Towards an Enterprise Ontology-based Approach to Information Architecture

Miguel Catarino Tavares

Under supervision of Prof. Doutor André Vasconcelos

and Prof. Doutor Artur Caetano

IST - Taguspark, Porto Salvo, Portugal

May 14, 2013

Abstract

The role of information has become increasingly important and crucial for organizations. Therefore improving the management of information has been a real concern for organizations, and for that reason the importance of Information Architecture (IA) on organizations has become very high. So, this work pretends to explore how can an organization create an IA, in the context of the Portuguese Public Administration (PA).

This work pretends to address this problem through an Enterprise Ontology (EO) approach by applying its methodology Design & Engineering Methodology for Organizations (DEMO). The EO focus its theory and application on the business essence of an enterprise, which means that is independent from the business implementation.

This work proposes to use the DEMO to create an IA and assesses if the result is a valid IA that is well accepted in the PA context. In order to demonstrate how DEMO can create an IA, the proposed methodology was applied in three case studies, namely, two Portuguese PA service providers and an on-line appointment application of a Portuguese public organization. In the end, we concluded that DEMO is a valid and reliable method to create an IA.

Keywords: Information Architecture, Enterprise Ontology, DEMO, Enterprise Architecture, Information Entities, Public Administration

1 Introduction

The importance of Information Technology to support business in organizations is a given fact nowadays [1]. The alignment between business and IT and the alignment among the various areas and architectures within IT is an important and difficult challenge for organizations, since many of them do not manage their information well. Taking this into account, it is important to understand the context of information within an organization. According to [2] the reliability of the information will greatly affect decision making and the organization itself. The importance of information is a crucial factor within both the business and organizational design domain [3].

The main motivation of this work relates with the impact and the importance of information for organizations and their business. Information plays a key role in organizations since it affects decision making, as well as the costs of the organization [2]. Information also affects the quality of service for the client, since is also very important when dealing with the client [2]. So to better manage information, an information architecture (IA) is essential for a more effective collecting, analysing, managing and sharing of information [2]. Taking this into account it is easy to conclude that the main objective of IA is to support business, and improve the alignment between business and IT [4].

The objective of this work derives from these concerns, in the context of Public Administration (PA), since PA is an aggregation of organizations and the management of their information is very important [5]. This means that this work pretends to address the concerns of developing an IA, in the context of PA, through an Enterprise Ontology (EO) approach, which is a new subject that analyses enterprises from a new and objective perspective focused on their essence, rather than its actual appearance [6].

1.1 Problem

The main problem is that there is not a specialized methodology or framework designed to achieve an IA. As [7] states, there is no organization or process for creating and sustaining an IA. There are some approaches to IA, but the problem is that they are focused on specific contexts. Many of the existing Enterprise Architecture (EA) frameworks approach the information layer, but do not focus and, more importantly, do not specialise in IA. So, the main problem that we propose to resolve in this thesis is:

The organization's struggle to create an IA with a well defined methodology.

With this in mind and taking in consideration the importance of information for PA, the objective of this work and what it proposes to achieve is a precise and efficient method to obtain an IA. The course chosen to achieve this purpose is through the fields of EOs and its application with the Design & Engineering Methodology for Organizations (DEMO) [8]. This new way of understanding en-

terprises and their relations with their intervening actors, through transactions, was mainly researched and developed by Professor Jan Dietz [8]. These fields approach enterprises from an ontological point of view and seek to analyse and design them as a whole, but lack focus and specialization on the IA. So, if the DEMO methodology was not conceive for the purpose of creating an IA, this leads us to the main question of this work:

Can Enterprise Ontologies, with the application of DEMO methodology, be used in order to achieve an Information Architecture?

Apart from this question, there are three more questions this thesis addresses, for the reasons that follows:

- Can we define a more efficient alternative to the DEMO text approach?
- Is the State Model (SM), in the context of Portuguese PA, a well accepted IA representation model?
- And also, is SM a better accepted IA representation model than a more common and well known representation model like the Unified Modeling Language (UML)?

