An Ontology for Formalizing and Automating the Strategic Planning Process

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Abstract—**From late 1980s and early twenty-first century, the environment where the organizations develop and act, has become increasingly uncertain and complex. Under these conditions, organizations have detected the need to move towards a more participatory model to address and reduce the complexity, based on information and knowledge as core assets to reduce environmental uncertainty and thereby ensure better decision-making. This new form of governance involves changes in the Strategic Planning process that are aligned with the characteristics of the new organizational model. Ontologies, as theories of content that allow the formalization of processes and knowledge, are a key element in this context. The aim of this paper is to formally define an ontology that could be defined in the future using the Web Ontology Language (OWL) that meets the standards approved by the World Wide Web Consortium (W3C) and that is used to formalize the process of SP, as well as the knowledge that is created and flows among the several participants in the process.**

Keywords—ontologies; strategic planning; intelligent organizations; collective intelligence.

I. INTRODUCTION

From late 1980s and beginning of XXI century a series of events have occurred that, taken as a whole, paint a new landscape within the world of organizations in which the environment around them is increasingly uncertain and complex. Some of the most important facts behind this assertion are the internationalization of organizations, the economy globalization, the technological dynamism and, as a result, the growing need and importance of knowledge and learning within organizations [1].

Knowledge and ability to learn are today the main assets of the new model of intelligent organization referenced in [2]. The complexity and uncertainty of the environment can be reduced by providing and managing valuable information to help detect new needs in the environment and to guide the realization of new ideas to compete. To this end, the model of intelligent enterprise stands on three pillars: the collective intelligence, knowledge management and information and collaboration technologies.

The Collective Intelligence (CI) is the ability of an organization to engage its stakeholders in a task of intellectual cooperation to ask questions and find answers to questions concerning the organization [2].

The Knowledge Management was initially defined by Nonaka and Takeuchi [3] as the process of applying a systematic approach to the capture, structuring, management, and dissemination of knowledge throughout an organization to work faster, reuse best practices, and reduce costly rework from project to project.

The information and collaboration technologies are the quantity and quality of software, hardware and networks facilitating relational and information flows.

From the new model of intelligent organization, it can be concluded that the traditional paradigm and process (centralized and reactive) for strategic planning that organizations utilize must be adapted to also be focused on that shared, participatory and collaborative learning-based vision, which supports the intelligent company [4]. The objective is to reduce complexity and increase the agility and flexibility of the process.

The process of Strategic Planning (SP) is defined as the process by which managers of the firm analyse the internal and external environments for the purpose of formulating strategies and allocating resources to develop a competitive advantage in an industry that allows for the successful achievement of organizational goals [5].

From the previous definition and the new needs of organizations, two key issues of formalization should be addressed and solved within the new Strategic Planning:

1) Formally define a conceptual framework that serves to represent the information/knowledge extracted from the internal and external environment of the organization and from each participant in the process, so that it constitutes a common vocabulary with which all managers can have a unified vision of the facts and that they can use to communicate and cooperate.

2) Formalize the Strategic Planning process itself to determine the steps that make up this process (listed in [6]), the information/knowledge type that is used and who is involved in each case.

The problem of formalization and conceptualization commonly appears in the literature linked to the concept of ontology. In 1993, Gruber [7] originally defined the notion of ontology as an "explicit specification of a conceptualization". In 1997, Borst [8] defined ontology as a "formal specification of a shared conceptualization". Finally, in 1998, Studer [9] merged these two definitions stating that: "An ontology is a formal, explicit specification of a shared conceptualization". These definitions identify two key aspects to keep in mind: on the one hand this formalization allows for a strict description of ambiguities-free knowledge that can be machine-readable and, on the other hand, it

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reflects the idea of sharing knowledge among individuals in a group.

Guarino stated in [10] a classification of ontologies based on the level of generality proposing four types: high-level, domain, task and application ontologies. The latter describes concepts simultaneously belonging to a domain and a particular task.

In this paper, we present an application ontology whose domain covers all the terminology associated with the SP and its implied task/process.

