfaction
  - Maintain and enhance self image as "modern and high tech" by requesting an IT system that is "more modern and high tech feel."
- Maintain employee relationships
  - Maintain and enhance self image as "modern and high tech" by requesting an IT system that is "more modern and high tech feel."

The maintenance goals of the communities in this model are deliberately described in more abstract terms than those found in the Video Store requirements document. Thus instead of stating that there is a limit on the number of outstanding loans per customer, we define a maintenance goal which states that we want to maintain the availability of existing videos. This abstract definition enables us to explore alternative strategies such as enforce quantity of outstanding loans or enforce time limited loans or a combination of both, or even none of them if we find some technology which makes this regulation possible with no restrictions on customers.

In a world with endless resources, the goals above can be maintained all at the same time. However, in a world where the customers are few and where competitors exist, which place a cap on the number of customers the store may have, we must make choices among these goals and define solutions that can help us maintain most of these goals at an acceptable level.

The list of maintenance goals enables the stakeholders to discuss the relative importance of these maintenance goals. We can ask ourselves, what is more important to us? Is it the revenues and profits or is it the employee satisfaction? These goals are not necessarily mutually exclusive. We may be able to find solutions that can help us maintain several goals at the same time.

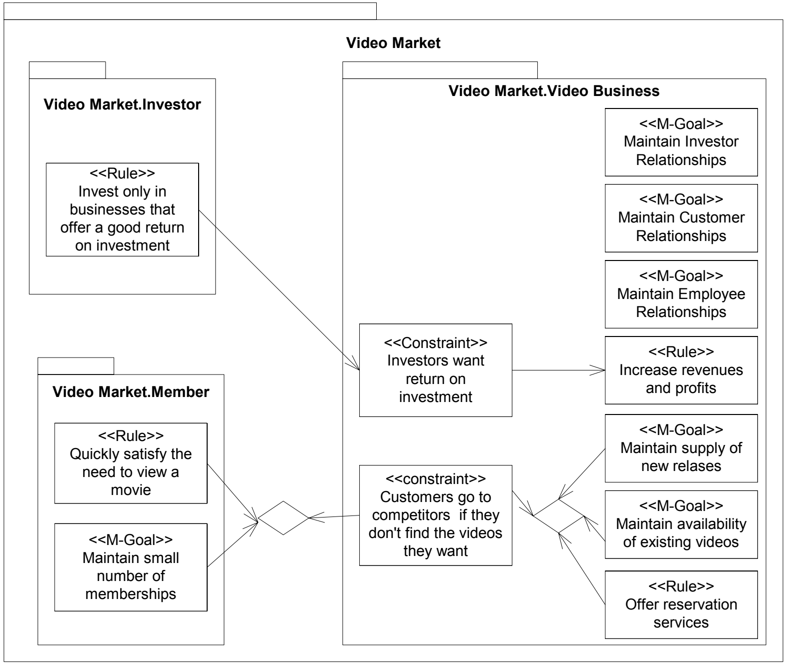
Video Market
Video Market.Investor
<<Rule>> Invest only in businesses that offer a good return on investment
Video Market.Video Business
<<M-Goal>> Maintain Investor Relationships
<<M-Goal>> Maintain Customer Relationships
<<M-Goal>> Maintain Employee Relationships
<<Constraint>> Investors want return on investment
<<Rule>> Increase revenues and profits
Video Market.Member
<<Rule>> Quickly satisfy the need to view a movie
<<M-Goal>> Maintain small number of memberships
<<constraint>> Customers go to competitors if they don't find the videos they want
<<M-Goal>> Maintain supply of new relases
<<M-Goal>> Maintain availability of existing videos
<<Rule>> Offer reservation services

Figure 5. Video Store's relationships with customers and investors

From the model of the market in figure 3, we can "zoom" into any of the communities we have identified as composing this market. In the model of each community we can define the maintenance goals we assign to it, the constraints it identifies on these maintenance goals and the relationships between the constraints and the maintenance goals. Figure 5 shows the possible relationships between Video Store, a typical member and a typical investor. A similar model can be defined between the Video Store and competitors, and the Video Store and its suppliers etc. The model of the members and what is important to them, defines what we view as a typical member. This typical member influences the choices we will make for the Video Store. If we believe that the typical member wants more video related services than simply loaning videos than we can use the membership concept to maintain a member community? We could offer reservation services for new releases and currently loaned videos. We could offer members a service that puts them in relationships with other members by analyzing their loan patterns etc. In short, we would transform the Video Store into a Video Club.

