

2014

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Recommended Citation

Mansingh, Gunjan and Rao, Lila, "Enhancing the Decision Making Process: An Ontology-based Approach" (2014). *CONF-IRM 2014 Proceedings*. 9.

<http://aisel.aisnet.org/confirm2014/9>

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21P. Enhancing the Decision Making Process: An Ontology-based Approach

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Abstract

Decision making is a key activity for management in any organization, several decision making methods including Multi Criteria Decision Making (MCDM) have been used to assist this process especially when the decision involves multiple stakeholders and multiple criteria. These methods, which evaluate each alternative by a set of criteria, tend to be subjective in nature. However, although they are subjective it should be ensured that the decisions makers have as much knowledge about the alternatives as is possible. This would include understanding all the consequences of each alternative and all the effects of these consequences. This requires a thorough understanding of the domain within which the decision is being made. We argue that an organizational ontology provides this understanding and propose a method for integrating an ontology into typical multi-criteria decision making techniques. The overall aim of this method is to improve the decision making process. We demonstrate the applicability of this method by applying it to decision making at a university in the Caribbean.

Keywords

Organizational decision making, Multi-criteria decision making, Ontology.

1. Introduction

The process of decision making involves making a choice from a set of alternatives. Decision makers often examine goals, values and criteria in evaluating this set of decision alternatives. There are typically multiple, often conflicting, criteria that needed to be evaluated in decision making. In considering the alternatives decision makers need to weigh these multiple criteria and to do this effectively they must fully understand the consequences of each choice. In many cases decision makers use intuition to make their choice, however for most complex and important decisions at the organizational level it becomes important to properly structure the problem and ensure the alternatives are explicitly evaluated in terms of the criteria.

Researchers have been focusing on providing tools to the decision makers to assist them in their decision making process. Several decision making methods and tools exist to assist decision makers in this exercise, for example, Multi-Criteria Decision Making (MCDM) and Value-Focused Thinking (VFT). The four phases of decision making as characterized by Simon are (Turkia, Kassel, Saad & Gargouri 2013);

1. Intelligence – in this phase the problem is identified or the situation where the decision has to be made is determined.
2. Design – in this phase possible courses of action (i.e. the alternatives) are developed and analyzed.
3. Choice – this phase entails selecting a course of action from those available.
4. Implementation – in this phase the course of action is executed.

Other rational decision making models have identified the following steps when faced with a given problem (McGrew & Wilson 1982);

1. Clarify goals, values or objectives and then rank or organize them.
2. List all possible ways to achieving these goals, values or objectives i.e. the alternative strategies.
3. Determine all the consequences that follow from each of these strategies.
4. Compare consequences of each policy with goals, values or objectives.
5. Select one which best matches the goals, values or objectives.

The identifying of consequences for each alternative is an extremely important component of the entire decision making process. It is imperative that the decision maker considers not just the direct consequences but also seeks to identify those that are indirect. One way to do this is to identify all the business processes that will be effected by each alternative and then to examine these business processes in detail to determine the full extent (i.e. consequences) of the effect on the business process. However, to do this effectively requires analyzing the domain which in turn requires that the domain knowledge is represented in a structure that facilitates this analysis.

One such representation is an organizational ontology. An organizational ontology represents the knowledge of the domain as relationships between various organizational concepts (e.g. organizational goals, subgoals, processes, tasks, subtasks, resources, systems). This ontology assists in identifying all the tasks, subtasks, systems, roles and actors that are required for performing a business processes. This knowledge can then be used to understand the full consequence of the various decisions and to more accurately weigh the alternatives in terms of identified criteria which will lead to better decision making.

In this paper we present an ontology driven method for multi-criteria decision making that explicitly focuses on ensuring the consequences of each choice are considered.