According to Gruber [7], ontologies consist of concepts (formalized basic ideas obtained from the domain), relationships (they represent the interaction and the connection between the domain concepts), functions (they identify an element by calculating a function on several elements of the ontology), instances (they represent certain objects of a concept) and axioms (declarative theorems on relations that the elements of the ontology must fulfil).

There are several methodologies and languages to define ontologies. The methodologies proposed by Noy and McGuinness [11] and Uschold [12] and the languages proposed by Gruber [7] and Smith et al.[13] are considered as the most notable.

In Section I an overview about Strategic Planning inside organizations is introduced. The definition and steps of the strategic planning process are described in Section II. Ontologies are formally defined in Section III and finally, in Section IV, the ontology for strategic planning process is presented.

II. STRATEGIC PLANNING PROCESS

According to Hill and Jones [6], the Strategic Planning process is defined on the basis of a model that consists of five main steps:

1) Selection of the corporate mission and major corporate goals.
2) Analysis of the external competitive environment of the organization to identify opportunities and threats.
3) Analysis of the internal operating environment of the organization to identify strengths and weaknesses.
4) Selection of the strategies that are build on the strengths of the organization and correct their weaknesses to take advantage of external opportunities and oppose external threats.
5) Implementation of the strategy.

In practice, there are several strategic planning models which contain the steps of the previously presented model but that may have some special features. In Figure 1 a graphical representation of the model of SP stated by Llorens [14] is presented. It is possible to establish which element of the SP model is defined in each aforementioned step of the process [15].

Mission, vision, values and strategic axes are determined in step 1 and they define the reason for the organization, the state to be achieved in the future, the areas of action to achieve the vision and the organizational culture, respectively.

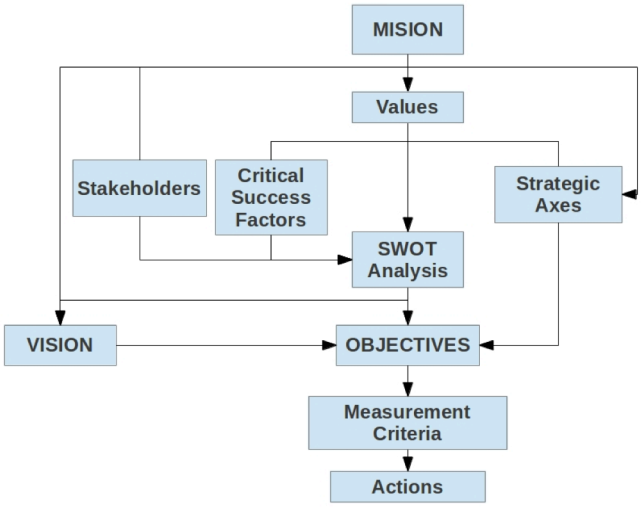

Figure 1. SP model, obtained from [14]

Critical Success Factors are determined in steps 2 and 3 from an analysis of the phenomena of the organization environment (internal and external) that can positively or negatively affect the fulfilment of the mission and a subsequent selection of the key factors.

The Strengths, Weaknesses, Opportunities and Threats Analysis (SWOT), the Objectives and the Measurement criteria are part of step 4. SWOT Analysis [16] is an analysis tool for decision-making. From the Critical Success Factors, the main strengths, weaknesses, threats and opportunities of the organization are identified. The following step is to determine which strengths and weaknesses are the most relevant to take advantage of the opportunities and to avoid the threats. The result is the Strategic Solution.

The Strategic Objectives are the major changes to perform so that the vision is achieved while fulfilling the mission. They should respond to the problem and to the identified strategic solution. At least one Strategic Objective must be defined for each Strategic Axe.

The Measurement Criteria are specific and usually quantitative targets for determining how far the organization is fulfilling its Strategic Objectives.

The Action Plans or Actions are a set of initiatives that are necessary to achieve the fulfilment of the Measurement Criteria and thus the Strategic Objectives.

The Stakeholders are those individuals, groups of individuals and institutions whose actions can positively or negatively influence the accomplishment of the Mission. They are important because, on one hand, they are involved in the phases of analysis and strategic selection and, on the other hand, the success of the strategies depends critically on the position and commitment of these individuals (internal and external) to bring them to fruition.

