Towards a Semantic Alignment of the ArchiMate Motivation Extension and the Goal-Question-Metric Approach

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Abstract. *Supporting Goal-Oriented Requirement Engineering (GORE) in a systematic and comprehensive way may require the combination of distinct goal-oriented approaches. However, due to lack of common semantics, to combine these approaches can be challenging. In this work, we propose a semantic alignment between two complementary goal-oriented approaches: the ArchiMate Motivation Extension and the Goal-Question-Metric. The approaches are semantically analyzed in light of the Unified Foundational Ontology (UFO), which provides real-world semantics for both languages, serving as a reference ontology to support the ontological analysis of concepts and relationships of both approaches and the alignment between them.*

1. Introduction

In the past decade, *Goal-Oriented Requirement Engineering* (GORE) became a de facto standard approach in *Requirements Engineering* (RE) [Kavakli and Loucopoulos 2005][Yu et al. 2011]. In this context, many GORE approaches have been proposed, but they use to focus on particular perspectives, and no single approach can address all the needs of this engineering process. However, these single approaches can be put to work together in order to compound a stronger and more complete GORE framework, which could benefit of the strengths of each approach [Kavakli 2002].

Considering this, the current paper focuses on the alignment of ArchiMate Motivation Extension and Goal-Question-Metric (GQM) approaches. ArchiMate is a modeling-based framework that has gained visibility both in academia and in industry. This framework provides a component called Motivation Extension (ME) that supports modeling of the enterprise's actual motivations or intentions by adopting the concept of "goal", among others [The Open Group 2012]. GQM [Basili, Caldiera and Rombach 1994], in turn, is an approach for evaluating the fulfillment of enterprise's goals. It is a well established and widely used approach [Boyd 2005] [Kaneko et al 2011]. By being complementary, ArchiMate ME and GQM can be adopted in tandem as a way to define a more comprehensive goal-oriented framework.

Combining different languages, however, clearly characterizes a *Semantic Interoperability* problem, since for combining languages one has to: (i) make clear the meaning of the primitives that compose the languages (i.e., the real-world semantics of the languages); (ii) establish the correct ontological relations between the alternative semantic domains [Guizzardi 2005].

One of the defining aspects of ontologies is their use in making explicit shared conceptualizations. *Reference ontologies* are kinds of ontologies used in an off-line manner to assist humans in tasks such as meaning negotiation and consensus establishment [Guizzardi 2005]. *Foundational* (or *top-level*) *ontologies* are domain-independent reference ontologies that describe very general concepts independently of a particular problem or domain (e.g., object, event, quality, action, etc.) [Guizzardi 2005][Guarino 1998]. These ontologies can provide real-world semantics for general representation languages and constrain the possible interpretations of their modeling primitives [Mika et al. 2004][Guizzardi 2005]. Also, by being adopted as a common reference, foundational ontologies can be used to map different representation languages and approaches [Cardoso et al. 2010].

In this paper, we propose the use of the Unified Foundational Ontology (UFO) [Guizzardi 2005] [Guizzardi et al. 2008] as a well-founded basis for defining (ontological) real-world semantics for the concepts of ArchiMate ME and GQM approaches. However, we have two basic semantic-based problems: (i) the ArchiMate ME and the GQM do not share the same semantics; and (ii) some of their concepts' semantics are not clearly defined. These problems, therefore, may lead different designers to assume distinct meanings and uses for the supposed same concepts. Thus, in order to properly use ArchiMate ME and GQM together, it is necessary to understand the semantics of the concepts of each approach, and how to map the concepts between the approaches. The choice for UFO as a foundational ontology here is motivated by a number of successful cases of using this ontology in the analysis, re-design and integration of different major modeling languages, including UML [Guizzardi 2005], *i** [Guizzardi et al. 2012] and ARIS [Cardoso et al. 2010], among others.

The remainder of this paper is organized as follows: Section 2 presents briefly ArchiMate ME, GQM and the used alignment process; Section 3 describes the fragment of UFO necessary for this work; Section 4 contains the proposed ontology-based alignment between ArchiMate ME and GQM; Section 5 describes a running example that illustrates how the semantic alignment may be put in practice; Section 6 presents some related works; and, finally, Section 7 draws final considerations.

