Developing a Conceptual Framework to Structure an IT Organization using an Ontology Engineering Methodology

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Abstract: Organizations are struggling to adopt practices that allow the best results trying to achieve alignment between IT and an organization's concepts and dimensions, pursuing efficiency and effectiveness. Therefore, the structure of an IT organization is fundamental. However, despite the recognized importance of IT organizational structure and the efforts made in the development of disparate perspectives and relationships, no relevant references about its structure are found, and the existent ones are far from satisfactory. There is neither a single framework nor one relating to what we consider to be relevant or clearly dominant. This paper proposes the use of ontology engineering methodology to identify and enumerate concepts and develop a conceptual framework in order to structure and establish a relationship among concepts within an IT organization, which will allow the definition of an IT organization.

1 INTRODUCTION

Regardless of the type of organization, they all have different concepts such as people, structure, strategies, objectives, and approaches to Information Technology (IT). The alignment between these concepts, architectures and views is an imperative.

Considering that "having the right organization is more important than having the right technology" (Thompson, 2002), the pressure to define a perfect alignment and the high inter-dependence between IT and the organizations' concepts increase, raising the need to define the relationships able to meet these demands (Zacarias et al., 2010). Moreover, structures (such as a department, division, directorate, etc.) and organizational concepts should be defined to accommodate organizational needs and IT. However, it is neither clear what the relevant concepts are nor their relationships.

In the last years, organizations are struggling to adopt the best approach, pursuing efficiency and effectiveness in the alignment between IT and organization's concepts and dimensions.

Different proposals have been made to develop the management of a system's complexity and deliver services, in accordance with an organization's strategies (Tiwana and Konsynski, 2010; Weill and Ross, 2004). Although there are plenty of studies about IT structures (Cross et al., 1997), no strong references on "how to" define an IT Organization to be aligned with business strategy and IT infrastructure were found. There is even less documentation on restructuring IT Organizations in research literature.

Due to the inexistence of approaches to structure an IT organization (Gama et al., 2011), this paper suggests ontology engineering methodology to validate a conceptual framework as a proposal to structure an IT organization and the concepts within it.

This paper is organized as follows: "Related Work" gives us the theoretical background and "Research Methodology" presents the addressed solution. Sample design is presented in section 4 and section 5 instantiates our proposal with two case studies. Section 6 evaluates the proposal, followed by "Conclusion".

2 RELATED WORK

2.1 Ontology Definition

An ontology provides a foundation for

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understandable knowledge, creating meaning; aligning individuals and organizations through a definition of concepts and simultaneously generating new concepts while expanding existing ones (Dietz, 2006; Gama, et al., 2011). Usually ontology is expressed by conceptual modelling grammars, constituted by vocabulary plus meaning and constructing a formal representation of interesting areas (Dietz, 2006; Shanks et al., 2003). Besides the ontological concepts reference, it is preferable to have a graphical representation in which the relationship is recognized among concepts (Gama, et al., 2011; Zacarias, et al., 2010). To do this, we used conceptual maps.

2.2 Concept Maps

Concept maps are graphical representations of knowledge, namely of the concepts and relationships between them (Novak and Cañas, 2008). Concept maps are indicated to capture, represent, structure and share tacit knowledge, in disparate domains, but also to create new knowledge (Novak and Cañas, 2008). Beyond a knowledge representation, concept maps are useful as an evaluation tool (Mintzes et al., 2000). To construct a concept map, we begin with a domain of knowledge, which diminishes difficulties that arise in the origin of concepts. We should use an "expert skeleton", prepared by experts or practitioners on a defined topic. This "expert skeleton" concept map serves as a guide, an aid for people with less knowledge in the domain to begin (Novak and Cañas, 2008).

2.3 Organizational Theory

To understand organizations we should identify the structure's determining factors and influences, both in the internal (technology, involving skills, tools, applications, knowledge, and human resources) and external environment (government, competitors, suppliers and users). The organization's structure, based on functional division, aims at increasing efficiency by combining functions and skills. However, this functional division promotes the presence of silos and misalignment within organizations. On the one hand, strategy is a key concept to consider in alignment efforts, since different strategies require different structures (Porter, 2008). On the other hand, internal competencies ensure a defined strategy while business processes guarantee the alignment between strategy and customer's needs (Gama et al., 2011).

