Aligning Goal and Decision Modeling

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Abstract. Making decisions is part of the everyday life of any organization. Documenting such decisions is important to allow organizational members to learn from past mistakes, and to support newcomers in adjusting into the organization. However, nowadays, decisions are usually documented in unstructured ways, which makes it hard to find and interpret them. In this work, we propose the alignment of goals and decision modeling, by using two existing modeling notations, namely *i** and DMN. This alignment is based on a semantic approach, in which the elements of the notations are mapped into a decision-making ontology, also developed in the context of this work.

Keywords: Decision-making · Goal · Alignment of modeling notations Ontology

1 Introduction

Decision-making is an essential part of the everyday life of any organization. Individuals working in several points of action of the organization need to make decisions in a daily basis in order to accomplish their goals. In this context, documenting decisions is useful for: (a) capturing expert knowledge on decision-making to help understand how decisions have been made, possibly avoiding pitfalls i.e. decisions that led to unwanted outcomes; (b) providing newcomers with the means to understand how the decisions have been made, so that they can learn from them; and (c) documenting the evolution of organizational services and products in terms of the decisions that have been made in their regard.

Organizations usually document decisions by recording them as lessons learned [1]. However, these records are often made in natural language, thus being generally unstructured. Recently, OMG has created the Decision Modeling Notation (DMN) [2], aiming at providing a standard language to model human decision-making, and to model and implement automated decision-making. Using a modeling language to document decisions may prove useful to allow a more consistent, structured and uniform view about decisions taken within an organization.

Most of the works applying DMN use this language in connection to the Business Process Modeling Notation (BPMN), as a means to make explicit the specific tasks where decisions are taken [2, 3]. However, in these cases, much of the rationale is

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hidden w.r.t. 'why' a decision must be taken (i.e. which goals it achieves) and 'why' using a specific set of criteria to take a decision. Providing an in depth analysis of this rationale is exactly the focus of goal-oriented modeling. Hence, we claim that aligning DMN with a goal-oriented modeling language will allow one to make explicit the decision rationale. Specifically, we consider the *i** framework [4], since it is among the most used ones in goal-oriented modeling research, and it supports several language extensions, but our approach is general and can be adapted to other languages.

In this short paper, we present the key idea in our approach, that is the alignment of *i** and DMN, using an ontological approach to map the elements of each notation. By doing so, we aim at making sure that the alignment is based on the real semantics of the notation's elements, not only on their label. This approach has been followed with success in previous works [5, 6]. To support the alignment, we propose a decision-making ontology, whose development is based on the Unified Foundational Ontology (UFO) [7, 8]. We choose UFO because it already covers some basic concepts that are needed to define the decision-making domain.

Throughout the years, there have been some related works supporting decisions' representation and reasoning. For example, the works about decisions on goals in KAOS [9] and in the Business Intelligence framework [10]. Lamsweerde [9] proposes the use of decision tables to represent the options related to goal achievements in an OR goal decomposition. The tables allow to perform both qualitative and quantitative reasoning about the best choice of goals achievement, given some quality criteria to be ensured. The Business Intelligence (BI) framework [10] proposes the use of GRL modelling language (based on *i**) to perform a quantitative reasoning on goal achievements, thus supporting the decisions related to the best strategies to pursue a given business objective. Both these proposals add elements (such as tables, or business parameters) either as tools not integrated or as extension of the modelling language (in the case of the BI proposal). On the contrary, our proposal intends to bridge and align two complementary languages using ontologies.

The remaining of this paper is organized as follows: Sect. 2 presents the proposed alignment between goals and decision modeling; Sect. 3 illustrates the approach with a working example; and Sect. 4 concludes this paper.

2 Towards the Alignment of Goal and Decision Modeling

2.1 Decision-Making Ontology

Figure 1 shows the proposed ontology. As aforementioned, the ontology has been created based on a foundational ontology named UFO. Thus, the UFO concepts are labeled with *"UFOx:"* where "*x"* is substituted with the part of the foundational ontology which defines such concept. From now on, for clarity purposes, the words corresponding to the ontology concepts have a different font.

