FEDERAL UNIVERSITY OF ESPIRITO SANTO

COMPUTER SCIENCE DEPARTMENT

An Semantic Alignment of ArchiMate ME and GQM

Technical Report

Subject of Goal Analysis

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1. Introduction

"[...] people do not strictly follow rules or procedures, rather they are aware of the personal and group goals and act accordingly." (Smith and Boldyreff cited by Kavakli & Loucopoulos, 2005)

Requirements Engineering (RE) is considered one of the most critical phase of software lifecycle, and *goals* have long been recognized as an essential component involved in the requirements engineering process. This relation between RE and *goals* has been discussed by several authors (KAVAKLI, 2002). According to Kavakli (2002), "the influence of goal-orientation on contemporary RE methods and techniques is evident. A large number of RE approaches use the notion of goal as a high-level abstraction medium for structuring and abstracting the content of requirements. In addition, goals are an important component of use-cases in object-oriented approaches and have also been proposed as a way to structure use cases. Moreover, goal analysis is incorporated in existing methodologies. [...]. This widespread adoption of goal concepts in many RE approaches indicates that goals are a core concept for RE in general"

Goal-oriented Requirements Engineering (GORE) establishes the use of *goals* for eliciting, elaborating, structuring, specifying, analyzing, negotiating, documenting, and modifying *requirements*. It is based on develop models that show how *goals*, *objects*, and *agents*, among others, are inter-related (LAMSWEERDE, 2001).

However, despite awareness of the influence of GORE in the process of software development, particularly in the business environment, neither the state of art nor the state of practice have been fully established. There is no consensus, there is no pattern. There are many good approaches and languages being proposed, but they are not necessarily made to interact and cover all aspects involving the relationship between RE and *goals*. As (KAVAKLI, 2002) highlights "Existing RE frameworks mention goals in several RE contexts, however none considers the overall role of goals in RE. Moreover, authors of goal-oriented methods have convincingly argued for the significance and usefulness of goals in their respective approaches, nevertheless there has not been a comprehensive attempt at understanding and clarifying the role of goal modeling across different stages of RE".

But there are emerging proposals to increase the comprehension of the relationship between RE and *goals*, as well as to integrate and adapt approaches already disseminated of GORE to cover a wider aspect of this relationship. As (KAVAKLI, 2002) says: "[...] the various goal-oriented approaches can be put together thus leading to a stronger goal-driven RE framework that takes advantage of the contributions from the many streams of goal-oriented research".

(KAVAKLI; LOUCOPOULOS, 2005) presented an overview on the state of art in GORE, identifying as the modeling of *goals* can fit into the typical activities of RE (elicitation, negotiation, specification, and validation), and they also proposed a framework for understanding goal-oriented approaches. Besides that, (KAVAKLI; LOUCOPOULOS, 2005) remark that few studies focus on the evaluation of *requirements/goals*. From that, in this work, we propose a semantic alignment between an approach of modeling of *goals* (Archimate ME), and an approach of goals assessment (Goal-Question-Metric (GQM) (BASILI; CALDIERA; ROMBACH, 1994)). These two approaches were semanticly aligned at light of UFO (Unified

Foundational Ontology), a foundational ontology that has been developed with an interdisciplinary approach inspired by Formal Ontology, Philosophical Logic, Linguistics, and Cognitive Psychology.

This paper is organized into the following sections: 1- Introduction; 2 - An overview on GQM; 3 - An ontological interpretation for GQM *goal* concept; 4 - An overview on ArchiMate ME; 5 - An ontological interpretation for ArchiMate ME; 6 - Proposed alignment of ArchiMate ME and GQM concepts; 7 - Conclusions; 8 - References.

2. An overview of *Goal/Question/Metric* (GQM)

"Measurement ... Must be focused, based on goals and models ... Which metrics one uses and how one interprets them it is not clear without the appropriate models and goals to define the context" (BASILI; CALDIERA; ROMBACH, 1994)

According to (BASILI; CALDIERA; ROMBACH, 1994) GQM (*Goal / Question / Metric*) approach was originally proposed to define and evaluate the objectives of a specific project (NASA, 1984) and was later expanded to a broader context . It is used as a basis for setting *goals* in a quality improvement paradigm tailored to an organization of software development.

(BASILI; CALDIERA; ROMBACH, 1994) show GQM as an approach based on the assumption that for an organization work efficiently with a measurement program, it should first specify the *goals* of the organization itself and its projects, then it should map those *goals* to data that define the *goals* operationally (through *questions* and *metrics*), and finally provide a framework for interpreting these data in relation to the established *goals*. Thus, it is important to define what are the informational needs of the organization so that these needs can be quantified to the maximum, and that such quantified information can be analyzed for the satisfaction, or not, of the established *goals*.

The GQM defines 3 basic elements that comprise its hierarchical structure, namely: (i) *goals*, which define the objectives of an organization / project, (ii) *questions*, that direct the information that support the evaluation of a *goal*; (iii) *metrics*, which indicate the types of data to be collected in order to answer the *questions*. Figure 1 illustrates the hierarchy among such elements.
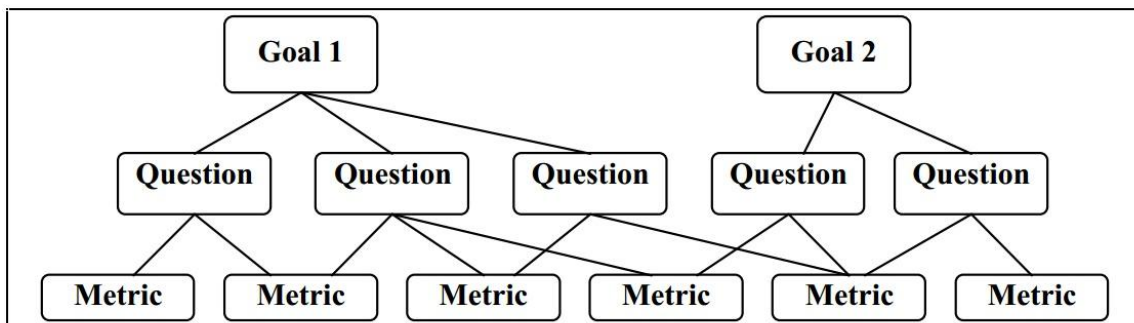

Figure 1 – GQM´s hierarchy of concepts (Basili et al., 1994)

In GQM, for each *goal* several *questions* are formulated in order to provide information to evaluate the satisfaction of this *goal*. For each of these *questions*, measurement *metrics* are defined for providing data to produce the answer to each *question*. These questions may have a set of answers, from which ir should be possible to assess the attendance of each *goal*. It is worth mentioning that each *metric* can be used on several *questions*.