Since the objective of this work is to achieve a method of achieving an IA for organizations, with special attention to PA organizations, the DEMO text approach might be considered a problem regarding an efficient approach. Considering that obtaining all the necessary information to thoroughly make a business description (DEMO text) is not always easy, specially for enterprises with a broad business scope, we considered that the DEMO text can become a constraint to the application of DEMO methodology.

Regarding the DEMO's SM there is the concern that this model may not be a good representation model as an IA, for the reason that DEMO methodology and World Ontology Specification Language (WOSL) are not very well known concepts, specially in the Portuguese PA, and because of that it may be difficult to understand these models [9].

1.2 Contributions

Taking into account the problem defined in the previous section the main contributions this work pretends to achieve are:

- Assess that an EO approach with the application of DEMO methodology is a valid method for the creation of an IA.
- Provide a simple, efficient and valid method for the creation of an IA, for the Portuguese PA.
- Provide a more efficient alternative for the DEMO text approach.
- Assess if the SM is a valid representation model for an IA, in the context of Portuguese PA.

2 Theoretical Background

In this section we address the main concepts of this work, namely, the Information Architecture (IA) and the Enterprise Ontology (EO).

2.1 Information Architecture

As this work aims to improve the definition and creation of an IA for the Portuguese PA, it is important and necessary to define what is an IA and what are its components. The concept of IA can be considered an ambiguous concept, since there is not a general consensus regarding its definition. As [10] once said, citing [11], one of the most obvious problems encountered in developing an IA is its broad scope.

In [12] is referred that IA describes the structure of a system, i.e., the way information is grouped and used within a system. Dillon defined IA as *"the process of designing, implementing, and evaluating information spaces that are humanly and socially acceptable to their intended stakeholders"* [13]. However, the adopted IA definition in this work was the one defined in [4], which states that an IA has the objective of identifying and defining the most important types of data that support the development of the organization's business. The goal behind the IA is to describe the different Information Entities (IE) necessary for the achieving of the business processes of an organization. According to [4] the IA should be composed by: IEs, Relationships, which must describe the type of relationship between the IEs, and the IE's Attributes.

2.2 Enterprise Ontology

Gruber defined ontology has an *"explicit specification of a conceptualization"* [14]. According to [15], in its modern use, ontology has preserved its original meaning of dealing with the essence of something. Dietz refers that the objective is to define the concept of EO through a notion of ontology that includes the dynamic aspects of a system, and that at the same time does justice to the nature of enterprises [8]. Dietz also defines enterprises as social systems, and their operating principle consists of the ability of human beings to enter into and comply with commitments [8]. This means, that the purpose is to understand the essence of the construction and operation of complex systems, more specifically, of enterprises [15].

3 Related Work

The EO theories application is made through the DEMO methodology. According to [15] the DEMO methodology is based on the Ψ theory, and takes into consideration the organization theorem. This methodology is composed by four distinct aspect models, which correspond to diagrams, tables and lists. The aggregation of these models constitutes the complete ontological knowledge of an organization. The DEMO models are:

The Construction Model (CM). The CM specifies the construction of the organization, more

specifically and according to [8], the CM of an organization *specifies its composition, its environment, and its structure.*

The Process Model (PM). The PM of an organization is, according to [8], *the specification of the state space and the transition space of the C-world.* This means that the PM specifies the transaction pattern for every transaction defined in the CM, and also the relations between transactions, and the participating actors [8].

The Action Model (AM). The AM consists of a set of action rules, which serve as guidelines for an actor [8]. These rules serve to define the actions the actors should take, but sometimes that does not happen. According to [8] the AM is the *basis of the other aspect models since it contains all information that is (also) contained in the CM, PM and SM.*

The State Model (SM). According to [8], the SM specifies *the state space of the P-world: the object classes and fact types, the result types, and the ontological coexistence rules*, that are contained in the AM. The SM may be viewed as the detailing of the contents of the information banks (coordination and production banks), which are part of the CM.