Before going into the concepts of the decision-making ontology, it is important to understand some UFO distinctions. The most fundamental distinction is the one between `Substantial` and `Event`. `Substantial` is a kind of Endurant, i.e. an entity that does not have temporal parts, and persists in time while keeping its identity (e.g. a person and the color of an apple). On the other hand, `Event` is composed of temporal parts (e.g. heart attack, trip). A `Substantial` is also different from a `Moment`. While the former is an independent entity (e.g. a person or a car), the latter (usually referred to as property) is dependent on a `Substantial` (e.g. someone's headache, the brand of a car). We usually say that a `Substantial` bears a `Moment`, or that a `Moment` inheres in a `Substantial` [7]. An `Action` is a kind of `Event` performed by a particular type of `Substantial`, named `Agent` (examples of agents are person, student and software developer). Besides performing actions, agents can perceive events and bear special kinds of moments, named `Mental Moments`. `Mental Moments` are properties existing in the `Agent's` mind [8]. The remaining concepts of UFO are explained in the context of the decision-making ontology.

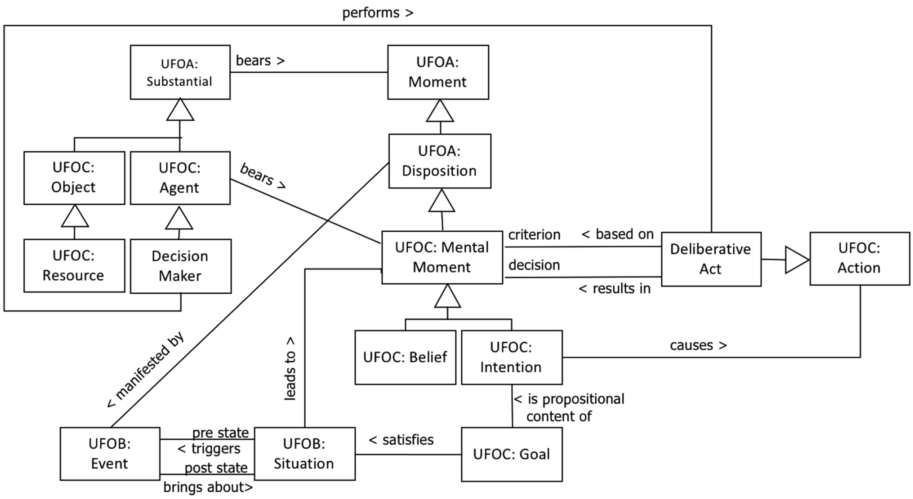

Fig. 1. Decision making core ontology conceptual model

A `Decision Maker` is an `Agent` who performs `Deliberative Acts`. A `Deliberative Act` is, on its turn, a kind of `Action` that results in the creation of a `Mental Moment` termed `Decision`. The `Decision` is thus beared by the `Decision Maker`. In other words, a `Decision` is a `Mental Moment` inhering in a `Decision Maker`, as a result of this `Decision Maker's Deliberative Act`.

As a `Mental Moment`, a `Decision` may be both a `Belief` or an `Intention`. For example, if by looking at a restaurant's menu, someone decides to order fish, then this `Decision` is an `Intention`. UFO defines `Intention` as a kind of `Mental Moment` associated to a particular `Goal` (i.e. the person's goal of ordering fish) and causing a particular `Action` (i.e. the person's action of ordering fish). On the other hand, if just by thinking or talking to others, one decides that one likes fish better than red meat, without actually acting on it, this `Decision` is a `Belief`, even if this may have an impact on the person's future intentions.