2. Background: ArchiMate Motivation Extension (ME) and GQM

ArchiMate ME addresses the way the enterprise architecture is aligned to its context by using of motivational elements [The Open Group 2012]. It builds upon existing work on GORE, such as KAOS and *i** [Kavakli and Loucopoulos 2005], adopting interesting findings of these previous initiatives. The concepts defined by ArchiMate ME are *goal*, *stakeholder*, *driver*, *assessment*, *requirement*, *principle* and *constraint*.

To clarify the use of some concepts that are considered in this work, Figure 1 depicts a diagram developed by using of ArchiMate ME language. This diagram presents two *stakeholders*, each one having at least one *driver*, which can be shared. For each *driver*, a *goal* is defined. These *goals* are related to the *stakeholder* that commits

on pursuing it. Also, one can model that a fulfillment of a goal contributes positively (or negatively) to the realization of other goals.

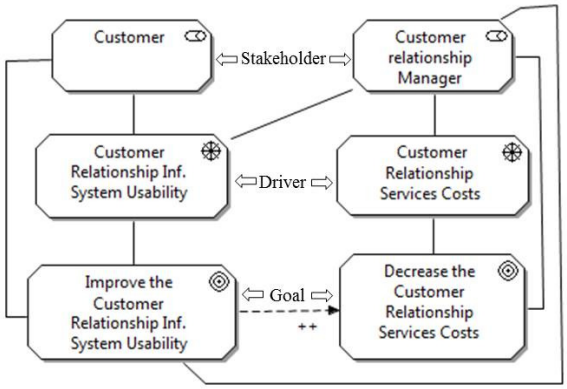

Figure 1. Illustrating some concepts of ArchiMate ME

GQM defines an approach for setting *goals* in a quality improvement paradigm. It is based on the assumption that for an organization to work efficiently with a measurement program, it should [Basili et al. 1994]: (i) specify the *goals* of the organization itself and its projects; (ii) map those *goals* to data that operationally define the *goals* (through *questions*, which direct the information that support the evaluation of a *goal*; and *metrics*, which indicate the types of data to be collected in order to answer the *questions*); and (iii) provide a framework for interpreting these data in relation to the established *goals*. Figure 2 presents an example of a GQM model for illustrating the relations between *goals*, *questions* and *metrics*.

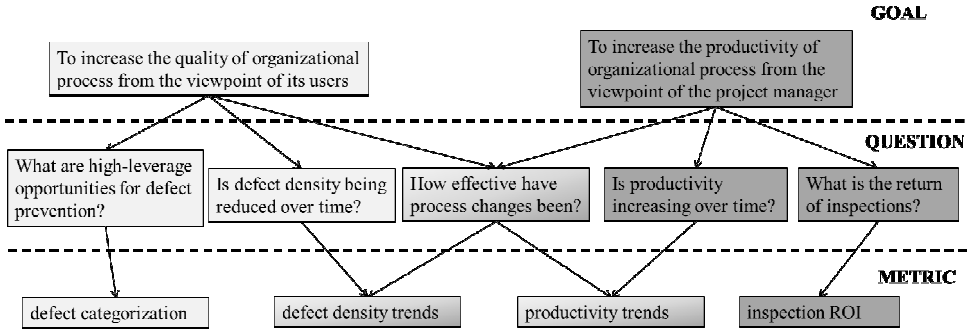

Figure 2. An example of the relations between *goals*, *questions* and *metrics* in GQM

In GQM, a *goal* is defined for an object (i.e. a *process*, a *product*, or a *resource*) based on a number of reasons (the *purpose*) with respect to models of quality (*issue* of quality) from *viewpoints* in relation to a particular environment. Thus, a *goal* consists of three coordinates (*object*, *issue/focus* and *viewpoint*) and a *purpose* [Basili et al. 1994].