4 Proposal

Our proposal can be divided in three main phases: the first phase is a proposed alternative approach to the DEMO text, the second phase is the application of the DEMO methodology and lastly the third phase is an extra step in the validation process to have a better understanding of the SM quality as an IA.

So, this thesis proposal is to assess the validity of using DEMO methodology as a method to create an IA and therefore DEMO methodology is the proposed solution for this thesis main problem. However, to answer two other questions this thesis poses there was a change in the traditional input used in the DEMO methodology and an extra step in the validation process. So, in an traditional DEMO approach the input would be a DEMO text, but in this thesis we propose an alternative to this artifact. After applying the DEMO methodology and in the validation process we construct an UML version of the resulting SM and use it to assess the SM's level of acceptance by the evaluating stakeholders. In Figure 1 is represented the proposal overview.

5 Demonstration

This section aims to demonstrate the use of the proposal in different case studies. The first two case studies were applied to two Portuguese PA organizations, namely, Loja do Cidadão's service, named Balcão Multiserviços (BMS) and Loja do Munícipe (LDM) of Câmara Municipal de Almada. Both these organizations provide services to citizens and act as a front end intermediate between the citizen and other institutions to provide some of their services. The third case study was applied

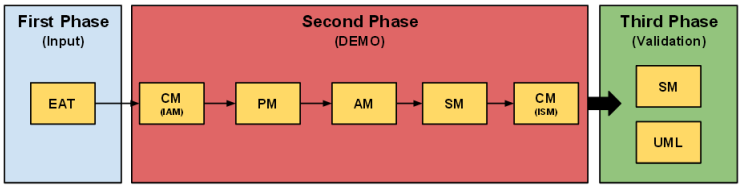
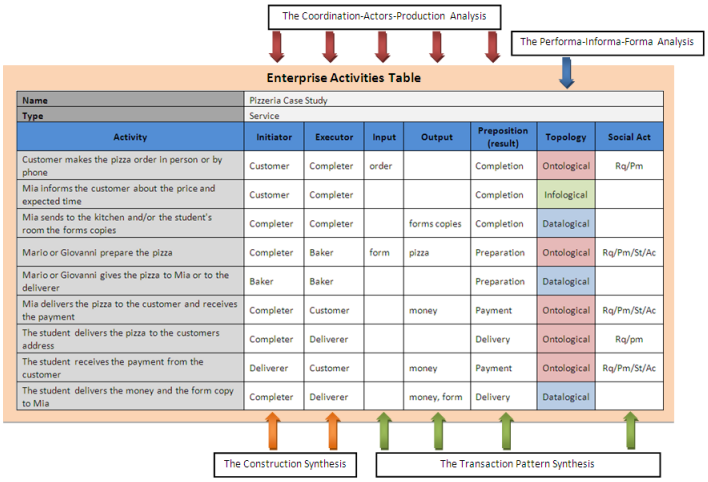


Figure 1: Proposal Overview



Name	Pizzeria Case Study						
Type	Service						
Activity	Initiator	Executor	Input	Output	Preposition (result)	Topology	Social Act
Customer makes the pizza order in person or by phone	Customer	Completer	order		Completion	Ontological	Rq/Pm
Mia informs the customer about the price and expected time	Customer	Completer			Completion	Infological	
Mia sends to the kitchen and/or the student's room the forms copies	Completer	Completer		forms copies	Completion	Datalogical	
Mario or Giovanni prepare the pizza	Completer	Baker	form	pizza	Preparation	Ontological	Rq/Pm/St/Ac
Mario or Giovanni gives the pizza to Mia or to the deliverer	Baker	Baker			Preparation	Datalogical	
Mia delivers the pizza to the customer and receives the payment	Completer	Customer		money	Payment	Ontological	Rq/Pm/St/Ac
The student delivers the pizza to the customers address	Completer	Deliverer			Delivery	Ontological	Rq/pm
The student receives the payment from the customer	Deliverer	Customer		money	Payment	Ontological	Rq/Pm/St/Ac
The student delivers the money and the form copy to Mia	Completer	Deliverer		money, form	Delivery	Datalogical	