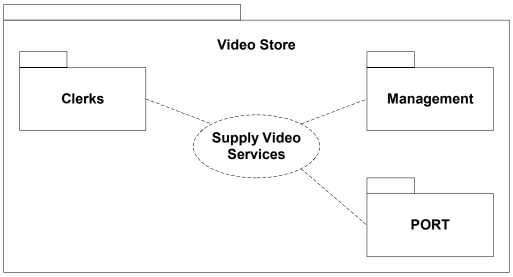

Figure 6. The role of the PORT in the Video Store.

We can now return to the role of the PORT in this model. Figure 6. shows a view of the Video Store. We can see that the clerk, the management of the store and the PORT participate in providing a video related service to customers. We can now assign goals to the PORT which are in direct relationship with the model of the Video Store (or video club) we have defined above. These goals could be the following:

- Help members to get new video releases
- Offer news feeds triggered by new arrivals registered with the PORT
- Offer registration services for unavailable videos
- Offer member linking services
- Coordinate services with other Video Queen stores, e.g. quickly obtain videos that are unavailable in one store from another store

The PORT will have to maintain its own structures in a stable condition with respect to its own environment, i.e. the video store. It will have the following “internal goals:”

- Maintain Member Catalog Integrity
- Maintain Video Catalog Integrity

The goals we have defined above contrast sharply with the goals assigned to the PORT in the Video Store requirements document and identifiable through goal-directed requirements engineering methods. The most interesting change we have operated is a change in the understanding of the PORT’s role within the Video Store from an IT system for registering loans and imposing some organizational policies, to an IT system that is an active participant in the maintenance of the relationships of the video store. Obviously, there are many other achievement and maintenance goals that can be assigned to the PORT when we think of it as participating and enhancing the relationships between the Video Store and its internal and external environment.

5 Conclusions

In this paper we have described a method for understanding stakeholders’ goals and defining the IT system goals by using regulation principles. In our method we have the following steps:

1. Understanding how the goals expressed by stakeholders are motivated by the stakeholders’ and the organization’s relationships to their environment
2. Identifying the constraints imposed on the organization by these relationships
3. Identifying the relationships that the stakeholders seek to maintain and their relative importance to the stakeholders
4. Stating these relationships to be maintained in broad and explicit terms as maintenance goals
5. Define a set of achievement goals for the IT system that helps the organization adapt to the environment in ways that preserve the relationships that it deems important.

The study of regulation gives us the necessary tools to discuss the merits (and relative importance) of stakeholders’ goals. Indeed, the evolution of requirements engineering shows a gradual shift from the exploration of IT system functions and users’ interactions with the system to the exploration of goals. This evolution is explained by the need to explore as many options as possible. Goals give this possibility because they specify ends to be met rather than the means by which to achieve the ends. However, goal-directed methods do not offer adequate tools for understanding the goals themselves. As defined by Weinberg, “To understand change, we first need to understand stability.” If we refer to goals as ends to be achieved, then goals represent change. To understand the changes requested by stakeholders, we need to understand what makes their world stable. To understand the stability of a system, we postulate that it is the consequence of the successful regulation that the system imposes on itself and its environment. Thus systems regulate themselves with respect to their environment or else they disappear. Thinking in terms of regulation can help us in the following ways:

- It provides an explanation of the source of goals
- It gives us a conceptual tool for expanding the set of initially defined goals
- It places bounds on those goals that are acceptable to stakeholders and those that are not
- It addresses the sources of the non acceptance of an IT system by its stakeholders

Maybe the most important aspect of the study of regulation is its power to prevent us from thinking in absolute terms. By moving our attention from means to ends we still think in absolute terms. We define, for instance, that one aspect is a goal whereas another is a task. This distinction is not necessary when we investigate a system from the point of view of regulation. We have shown that this distinction is not only unnecessary but potentially harmful when applied during early requirements. Furthermore, the concept of goal itself implies some absolute notion of what systems can desire. We can reasonably doubt that all commercial entities need to have the goal of expanding their market share, or their stockholder’s value. When investigated through regulation, we are encouraged to think in terms of what will ensure the long term survival of the company in question. One option is to keep expanding the market share because this is in tune with the wishes of some parts of the environment of the company, i.e. investors. However, it is possible to build a different value structure where never-ending expansion is not the most important aspect of the company. Thus, we see that goals are not given from the outside of the system but are defined by the system itself from aspects in its environment that it wants to address. This helps us explore more adequate goals than current goal-directed techniques.

