Where do Goals Come from: the Underlying Principles of Goal-Oriented Requirements Engineering

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Abstract

Goal is a widely used concept in requirements engineering methods. Several kinds of goals, such as achievement, maintenance and soft goals, have been defined in these methods. These methods also define heuristics for the identification of organizational goals that drive the requirements process. In this paper we propose a set of principles that explain the nature of goal-oriented behavior. These principles are based on regulation mechanisms as defined in General Systems Thinking and Cybernetics. We use these principles to analyze the existing definitions of these different kinds of goals and to propose more precise definitions. We establish the commonalities and differences between these kinds of goals, and propose extension for goal identification heuristics.

1 Introduction

The emergence of requirements engineering as a separate discipline from computer science and systems engineering in the early 1990s coincided with the development of methods for defining requirements based on goals, the so called Goal-Oriented Requirements Engineering (GORE) methods [19]. Goals are now considered as a core concept in RE [9].

Requirements engineering research has focused on goals as a way of providing the rationale (why) for an envisioned system [18]. This helps in identifying, organizing, and managing requirements as well as in driving the requirements elaboration process [1].

Several GORE methods have been defined that give more attention to one or more of these aspects e.g. CREWS [15], GBRAM [1], GRL [8], i* [28], KAOS [7], TROPOS [11], etc.

GORE research has focused on the development of methods. Little research has been done on the underlying principles of GORE [9]. As a result there is room for improvement in the understanding of the similarities and differences between the many kinds of goals that have been proposed in GORE methods, e.g. achievement, maintenance and soft goals. For example, achievement goals are said to comply with maintenance goals [1] but this relationship has not been made more precise. The same applies to the relationship between maintenance and soft goals.

In this paper we propose a set of underlying principles for Goal-Oriented behavior in organizations. These are based on regulation mechanisms proposed in General Systems Thinking (GST) and Cybernetics [2, 20, 21, 25, 26, 27]. Studying regulation in organizations implies studying how they maintain their identity, i.e. survive, in a changing world.

With this work we are able to propose general purpose, precise definitions for achievement, maintenance, and soft goals. Our purpose is to explain the relationships between these kinds of goals, and to extend goal identification heuristics. This work is part of the Lightswitch Goal-Oriented framework. It is a revised version of the work presented in [13]. Lightswitch is itself a part of SEAM, an Enterprise Architecture framework [24].

In Section 2 of this paper we present the different kinds of goal defined in several leading GORE methods. In Section 3 we present the underlying principles goal-oriented behavior. In Section 4 we apply the underlying principles to GORE concepts. In Section 5 we describe the related work. In Section 6 we conclude with an outlook on future possible research.

2 The Use of Goals in GORE methods

GORE methods take their root in AI research into problem solving [18]. The reasons for focusing on goals, found in the GORE literature [1, 8, 18], are the higher level view of requirements afforded by goals as

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compared with traditional requirements specifications; the stability of goals compared with the requirements that implement them; the ability to consider alternative solutions; the verification of completeness of requirements and traceability from the organizational context to requirements offered by goals.

In the following subsections we describe some of the kinds of goals found in GORE methods and analyze their definitions. The GORE methods we take into account are KAOS [7], GBRAM [1] and GRL [8]. The CREWS-L'Ecritoire [15] project is also mentioned for its goal identification

2.1 GORE methods

The Knowledge Acquisition in autOmated Specification (KAOS) [7] is a formal approach for analyzing goals and producing requirements based on pre-stated goals. The KAOS approach is mainly oriented towards ensuring that high-level goals identified by stakeholders are transformed into concrete system requirements. The method is composed of:

- A specification language based on concepts such as object, action, agent, goal, constraint, etc.
- An elaboration method for transforming stakeholders' goals into requirements
- A meta-level knowledge base used for guiding decisions during the elaboration process

The Goal Based Requirements Analysis Method (GBRAM) [1] was developed as a response to the lack of goal identification techniques in other GORE methods. GBRAM offers a set of heuristics for goal identification and their elaboration into a software requirements document.