Figure 2: EAT for the pizzeria case study (second phase)

to an appointment scheduling application. The case studies started with interviews and information gathering to create what we called the Enterprise Activity Tables (EAT) for each case study. The EAT is a business description structured differently from the DEMO text. It structures all the business's activities and applies the following analyses and synthesis: *The Performa-Informa-Forma Analysis* identifies if the activity is an ontological, infological or datalogical act. *The Coordination-Actors-Production Analysis* Identifies the intervening actors for each activity, taking into account the Performa-Informa-Forma Analysis and what is produced in the activity. *The Transaction Pattern Synthesis* identifies the transaction and the transaction type to which each activity belong. *The Construction Synthesis* identifies the roles for the intervening actors in each activity. In Figure 2 we present the EAT example for the pizzeria case study. From the EAT its extracted the transactions and the actors necessary to create DEMO's first models the ATD, consists mainly in the identification of the transactions and the actors that perform these transactions, and the TRT, which consists in transactions types and their respective result types identified from the analysis of the EAT.

After completing the TRT and the ATD we start to define the PM by creating the IUT and

the PSD. The PM consists in the specification of the transaction patterns for the transactions identified in the CM. Here is performed the *Transaction Pattern Synthesis*, which identifies the dependencies between transactions, because we need to know the dependencies between transactions in order to conclude the transaction patterns for those transactions. In the PSD its identified the process steps for each transaction and the relations within composed transactions.

With the PM completion we start the AM, which defines the possible actions an actor can make in each step of the PM, and the rules that define those actions. The definition of the rules for each process step, of each internal actor, must be considered by the analysis of all the gathered information about the case study.

Finally, we define the SM which consists in the specification of the object classes, the fact types and the result types, as well as the relations between them. The SM is represented by the OFD and the OPL, which can be interpreted as the representation of the object classes, the fact types, the result types and the relations between them, in the OFD case, an the object classes properties, in the OPL case. The internal object classes derive from the transaction's result types and the external classes are derived from the inputs and outputs of the transactions. The fact types must be analysed from each transaction. We then present the SM for the BMS case study in Figure 3 and Table 1.

The DEMO methodology ends with the creation of the ISM which consist in the BCT and the OCD. The BCT consists in the identification of the production banks for each object class, fact type and result type. The OCD consists in the identification of the production banks in the ATD model.

6 Evaluation

In the evaluation process of this work we used the Moody & Shanks Framework, which defines quality factors for a data model [16], and the feedback from the stakeholders of each case study. The Moody & Shanks Framework quality factor are [16]: **Completeness:** refers to whether the data model contains all user requirements. **Simplicity:** means that the data model contains the minimum possible entities and relationships. **Flexibility:** is defined as the ease with which the data model can cope with business and/or regulatory change. **Integration:** is defined as the consistency of the data model with the rest of the organization's data. **Understandability:** is defined as the ease with which the concepts and structures in the data model can be understood. **Implementability:** is defined as the ease with which the data model can be implemented within the time, budget and technology constraints of the project.