When performing a `Deliberative Act`, a `Decision Maker` may use some criteria to take a `Decision`. Thus, we say `Deliberative Act` is based on `Criterion`. A `Criterion` is also a kind of `Mental Moment`, i.e. a `Belief` or an `Intention` of the `Decision Maker`. For instance, taking the previous example, the `Decision` of ordering fish might have been taken based on one's `Belief` that fish is healthier than meat or in one's `Intention` to pay a more economic meal. Note that as both `Criterion` and `Decision` are `Mental Moments`, a `Criterion` may also be a previous `Decision`, thus allowing the creation of a chain of dependence between different decisions.

Understanding the consequences of a particular `Decision` is also an important issue in decision making. This may be achieved by analyzing the UFO concepts of `Disposition`, `Event` and `Situation`. A `Disposition` is a kind of property (i.e. `Moment`) of a `Substance` that may be manifested through the occurrence of `Events`. Take for example the `Disposition` of a magnet to attract metallic material. This magnet has this `Disposition` even if it is never manifested, for example, because the magnet is never close to any magnetic material [11]. A `Mental Moment` is a kind of `Disposition` and as such, it may be manifested by the occurrence of an `Event`. UFO defines `Situation` as a state of the world which may either trigger an `Event` (pre state) or be brought about by one (post state). The `Decision's Consequence` is the `Situation` brought about by the `Event` manifested by the `Decision`.

An interesting aspect of this ontology is to allow reasoning about a typical cycle in decision making processes. Based on specific criteria, a `Decision Maker` takes a `Decision` through a `Deliberative Act`. Such `Decision` is manifested by an `Event` which brings about a particular `Consequence`. Such `Consequence` leads to new `Mental Moments` (i.e. beliefs and intentions) in the mind of that `Decision Maker`, who is liable to take a different `Decision` next time, based on these revised `Mental Moments` (i.e. criteria).

2.2 Mapping Rules from *i** to DMN

This work takes a model-driven approach, in which *i** modeling elements are mapped into DMN modeling elements. By doing that, we aim at facilitating automatic mapping from one language to the other, whenever possible. Besides, we take into account the semantics of the modeling elements of each notation, mapping them to the decision-making ontology described in Sect. 2.1. An *i** modeling element corresponding to the same ontological concept of a DMN element will thus be mapped to each other. By taking this semantic strategy, we aim at avoiding the pitfall of mapping modeling elements only based on their label, which may be misleading.

A goal in *i** may be directly mapped to UFO `Goal`, which is basically defined as a proposition that satisfies a specific `Situation` (or as previously explained, a state of the world). As seen in Sect. 2.1, by possibly being an intention, a `Decision` has a goal as propositional content. This justifies the first mapping we make between ***i* goal and DMN decision***. It is important to emphasize that we are particularly interested in goals that are parents in OR-refinements, as the analysis of alternatives in *i** clearly indicates a point in which a decision needs to be made, i.e. the decision to pursue one of the subgoals of the OR-refinement relation. The relation between ***goals that pertain to the same OR-refinement tree indicate a DMN decision dependency***. As seen in Sect. 2.1, this dependency happens because the `Consequence` of one `Decision` leads to the definition of criteria for another.

A resource in *i** may be either mapped to a `Resource` or to an information believed by an `Agent` (and thus a propositional content of a `Belief`). In case of the former, the *i** resource is mapped into a DMN knowledge source. In DMN, a knowledge source may be either a person or a document associated to a knowledge model containing the decision's criteria; or a person who participates in a decision [2]. Thus, we highlight that ***an i* resource is a DMN knowledge source document*** (not a person).

An actor in *i** is associated to `Agent`. ***The actor whose goals are being analyzed as well as the ones on whom this actor depend are mapped to DMN knowledge sources*** (however, human knowledge sources this time, not documents).

A quality goal in *i** is mapped to `Softgoal`, which is a particular kind of `Goal` in UFO, whose satisfaction is a relation connecting `Softgoal`, `Agent`, `Belief` and `Situation`. To be more precise, a `Softgoal` is said to satisfy a `Situation` according to the `Belief` of the `Agent` bearing an `Intention` whose propositional content is that `Softgoal`. A `Criterion` may be such `Intention`. In practice, this justifies the mapping between ***i* quality goal and DMN criterion***. The DMN elements explained in the previous paragraphs belong to a specific model named Decision Requirement Diagram (DRD). Nevertheless, a criterion belongs to a different model, known as Decision Table, which is associated to the DRD by being linked to a knowledge model. ***A knowledge model is thus also added to a DRD, inferred from the presence of quality goals in the i* model***.