The Goal-oriented Requirement Language (GRL) [8] is a modeling method that aims at modeling "strategic relationships" between actors that represent stakeholders and their goals. GRL can be seen as an evolution of the NFR, i*, and Tropos methods. In order to avoid confusion and to maintain the brevity of the discussion we will refer to GRL as a representative of this family of methods. GRL 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

GRL defines a set of intentional modeling concepts. This category contains the following concepts: goal, task, softgoal, resource and belief. The intentional concepts are part of the GRL basic modeling concepts that also include actors and links.

These concepts are said to be intentional because they are used to address such questions as why and how a particular solution was selected among several alternatives.

2.2 Definitions of goals in GORE methods

We first analyze the definitions of the concept of goal itself. We then analyze the definitions of the concepts of achievement goal, maintenance goal, softgoal, belief and constraint. These concepts were selected among the numerous goal concepts because they form a coherent set of interrelated concepts explainable by the underlying principles we propose.

Goal:

The concept of goal is defined in KAOS as [7]:

> "a nonoperational objective to be achieved by the composite system."

A goal in KAOS is refined until it becomes an objective that can be satisfied through state transitions of the envisioned system. It then becomes a constraint (later called "requisite" [17]), i.e. a requirement assigned to an individual agent.

In KAOS goals are classified 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 [7].

In GBRAM goals are defined as [1]:

> "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."

The main kinds of goals used in GBRAM are achievement and maintenance goals. GBRAM focuses mainly on the identification and reduction of achievement goals into requirements because they are more closely linked to functional requirements [1].

In GRL a goal is defined as [8]:

> "A goal is a condition or state of affairs in the world that the stakeholders would like to achieve. How the goal is to be achieved is not specified, allowing alternatives to be considered."

GRL doesn't use the concepts of achievement and maintenance goals as in KAOS and GBRAM. It defines other concepts (hard)goal, softgoal and belief.

	KAOS (from [7])	GBRAM (from [1])	GRL (from [8])
Goal	"a nonoperational objective to be achieved by the composite system"	"targets for achievement which provide a framework for the desired system."	"a condition or state of affairs in the world that the stakeholders would like to achieve."
Achievement Goal	a property that "holds in current or some future state"	"objectives of an enterprise or system [..] satisfied when the target condition is attained."	Not used
Maintenance Goal	property that "holds in current and all future states."	"goals which are satisfied while their target condition remains constant or true."	Not used
Softgoal	Not used	Not used	A goal for which "there are no clear-cut criteria for whether the condition is achieved."
Belief	Not used	Not used	"represent design rationale."
Constraint	Not used	place a condition on the achievement of a goal	place a condition, positive or negative, on the achievement of a (hard) goal

Table 1 Overview of goal concept definitions in KAOS, GBRAM and GRL

The following briefly presents the definition of the goal concepts identified above. Table 1 shows an overview of these concepts and their definitions in the different methods.

Achievement Goal:

The concept of achievement is defined in KAOS as a property that "holds in current or some future state" [7].

In GBRAM achievement goals are defined as [1]:

> "Achievement goals are objectives of an enterprise or system."

and

> "An achievement goal is satisfied when the target condition is attained."

Maintenance Goal:

The concept of maintenance goal is defined in KAOS as a property that "holds in current and all future states" [7]. In KAOS maintenance goals are distinguished from avoidance. An avoidance goal specifies a state that is to be avoided [7].

Maintenance goals are defined in GBRAM as [1]:

> "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."

In GBRAM, the concept of maintenance goal encompasses avoidance as well. The relationship between maintenance goals and achievement goals is defined in GBRAM as [1]:

> "Maintenance goals are usually high-level goals with which associated achievement goals should comply."

The compliance relationship between maintenance goals and achievement goals is not specified in more detail.

Softgoals:

A softgoal is defined in GRL as [8]:

> "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."

Beliefs:

The concept of belief is defined in GRL as [8]:

> "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."

Notice that unlike the definitions of goal and softgoal, the definition of belief doesn't describe to whom a belief belongs. The formal definition of a belief does include an entry for the belief *holder*. However, 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 models that appear in the literature. Furthermore, it seems to be used essentially for capturing the design rationale of the designer as suggested by its informal definition.

Constraint:

The concept called constraint in the early KAOS literature seems to be far different from the concept of constraint as it is understood in the other GORE methods. We therefore assume that the concept of constraint is not used in KAOS. This is coherent with the name change from constraint to requisite operated in the later KAOS literature.