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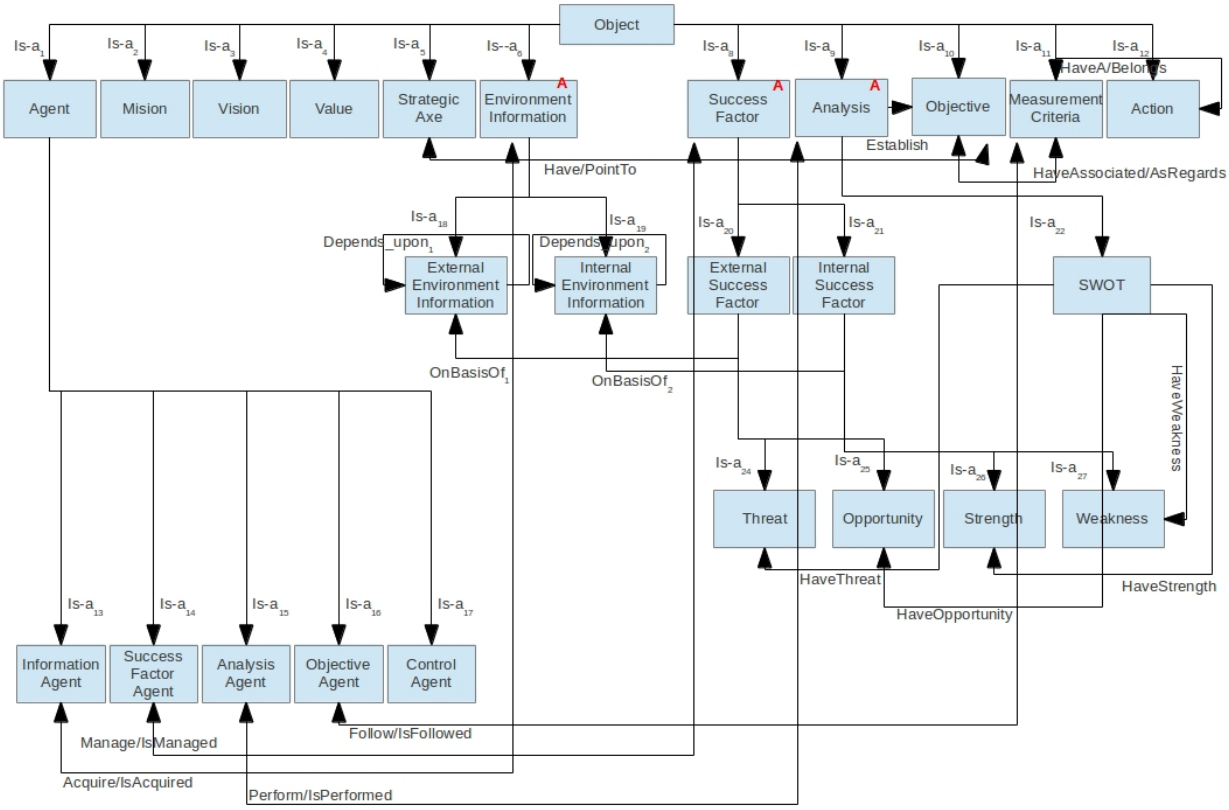

Figure 2. Ontology for SP process

Nowadays, the organizations approach the SP process using, in the best-case scenario, several tools and software technologies for some of the aforementioned steps, to achieve a certain degree of automation and formalization. This is the case of tools for Competitive Intelligence (CI) [17] or Business Intelligence (BI) [18] for the analysis of the environment. However, they are not integrated with the rest of the SP process and, often, they just provide reports and documents which substantially decrement the agility of the subsequent revisions of the Strategic Plan. There are approaches towards strategy content management [20] that consider the strategic planning process couldn't be automated. In this paper, an ontology is presented to achieve some degree of automation and parallelism in the strategic planning process.