The assessment of this quality factors in the case study models was done by the respective stakeholders through a questionnaire, with an evaluation from "1" to "10" where "1" is very bad and "10" excellent. The questionnaire evaluated the qual-

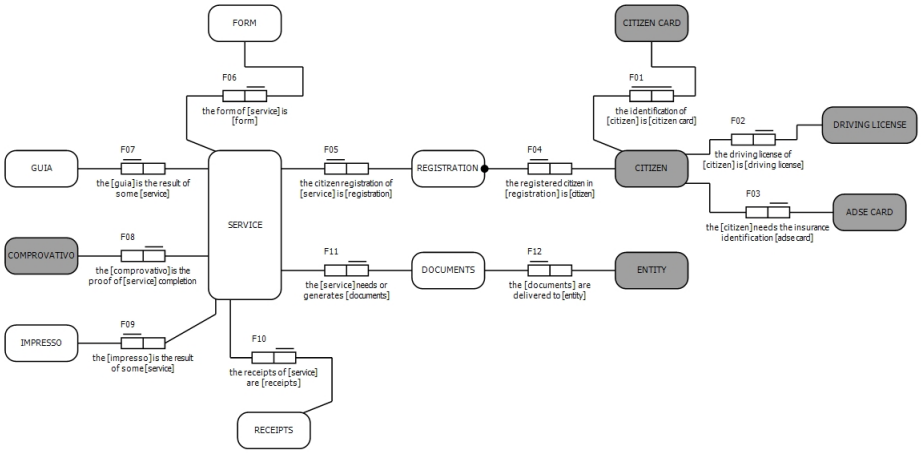


Figure 3: The OFD for BMS case study

Property Type	**Object Class**	**Scale**
NIB	CITIZEN	NUMBER
NIF	CITIZEN	NUMBER
NISS	CITIZEN	NUMBER
payment_value	SERVICE	EURO
type	DOCUMENTS	CATEGORY
photo	FORM	BOOLEAN

Table 1: The OPL for BMS case study.

ity factors of the models and evaluated the models as an IA as well. The implementability factor was not considered in this work because it implies that stakeholders know financial and technological information about the organization, which they may not have. In order to have a better understanding of the results and a better understanding of the SM quality as an IA we confronted the stakeholders with both the SM and a conversion of the SM to an UML modulation.

In the first case study, the BMS there was only one stakeholder evaluating the results an his evaluation to the SM as an IA was 10 and the UML evaluation was 9. In the second case study there were five stakeholders evaluating the results and the average result for each quality factor of the SM was: completeness 9, simplicity 8.4, flexibility 8.4, integration 9, understandability 8. Their evaluation of the SM and the UML as an IA is presented in Figure 4, in the left graphic.

The last case study was evaluated by three stakeholders that gave an average result for each quality factor of the SM of: completeness 6.33, simplicity 5, flexibility 4.67, integration 6, understandability 5. These results were due to the low evaluation of one of the stakeholders who did not comprehend the SM very well and therefore did not accepted it very well evaluating all the quality fac-

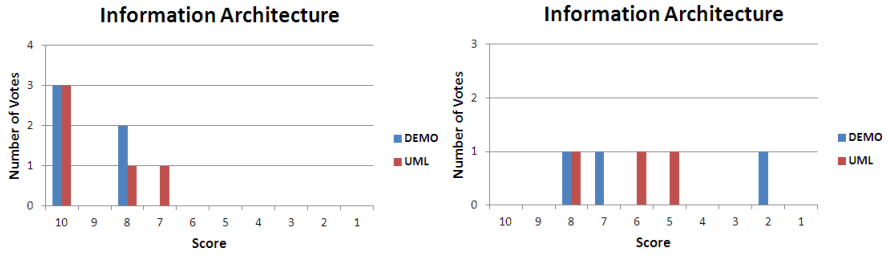


Figure 4: The IA evaluation of the second (on the left) and the third (on the right) case study

tors with 2. Otherwise the average result would be much higher. Their evaluation of the SM and the UML as an IA is presented in Figure 4, in the right graphic.

7 Conclusions

The increasing importance of information and its management for organizations the question of how can organizations improve and better manage their information arises. Therefore, a well designed and developed Information Architecture (IA), that maps the essential business information of an enterprise, has become an essential response to this information management.