According to (BASILI; CALDIERA; ROMBACH, 1994), (i) a *goal* is defined for an *object*; (ii) based on a number of reasons; (iii) with respect to several models of quality; (iv) from several *viewpoints*; (v) in relation to a particular environment. Thus, a *goal* consists of three coordinates: *object*, *issue/focus* and *viewpoint*, and also has a *purpose*.
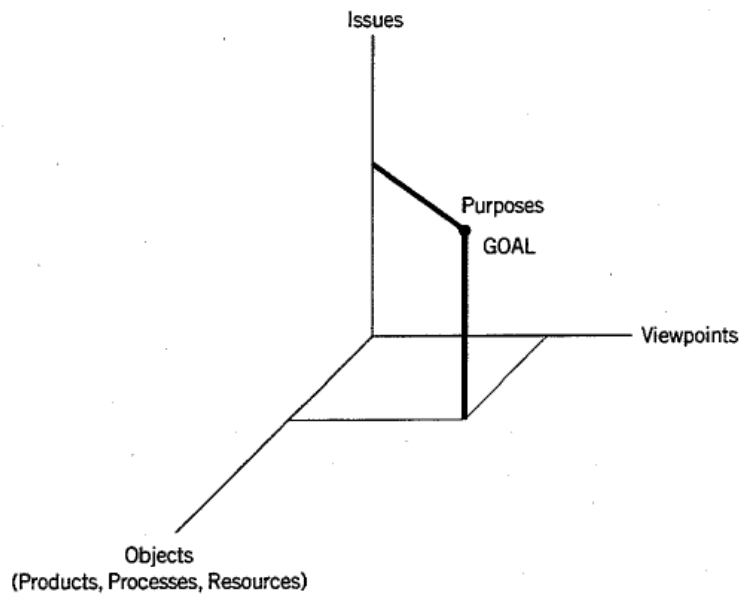
Figure 2 illustrates this interpretation.

Figure 2 – Coordinates of GQM (Source: Basili et al., 1994)

The use of GQM has spread over the years, and the emergence of a template to assist its characterization was a natural step. As highlighted by (SOLINGEN; BERGHOUT, 1999) templates are available to assist the definition of measurement *goals* by setting a *purpose* (what *object* and why), perspective (what aspect and who) and characteristics of context. The template used is the following:

- Analyze <<the *object* under measurement>>

- For de *purpose* of <<understanding, controlling or improving the *object*>>

- With respect to <<the quality *focus* of the *object* that the measurement focus on>>

- From the *viewpoint* of <<the people that measure the *object*>>

- In the context of <<the environment in which measurement takes place>>

From the above characterization, based on the work of (BASILI; CALDIERA; ROMBACH, 1994) and (SOLINGEN; BERGHOUT, 1999) about the coordinates and *purpose* that composes a *goal*, the following can be summarized:

- *Issue/Focus*.
    - o Associated question: what aspect?
    - o Focus on quality - identification of a quality criteria to associate the *goal*;
- *Object*.
    - o Associated question: what *objetct*?
    - o It can be: *Product*, *Process*, *Resource*;
- *Viewpoint*.
    - o Associated question: who?

o The *viewpoint* from which the measurement is performed;

- *Purpose*.
    - o Associated question: why?
    - o Purposes of measurement are usually related to the verbs: to understand, to control, to improve.

Figure 3 illustrates an example of application of GQM. This model presents the main concepts (*goal*, *question*, *metric*). In the example there are three *goals* (first level of figure). On the second level the *questions* are displayed, and we can see which are the *questions* that are linked with the *goals* established. Highlight to the fact that a *question* can be related to more than one *goal*. The third level shows the *metrics* that are linked with each *question*. Again, highlight to the fact that a *metric* can be related to more than one *question*.
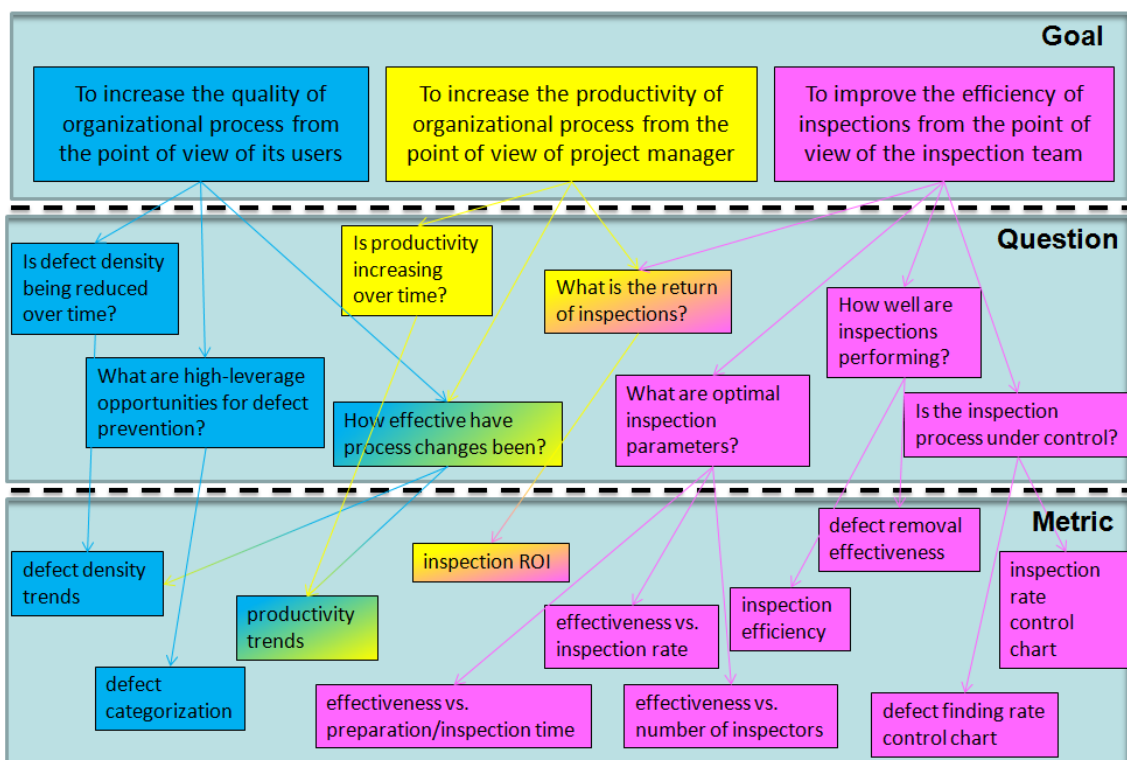