2. Background

Decision making entails making a choice amongst the alternatives and decision problems arise due to action of competitors, customers, government, stakeholders or by circumstances such as recession and natural disasters (Keeney 1996). Decision making method such as MCDM have been applied to various group decision making environments (Lee & Kozar 2006; Ngai 2003) and their aim is to integrate multiple subjective measures into a single overall score for ranking decision alternatives. In MCDM first the decision problem is converted to a hierarchical structure consisting of criteria and alternatives (Saaty 1980a). A pairwise comparison is then performed which combines the criteria importance with the alternative preference measure to derive a numerical priority for each solution alternative. Such a priority helps in identifying the

solution alternative which fulfils the initial goal for which the hierarchy was built. Decision making methods such as MCDM are also referred to an alternative-based approach.

The Value Focused Thinking (VFT) approach emphasizes the importance of considering values in the decision making process. According to Keeney (1996), values should be the core and the major driving force of decision making and not the alternatives. He emphasized that focus on identifying the alternatives before the values is a shallow and a reactive way of examining decision situations. Values were identified as being fundamental to decision situations and alternatives as a means to achieving these values. Therefore, the initial focus should be on explicating the values and later on the creating the alternatives. Keeney (1996) outlined several devices to assist in explicating the objectives, one of the methods focuses on developing an understanding of the consequences. Understanding the consequences helps in determining “What might occur that you care about?”

Both subjective decision making methods such as, MCDM and VFT, require an understanding of the consequences to provide better inputs into the decision making process. A better understanding of the consequences leads to well-formed criteria and values, however the methods to systematically determine the consequences of certain decisions are lacking. Such an analysis requires access to organizational knowledge such as its business processes and the various information systems that are being used by these processes. Ontologies represent the knowledge of the domain as a set of concepts and they provide a framework for facilitating effective and efficient knowledge-sharing (Gruber 1995).

There are several benefits of developing an ontology to make domain assumptions explicit, these include: (1) facilitating the sharing of a common understanding of the structure of information among stakeholders in a domain (2) facilitating more effective communication and idea-sharing (3) assisting new entrants in a field to quickly assimilate important domain concepts and knowledge and (4) generally supporting the analysis of domain knowledge (Noy & McGuinness 2001).

An organizational ontology provides a set of terms and constraints that describe the structure and behaviour of the organization (Fox & Gruninger 1998; Zhang, Kishore, Sharman & Ramesh 2007). They have been used for modeling the enterprises activities, goals, processes, tasks, systems and constraints (Fox, Barbuceanu, Gruninger & Lin 1998). Organizational ontologies are being used to develop methods for making organizational knowledge accessible for decision making (Mansingh, Osei-Bryson & Reichgelt 2009; Rao, Mansingh & Osei-Bryson 2012). Such ontologies provide access to the knowledge items which are involved in the various business processes. The ontology models the structural context specific knowledge and the workflow knowledge of the process formally, and can be used to identify the relevant goals, resources and systems needed for each process and alternatives. This will assist in systematically determining the extent of the effect in a particular decision making context.

3. Approach to Decision Making

In this study we propose a method which will assist in the organizational decision making process. Decisions have multiple alternatives and there is a need to examine these alternatives in

a structured manner. This section outlines our proposed method which focuses on understanding the full consequences of each alternative. This has been done by incorporating an organizational ontology with a typical multi-criteria decision making process. This extension will ensure that the weighing of alternatives in terms of the criteria is more informed. The proposed method involves the following steps:

- Step 1. State the decision that needs to be made.
- Step 2. Identify the alternatives.
- Step 3. Determine the criteria for assessing the alternatives.
- Step 4. For each alternative:
 - i. Identify the business processes affected.
 - ii. In this step an organizational ontology can be created or reused if it already exists. Use the ontology to identify the tasks and subtasks for each business process identified in 4. i.
 - iii. Use the ontology to identify the roles, actors and resources that are involved in performing the tasks and subtasks identified in 4. ii.
 - iv. Interview the actors identified in 4 iii. to determine how their existing (sub) tasks may be affected by the alternative.
 - v. From the information obtained from the interviews determine the consequences of the alternative.
- Step 5. Assess the consequences in terms of the stated criteria to derive a ranking of the alternatives.
- Step 6. Choose the alternative that has the highest ranking.