2.4 IT Governance

IT Governance designates the internal mechanisms developed by organizations to align IT with strategic objectives and manage a system's complexity (Weill and Ross, 2004), focusing on decisions mechanisms rather than on structuring (Haes et al., 2005). However, effective IT Governance goes through a combination of concepts, processes and relational mechanisms (Haes et al., 2005) encompassing frameworks with widespread use, of which one has had major relevance: Enterprise Architecture (Spewak and Hill, 1992; Zachman, 1987).

Nevertheless, IT Governance principles do not offer a solution to our problem because they do not provide any ideas on how to define and relate disparate concepts within an organization. They do reinforce that to enable IT Governance, we must clarify concepts and their relationships.

2.5 Structuring an IT Organization

In our previous work (Gama et al., 2011), we proposed a conceptual framework as an ontological representation of a set of concepts within an organization through a concept map. Our contribution was to help making it clear that an IT organization could not be a simple chart of units from functional divisions. Instead, structuring an IT Organization should reflect the requirements necessary to align and meet needs and strategies. However, the proposed framework remains untested and the defined concepts have not been validated. As Shanks stated (Shanks et al., 2003), the validation of conceptual models is to generate quality, and a suitable ontology can only make sense without ambiguous semantics if its concepts are validated.

Moreover, we have already defined several concepts that must be validated in accordance to a methodology, avoiding ambiguity or omissions.

3 RESEARCH METHODOLOGY

3.1 Design Science Research

We follow Design Science Research (DSR) so as to develop and validate the proposal to solve our problem (Oates, 2006). DSR is a typical problem-solving paradigm, addressing research through the development and evaluation of designed solutions in order to meet identified needs (Hevner et al., 2004). Over a process with interactive steps, DSR is applied according to two processes (March and Smith,

1995): build and evaluate. In our proposal, the build process corresponds to defining a conceptual framework to structure an IT organization.

Both build and evaluate processes are composed by two stages. In the first stage of the build process we construct the domain definition and concepts identification. This stage requires a construction methodology. However, although DSR methodology became widely mentioned, its methodology guidelines are not clear or are rarely applied (Hevner et al., 2004). In this context, we understand a methodology as a collection of procedures to help the development of a new or innovative idea.

3.2 Ontology Engineering Methodology

We use Ontology Engineering Methodology (OEM) in the construct step (Ostrowski et al., 2012) using conceptual maps. The OEM process, as illustrated in Figure 1, is done through the collaboration of practitioners from the same field and through literature review (Ostrowski et al., 2012). Applying this technique allows us to systematize a clear methodology, with defined steps and procedures, and to clarify knowledge before developing a solution to an identified problem.

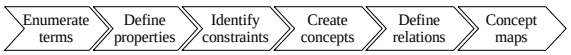

Figure 1: Simplified ontology engineering process methodology applied [based on (Ostrowski et al., 2012)].

Following the OEM process, involving practitioners from the IT department with disparate roles and functions, we started by defining the domain, the terms, their properties and purposes, identifying limitations and evaluating possible constraints. Thereafter, we created the concepts and determined their relations to others concepts.

After this first step, we created and generated (construct) concepts providing the ontological vocabulary and symbols used to define a domain's problems and solutions (Hevner et al., 2004; Vaishnavi and William Kuechler, 2007).

In the second step of the build process, we present the concept maps relating concepts graphically, as the meta-model of the conceptual framework in "a set of propositions or statements expressing relationship between constructs" (March and Smith, 1995; Vaishnavi and William Kuechler, 2007).

In the evaluation process the construct is demonstrated with a case study and then evaluated.

4 PROPOSAL

4.1 Domain Definition

We characterize an organization by defining the domain of applicability and the boundaries of influence. After, we proceeded to the definition of the concepts through the ontology engineering process. Our interest boundary is our internal domain (Henderson and Venkatraman, 1993), as is illustrated in Figure 2.

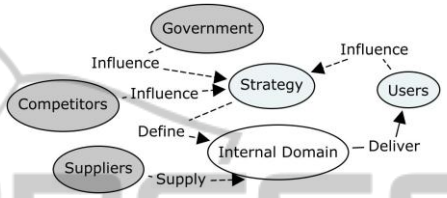

Figure 2: Boundaries of internal domain.