Figure 3 – GQM´s Example

Characterizing GQM as an approach that elaborates *questions* and *metrics* to be used to assess satisfaction of *goals*, emerged the idea of aligning the concepts of GQM to the ones on ArchiMate ME, an approach which is focused on modeling *goals*, to fill the latter´s needs to systematize the evaluation and verification of established *goals*. More information about the ArchiMate ME will be presented in section 4.

3. Ontological Interpretation for GQM *Goal* Concept

Considering *goal* as the common concept between GQM and ArchiMate ME, we believe that it should be the key for the alignment of these two approaches.

The concept of *goal* in GQM is characterized as having a *purpose* (the intended effect), which is associated to these three coordinates: *object, issue* and *viewpoint*. In order to give an ontological interpretation to *goal* concept, we interpreted the three coordinates singly, and then, linked all them considering the fact that a *goal* has a *purpose.*

According to GQM, in the context of an organization or a project, an *object* can be a *process*, a *product*, or a *resource*. In terms of UFO, a *process* can be interpreted as an *event*, which is a particular composed of temporal parts, i.e., it happens in time in the sense that it extends in time accumulating temporal parts (BRINGUENTE; FALBO; GUIZZARDI, 2011). In UFO, a resource is a *non-agentive substantial* (*object* in UFO) participating in an *event*. However, we believe that in organizational contexts it is necessary to consider another type of *resource*, which is commonly referred as human resource. At light of UFO, we can assume that a human *resource* is a person (i.e., an *agent*) participating in an event playing a specific role. Therefore, the concept of *resource* in GQM involves the idea of a *non-agentive substantial* as well as the idea of an *agent* playing a role. Following the same idea, a *product* is a *resource*, in terms of UFO (*non-agentive substantial*) whose participation in events is limited to two types of participations: creation participation (i.e., a product can be created) and changing participation (i.e., a product can be changed along an event) (GUIZZARDI; FALBO; GUIZZARDI, 2008).

In GQM, an *issue* refers to a quality aspect of an *object*, which can be interpreted based on the concept of *quality* in UFO-A (GUIZZARDI, 2005). *Qualities* (in UFO-A) are *intrinsic moments* associated to *quality structures* that inhere in an *individual*. A *quality structure* is defined by two elements: *quality domain*, and *quality dimension*. Thus, a color (*quality*) "c" of an apple (*individual*) "a" takes, for example, its value in a structure of three-dimensional color domain constituted of the dimensions hue, saturation and brightness. Thus, an *issue* is a *quality* that inheres in *individuals* (*events* and *endurants*). The *individual* that bears such *quality* (in terms of UFO) is aligned to the concept of *object* (in GQM), as aforementioned.

A measure in GQM is taken from a *viewpoint*, such as manager's viewpoint, or customer's viewpoint. The concept of *viewpoint* in GQM is associated with the "who" question in the sense that it is defined by an *agent* playing some *role* in the context of the *object*, which is the measurement focus. Therefore, in terms of UFO, we interpret *viewpoint* as a set of mental properties (*mental moments* in the sense of UFO) that inheres in an *agent* when he plays a *role*. Thus, a *viewpoint* is existentially dependent on the *agent* (e.g. person, team, organization), but many of the properties that constitutes the *viewpoint* are derived, mainly, from the *role* played by him/her. For example, an *agent* playing the *role* of manager in an organization is characterized by a set of *mental moments* derived from the responsibilities, skills, desires, concerns, intentions, etc, that characterizes the *role* played.

As stated earlier, a *goal* in GQM is defined as having a *purpose* associated with three coordinates: *object*, *issue* and *viewpoint*. We have already discussed possible ontological interpretations for each coordinate. The *purpose*, in turn, is related with the

"why" question in the sense that it maps the intended effect of the *goal*. By considering that a *goal* has a *purpose* that maps its intended effect leads us to interpret a GQM *goal* as an *intention*, in terms of UFO. In UFO, an *intention* is a kind of *mental moment* that express a desired state of affairs for which the *agent* (that bears the *intention*) commits at pursuing. This desired state of affairs is expressed by a proposition, which is the propositional content of the *intention.*

In GQM, the *purpose* of the *goal* regards to a quality aspect (*issue* coordinate) of an object (*object* coordinate). In terms of UFO, the propositional content of the *intention* defines the states of the *object*, with respect to that specific quality *issue*, that satisfies the *intention's* propositional content. The *viewpoint* coordinate, in turn, is related to mental properties that inhere in the *agent* who will judge the fulfillment of the propositional content.