4. Application of Method

We demonstrate the applicability of this method using a case study of a university domain in the Caribbean. One of the major issues at this university is that students have not been paying their fees hence the university administrators are facing the problem of improving fee collection. There are a number of alternatives and criteria that need to be considered for this decision, hence the suitability of applying this method:

Step 1 Decision: “how to improve tuition fee collection”

Step 2 This step involves the identifying the alternatives which have to be elicited from the decision makers. Various knowledge acquisition techniques such as structured interviews, card sort and laddering can be employed to extract these alternatives (Reichgelt & Shadbolt 1992). Based on discussions with senior decision makers at the university they stated that they were considering the following three alternatives for the collection of fees:

Alternative 1: Deregister students.

Alternative 2: Block students from taking exams.

Alternative 3: Allow students to complete current semester but block their grades and stop them from registering in the subsequent semester and if they are graduating students then stop them from graduating.

Step 3 The criteria for assessing the alternatives have to be decided by the decision makers. In this step as in the previous step knowledge acquisition techniques can be used to elicit this knowledge from the decision makers. In this scenario, the criteria that decision makers identified were (i) *speed* of payment, (ii) *investment of time* by the various actors and (iii) the university's *reputation*. Collection time considers the time within which fees are paid as they could be paid anytime during the semester and the administrators are not sure of how much money will be collected, when it will be collected or whether they will actually be able to collect it. Investment of time is the criterion which quantifies the time and effort of different roles within the organization to implement the alternative. The third criterion university reputation assesses the impact of pursuing an alternative on their image and how it affects the institutions reputation.

Step 4

- i. For each alternative the decisions makers were asked to identify the business processes which would be affected by implementing the alternative (see Table 1). For the alternative *Deregister student* these are *Deliver Course* and *Register Student*.
- ii. In this study we adapt an existing organizational ontology (Rao et al. 2012). This ontology provides framework for representing the organizational concepts, the relationships and the constraints between the different organizational concepts. The ontology (see Figure 1) was used to identify the tasks and subtasks for each business process. This can be done by extracting the *Made_up_of* and *Divided_into* relationships from the instantiation of the ontology. Thus, the tasks associated with the business process *Register Course* are *Select a course*, *Drop a course*, *Withdraw from a course* and *Get Financial Clearance* (see Table 2). For each of the tasks the corresponding subtasks are also displayed in table 2.
- iii. The ontology is then used to identify the roles performing the subtasks identified in 4 ii. (*Needed_for relationship*), the actors in these roles (*Plays relationship*) and the resources that are used or affected by these subtasks (*Aim_support* and *Consumes relationship*). All information systems are resources and hence Table 2 and 3 also displays the various systems that are affected while performing the subtasks.
- iv. The lecturers, students and administrators (see Table 3) were identified and discussions were held with them about which of the tasks each alternative would effect and in what way. It was ascertained, for example, that the first alternative *Deregister students* would affect the tasks *manage coursework grades* and *Withdraw from a course*. *Manage coursework grades* is one of tasks of the business process *Deliver Course* and *Withdraw from a course* is a task of the business process *Register Student*.
- v. When asked to elaborate on how *manage coursework grades would be affected* it was revealed that students would no longer have access to the Learning Management System through which they submit their coursework and do their on-line quizzes, etc. (see Table 2).

Step 5 In determining the full consequences of deregistering the students the subtasks affected were analyzed and it was recognized, for example, that the fact that students are unable to submit their coursework and do their tests through the Learning Management system means that they could fail the coursework. Given that the students must pass both the coursework and exam component to pass the course they would in turn have fail the

course. From the interviews and analysis it was also seen that if students are unable to submit coursework for the period of time they told to leave until they pay, when they returned the lecturers tried to facilitate them by giving them the coursework and then having to get these marks included in the overall marks. It was seen that the various effects of the consequences (see Table 2) could be mapped to the various criteria. For example:

- when students returned to the class once they paid their fees it increased the investment of time lecturers had to make in tabulating coursework and examination grades.
- when students are deregistered later on in the semester the students records unit also spends time dealing with these cases
- students being deregistered for lack of payment can affect the reputation of the school as the public could feel that the university is unsympathetic to the financial hardships faced by students
- however, this alternative is quite drastic so it is more likely that the student will come in to pay the fee quickly

The decision makers will now have more knowledge that can be used to compare the alternatives in terms of the criteria. A pairwise comparison can then be made for each of the alternatives, for each of the criteria, which then can be combined to derive the ranking of alternatives for an overall priority matrix (Saaty 1980b).