Internal domain involves organizational design (including structure, roles, and relationships), processes (defining organizational activities to deliver product and services), and skills (which indicate the organizational capabilities needed to achieve the required organizational competencies).

Any organization exists to deliver a defined and expected output to its users. We adopted the term "user" to refer to the end point of an organization's service delivery. We differentiate and prioritize users, considering and relating different criteria (Martilla and James, 1977). Thus, one of the internal domain interfaces is with users through services delivered. Suppliers are another domain interface as they deliver services to the organization. We consider suppliers, government deliberations and competitors concepts out of this paper's scope (Porter, 2008).

4.2 Concepts Definition

After identifying the internal domain, the next step is the identification of key concepts applied to the selected domain. These concepts should be listed and the relationships between them established, constructing a preliminary concept map. After a preliminary map has been constructed, a revision is needed in an iteration process, improving the map, clarifying all structure and preparing the final map.

One of the very first concepts' definitions should be about the services delivered, the organization's output. The services supplied are the focal point of business (defined by the strategy) and must be understood by the users. They are defined as

business services which are decomposed into basic services with elementary functionality (Kieninger et al., 2011), as illustrated in Figure 3. A technical service identifies what is required to support a business service, avoiding the need to know users' needs in detail.

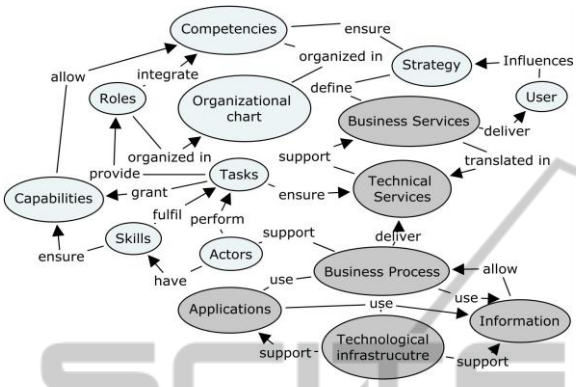

Figure 3: Proposed conceptual framework.

Each technical service is supported by processes as a sequence of value-added tasks performed by actors and by the use or consumption of resources (Ko, 2009). We use processes modulation to identify actors, skills, tasks, information, and applications. In addition to providing a new cross-function way of developing activities, process modulation allowed us to involve people, receiving their contribution to a process reengineering and optimization as well as knowledge sharing. Each process is evaluated in regard to how it is related to others.

An actor is an interventional resource, usually a person or a team, with special skills that enable them to fulfil tasks performing three kinds of actions: management, development and maintenance (Dietz, 2006; Zacarias et al., 2010).

Tasks are the fundamental unit of work, usually a job function, assigned to actors (individually or grouped) (Oh and Park, 2003). Tasks are associated to roles indicating the skills required to execute them.

Roles define a set of tasks performed for a defined organizational function that is accomplished by the development of defined skills (Jeston and Nelis, 2006; Oh and Park, 2003). A function can be described by code (description), competence and developed tasks.

Skills are a set of characteristics obtained from the acquisition, training and development of knowledge and abilities required to perform assigned tasks (Henderson and Venkatraman, 1993).

Information, applications and technological infrastructure refer to Enterprise Architecture concepts. In our research we have used the work around Enterprise Architecture, like an "expert skeleton", as a basis of our concept map (Lankhorst, 2009; Spewak and Hill, 1992): Information defines the fundamental organization data in a relevant organizational context, focusing on the required data for technical services; Applications are the fundamental set of software artefacts, services, and components, needed to fulfil an organization's requirements; Technological infrastructure groups equipment and hardware, providing the support to applications and information as well as describing the infrastructure.

Capability defines the capacity of an actor (group or individual), with a distinctive set of skills and the know-how to perform and create synergies (existent or prospective) with value to the organization. Capability can be described as: code, skills, and tasks, among others (Ljungquist, 2007).

Competence is a "cross-functional integration and co-ordination of capabilities" (Ljungquist, 2007) provided by roles, which implies a quality inherent to a cumulative hierarchy. Competence regards development and improvement as a primary focus, resulting from the combination of capabilities, skills and roles.