It is important to realize that, in terms of UFO, every *goal* is associated to, at least, one intention that inheres in an *agent*, which is committed at pursuing this intention. So, we have two *agents* in the context of this interpretation: the agents who bears the intention associated to the achievement of the *goal*, and the agent who will judge the fulfillment of the *goal*. In terms of GQM, the latter is related to the *viewpoint* coordinate as discussed earlier. The former, in turn, is the *agent* that defines all the aspects of the *goal,* but is not directly represented by any coordinate. In some cases the same *agent* plays the two roles: bearing the intention of the *goal* and judging the fulfillment of this *goal*. But we cannot take it as rule. For example, on the model presented in Figure 3 we have the *goal* "To improve the efficiency of inspections from the point of view of the inspection team." In this case, the inspection team represents both the *stakeholder* that will judge if there was an improvement in the efficiency of inspection and the one that will work to achieve this improvement. Still on the same model we have the *goal* "To increase the quality of organizational process from the point of view of its users." In this case, the users are the ones who will judge whether there was an increase in the quality of the organizational process, but they are not necessarily committed to achieving this *goal.* There may be other *stakeholders* that commits at pursuing it, e.g. the enterprise managers.

4. An Overview of ArchiMate's Motivation Extension

"In large companies the gap between business and IT is usually bridged by designing and maintaining a so-called *enterprise architecture* (EA), which is a high-level representation of the enterprise, used for managing the relation between business and IT [...] This requires traceability of business goals to IT architecture (to quickly identify the impact on IT of changes in business goals) and of IT architecture to business goals (to justify the contribution of an IT component to a business goal). This requires a goal-oriented addition to the current crop of EA modelling languages". (ENGELSMAN; WIERINGA, 2012)

ArchiMate is an enterprise architecture modeling language that aims to provide a uniform representation for diagrams that describe enterprise architectures, offering an integrated architectural approach that describes and visualizes the different architecture domains and their underlying relations and dependencies.

In order to suport goal-oriented concepts, the **ArchiMate 2.0 Specification** (THE OPEN GROUP, 2012) included to the ArchiMate framework the **ArchiMate's Motivation Extension (ME)**. The ArchiMate's Motivation Extension (ME) addresses the way the enterprise architecture is aligned to its context, as described by motivational elements.

The ArchiMate's ME defines the concepts of *goal, principle, requirement* and *constraint* to suport the modeling of the enterprise's actual motivations or intentions. In order to suport the modeling of the sources of these intentions, the concepts of *stakeholder*, *driver* and *assessment* are defined. Figure 4 depicts the ArchiMate's ME Metamodel.
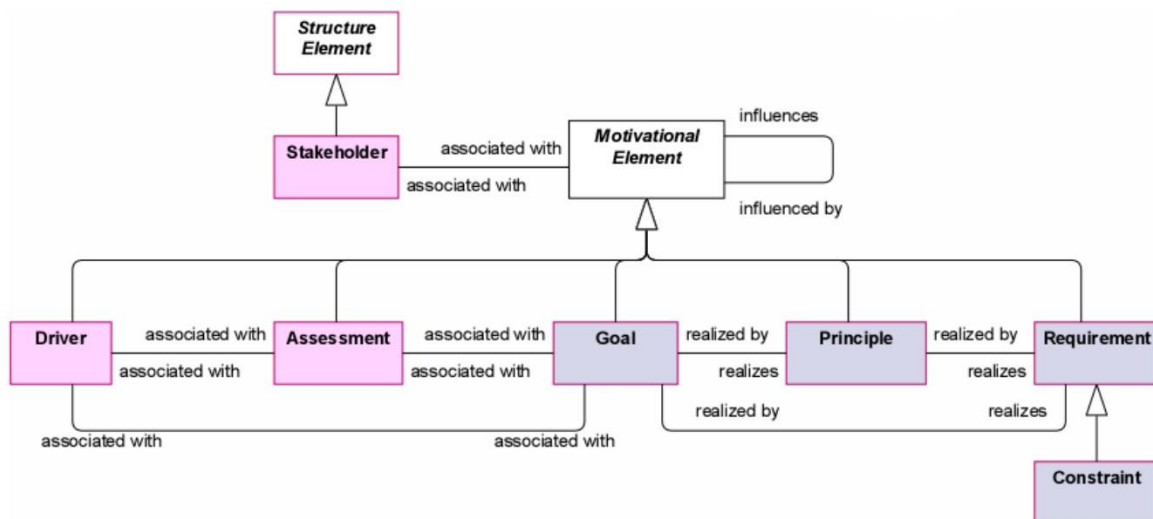

Figure 4 – ArchiMate's ME Metamodel (THE OPEN GROUP, 2012)

One of the key concepts introduced by ArchiMate ME is the concept of *goal*. According to ArchiMate 2.0 Specification (THE OPEN GROUP, 2012) "a goal is defined as an end state that a stakeholder intends to achieve". In principle, an end can represent anything a *stakeholder* may desire, such as a state of affairs, or a produced value. A *stakeholder*, in turn, "is defined as the role of an individual, team or organization (or classes thereof) that represents their interests in, or concerns relative to, the outcome of the architecture".

With respect to the stakeholder's *concerns* representation, the *driver* concept plays a central role. The *driver* concept is defined as "something that creates, motivates, and fuels the change in an organization". *Drivers* may be classified as *internal* or *external driver*. The *internal drivers* are usually associated with a *stakeholder* and are also called *concerns* (e.g.: customer satisfaction, compliance to legislation and profitability). *External drivers* refer to factors external to the organization as economic changes or changing legislation (THE OPEN GROUP, 2012).