Step 6 The alternative with the highest ranking was chosen.

Task	Subtask	Role	Resources
Select a course	1. Check Prerequisites 2. Update Credit 3. Select different course components	Student	Grades system Registration system Timetable system Learning Management system
Drop a course	1. Reduce Credits 2. Remover course from student's record	Student	Timetable system Registration system Learning Management system
Withdraw from a course	1. Get approval from department and faculty 2. Remove the course from the student's registration system	Student Lecturer Dean Admin for Student records	Registration system Learning Management system
Get Financial clearance	1. Pay fees	Student	Financial system

Table 1: Business Process - Register Student

Decision	Alternatives	Business Processes affected	Tasks affected	How Resources are affected	Consequences	Effects of Consequences
Improving Tuition Fee Collection	1.Deregister Student	1. Deliver Course	Manage coursework grades	Student is blocked from Learning Management System	Student unable to Submit Coursework	Student can fail coursework which leads to failing exam.
					Student unable to do online Tests	
					Student unable to access lecture material	
					Lecturer to manage coursework grades for students who return in the given semester	Instead of using computerized systems lecturer has to resort to manual systems
		2. Register Student	Withdraw from a course	Update Registration system Remove from Learning Management System.	Student can withdraw from the course at a late stage as already failing course.	Student has already used resources in the course such as lecturers, tutors, graders and lab
					Student has some coursework	Student has to repeat coursework

Table 3: Mapping Decision – Alternatives – Consequences

Task	Subtasks	Role	Resources
Create course material	<ol style="list-style-type: none"> 1. Make lecture notes available 2. Create quizzes and assignments 	Lecturer	Learning Management system
Manage Coursework	<ol style="list-style-type: none"> 1. Submit coursework 2. Take online quizzes 3. Take midterm exams 4. View coursework grades 5. Record and compute coursework grades 	Student Lecturer	Learning Management system
Manage Exams	<ol style="list-style-type: none"> 1. Submit exam paper 2. Mark exam scripts 3. Enter exam and coursework grades 	Lecturer	Learning Management system Grades system

Table 2: Business Process – Deliver Course

5. Conclusions

In this paper we propose the use of an organizational ontology to improve existing decision making processes. A decision making process requires access to domain knowledge to understand the consequences of applying an alternative decision. Some of this knowledge can easily be extracted from an organizational ontology, which will assist the decision makers in assessing the multiple criterions. The proposed method demonstrates that for a decision scenario with multiple alternatives how the consequences of these alternatives can be determined. For a given decision, the alternatives and the criteria for assessing these alternatives, and the affected business processes were elicited from the domain experts. The ontology was then used to identify the corresponding tasks, subtasks, roles, actors and resources of the affected business processes. By interviewing the actors who perform these roles the decision makers are better able to identify the relevant issues for the affected business processes (e.g. which resources will be affected), understand the consequences and their affects. This analysis provides decision makers with more domain knowledge to compare the alternatives and evaluate the criteria especially in subjective decision making methods, such as MCDM. Using an ontology to improve the understanding of consequences and their affects improves the existing decision making methods.