An organizational chart refers to hierarchical relations and vertical divisions based on a combination of functions to organizational optimization. It is a structure representation of roles competencies, reporting relationships, hierarchic levels and authority (Daft, 2004).

4.3 Conceptual Framework

A graphical representation outlines the conceptual definition clarifying ambiguous semantics in the model (Shanks et al., 2003). Therefore, a graphical depiction of an ontological representation (Figure 3) is a model (our conceptual framework) and models are effective artefacts to support communication and enable understanding (Zacarias et al., 2010).

The proposed conceptual framework uses the ontological defined concepts, providing a model for representing the real world through the relationship among these concepts. The defined concepts should be characterized with as many attributes as needed in each organization.

5 DEMONSTRATION

To demonstrate and validate our proposal, we applied it at the IT departments of two Portuguese

public organizations.

In the first organization there were two different departments with responsibilities related to IT that did not fit their purposes: subjects were simultaneously addressed to both departments; there was misalignment between the departments and between strategy and IT; users did not know which department to contact to support issues; problems in performance, communication, among others. To better the service level, the organization improved the IT departments' coordination with our conceptual framework in order to overcome the above-mentioned problems.

In the other organization the problems were related with misalignment between strategic objectives, services provided, and IT support. Without a clear definition of business services, activities were developed within the defined functions. Moreover, knowledge is rarely shared and changes are barely discussed. There was a high turnover rate of IT professionals leading to the loss of specific knowledge and skills. To diminish problems, a well-defined job description is needed, clarifying the required skills to perform expected tasks and accomplish the defined set of goals.

In both organizations, we started by sharing the proposal's framework with all personnel, edifying the issues we wanted to address and the expected benefits, involving and motivating people. We identified the domain of interest and from terms enumeration to concepts creation, we followed the ontology engineering methodology. We populate a single and shared common repository tool to support all concepts and their relations. We used IBM Rational System Architect as a repository tool and our conceptual framework as the meta-model.

6 EVALUATION

We evaluated our proposal using a Conceptual Model Quality Framework (Moody et al., 2003) along three quality categories (syntactic, semantic and pragmatic) and four components (domain, interpretation, language, and model).

The model presented in Figure 3 is the endpoint of the ontology engineering process. Along with it we involved practitioners in the creation of concepts from listed and enumerated terms. Therefore, the expressed concepts and their relationships have syntactic validity and provide the model's validity too. The followed methodology allows us to identify all relevant terms and from them create our concepts granting the model completeness. As the audience was composed of practitioners, we can conclude its pragmatic quality by the perfect interpretation. Despite the quality validation of the model, it is our intention to evaluate the proposed framework in a wider group of practitioners from other organizations. In the first case study we only evaluated the proposal's quality with the practitioners involved in the project. In the second one, we received criticism and contribution through a provided questionnaire with questions about the syntactic, semantic and pragmatic quality categories. Moreover, we asked a group of eight professionals, from four different organizational functions, to separately identify concepts related to the IT structure. After comparing the different proposals with ours, we concluded that our proposal has high quality. To the same professionals we gave our first list of concepts, without relationships, and asked them to establish those relationships, adding more concepts if they thought needed. With them we compared the different proposals against ours and, in all cases, the people involved in this experiment showed a preference for the quality of our proposal.

Therefore, we may conclude that the proposed conceptual framework has both validity and quality.

7 CONCLUSIONS

We developed and evaluated a proposal framework to structure an IT organization, using an ontology engineering research methodology to define concepts and relationships.

Our proposal to structure an IT organization ends in a conceptual framework, which constitutes an ontological reference. We propose a framework to identify concepts as an organizational ontology. In addition, our work can be used as an "expert skeleton" to further develop or adopt in other organizations.

Our goal was not to define ontological concepts, since we use much of the available identified concepts. Our main contribute was a conceptual framework developed to provide a model that enables definition and correlation between concepts enabling us to structure an IT Organization.

The proposal framework shows the alignment between concepts within an IT organization's internal boundary. Through the identification of concepts, the conceptual framework establishes a relationship among them in an ontological graphical representation providing us a reference and, thus, the end result is aligned with this goal.

Our future work aims at applying the conceptual

framework in other contexts and organizations. It is also our intention to present our work to other practitioners to obtain critical enhancements in order to improve the model and the development methodology.

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