Table 1 summarizes the mapping rules between *i** and DMN, also showing their associated UFO concepts.

Table 1. *i** to DMN mapping rules

***i** Element**	**DMN Element**	**Ontological Concepts**
OR-refinement parent goal	decision	`Goal`
goals pertaining to the same OR-refinement tree	decision dependency	`Goal, Deliberative Act, Decision, Criterion`
resource connected to goal pertaining to an OR-refinement tree	knowledge source (document)	`Resource`
	input data	`Belief propositional content`
actor A whose rationale is being analyzed or other actors on whom A depends.	knowledge source (human)	`Agent`
quality goal (sometimes hardgoal) related to a goal pertaining to an OR-refinement tree	criterion to be refined in a decision table	`Goal (Softgoal), Intention, Criterion`
	knowledge model	`Criterion`

3 Working Example

Figure 2 depicts an *i** model of our working example. This model is adapted from a well-known case and it was chosen because it depicts all elements we need to illustrate the proposed alignment approach.

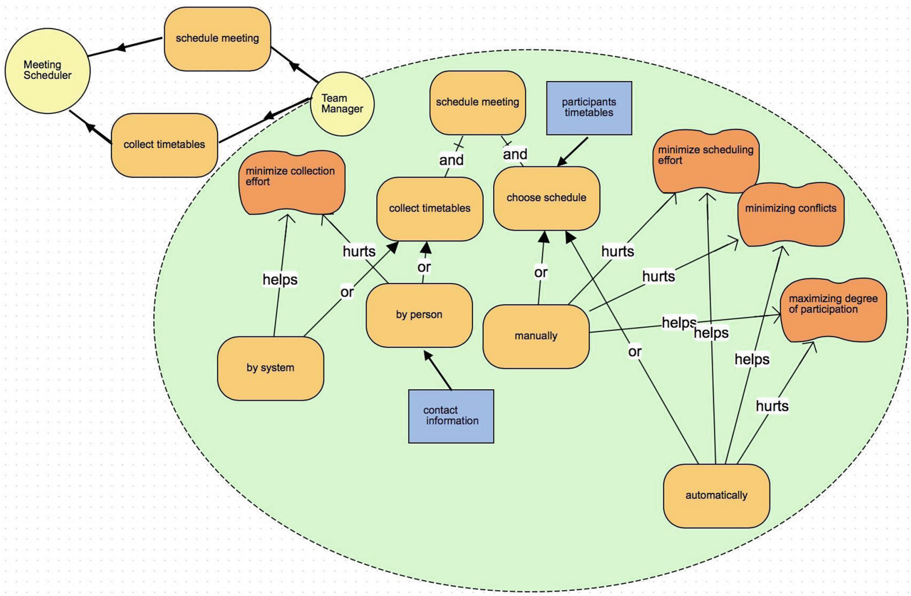

Fig. 2. *i** model of the Meeting Scheduling case

The model in Fig. 2 analyses the goals of a Team Manager actor, who wants to schedule a meeting. To accomplish such goal, s/he needs to collect the timetables from the participants and to choose a schedule. Then, the model shows some alternatives s/he may follow to accomplish her goals, which gives us the opportunity to explain how the *i** elements map to DMN elements. The resulting DMN DRD is depicted in Fig. 3.

The Team Manager needs to decide whether to collect timetables by herself or by the Meeting Scheduling system (see the goals *by person* and *by system* in Fig. 2). Thus, *collect timetables* (as a parent goal in an OR-refinement, as stated on Table 1) becomes a decision in the DMN DRD; for similar reasons, a decision has been added in the DRD for the *choose schedule* goal (refer to *Collect Timetable Mode* and *Choose Schedule Mode* decisions in Fig. 3).