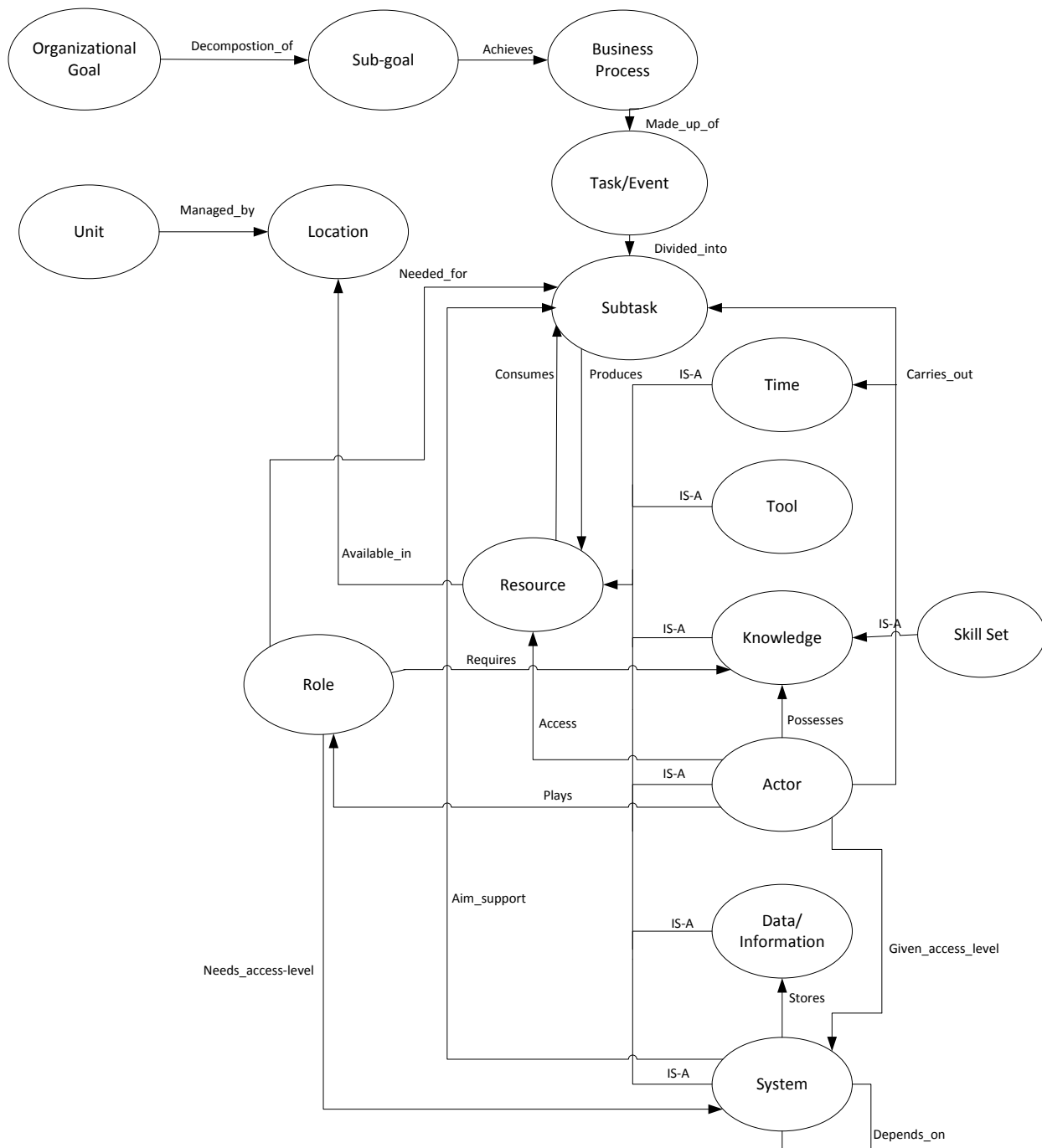


Figure 1: Organizational Ontology
 Source: (adapted from Rao et al., 2012)

In future work we will demonstrate the applicability and generalizability of this method by:
 (i) Extending the given case to consider a larger number of alternatives. This will provide a more realistic scenario and better demonstrate the importance of these techniques for complex strategic decisions. This will also demonstrate the ability of the method to scale to large problems.

(ii) Applying the method to different domains to demonstrate its applicability. The method is not limited to the university domain but can be used by all organizations requiring multiple criteria decisions. The organizational ontology can also be shared across organizations and thus not limited to a specific domain. It will just require that the given organization creates the instantiation of the ontology.

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