Besides the fact that both approaches deal with *goals*, ArchiMate ME and GQM present some distinctions. While GQM focuses on measurement and evaluation of the fulfillment of organizational *goals*, ArchiMate ME focuses on specifying/representing these *goals*. In the context of GORE, a GQM model aims at describing *goals* that should have their fulfillment evaluated. ArchiMate, in turn, does not offer any approach for *goal* measurement. The ArchiMate ME supports the representation of organizational *goals* and their relations with other organizational elements. Some of these relations cannot be clearly expressed in GQM. Moreover, providing guidelines on how to identify

goals is out of the scope of ArchiMate ME. The aforementioned distinctions indicate that GQM and ArchiMate ME are complementary approaches. However, considering that the semantics of these approaches are not clearly defined and harmonized, a semantic alignment between them becomes necessary as a first step towards their use in tandem. For example, despite being a common term in both approaches, a deeper analysis reveals that the concept of *goal* in GQM specializes *goal* in ArchiMate ME, since the definition of *goal* in GQM comprises a set of interrelated concepts in ArchiMate (e.g., *goal*, *driver*, and *stakeholder*). We believe that understanding these semantic aspects may be useful for establishing an integrated framework.

For performing the ontological analysis and the alignment between ArchiMate ME and GQM we have followed the iterative process illustrated by Figure 3. This process is composed of three basic phases. In the "phase 1" and "phase 2", respectively, ArchiMate ME concepts and GQM concepts were analyzed and grounded in light of UFO. In "phase 3", such concepts were aligned taking as basis the ontological analyzes.

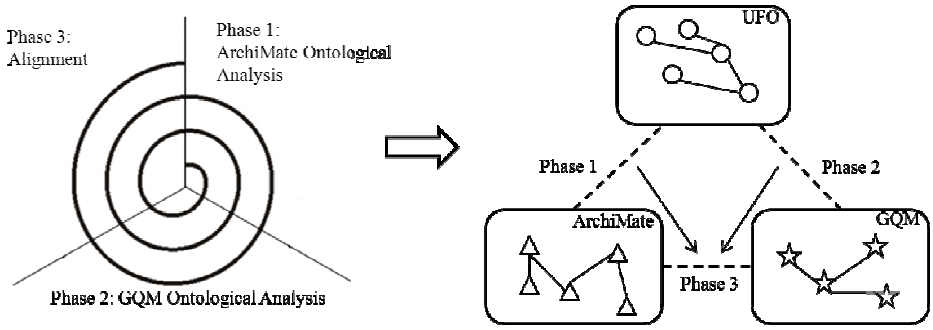

Figure 3. The iterative process used in the ontological alignment

3. The Unified Foundational Ontology (UFO)

UFO is a foundational ontology that has been developed with an interdisciplinary approach comprising theoretical and empirical results from Formal Ontology, Philosophical Logic, Linguistics, and Cognitive Psychology. UFO consists of three main parts: UFO-A, UFO-B, and UFO-C. UFO-A is an ontology of endurants [Guizzardi 2005], UFO-B is an ontology of events (perdurants) [Guizzardi et al. 2008][Guizzardi et al. 2013], and UFO-C is an ontology of social entities built on the top of UFO-A and UFO-B [Guizzardi et al. 2008].

A fundamental distinction in UFO is between individuals and universals. Universals are predicative terms that can be applied to a multitude of individuals, capturing the general aspects of such individuals. Individuals are entities that exist in reality possessing a unique identity and that can instantiate a multitude of universals [Guizzardi, 2005]. Figure 4 presents a fragment of UFO.

In UFO-A, endurants are individuals that are wholly present whenever they exist, and that can be further specialized into substantials and moments. Substantials are existentially independent endurants (e.g., a person, a car). Moments are individuals that can only exist in other individuals, being existentially dependent on their bearers (e.g., a person's headache, a covalent bond between atoms) [Guizzardi 2005]. Intrinsic moments are kinds of moments that are dependent on one single individual (e.g., John´s headache). Qualities are intrinsic moments associated with quality structures that inhere in an individual. A quality structure can be either a quality domain or a quality

dimension; quality domains are composed of multiple quality dimensions. For example, a color (quality) "c" of an apple (individual) "a" takes its value in a structure of three-dimensional color domain constituted of the quality dimensions "hue", "saturation" and "brightness". Modes are intrinsic moments that are not directly associated with a quality structure (and, hence, are not directly measurable) (e.g., John's intentions) [Guizzardi 2005]. Relators, in turn, are moments that existentially depend on two or more endurants [Guizzardi 2005]. For example, consider that John and Mary are married. In this case, the relator (their marriage) mediates the relation between John and Mary aggregating all externally-dependent modes that they acquire by virtue of participating in this relation (e.g, all commitments and claims towards each other). Thus, by virtue of being connected by this particular marriage, John plays the role of "husband" and bears responsibilities and rights towards Mary, who, by playing the role of "wife", and also bears the responsibilities and rights towards John.