When concerning about a *driver*, a *stakeholder* may analyze this *driver* trying to reveal strengths, weaknesses, opportunities, or threats related to it. In this context, the *assessment* concept represents "the outcome of some analysis of some driver". "These outcomes need to be addressed by adjusting existing goals or setting new ones, which may trigger changes to the enterprise architecture". (THE OPEN GROUP, 2012)

In order to achieve the ends stated by the *goals* some *requirements* can be set. A *requirement* is defined as "a statement of need that must be realized by a system". The term 'system' is used with a large scope and may "refer to any active structural element, behavioral element, or passive structural element of some organization". Thus, we can say that "requirements model the properties of these elements that are needed to achieve the 'ends' that are modeled by the goals". In contrast to a *requirement*, a *constraint* is defined as "a restriction on the way in which a system is realized". (THE OPEN GROUP, 2012)

A *principle* is defined as "a normative property of all systems in a given context, or the way in which they are realized". In order to enforce that the system conforms to a *principle*, the *principle* needs to be made specific for the given system by means of one or more *requirements*. Thus, we can say that a *principle* defines a general property that applies to any system in a certain context while a *requirement* defines a property that applies to a specific system. (THE OPEN GROUP, 2012)

The metamodel shown in figure 4 states the allowed relationships between the ArchiMate ME's concepts. All the Archimate ME's concepts may be *associated with* stakeholders. The concept of *goal,* as the ArchiMate ME's central concept, has relationships with all other concepts. A *goal* may be *associated with* drivers and assessments and also may be *realized by requirements* and *principles.* It is important to remark that the *requirement* concept is used to link the ArchiMate ME with the core elements of the ArchiMate language: "*goals* and *principles* have to be translated into *requirements* before core elements, such as *services*, *processes*, and *applications*, can be assigned that *realize* them".

In order to clarify the use of these concepts and to present the concrete syntax of ArchiMate, the figure 5 depicts a model developed using that language.

In the presented model there are two *stakeholders* represented: the "CEO" and the "CFO". The CEO is concerned about the "customer satisfaction" (a *driver*) while the CFO concerns about the "costs" (another *driver*). Due to the concern about the customer satisfaction, it was decided to define a *goal:* to "improve the portfolio management". The concern about the costs leads to state two other *goals: "*reduce interaction with customers" and "reduce manual work".
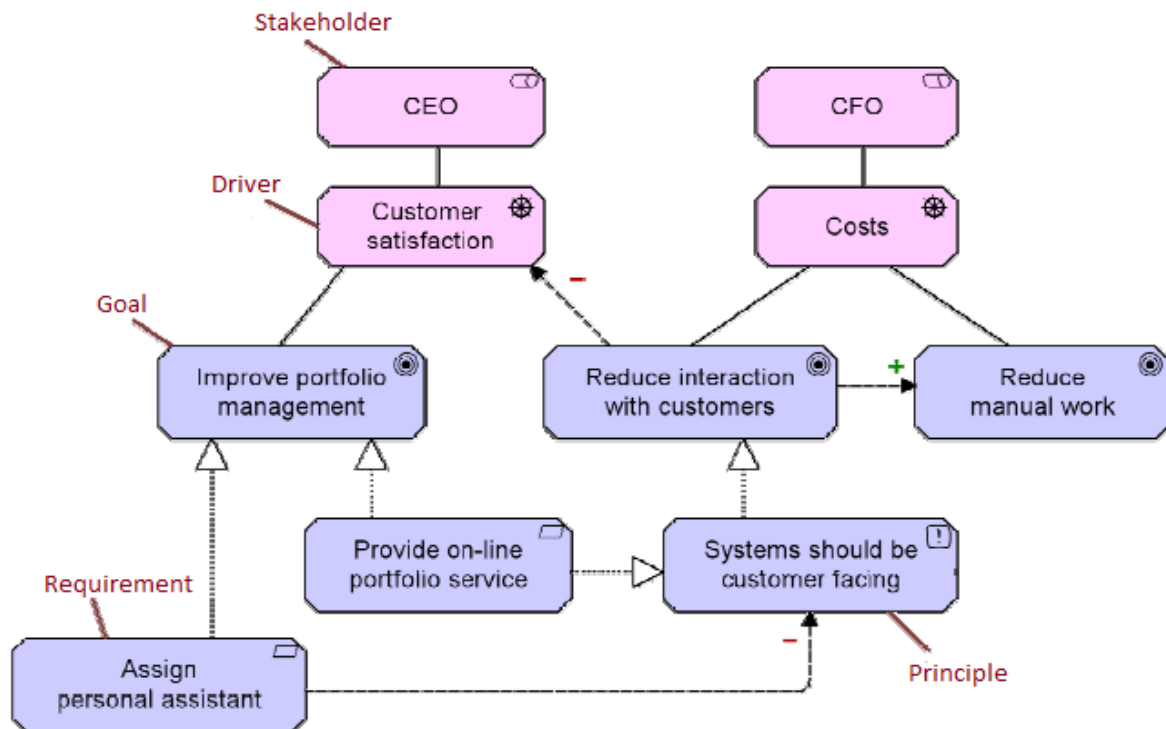
Figure 5 – ArchiMate ME´s example (GROUP; FORUM, 2012)

In order to *realize* the *goal* of "improving the portfolio management" two *requirements* were defined: "assign personal assistant" and "provide online portfolio management". There are no requirements aiming to realize the other goals.

The organization has a *principle* that states that the "systems should be customer facing". This *principle realizes* the *goal* "reduce interaction with customer" and it is *realized by* the requirement "provide online portfolio service".

Finally, the modeler analyzes the *contribution relations* existing between the motivational elements. In this context, the *goal* "reduce interaction with customers" *contributes positively* with the *goal* "reduce manual work" and *contributes negatively* with the *driver* "customer satisfaction", while the *requirement* "assign personal assistant" *contributes negatively* with the only stated *principle.*

Next section presents an ontological interpretation to some of the concepts presented by this section.