Besides the decisions automatically added by following the mapping rules, we also noted that the goals *(choose schedule) manually* and *automatically* require decision-making. We thus added them to the DRD of Fig. 3, and we use colors to differentiate between modeling elements automatically inferred from the mapping rules of Table 1 (in white) from the ones we added later in the diagram (in grey).

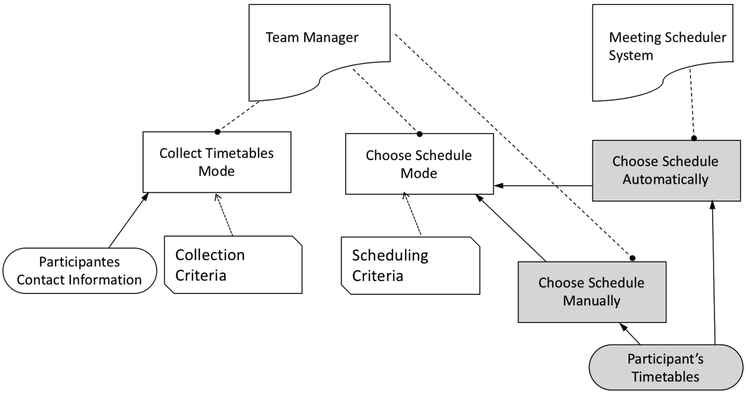

Fig. 3. DMN decision requirement diagram

The *Participant's Contact* input info of Fig. 3 comes from the *contact information* resource associated to the *(collect timetables) by person* goal of Fig. 2. Analogously, we added an input info entitled *Participant's Timetables*, which is related both to the *Choose Schedule Manually* and to the *Choose Schedule Automatically* decisions.

The actors in Fig. 2 became knowledge sources in the DRD of Fig. 3. The relation between the Team Manager and the decisions for which she is responsible may also be automatically inferred from Fig. 2, since the goals that originated such decisions belong to the perspective of the Team Manager. This is not true for the link between Meeting Scheduler and the Choose Schedule Automatic decision, manually added to the DRD.

Finally, the two DRD knowledge models may be inferred from the fact that there are a few quality goals related to the subgoals of the OR-refinement depicted in the goal model of Fig. 2. According to DMN, each knowledge model from a DRD is associated to a Decision Table, detailing the criteria used to take the decision. For example, Table 2 shows the Decision Table associated to the Collection Criteria knowledge model. The Decision Table's last column present the decision (e.g., manual and automatic) obtained by the analysis of the criteria's values; the first column enumerates the values to be analyzed; and the remaining columns present the criteria used to obtain this decision (in Table 2, only one criterion, i.e. the number of participants in a meeting).

Table 2. Example of DMN decision table

Collection criteria		
U	Number of participants	Collection mode
1	<=2	Manual
2	>2	Automatic

The criteria presented in the Decision Table are based on the quality goals of the *i** model. For instance, on Table 2, we interpret that the collection effort (based on the *minimize collection effort* quality goal) may be given by the number of participants in the meeting being schedule.

4 Conclusion

In this paper, we proposed the alignment between goal and decision modeling, by mapping *i** to DMN. The proposed alignment is based on a semantic approach, by mapping the notation's elements to the concepts of a decision-making domain ontology.

In the past, we have investigated the alignment of *i** and BPMN [6, 12]. One could then argue for an approach combining all three dimensions: goal, business processes and decision modeling. Nevertheless, aligning DMN with *i** directly allows a more strategic (and thus, more abstract) view, instead of an operational one, which may prove useful in situations in which knowing in detail the activities leading to a decision is not necessary.

Main steps in our future work include the validation of the proposed alignment in general, both by conducting experiments and by applying it in different case studies. More generally, evolving the proposed ontology by adding other decision-making concepts will be performed iterating alignment refinement and validation activities.

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