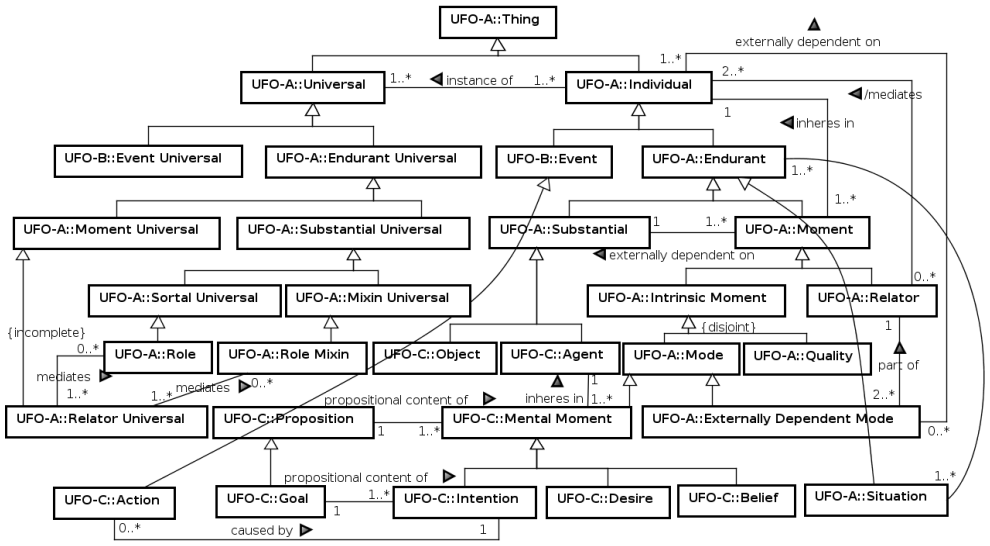

Figure 4. A fragment of UFO

Universals in UFO-A are types instantiated by endurants (universals) and can be substantial universal and moment universal, whose individuals are substantials and moments [Guizzardi 2005], respectively. Sortal universals are substantial universals that carry a principle of identity for their individuals (e.g., Apple, Person). The specialization of sortal universal is based on a meta-property called rigidity. An universal is rigid if it necessarily applies to its instances in every possible world (e.g., Apple, Person). In contrast to rigid universals, an universal is anti-rigid if it does not apply necessarily to all its instances. For example, an individual 'x', which is instance of the universal 'Student' in a world 'w_1' can cease to instantiate this universal in another world 'w_2' without ceasing to exist as the same individual. Roles are anti-rigid and relationally-dependent sortal universals (e.g., Student, Husband) [Guizzardi 2005], which means that roles are played by a substantial whenever there is a relator connecting it to other substantials. Role mixin represents an anti-rigid and externally-dependent non-sortal universal, which aggregates properties that are common to different roles (e.g., the role mixin 'Customer' aggregates properties from 'Personal Customer' and 'Corporate Customer') [Guizzardi 2005].

In UFO-B, events are individuals composed of temporal parts. They happen in time in the sense that they extend in time and accumulate temporal parts (e.g., a

conversation). Whenever an event is present, it is not the case that all its temporal parts are present. Events universals are patterns of features that can be realized in a number of different events [Guizzardi et al. 2008][Guizzardi et al. 2013].

In UFO-C, a basic distinction is the one between agents and (non-agentive) objects. Agents are agentive substantial individuals that are classified as physical agents (e.g., a person) or social agents (e.g., an organization). Objects are non-agentive substantial individuals that are classified as physical objects (e.g., a book) and social objects (e.g., a language) [Guizzardi et al. 2008]. Agents can bear special kinds of modes named mental moments. Mental moments refer to situations in reality (also called state-of-affairs, i.e., a portion of reality that can be comprehended as a whole) and has propositional content (an abstract representation of a class of situations referred by an intentional moment) [Guizzardi et al. 2008]. Mental moments are specialized in intentions, beliefs, and desires. Belief can be justified by situations in reality (e.g., my belief that the Moon orbits the Earth). Desires and intentions can be fulfilled or frustrated. Whilst a desire (e.g., a desire that Brazil wins the 2014 World Cup) expresses a will of an agent towards a state-of-affairs, intentions (e.g., go to the beach today) are desired state-of-affairs for which the agent commits to pursuing (i.e., intentions are self-commitments). Intentions cause the agent to perform actions and have propositional contents that is termed goal [Guizzardi et al. 2008].