5. Ontological Interpretation for ArchiMate ME Concepts

(AZEVEDO et al., 2011) interpreted the concepts defined by the first specification of the ArchiMate Motivation Extension by using UFO. In this work, we aim to interpret the concepts specified by the ArchiMate Specification 2.0 (THE OPEN GROUP, 2012). Some of the definitions have changed from the first specification to the specification 2.0 while others definitions remained the same. Thus, we are only concerned on interpreting the concepts whose definitions have changed. For the others, we only refer to the interpretations presented by (AZEVEDO et al., 2011). Considering that the main purpose of this work is to define a semantic alignment between GQM and ArchiMate ME we focus on exploring only the concepts we consider useful for performing the alignment.

Interpreting the GQM's *goal* concept we have realized that the three coordinates (*object*, *issue* and *viewpoint*) seem to characterize the problem being addressed by the *goal*, in other words, the source of the *goal*. Thus, we believe that, in order to provide a semantic alignment between GQM and ArchiMate ME, the interpretation of the ArchiMate's *goal* concept only is not enough. Besides the *goal* concept it is also necessary to ontologically analyze the ArchiMate ME's concepts used to model the source of the modeled intentions, namely, *stakeholder, driver* and *assessment.*

According to ArchiMate Specification 2.0 (THE OPEN GROUP, 2012) "a stakeholder is defined as the role of an individual, team, or organization (or classes thereof) that represents their interests in, or concerns relative to, the outcome of the architecture". Taking UFO's conceptualization, a *stakeholder* can be interpreted as a *role* played by an *agent* (individual, team or organization) able to refer to the reality (in this case 'the architecture'). In UFO, an *agent* playing a *role* means that this *agent* instantiates a *role*, and, as consequence, the *agent* bears all the instances of properties that characterizes that *role*, what include *intrinsic moments* (such as skills and capacities that a person should have in order to play the role of project manager) as well as other relational ones (such as the rights and obligations that a person bears by participating on an employment contract). Therefore, we consider *stakeholder* as a *role universal* in UFO. We must carefully treat the fragment "or classes thereof" in the definition of *stakeholder* since it sounds ambiguous. We do not know if we should consider "classes thereof" as (i) classes of "individual, team, or organization" that play a specific *role*, or (ii) as classes of *roles*. The former interpretation refers to what we have discussed regarding *roles* played by *agents*. The latter would refer to possible class of *roles*, i.e., classes of classes instantiated by *agents* (individuals, team, or organization).

A *driver* is defined as "something that creates, motivates, and fuels the change in an organization". This definition is too vague and, therefore, allows many interpretations. Thus, we consider that a *driver* may be interpreted as an *event* (external or internal to the organization) that leads to a change of states that generates a *concern* associated to a key interest (such *process*, *product*, *resource*) of an organization. On other hand, considering that some changes in organizations may also be motivated by some *stakeholder's concerns* (despite explicitly consider the *event* that has generated the *concern*) a *driver* may also be interpreted as representing a *stakeholder´s concern*. In this context, we believe that it is a case of construct overload in the language since a *driver* may represents an *event* that generates a *concern* or the *concern* itself (without considering the event).

According to (AZEVEDO et al., 2011), a *concern* is something that a *stakeholder* believes to be important. Therefore, a *concern* can be interpreted as "the propositional content of a stakeholder's belief" (AZEVEDO et al., 2011). The propositional content of the *belief* refers especially to properties or characteristics believed to be important (the object of the *concern*) in a specific situation. In this sense, a *concern* may be shared, but a *belief*, by being *an intrinsic moment* (in terms of UFO), may not.

An *assessment* "represents the outcome of some analysis of some driver" (THE OPEN GROUP, 2012). According to (AZEVEDO et al., 2011) it indicates that some *agent* makes an analysis about a *concern*, drawing conclusions from this analysis. Thus, in terms of UFO, this means that some *agent* acquires new *believes* with propositional contents referring to properties or characteristics believed to be important. So, an *assessment* represents a *belief* of an *agent* that refers to the *object* of a *driver*. The *assessment* may be shared by some *stakeholders*, but the belief associated to it, may not.

According to ArchiMate Speficification 2.0, "a goal is defined as an end state that a stakeholder intends to achieve" (THE OPEN GROUP, 2012). Although (AZEVEDO et al., 2011) has not interpreted the concept of *goal* at light of ArchiMate Specification 2.0, we consider that their interpretation remains valid. Thus, in terms of UFO, a *goal* may be interpreted as "the propositional content of an agent's intention". Furthermore, based on their work, we can observe that: (i) a *stakeholder* is committed to achieving a *goal*; and that, (ii) achieving the *goal* means bringing out certain effects in reality. In terms of UFO, it means that some *agent* has the *intention* of bringing about the *goal*. Thus, the *agent* intends to perform actions that lead to a situation (a state-of-affairs) that satisfies the *goal*. Since *goals* in the ArchiMate ME can be a "produced value or a realized effect", the situations that satisfies the *goal* are those one in which this value has been produced or this effect is realized.

According to the interpretations presented, in terms of UFO, *goals*, *drivers* and *assessments* refers to elements such as intentions and believes, which are *intentional moments* that inhere (they are existentially dependent on) in an *agent*. According to the ArchiMate's ME Metamodel (depicted by Figure 4) all the *Motivation Elements* (which includes *goals*, *drivers* and *assessments*) may be associated with *stakeholders*, despite it is not a mandatory relationship. Thus, we conclude that all these representation elements (goals, drivers, and assessments) should be associated to, at least, an undetermined *stakeholder*. This association could be, in some sense, a derived relation from the fact that goals, drivers, and assessments refers to intentional moments that are, then, associated (inhere in) to an agent (play some role).

6. Semantic Alignment between GQM and ArchiMate ME Concepts

In this section we present a proposal of semantic alignment among some concepts of GQM and ArchiMate ME. This proposal is based on the interpretations presented on previous sections.