In GBRAM constraints place a condition on the achievement of a goal. These conditions can be either goal enablers or conditions that act against the achievement of a goal. Maintenance goals are said to "place constraints on an entire class of goals" [1].

In GRL softgoals act as constraints on the achievement of (hard) goals. Selection between alternative goals is made by the extent to which they satisfy these constraints.

2.3 Identification of goals

The identification of stakeholders' goals has been recognized as a complex issue [17]. Therefore, GORE methods provide a range of techniques for goal identification. The following list gives a summary of these techniques [1, 15, 18]:

- Understanding stakeholders' problems and negating them
- Extracting intentional statements from:
  - interview transcripts
  - enterprise policies
  - enterprise mission statements
  - enterprise goals
  - workflow diagrams
  - scenarios written with stakeholders
- Asking "How" and "Why" questions about these initially identified goals in order to go up and down the goal hierarchy
- Asking "How else" questions to identify alternative goals.

GBRAM achievement keywords	GBRAM maintenance keywords
Achieve, Make, Improve, Speedup, Increase, Satisfied, Completed, Allocated	Maintain, Keep, Ensure, Avoid, Know, Monitor, Track, Provide, Supply, Found out

Table 2 Keywords for identifying achievement and maintenance goals [1]

GBRAM offers a further set of heuristics for goal identification extracted from intentional statements. These heuristics suggest [1]:

- Searching for action words that describe a state that is to be achieved, maintained, avoided, etc. (see Table 2).
- Asking what goal a given statement exemplifies and what goals are blocked or obstructed by a statement
- Asking why an identified goal is to be achieved or maintained.
- Looking for statements that guide design decisions at different levels of the IT system or enterprise
- Considering pre and post conditions of already identified goals
- Using domain knowledge
- Identifying goal obstacles and constraints
- Considering possible scenarios for goal achievement and obstruction.

2.4 Summary

One of the main aspects of GORE methods is their capacity to establish traceability links from strategic goals of the enterprise to requirements of the envisioned system. Therefore these methods provide powerful mechanisms for goal identification, goal refinement and goal elaboration into requirements.

However, the relationship between these strategic goals and the types of goals defined in these methods is unclear. Maintenance goals are said to be higher level goals but there is no explanation to this assertion. As a result the relationship between maintenance goals and achievement goals remain somewhat unclear.

Both softgoals and maintenance goals are said to lead to non-functional requirements. There must therefore be some relationship between these two kinds of goals. For example, softgoals are defined as goals with soft achievement criteria. Therefore, softgoals seem to be a particular kind of achievement goals. But softgoals are also said to represent global qualities that need to be maintained in the enterprise and IT system. This makes them closer to maintenance goals. These relationships have not been studied yet.

The relationship between goals and beliefs has not been studied. The concept of belief has been proposed in one of the GORE methods but is defined as a design rationale rather than as the worldview of an agent and seems to be used only occasionally.

Similarly, the relationships between the concepts of constraint and goal have not been extensively studied.

3 Underlying principles for GORE

The regulation principles explain why human and organizational behavior appears to be goal-oriented. They are based on the works of Weinberg & Weinberg [26], Vickers [20, 21], and Ashby [2], who all seem to view goal-oriented behavior as a reduction of what we can term the regulation-oriented model of behavior.

In this section we describe the regulation principles of GORE, we begin with the epistemological foundations, i.e., how we know what we know. We then explain the need for regulation in terms of survival. This is followed by a short explanation of survival and a description of a few regulation principles. Finally, we link these principles to the GORE concepts we analyzed in the previous section.

3.1 Epistemological foundations of systems

At the base of our epistemology we investigate how we perceive the world, or how we know what we know.

As an example, consider the definition of a *system* in general system theory[1]. The common definition of a system is "as a set of elements standing in interrelations" [22]. As noted by Weinberg [25] 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. Someone must decide which elements and relationships belong to the set and which do not.

We call *observer* the person making this judgment. In this view, the set of elements is an *interpretation* of the observer. The observed thing is what we call *entity*. Hence a system is a set of interrelated elements representing entities in the observed reality as defined by an observer. The concepts of observer and interpretation are compatible with the social constructivism world view [3].