4. Ontology-based Alignment between ArchiMate ME and GQM

This section presents the proposed semantic alignment between GQM and ArchiMate ME in light of UFO. Since *goal* is the common concept between these two approaches, it was considered as the key concept for performing the alignment.

In GQM, a *goal* is characterized as having a *purpose*, which is associated with three coordinates: *object*, *issue* and *viewpoint* [Basili et al. 1994]. According to GQM, an *object* can be a *process*, a *product*, or a *resource*. In terms of UFO, a *process* can be interpreted as an (complex) event [Guizzardi et al. 2008]. A *resource* is defined in UFO as a non-agentive substantial (i.e., an object) participating in an event [Guizzardi et al. 2008]. However, in organizational contexts the term "resource" is also used to refer to "human resource". In light of UFO, 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 comprises the idea of a non-agentive substantial (object) as well as the idea of an agent playing a role. In UFO, a *product* is a resource whose participation in events is limited to two types [Guizzardi et al. 2008]: creation participation (i.e., a *product* can be created) and changing participation (i.e., a *product* can be updated).

An *issue,* in GQM, refers to a quality aspect of an *object*, which can be interpreted based on the concept of quality in UFO [Guizzardi 2005]. Thus, an *issue* is as a quality that inheres in individuals (events and endurants). The individual that bears such quality (in terms of UFO) can be interpreted as being the *object* in GQM. For example, an *issue* can be the efficiency of a maintenance process (process as an *object* in terms of GQM) in an organization.

According to GQM, the fulfillment of a *goal* must be measured from a *viewpoint* (e.g., a manager's viewpoint, or a customer's viewpoint). Thus, the concept of *viewpoint* is associated with a "who" question, which makes reference to the roles played by one or more agents interested in a *goal*. Based on that, we may interpret that the *viewpoint*,

in terms of UFO, is associated with the role that an agent must be playing in the organizational context in order to be a possible measurer of the *goal's* fulfillment.

A *purpose* is related to a "why" question, in the sense that it refers to the intended effect associated with a *goal*. This intended effect is associated with a quality aspect (the *issue* coordinate) of an object (the *object* coordinate). For example, considering the *goal* "decrease the rate of error of the manufacturing process" the associated *purpose* is "decrease", the *issue* is "the rate of error", and the *object* is "manufacturing process". Thus, in light of UFO, we can interpret that the propositional content of the intention defines an intended effect (*purpose*) associated with a quality (*issue*) of an individual (*object*).

According to ArchiMate Specification 2.0, "a goal is defined as an end state that a stakeholder intends to achieve" [The Open Group 2012]. Thus, we can say that a *stakeholder* is committed (has an intention) to achieve a *goal*, and by achieving the *goal*, certain effects in reality are brought about. Thus, in terms of UFO, a *goal* (in ArchiMate ME) may be interpreted as "the propositional content of an agent's intention" [Azevedo et al. 2011]. In this context, we may state that GQM and ArchiMate ME can be aligned w.r.t. the concept of *goal*, given that in both approaches a *goal* may be interpreted, in terms of UFO, as a propositional content of an intention. As follows, however, we will discuss the concept of *goal* in GQM as a specialization of the concept of *goal* in ArchiMate ME.