The discussion about the proposed alignment is driven by an example. This example considers an organization which has established an evaluation program that uses the GQM approach and wants to keep the traceability of its organizational *goals* with its IT architecture using the ArchiMate´s framework. As part of its GQM model, the four following goals were described using a GQM template:

i. Analyzing the manufacturing process (*object*) for the purpose of improving its efficiency (*issue*) from the *viewpoint* of the CEO.

ii. Analyzing the manufacturing process (*object*) for the purpose of decreasing its costs (*issue*) from the *viewpoint* of the CEO.

iii. Analyzing the costumer relationship process (*object*) for the purpose of decreasing its costs (*issue*) from the *viewpoint* of the customer relationship manager.

iv. Analyzing the costumer relationship information system (*object*) for the purpose of improving its usability (*issue*) from the *viewpoint* of the costumer.

We have interpreted that, in GQM, a *goal* refers to desired states of an *object* with respect to specific quality *issue*. So, it seems that the *object* and *issue* coordinates address the element of interest of the *goal* in GQM.

Interpreting the concepts defined by ArchiMate ME, we have proposed that a *driver* may be interpreted as an event that generates a *concern* associated to a key interest of an organization or, also as the *concern* itself (without consider any source event). The *concern*, in turn, was interpreted as the propositional content of a *stakeholder's belief*. The propositional content of the *belief* refers to the importance that the *stakeholder* ascribes to certain *concern*.

In this context, it seems that the *driver* concept from ArchiMate ME is, somehow, related to the *object* and *issue* coordinates from GQM, in the sense that all them refers to something a *stakeholder* is interested in, i.e., something the *stakeholder* believes be important. Thus, it is relevant to point out that the *object* in GQM may represent a *product*, a *process* or a *resource*. Thus, it may represent only a subset of the possible objects of the *stakeholder's concerns*.

Using the aforementioned example, by the first GQM *goal* we can infer that the manager is concerned with the "manufacturing process efficiency". Thus, we can state that, in terms of ArchiMate ME, the "manufacturing process efficiency" may be seen as the object of a *concern* (or *driver*). In a similar way, assessing the second GQM goal, the "manufacturing process costs" may be represented as a *driver*. So, in a broader sense, we may interpret that the CEO is concerned with the properties of the "manufacturing process" in general and, therefore, refers to the "manufacturing process" as a *driver* that encompasses the two previous proposals.

We consider that another possible alignment between GQM and ArchiMate ME can be achieved by analyzing the relation between the *viewpoint* coordinate from GQM and the *stakeholder* concept from ArchiMate ME. A measure in GQM is taken from a *viewpoint*, such as manager´s viewpoint and customer´s viewpoint. Therefore, we interpret *viewpoint* as a set of mental properties that inheres in an *agent* when he plays a *role*. The ArchiMate ME's concept of *stakeholder,* in turn, is interpreted as a *role* played by an *agent* able to refer to the reality. So, the concept of *viewpoint* as well as the concept of *stakeholder* are related with *roles* played by *agents*.

For instance, the first and the second GQM *goals* of the example (given in the beginning of this section) will be measured by the *viewpoint* of the CEO. Thus, we can infer that some *agent* in the context of the organization will play the *role* of CEO. So, in terms of ArchiMate ME, CEO may be defined as a *stakeholder*. Similarly, by the third and the fourth *goals*, we can state that there are, at least, two other *stakeholders* in the context of the organization: customer relationship manager and customer.

While interpreting the GQM *goal's* concept (section 3) we remarked the fact that the *viewpoint* coordinate is related to the *agents* that judge the fulfillment of the *goal* and that those *agents* are not necessarily the ones that commit at pursuing the *goal*. The fourth *goal* of the example illustrates it. In that case, the *customers* will judge the fulfillment of the *goal*, but they do not necessarily have a commitment at pursuing the *goal*. For example, having a system with a great usability may be only a desire for the costumers, whereas other *stakeholder*, possibly the *customer relationship manager*, has the commitment at pursuing it.

Thus, in that example, there are two *stakeholders associated with* the *goal* of "improving the costumer relationship information system usability". The *customers* are *associated with* the *goal* in the sense that they desire and evaluate the fulfillment. The *customer relationship manager,* in turn, is *associated with* the *goal* in the sense that he may have a commitment at pursuing the *goal*. The ArchiMate ME does not support the representation of these distinctions since the *association with* is the only relationship allowed between *stakeholders* and *goals* according to the ArchiMate Specification 2.0.

The aforementioned semantic alignments may be used to generate ArchiMate ME models based on GQM *goals*. For instance, Figure 6 depicts an ArchiMate ME model generated based on the four GQM's *goals* specified in the beginning of this section.

It is important to note that there is not a one to one relation between the GQM´s concepts and the ArchiMate ME´s concepts. Thus, the depicted diagram is not the only one that may be produced using the alignment approach proposed here. For instance, one could choose to represent the "manufacturing process efficiency" and the "manufacturing process costs" as *drivers* while others could represent the "manufacturing process" as a single *driver*.