After analysing the problem and the related work we decided to take an Enterprise Ontology (EO) approach to solve this problem, for two main reasons. First, the EO theory focus its analysis in the ontological layer of an enterprise and therefore in the business essence of an enterprise, disregarding its implementation, which suits well in the creation of an IA, which should focus in the business essential information. Secondly, the EO is a very academic researched and accepted concept, which gives this work a very acknowledged theoretical foundation.

In order to demonstrate how DEMO could create an IA we conducted three case studies. After analysing the feedback from the stakeholders and their evaluation to the results we arrived to the conclusion that an EO approach with a DEMO methodology application can be used to create an IA and this method is a valid tool for the creation of an IA, in the Portuguese PA. With the positive results we proved that our alternative for the DEMO text approach is a valid alternative, regarding the production quality DEMO models. Finally, we proved as well that, in the Portuguese PA, the SM is a good representation model for the IA as is a well accepted representation model, since only one of the nine stakeholders involved in the evaluation process gave a bad review to the DEMO results.

References

[1] A. Aerts, J. Goossenaerts, D. Hammer, and J. Wortmann, "Architectures in context: on the evolution of business, application software, and ict platform architectures," *Information & Management*, vol. 41, pp. 781 – 794, 2004.

[2] Erlin, Y. A. Yunus, and A. A. Rahman, "The evolution of information architecture," in *Information Technology, 2008. ITSim 2008. International Symposium on*, vol. 4, 2008, pp. 1 –6.

[3] J. A. P. Hoogervorst and J. L. G. Dietz, "Enterprise architecture in enterprise engineering," *Enterprise Modeling and Information Systems Architecture*, vol. 3, no. 1, pp. 03–13, July 2008.

[4] A. Vasconcelos, "Arquitectura dos sistemas de informacao: Representacao e avaliacao," Ph.D. dissertation, Instituto Superior Tecnico, 2007.

[5] AMA, "Agencia para a modernizacao administrativa: Arquitectura informacional," June 2011, versao 1.0.

[6] J. Dietz and J. Hoogervorst, "Enterprise ontology and enterprise architecture, how to let them evolve into effective complementary notions," *GEAO Journal of Enterprise Architecture*, vol. 2, no. 1, 2007.

[7] R. Watson, "An enterprise information architecture: a case study for decentralized organizations," in *System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on*, 2000, pp. 10 pp.–.

[8] J. L. G. Dietz, *Enterprise Ontology: Theory and Methodology.* Springer, 2006.

[9] P. Huysmans, K. Ven, and J. Verelst, "Using the demo methodology for modeling open source software development processes," *Information and Software Technology*, vol. 52, no. 6, pp. 656 – 671, 2010.

[10] J. C. Brancheau, L. Schuster, and S. T. March, "Building and implementing an information architecture," *SIGMIS Database*, vol. 20, pp. 9–17, July 1989.

[11] J. C. Brancheau and J. C. Wetherbe, "Information architectures: Methods and practice," *Information Processing & Management*, vol. 22, no. 6, pp. 453 – 463, 1986.

[12] M. Kirikova, "Towards flexible information architecture for fractal information systems," in *Information, Process, and Knowledge Management, 2009. eKNOW '09. International Conference on*, feb. 2009, pp. 135 –140.

[13] A. Dillon and D. Turnbull, *Information Architecture*. New York: Marcel Dekker, 2005.

[14] T. R. Gruber, "Toward principles for the design of ontologies used for knowledge sharing," *Int. J. Hum.-Comput. Stud.*, vol. 43, pp. 907–928, 1995.

[15] J. L. G. Dietz and J. Hoogervorst, "Enterprise ontology in enterprise engineering," *Proceedings of the 2008 ACM symposium on Applied computing SAC 08*, vol. 28, p. 572, 2008.

[16] D. L. Moody and G. G. Shanks, "Improving the quality of data models: empirical validation of a quality management framework," *Information Systems*, vol. 28, no. 6, pp. 619 – 650, 2003. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0306437902000431