As aforementioned, the GQM *viewpoint* coordinate can be interpreted as the roles played by agents that judge the fulfillment of (organizational) goals. These agents bear the intention of performing the evaluation of the (organizational) *goals*' fulfillment. On the other hand, there may be agents that bear the intention of pursuing the (organizational) *goals*' fulfillment, i.e., they are committed to perform actions in order to fulfill these *goals*. Thus, there may be agents that are committed at pursuing (organizational) *goals* and agents that are committed to judge if these *goals* were achieved or not. For example, in *goal* "Analyzing the customer relationship information system (*object*) for the *purpose* of improving its usability (*issue*) from the *viewpoint* of the customer" the "customers" judge the fulfillment of the *goal*, but they do not necessarily have a commitment at pursuing the *goal*. "Having a system with a great usability" may be only a desire for the "customers", whereas other *stakeholder*, possibly the "customer relationship manager", has the commitment at pursuing it. It is important to highlight, however, that the same agent may be committed to both, pursuing the *goals*' fulfillment and judging their fulfillment, although this is not desirable in organizational quality programs. This distinction between these two kinds of agents becomes clearer by the ontological analysis in light of the intentional concepts of UFO.

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*, i.e., the "source" of the *goal*. Thus, in order to provide a semantic alignment between GQM and ArchiMate ME, the interpretation of the ArchiMate's *goal* concept is not enough. Besides that, it is also necessary to analyze two other ArchiMate ME's concepts used to model the "source" of the intentions: the *driver* and the *stakeholder*.

In Archimate ME, a *driver* is defined as "something that creates, motivates, and fuels the change in an organization". This definition is too vague and allows many interpretations. We consider that a *driver* may be interpreted as an event (external or

internal to the organization) that leads to a change of situation, which generates a *concern* about a key interest (e.g., *process*, *products*, *resources, costs, etc.*) of an organization. On the other hand, we can consider that some changes in organizations may also be motivated by some *stakeholder's concerns* despite explicitly considering the event that has generated the *concern*. In this case, a *driver* may also be interpreted as representing a *stakeholder´*s *concern*. 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 an agent's belief" [Azevedo et al. 2011]. The propositional content of the belief refers especially to properties believed to be important (the object of the *concern*) in a specific context. These two possible interpretations lead to a construct overload in Archimate ME language, since a *driver* may represent an event that generates a *concern* or the *concern* itself (without considering the event). 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 of them refers to something a *stakeholder* is interested in, i.e., something the *stakeholder* believes to be important. In terms of UFO, the *driver* concept as well as the *object* and *issue* coordinates are related to the propositional content of a belief that refers especially to properties or characteristics believed to be important. For example, considering that the manager of a company has a *goal* of increasing the employees' productivity we can infer, in terms of UFO, that the manager (an agent) has a belief that the employees' productivity is important (the propositional content of the belief). Thus, in terms of ArchiMate, "the employees' productivity" may be represented as a *driver*. In terms of GQM "employees" may be seen as the value of the *object* coordinate (*a resource)* while the "productivity" refers to the *issue* coordinate. However, we remark that the *object* (as a *product*, a *process,* or as a *resource*) and *issue* coordinates together comprise only a subset of the possible *drivers* (in ArchiMate ME).

Finally, a *stakeholder* is defined by ArchiMate Specification 2.0 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" [The Open Group 2012]. According to UFO, a *stakeholder* can be interpreted as a role played by an agent (e.g., human individual, team or organization) able to refer to reality (in this case, "the enterprise architecture"). Thus, the agent instantiates a role, and, as consequence, the agent bears all the moments that characterizes that role, which include intrinsic moments (e.g., skills and capabilities that a person should have in order to play the role) as well as externally dependent modes associated with relators (e.g., as the rights and obligations that a person bears by participating on an employment contract). In this context, we may state that the concept of *stakeholder* in ArchiMate ME is aligned with the *viewpoint* coordinate of GQM since both can be interpreted, in light of UFO, as a role played by an agent. Table 1 summarizes the ontological analysis aforementioned.

Table 1. Summary of the ontological analysis of GQM and Archimate ME concepts

GQM	
Concept	Interpretation in light of UFO
Object	An *object* can be a *process*, a *resource*, or a *product*. *Process:* an (complex) event. *Resource:* a non-agentive substantial or an agent playing a role (human resource). *Product:* resource whose participation in events is limited to creation participation and changing participation
Issue	A quality that inheres in individuals (events and endurants)