The set of elements 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

The discussion above enables us to propose the following definitions for system and environment:

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

Def 2: **Environment (of a system of interest)** is all of the systems distinguished by an observer that, from the point of view of the observer, are not elements of the system of interest or the system of interest itself.

3.2 The importance of open systems

Having introduced the concept of system, we now introduce the notion of open system. An open system is necessary to characterize the survival of systems. We use this concept in Section 4 to define goal identification heuristics.

The concept of open system relies on the following assumptions [27]:

1. The world as a whole (or any closed portion of it) continually moves toward disorder, i.e. positive entropy. This is the second law of thermodynamics.
2. Survival of organized entities in a world where the second law of thermodynamics is true requires an open system that regulates its relationships with other systems.

We therefore define an open system as:

Def 3: **Open system** is a system that has relationships with other systems in its environment.

3.3 Survival of open systems

Survival was defined by Ashby [2] as the maintenance of a set of variables in states that are within boundaries defined by an observer. For the observer, these *Identifying variables*[2] constitute the identity of the system, i.e. what distinguishes this system from its environment. In other words, a system survives as long as it maintains its identity for a given observer. The identifying variables will not remain within the boundaries by themselves. Continuous effort is needed to maintain the variables in these states.

Hence, entity and observer maintain variables in relatively stable states in order to survive in a changing world. For example, commercial enterprises survive from the point of view of the casual observer as long as they maintain a distinct financially responsible organization related to a legal entity. A counter example is an enterprise that completely changes its product line. The question then becomes, when does an enterprise lose its identity? Across the transformations that affect it over the years, when does it cease to be the same enterprise as before? Thus, survival depends on the stable states that the enterprise maintains for different observers such as customers, investors, suppliers etc.

We use the term *norm* to refer to the stable states maintained by a system. As we have seen, an open system is a system that has relationships with other systems in its environment. In order for the system under consideration to survive it must maintain the

[1] In this section, we use the term system in its most general sense as defined in General Systems Thinking, not in the sense of a software intensive system as the term is usually used in RE, CS and SE.

[2] Ashby [2] calls these variables essential variables. Weinberg and Weinberg [26] call them identifying variables. We use the latter name.

relationships it has with the other systems in very specific norms. This enables it to maintain its own internal norms.

For example, commercial enterprises need to maintain their relationship with their customers close to a norm that insures that these enterprises sell their goods to customers with a margin that enables the enterprises to pay their employees, suppliers, investors etc. Failing to do so, quite quickly results in the disappearance of the internal norms of these enterprises. Enterprises typically maintain a large number of such norms, for example, an enterprise's name, its reputation, its revenues, its profits, its number of employees, etc. Many of these norms are not explicitly identified but are nevertheless shared by most members of the enterprise.

Norms are often interdependent. For example, an enterprise's reputation depends on its revenues and profits, as well as on corporate governance that is in accordance with the environment it is in. If one of these norms is not properly maintained the enterprise's reputation will suffer. These norms in turn depend on a host of other norms, such as, customer and employee satisfaction, good economical conditions in the environment etc.

A norm is stable but not static. Norms change over time as the system adapts to its environment [26]. However, norms have a finite rate of change beyond which the enterprise fails to survive [21]. Norms change, for example, when the revenues grow as the business adapts to a growing market. Note that a steady growth or decline is also a kind of norm, for example, a steady revenue growth.

The main issue in survival is therefore to maintain a set of norms in a relatively stable state, changing the norms of the organization or those of the environment when needed and possible.

The discussion above gives us the following definitions for the concepts of state, variable and norm:

Def 4: **State (of a variable)** is a value defined by an observer that the variable can have at a given moment in time.

Def 5: **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 6: **Norm (of a system)** is a variable of the system whose state the system attempts to maintain unchanged as defined by an observer.

3.4 Regulation mechanisms in open systems

One of the ways of thinking about the maintenance of identity (i.e. of norms) is through the mechanism of Homeostasis, i.e. the maintenance of self [26]. Homeostasis is achieved by having several cooperating processes act against change whenever an undesired change is detected. Homeostasis also specifies that there should be processes in place to prevent overcompensation of this tendency to act against change. Overcompensation occurs for instance when an enterprise in financial difficulties lays off the very people who can help it rebound.