It is also important to remark that the diagram in Figure 6 made explicit some relationships that should not be represented by the GQM model as the association between the "Customer Relationship Manager" *stakeholder* and the "Customer Relationship Information System" *driver* and the *contribution relations* between the *goal* "Decrease the Customer Relationship Process Costs" and the *goal* "Improve the Costumer Relationship Information System Usability".
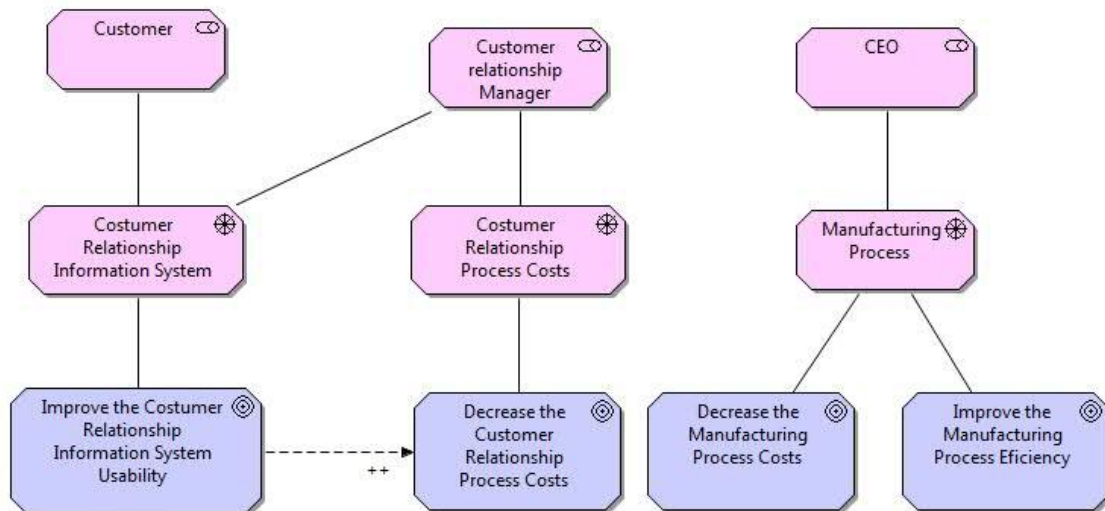
Figure 6 – An ArchiMate model generated from GQM goals

Finally, it is important to highlight some distinctions between the GQM's and the ArchiMate's approaches:

- The GQM approach focuses on measurement and evaluation while ArchiMate ME focuses on specifying *goals* in the context of an organization. Thus, in the context of GORE, a GQM model must aims to describe *goals* that should have their fulfillment evaluated and to define questions and metrics that should allow such evaluations. ArchiMate ME models, in turn, may specify all the organizational *goals* (not only the ones that should be measured) and describe the relations that may exists between each *goal* and the others ones, as well as the relations between the *goals* and other organizational elements.

- ArchiMate ME defines a *goal* as an end state intended by a stakeholder and does not elaborate on specific characteristics of this intention. GQM, in turn, states that a *goal* may be defined as an intended effect related to a quality *issue* of an *object*. Thus, in this sense, the ArchiMate's definition of *goal* is more generic, and encompasses the goal's definition presented in GQM.

- ArchiMate ME presents only an informal definition of *goal*. Providing guidelines on how to identify *goals* is out of the scope of ArchiMate. In this context, the GQM *goals* templates (SOLINGEN; BERGHOUT, 1999), may be used to assist the definition of the *goals* even in the cases in which no measurement activity will be conducted.

The aforementioned distinctions indicate that the GQM and the ArchiMate ME are complementary approaches and may be used in tandem. In this context, the semantic alignment proposed in this work may be a first step towards the definition of a systemic cyclic process of *goals* specification and evaluation based on ArchiMate and GQM.

7. Conclusion

This work presents a proposal of semantic alignment between two GORE approaches: the GQM that is focused on assessment of *goals*, and ArchiMate ME, which focuses in modeling of *goals*.

In general, GQM is applyed to assess *goals* of organizations and its projects. To better understand the *goals* are established three coordinates (*object*, *issue*, *viewpoint*), together with a *purpose*. Each *goal* is associated to *questions* that aims at identifying information related to this *goal*. *Metrics* are defined so that data that answer the *questions* are collected. From the data collected the *questions* are answered and the attendance of a *goal* is verified. From this verification improvements in the enterprise / project are proposed, the *goals* are again applied and creates a cycle of continuous improvement.

ArchiMate is a modeling language for EA that allows to create a specification that covers different aspects of an enterprise uniformly and diagrammatic. The ArchiMate Motivation Extension was designed to support goal-oriented concepts. Among its main concepts we have *goal*, *principle*, *requirement*, *constraint*, *stakeholder*, *driver, assessment*.

The alignment was based on UFO (Unified Foundational Ontology) a foundational ontology. Thus, firstly, the GQM was interpreted at light of UFO. Then, the same procedure was adopted for the ArchiMate ME. Only some concepts of these two approaches were considered. From the two interpretations we visualized some compatibility between the concepts explored, allowing us to relate them. Then it was suggested a simple way for aligning GQM´s models to ArchiMate ME´s models, based on the alignment of interpretations of the approaches. In order to check the feasibility of the proposal an example was presented as proof of concept.

One limitation of the study is the fact that we selected the two approaches involved in accordance with the interests of authors, while other approaches were not checked in order to determine whether alignment would be more appropriate.

This proposal is a preliminary discussion, and it was not tested it in a wide variety of models in order to evaluate it. Also, only some concepts of ArchiMate ME were considered. The concept of *assessment*, for example, is a proposal that deserves to be explored further. The same occurred with the GQM as yet not been studied possibilities involving *question* and *metric*. And it is precisely these limitations that we intend to explore in future.

We also remark that, although we have not used the *assessment* concept in the semantic alignment presented, this concept may be useful to align the ArchiMate ME to the GQM approach. According to ArchiMate Specification 2.0, an *assessment* "represents the outcome of some analysis of some driver" (THE OPEN GROUP, 2012). However it is out of the ArchiMate's scope to provide a tool to evaluate *drivers*. Considering that the GQM approach is used to evaluate the fulfillment of *goals* that are associated with *drivers*, it seems that the analysis of the *questions* and *metrics* obtained by a GQM process may be used in order to identify *assessments* in terms of ArchiMate ME. Thus, future works should focus on assessing the feasibility of using the GQM approach in order to evaluate *drivers* and compose *assessments (*in terms of ArchiMate ME).

Another future work regards definition of a cyclic process of goal´s specification/evaluation, in which the *goals* are specified using ArchiMate ME, an aligned GQM´s model would be used to assess the satisfaction of these *goals*, then the ArchiMate ME´s model would be reassessed based on the interpretation made by the evaluation of the GQM model, leading to a new version of the ArchiMate´s model and starting again. It would be a process of continuous improvement.

8. References

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