Viewpoint	The roles played by agents that judge the fulfillment of (organizational) goals
Purpose	The intended effect expressed by the propositional content of an intention
Goal	The propositional content of an intention which defines an intended effect (*purpose*) associated with a quality (*issue*) of an individual (*object*).
Archimate ME	
Concept	Interpretation in light of UFO
Driver	An event that generates a *concern* or the *concern* itself. A *concern* can be interpreted as the propositional content of an agent's belief. The propositional content of the belief refers to the importance that the agent ascribes to something.
Stakeholder	A role played by an agent (e.g., human individual or organization) able to refer to reality.
Goal	The propositional content of an agent's intention

5. A Running Example of the Alignment between ArchiMate ME and GQM

This section presents an example that illustrates how the proposed semantic alignment between GQM and ArchiMate ME may allow an organization to use the strengths of each approach maintaining the traceability between the generated artifacts. In the example, ArchiMate ME is used for specifying the organizational *goals* and GQM for implementing an evaluation program regarding the fulfillment of these goals.

GQM establishes a structure for defining *goals.* By other hand, the ArchiMate ME does not define any specific structure for *goal*. Thus, we believe that the more detailed definition proposed by GQM can assist the designer in eliciting the organization's *goals*, i.e., the detailed structure provided by GQM can guide the designer in asking about and conceiving *goals*. Thus, we start this example by describing two organizational goals by using a GQM template, as follows: (G1) Analyzing the customer relationship process (*object*) for the *purpose* of decreasing its costs (*issue*) from the *viewpoint* of the CEO; and (G2) Analyzing the customer relationship information system (*object*) for the *purpose* of improving its usability (*issue*) from the *viewpoint* of the customer.

The proposed semantic alignment has shown that the concept of *goal* in GQM is a specialization of the concept of *goal* in Archimate ME. Thus, each *goal* described in GQM can be represented in an ArchiMate ME model. Also, it is possible to derive *drivers* in ArchiMate ME from *objects* and *issues* in GQM. For example, by the *goals* "G1" and "G2", we can infer, respectively, two *drivers* - (i) "customer relationship process costs", and (ii) "customer relationship information system usability" – which are represented with their respective *goals*, as Figure 5a.

Moreover, the alignment shows that it is possible to derive *stakeholders* in ArchiMate from *viewpoints* in GQM (i.e., the agents that judge the goal's fulfillment). For example, the "G1" *goal* is said to be measured by the *viewpoint* of the "CEO", which indicates that the "CEO" may be defined as a *stakeholder* in ArchiMate. Similarly, by "G2" *goal* we can derive another *stakeholder*: the "customer". Figure 5a represents these two *stakeholders*, associated with the respective *drivers*. Thus, an initial ArchiMate ME diagram (as presented by Figure 5a) is directly derived from *goals* described in GQM using the proposed alignment.

Moreover, although GQM addresses the agent committed to judge the *goals*' fulfillment, it does not offer a coordinate that is directly associated with the agent committed to pursue the *goal*'s fulfillment. ArchiMate Specification 2.0, in turn, offers

the *association* relationship as the only way to link *stakeholders* to *goals*. However, this relationship does not differentiate the *stakeholders* committed to pursue the *goals*' fulfillment and the *stakeholders* committed to judge it. By understanding these particularities, we suggest that the designer names each association for differentiating the "pursue" relations from the "judge" relations. For example, in Figure 5b, there are two *stakeholders associated with* the *goal* "improve the customer relationship information system usability": (i) the "customer", who is *associated with* that *goal* to represent the commitment at judging the goal's fulfillment; (ii) and the "CEO", who is *associated with* that *goal* for representing the commitment at pursuing the *goal*. The diagram in Figure 5b also presents the *stakeholder* "system analyst", who is committed at pursing the "Improve the Customer Relationship IS Usability" goal.

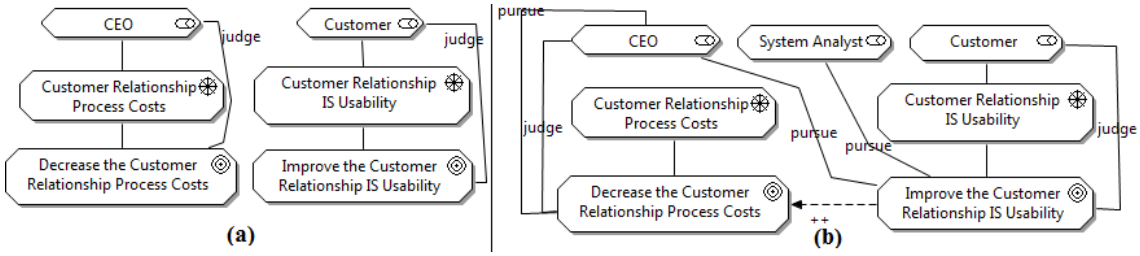

Figure 5 – An ArchiMate ME diagram derived from GQM (a) and an improved version (b)

As a result, the organization would have an ArchiMate ME diagram specifying the organizational *goals*, their sources and the relationships between them, aligned with a GQM model that could be carried out to evaluate the fulfillment of such *goals*.