Hence, if a state of a variable remains stable, it is because whenever change is detected, a *regulative action* [21] is taken to counter the change, i.e. to bring the variable into a state of affairs that is acceptable, see Figure 1. Therefore, regulation limits the possible states of identifying variables [2, 26]. However, while limiting the states of identifying variables, regulation creates many other variables and states to protect them [2]. For example, an enterprise that needs to maintain its revenue and profit at a state that corresponds to analyst expectations in the face of competition may launch new development projects, thus creating many other variables and expanding the possible states of existing ones.

In an open system, whenever the system's interpretation of the state of one of the relationships is outside of the acceptability threshold of the norm associated with this relation, a regulative action is likely to be taken by the system. When an enterprise's earnings, for example, are outside of the norm established by investors, the enterprise is likely to specify the regulative action of bringing the finances into the norm. The same may happen if the margins provided by the enterprise products fall below the norm so that it cannot maintain the levels of salary and benefits expected by its employees or the dividends expected by its investors.

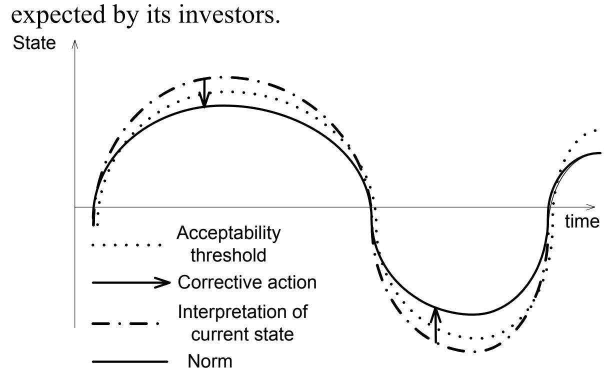

Figure 1 Regulation by norm

One of the important aspects of the maintenance of norms is the detection of change by the system of interest. In other words, a system needs to know in what state it is and how far from the norm this state is. We call interpretation of the system this understanding of itself and its environment. Hence, a system is an observer of itself and its environment. This is in accordance with the observer and interpretation concepts introduced in the beginning of the section.

As known by control engineers, regulative action cannot be taken with respect to the norm itself but when the state of affairs is believed to be outside of a threshold associated with the norm. Doing otherwise will require too much effort on the part of the system as action will have to be taken at the slightest straying from the norm. This will ultimately lead to the inability to maintain the norm stable. The resulting behavior is shown in Figure 1

The expected result of a regulative action (the goal) is also an interpretation. For example, an enterprise in financial trouble decides to invest in the development of new products, thus spending even more money. The expected result is linked to the norm only through the interpretation of the enterprise that this investment will bring its finances into the norm, i.e. through an anticipation of future results. Indeed, if the enterprise's interpretation of its situation is that investing in new products will not improve its finances but that cost cutting will, it will take the regulative action of cutting costs rather than develop new products. In practice it is often both actions that are taken as explained in Homeostasis, i.e. cost cutting in some areas in order to survive for the short term and new product development to insure long term survival.

Finally, regulative action is not always taken when the interpretation of the state of affairs is outside of the threshold [21]. Another possibility is to change the norm so that it will fit the interpretation thereby making the current state acceptable. We thus have either a regulative action or what we call a *learning action*.

The above considerations enable us to propose the following definitions:

Def 7: **Interpretation (made by a system of interest)** is a variable of the system of interest whose state represents the understanding of the system of interest of its own state or a state of its environment.

Def 8: **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 9: **Regulative action (of a system)** is an action taken by a system in order to bring one or several of its interpretations closer to a norm when this interpretation has drifted, or will drift out of a threshold associated with the norm.

Def 10: **Learning action (of a system)** is an action taken by the system that changes its interpretations, norms, and regulative actions.

4 GORE Concepts and the Underlying Principles

In the previous subsection we have defined the underlying principles of goal-oriented behavior in terms that are independent of goals, i.e. in terms of norms, actions, and interpretations. We can now establish the relationships between the concepts defined in GORE methods and these principles. In order to be compatible with GORE vocabulary, we sometime use the term agent as a synonym to what we called a system in the previous section.

4.1 Definition of GORE Concepts in terms of the Underlying Principles

Goal:

A goal corresponds to a state of a system in the underlying principles that is specified by an agent.