III. ONTOLOGIES

According to Pretorius [19] the ontological structure (explicit specification of the conceptualization of the domain) is formally defined as expressed by (1).

$$O = \{C, R, A^o\} \quad (1)$$

where:

- C is a set of elements called concepts / classes, which have properties that describe their features and attributes.
- $R \subseteq C \times C$ is the set of relationships between the concepts / classes of C, which is defined so that it contains the existing inherent hierarchical structure between concepts of C (hierarchical taxonomy).
- A^o is the set of axioms in O that impose restrictions on the concepts and their relationships.

The lexicon (language) L (common vocabulary regarding the conceptualization O) is defined as expressed by (2).

$$L = \{L^C, L^R, F, G\} \quad (2)$$

where:

- L^C is the set of elements called lexical entries of concepts.
- L^R is the set of elements called lexical entries of relationships.
- $F \subseteq L^C \times C$ is a reference to concepts that establishes the link between a concept and a lexical entry.
- $G \subseteq L^R \times R$ is a reference to relationships that establishes the link between a relationship and a lexical entry.

From the previous definitions an ontology O_m is formally defined as expressed by (3).

$$O_m = <O, L> \quad (3)$$

Where O is the ontological structure and L is the corresponding associated lexicon (language).

IV. ONTOLOGY FOR STRATEGIC PLANNING PROCESS

An ontology O_m of type application is proposed. In Figure 2, the concepts and relationships contained by

structure O, as well as entries of lexicon L, which constitute the common vocabulary with which to refer to them, are shown. The Web Ontology Language (OWL) format of the ontology for SP process is not included for reasons of space.

The basis of the design of O_m is the Strategic Planning model of Figure 1. This design for ontology O_m includes:

- The formalization of all concepts associated with this model and involved in the process and their properties and relationships between them. An extract of dictionary of the associated concepts is included in Table I.
- The formalization of existing tasks/steps and the order to perform them in the SP process, obtained from the dependencies and relationships between the various concepts.
- The formalization of the Stakeholders as types of agents that are associated with a particular task or concept in the SP process.

The concepts are organized into levels based on a hierarchical structure (hierarchical taxonomy), which determines the inheritance of properties between a father concept (or class) and the child concept (or class). All classes directly or indirectly inherit Object properties.

For practical purposes, when performing the SP process to obtain a Strategic Plan, the definition of this ontology will allow instantiating the concepts that serve to define and formalize how the process is done. Since all concepts inherit from concept Object, any created instance has a property Identifier that uniquely identifies the instance, a property Name to refer to it and a property Level that determines the step in the SP process which this instance is associated to. For example, concepts Mission, Vision and Value belong to the first level, since they are needed to be instantiated in step 1 of the SP process. However, concepts SWOT and Analysis Agents belong to level 4, because they take part in step 4 of the process.

As a summary, considering the aforementioned and the steps that the SP process comprises and that have been listed above:

- The completion of the first step would involve creating an instance of the concept Mission, among others, in which the Description property would be informed so that the mission of the organization in the SP process is fixed.
- In steps 2 and 3, some instances should be created, to define what information is needed, where is it obtained and who is involved in it. In this case they are instances of the concepts External Environment Information, Internal Environment Information and Information Agent. In the instances of the first two concepts, it can be specified where the information is obtained by defining the property Source, the type of value to be obtained (property TypeValue), as well as who is responsible for obtaining the value of this information, provided by a reference to an instance of the concept Information Agent.

TABLE I. EXTRACT OF O_M CONCEPTS DICTIONARY

Super Concept	**Concept**	***Properties***	***Type***	***Reference***
	Object	Identifier	String	
		Name	String	
		Level	Integer	
Object	Mission	Description	String	
Object	Environ. Informat.	Type	String (Internal/ External)	
		Value	String/ Decimal	
		Source	String	
		TypeValue	String (Quantity/ Quality)	
		Calculation Method	String	
		IsAcquired	ReferenceTo	Information Agent
Environ. Informat.	External Environ. Informat.	$OnBasisOf_1$	ReferenceTo	External Environ. Informat.
Environ. Informat.	Internal Environ. Informat.	$OnBasisOf_2$	ReferenceTo	Internal Environ. Informat.
Object	Agent	Frequency	String	
		AgentType	String (Information /Objective,..)	
		Module	ReferenceTo	Program Code
Agent	Information Agent	Acquire	ReferenceTo	Environ. Informat.