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Appendix 1. Community Concepts Definitions

Community	An autonomous object
Maintenance goal	Description of a norm to be maintained
Regulation Activity	The activity which is specified by the a maintenance goal
Norm	the state of the community which is compared with the current state during the regulation activity or the state that the community wants to maintain
Appreciative Setting :	The state of the community which determines the community's interpreted state. The appreciative setting determines what the community wants to see in its environment and the importance it gives to what it sees.
Interpreted state	The aspects of the state of a community that the community defines as pertinent for a given goal (maintenance or achievement) by applying its Appreciative Setting => obstacles and capabilities
Rule	A prescribed guide for conduct or action
Plan (with respect to a State)	Definition: 1. A decomposition plan of activities which a community specifies in order to bring the interpreted state of the community closer to the State taking into account a set of obstacles and capabilities 2. A decomposition plan of activities which a community specifies in order to carry out an activity taking into account a set of obstacles and capabilities – Each rule in the plan can be classified as either: • An obligation to carry out some action • A permission to carry out some action • A prohibition to carry out some action • A authorization to carry out some action (introduced in ODP-EL) • An encouragement to carry out some action – Note: This plan can be seen as a specification of achievement goals. – Note: The state can be specified by a Norm in which case the plan is called a Regulative Plan or a transitory state in which case the plan is called an Achievement Plan.
Policy	A plan that has been elevated to the status of a norm of behavior. Note: In AI this is called a Plan Schema, a kind of plan template which is instantiated with regard to an external event (perturbation) or with regard to a goal
Achievement Goal	Expected post-conditions of an activity
Obstacle (with respect to a goal)	A Interpreted State which opposes the achievement or maintenance of the goal Note: An obstacle can be attributed to: • the availability of a needed resource (can't make coffee without the availability of a coffee machine), most frequently time and space resources; • the imposition of plans designed to reach the goal plans imposed by interacting communities
Constraint (with respect to a goal)	A Interpreted State which limits the possible activities that may achieve the goal Note: For example, abstracts cannot have more than one paragraph
Capability (with respect to a goal)	A Interpreted State which helps in the achievement of the goal Note: A capability can be attributed to the same concepts as an obstacle. The community decides how to view a certain state, i.e. as a capability or an obstacle

Appendix 2: VideoStore Case Study

Video Queen – PORT System Requirements AW 10/17/2000

Regina Monarch owns a video franchising business. It's called Video Queen. Video Queen supplies a business that is organized and ready to go. Someone can open a Video Queen outlet. They receive all the backing and expertise of a running, proven operation and they have to supply the premises and the work.

Video Queen has a countrywide operation. They have stores in all major cities. To be able to loan a video, a customer has to become a member.

The current system works but it has some inefficiencies (related to the quantity of paperwork to be done). Ms. Monarch (referred to sometimes as "The Queen") wants to make it more efficient and to give the service a "more modern and high tech feel". For these reasons, the Queen requested the development of a computerized system supporting the video loan. The new system will be called PORT (Point Of Rental Terminal).

A Video Queen store will work like this:

Videos have a video id (a string) and a title (a string). When new videos are received, the clerk enters this information in the PORT. The PORT records the video information in its internal video catalog.

Members have a membership card. The card shows a member id (a string) and member info (a string). For new members, the clerk enters the member info in the PORT. The PORT assigns a member id and records the member information in its internal member catalog. Then, the new members receive their membership card (handwritten by the clerk) with their member id and member info written on it.

There is no time limit for a video loan. However, a "loan policy" restricts the number of videos a member can have simultaneously. Currently the limit is 5. The clerk has the authority to change it. The PORT enforces this limit. The PORT should allow the clerk to know which member has which video.

To loan videos, the member picks one or more videos that he or she gives to the clerk. They also give their membership card. The clerk enters the member id (found on the member's card), the video ids (found on the videos) into the PORT. More than one video can be entered in one transaction. The PORT is responsible to keep track of the loans (i.e. the fact that the member can take the video with him or her).

Videos can be returned either when the store is open (they are dropped on the front desk) or out-of-hours (via a special letterbox). The clerk is responsible to enter the returned videos in the PORT.

The PORT will be running on a MS-Windows platform. The clerk is the only person operating the PORT; the customer will not interact with it. The PORT should follow Windows guidelines, specifically:

- the PORT should allow the clerk to cancel at any time the entering of the videos;
- the PORT should be robust to operator's errors (e.g. typing errors, etc…);
- the PORT performs one operation at a time (modal user interface).

For example, he cannot enter new member information while entering a video to be loaned.

This document is not a legal contract. It explains what the Queen believes are the requirements. It is possible that some information might be missing or not clearly explained.