6. Related Work

We are unaware of competing approaches which have attempted either an ontological analysis of GQM or semantic alignments between complementary goal-oriented design approaches. There are, nonetheless, in the literature a growing number of reports on the use (foundational) ontologies for performing analysis of (goal) modeling languages.

For instance, in [Cardoso et al. 2010], Cardoso and colleagues propose a semantic alignment between the ARIS framework (for business process modeling) and the TROPOS (for modeling and analysis of goals). Their proposal (which is also based on UFO) contributes to the establishment of a more comprehensive goal-oriented modeling approach by connecting a goal-modeling perspective with the modeling of business processes which are supposed to achieve these goals.

In [Azevedo et al. 2011], the authors perform a semantic analysis of the ArchiMate ME in light of UFO. This analysis was conducted by considering the whitepaper of the Motivation Extension. The ontological analysis performed in our work, however, has considered the ArchiMate ME Specification 2.0, which presents some differences of the initial version presented in the whitepaper, such as: (i) in the ArchiMate ME Specification 2.0 there is no longer the concept of "concern", which was replaced by the concept of "driver"; and (ii) the definition of the "role" concept in the standard suffered some changes, which were actually driven by the ontological analysis in [Azevedo et al. 2011]. So, in one sense, the analysis of ArchiMate ME performed here benefits directly from the previous work of Azevedo and colleagues. The two efforts, however, also differ also in focus: their work focuses exclusively on the real-

worlds semantics of this fragment of ArchiMate; our focus instead is in leveraging this semantics for integrating it with a complementary approach.

In [Soffer and Wand 2005], the authors employs some of the concepts of the BWW ontology to analyze the notion of goals in the context of Business Process Modeling (BPM). The account provided there is a language independent one and, in this sense, it is comparable to the analysis of hardgoals and softgoals present in UFO [Guizzardi et al. 2012]. In contrast with UFO, the view of goal provided by these authors take them as "sets of states of the domain". Under this view, goals are sets of elements closer to what is termed a situation (or a state of affairs) in UFO and, as such, are independent of intentions and, hence, independent of Agents (e.g., people, organizations). Such a view seems to fail to capture the requirements engineering and enterprise modeling intuition that goals are "desired state of affairs" [Yu et al. 2011]. Moreover, from an ontological standpoint, the UFO view of goals as *propositional contents of intentions which can possibly satisfied by sets of situations* allows even for goals which are unsatisfiable (an important analysis notion since the satisfiability of goals cannot always be defined a priori), as well as for distinct goals but which happens to be satisfied by exactly the same set of situations.

7. Final Considerations

Specification of organizational goals and the evaluation of the fulfillment of these goals are two complementary and essential activities. For supporting these activities in a systematic way, it may be necessary to combine distinct goal-oriented approaches. Due to lack of a common semantics between different approaches, their combination can be challenging. In this work, we propose a semantic alignment between the Archimate ME and GQM, which are two complementary approaches that can be applied in tandem to support the aforementioned activities. These approaches were aligned in light of UFO, which was used as a domain-independent reference ontology.

The ontology-based analysis conducted in this work contributed to clarify the meaning of some concepts of GQM and ArchiMate ME and to identify how these concepts can be aligned. For future works, we plan to continue the ontological analysis of the ArchiMate ME and the GQM, addressing other concepts, such as, the *assessment* concept. After that, we plan to define a cyclic process that comprises goal's specification and fulfillment evaluation, by adopting of ArchiMate ME (along with the GQM goal structure) to specify goals and GQM to assess the goals' satisfaction. We also plan to apply the proposed approach in real organizations in order to evaluate it.

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