From the last point, a first advantage can be identified: comparing to the way the task of analysing the environment using CI tools is traditionally performed, the use of the ontology directly integrates the diversity of information and knowledge within the SP process itself. Until now, it was necessary to use different CI tools depending on the type of information to be collected for later generating reports for the rest of the SP process.

In addition, once the way of formally define and specify (using an instance) the information or a variable of the environment is set up, it can be reused for subsequent SP processes or reviews.

Moreover, the ontology itself provides some level of automation in the collection and updating of information, thanks to the property Frequency of concept Agent. This property determines how often the Agent has to update the value of the information that is related. This is interesting because of the need of organizations to regularly make adjustments or revisions of the SP, which implies a partial review of the whole process.

Due to the fact that agents represent the Stakeholders involved in the SP process, they have a property Module that contains the heuristics that is applied to obtain the value of the information to which they relate. Thus, each agent is

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responsible for providing to the process the information it knows.

The fact that instances of Environment Information contain a property Name, allows the creation of other instances of Environment Information that uses them and belongs to a higher level of abstraction (knowledge). For example, let Env_1 and Env_2 be two instances of the Environment Information concept, whose names are Env_1.Name = Country_Competition_Index and Env_2.Name = European_Competition_Index and they are computed by two instances of the Information Agent concept Ag_1 and Ag_2. It is possible to create another instance Env_3.Name = Ratio_Competition_Index of the Environment Information concept with a higher level of abstraction, which depends upon (relation $depends\_upon_x$ in O_m) the others and is computed by an instance of the Information Agent concept Ag_3. This way, the ontology enables two important features: the possibility of interaction between agents using a common vocabulary and its use to cooperate.

The relationships between concepts formalize the order in which the tasks of the process are carried out, due to the fact that they establish the restrictions and dependencies between instances of two associated concepts at different levels of the process. For example, to create an instance of the SWOT concept of level 4 it is necessary to create in advance instances of concepts Thread, Opportunity, Strengh and Weakness of which it depends according to the relationships HaveThreat, HaveOpportunity, etc., which are of level 2 and 3.

V. CONCLUSIONS AND FUTURE WORK

The complex and uncertain environment surrounding today organizations have imposed the need for a change in the organizational model. The intelligent organization model requires a new form of governance in which it is essential that the Strategic Planning process has a more participatory approach allowing an increased participation and interaction of the stakeholders in the procurement and management of information/knowledge, and based on it, in making decisions that serve to achieve the synchrony of the organization with this environment. This is the way to reduce the uncertainty and complexity of the environment due to the fact that, on one hand, a large amount of characterizing variables is obtained and, on the other hand, they are obtained in an easier and more agile way thanks to the participation of several specialists (Stakeholders).

The proposed ontology allows the formalization of the SP process by fixing its steps and its dependencies, the concepts of the domain that take part in the process, as well as their relationships and the Stakeholders involved in it. The formalization of the concepts provides a common vocabulary, which the Stakeholders can use to communicate and interact throughout the completion of the process. Finally, the fact that the development of the SP process is translated into a set of instances with a formal well-defined structure allows its reuse in other SP processes, as well as obtaining a complete documentation of the process in a more accessible format that is habitual nowadays. Moreover, it is even possible to automate certain parts of the SP process, so that the instances generated by previous operations are machine-readable (property of the ontology).

The presented ontology for SP process is the first stage to propose a formal, automated and agile model for Strategic Planning. The very next step is defining the ontology using OWL to obtain the subsequent generation of the associated classes of a programming language. The aim of this hierarchy of classes is allowing the development of a graphical tool to design and graphically display the SP process. It could be possible by incorporating a panel of visible objects that represent instances of the classes and which could be accessed to specify their properties. This graphical tool will be the germ of an integral system for automated SP.

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