Achievement goal:

The concept of achievement goal corresponds to a regulative action or a learning action in the underlying principles. Indeed, an achievement goal has definite pre and post-conditions. The pre-condition represents the interpretation that the state of affairs has drifted (or will drift) outside of the threshold associated with the norm. The post condition is an interpretation that is within this threshold. An achievement goal is satisfied as soon as its post-condition is reached. Alternatively, the quest for its achievement (the actions performed to achieve the post condition) can be stopped if the agent believes that the post-condition cannot be reached.

Maintenance goal:

The concept of maintenance goal corresponds to a norm in the underlying principles. Indeed, a maintenance goal is said to represent a condition that remains constant. This is almost exactly the definition of a norm in the underlying principles. Also, maintenance goals are said to limit possible states. As we have seen, this is also the case of a norm.

Note that maintenance goals are a simplification of the concept of norm. This is because the condition represented by the maintenance goal remains constant whereas a norm changes, however slightly, over time. A maintenance goal is needed for as long as the norm is in effect. Therefore, the concept of maintenance goal should be extended with the notion of change.

Softgoal:

A softgoal is defined as a goal that has no clear-cut criteria for achievement. There are at least two possibilities for these criteria to be unclear:

1. All stakeholders agree that the quest for achieving the goal has terminated but there is disagreement between stakeholders whether the goal was achieved completely (e.g. a product was repaired but there is disagreement on whether it was correctly repaired)
2. There are no clear-cut criteria to even say whether the quest for achieving the goal has terminated. The goal is on-going.

The first case is an achievement goal with disagreement over its achievement. The second case is in essence a maintenance goal representing a norm. Many of the examples of softgoals found in the literature represent norms such as "happy customers, continuing business" [11].

Belief:

The concept of Belief represents what we called an interpretation of a system in the underlying principles. A belief represents the worldview of an agent, i.e. the way the agent interprets its own state and the state of its environment. Since the agent defines its goals based on these interpretations, this is a very important goal-related concept.

Note that the concept of belief is not used in KAOS and GBRAM. In GRL it seems to be used to document the interpretations of the modeler rather than the agent being modeled.

Constraint:

A constraint is the interpretation of a norm that enables and/or limits the achievement of a given goal (i.e. it enables or limits the available state space). At any given time, an enterprise attempts to maintain a large set of norms. When some regulative action is carried out, the interpretations of these norms limit the possibility of success of the regulative action. At the same time the interpretation of another set of norms act in favor of the success of the regulative action because they offer a stable state on which the regulative action can be based. We have defined the concept of belief as the interpretation of a state of affairs. We now see that a constraint is a belief that constrains or enables the attainment of an achievement or maintenance goal. Thinking of constraints as beliefs shows their non absolute nature. Some state of affairs limits some agents and empowers others.

This explains the notion of constraint as enabling and limiting factor of achievement goals in GBRAM. It also explains why maintenance goals are said to constrain goals in GBRAM and likewise in GRL for softgoals.

4.2 Heuristics for goal identifications

Based on the regulation principles and their link to GORE concepts described above we can extend the existing GORE heuristics presented in Section 2 with the following ones (more heuristics can be found in [12] and [13]).

Identifying maintenance goals:

For each identified achievement goal, attempt to identify one or more norms that this achievement goal attempts to maintain. The search for norms can be performed by analyzing the achievement goal as a regulative action and asking what aspects of the enterprise is being maintained by this action. If necessary, the standard GORE technique of asking why questions on this achievement goal can be used to identify a goal that can be analyzed as a regulative action. Express these norms as maintenance goals.

For each achievement goal, attempt to identify as many norms that act as constraints on this goal. Express these norms as maintenance goals.

For each norm, attempt to identify whether and how it is changing. Express this change in the corresponding maintenance goals.

This process is hindered by the fact that many norms are not explicit and therefore stakeholders are often not aware of them even though they act in accordance with these norms.

Identifying highest level goals:

It has been recognized that GORE do not deal well with the concept of the highest level goal from which all other goals are refined [29].

The underlying principles that we have defined enable us to propose that the highest level goal that can be ascribed to an enterprise is the wish to survive. This suggests the maintenance of a large number of norms and therefore of maintenance goals. Examples of such goals depend on the nature of the enterprise and its environment. For a commercial enterprise these are typically to maintain its finances in good standing.

The enterprise norms are maintained by regulating its relationships with other enterprises in its environment. This suggests a maintenance goal of maintaining relationships with the enterprises with which the enterprise under consideration is related. Searching for subgoals of this maintenance goal provides a maintenance goal for each such relationship. For a typical commercial enterprise we would have the following maintenance goals: maintain relationships with customers, maintain relationships with suppliers, maintain relationships with employees, maintain relationships with investors etc.

These heuristics identify the highest level achievement goals that are defined in order to maintain the norm. Further subgoals are refined from this goal with goal refinement techniques.

Identifying Homeostasis related goals:

The Homeostasis principles can be an important source of goal identification (see also [14]). In particular, backup processes and automatic processes for avoiding over compensation can be searched for each norm that is identified. These processes can be expressed as maintenance or achievement goals according to their nature.

Identifying beliefs:

For as many goals as possible, attempt to identify what are the stakeholders' interpretations that support these goals. These interpretations will often expose norms of the enterprise. Express these interpretations as beliefs that support the corresponding goals. This will give a rationale to these goals and enable to challenge these beliefs. For an example of these heuristics see [13].

5 Related Work

Few studies have been conducted within the RE community to link the GORE theory to organizational theory.

Only one study known to us [9] establishes a link between GORE methods with an organizational context. This study proposes a unifying framework for GORE methods taking the perspective of the activities needed to perform a complete RE process (as-is, change, to-be, evaluation). It thus proposes a meta-model involving the following kinds of goals: current goals, future goals, change goals and evaluation goals. The study, therefore, focuses on the process of specifying requirements with each of the methods and the relationship between the kinds of goals and their usage in the RE process. It doesn't attempt to analyze the definitions of goals, their interrelationships and their connection with the organizational context as in our study.

SSM [5] has a similar theoretical approach based to a large extent on General Systems Thinking and most notably on the work of Vickers. In SSM human and organizational behavior is not assumed to be teleological but rather teleonomical, i.e. it is not necessarily goal-oriented but *appears* to be goal-oriented. As a result, the focus of analysis is on norms and their change rather than goals. SSM related research doesn't explicitly address the notions of regulation and the relationships between norms and goals as defined in GORE methods.

Organizational Semiotics is the study of organizational norms, their expression in signs, and the relationships of these signs and norms to IS development [6]. Shishkov et al. [16] in particular have proposed a method for deriving use cases and goals through a semiotic-based norm analysis. However, Organizational Semiotics has not been further linked to GORE methods. Also, Organizational Semiotics research is not linked to the more global aspect of regulation and organizational survival. Our work enables to explicitly link GORE concepts to concepts used in Organizational Semiotics, i.e. norms.

The relationships between norms and maintenance goals have been recognized in artificial intelligence research into social behavior of agents, e.g. [4]. However, the relationships with GORE and regulation have not been made.

6 Conclusions and Future Work

In this paper we presented the underlying principles of goal-oriented behavior. These principles are based on the General Systems Thinking and Cybernetics concept of regulation. The study of regulation, i.e. of the maintenance of identity in a changing world, enables us to propose precise definitions for several key goal concepts found in existing GORE methods and to show how these concepts are related to each other.

The study of regulation also enabled us to propose heuristics for goal identification that extend those already defined in GORE methods. These heuristics only apply to the origins of high-level, strategic goals. These goals can be used as the input for the goal refinement and elaboration techniques that are needed to produce requirements.

Among other aspects of GORE, we have also shown the importance of maintenance goals in enterprises and the importance of norms and beliefs in shaping goals.

The GORE principles proposed in this paper form part of the theoretical framework of the Lightswitch GORE method. The practical use of Lightswitch was demonstrated in [12, 13]. The proposed definitions were partially formalized using the Alloy constraint analyzer [10]. Further formalization can be attempted using the Wand and Weber ontology [23].

Regulation is a very complex issue. There are very many regulation strategies [2, 26]. In this paper, we could only show the outlines of this subject. More research into regulation and goals is needed. In particular, more regulation heuristics can be defined beyond [12, 13]. More research is also needed to study the relationships between norms, beliefs and goals. This can be done by linking with research in Organizational Semiotics for the study of norms and Artificial Intelligence (e.g. BDI) for the interaction of beliefs and goals.

7 References

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