Abstract

Organizations are constantly evolving. Changes in their environment are inevitable and change the way of working in various areas. A major objective of this work is to see how these changes affect or will affect the various projects or departments involved and how information systems are affected. This dissertation will use tools to help in the alignment between IT and business in order to allow a correct update of architectures.

The main objective of this thesis is to propose an evolutionary maintenance of the metamodel of our information systems from the public service, in order to meet the needs of our Public Administration. Given that each domain may have different needs in certain requirements specifications, we have to respond to these various changes with minimal changes possible and following well-established steps.

The evolution of this metamodel has been achieved through the study of multiple scenarios, following the different steps of the proposed methodology, we have provided a set of entities to evolve into a metamodel that is flexible.

Since all organisms are currently using this metamodel, it was necessary to create a set of primitives that provided an automation transition between the old model and the new model.

The end result of this work is a metamodel that can support the necessary extensions of the different areas of Public Administration, such as Health, Defense, Education, etc.. We used the tools EAMS from Link Consulting as a tool for representation and governance of the developed architectures and Archi from the Institute of Educational Cybernetics for the design of the architectures.

**Keywords:** Architecture, Public Administration, Primitives, Governance, Metamodel, Cost Savings, Efficiency.

1 Introduction

In the current times, enterprises prioritize the improvement in their information among their set of objectives [1]. The activities and processes, executed in the context of an organization, depend on the usage and management of information, bringing very high values associated with these practices.

Given these arguments, the information technologies are more and more important and have become such powerful tools to achieve goals that they constitute a large sum of every organization expenses [2].
Specifically, the agreement made by the Portuguese in the memorandum signed with the International Monetary Fund, the European Central Bank and European Commission, in the measure 3.46 propose in point ii): ii. «Rationalize the use of IT resources within the central administration by implementing shared services and reducing the number of IT entities in individual Ministries or other public entities. [Q4-2012].».

Nowadays, one of the biggest concerns of the organizations is the correct alignment between the IT and the business. The constant pressure to upgrade the information systems and optimize them is real and is increasingly important to deal.

Furthermore, within the public sector, the technologies systems can’t stop so every changes that are made, must be done in real-time with the minimum impact possible. Through the next sections we will address these problems, in the context of the Portuguese Public Administration, as well as provide the first glance towards a methodology to achieve the desired solution.

1.1 Problem

As said before the information technologies have become so powerful that a well-built architecture is needed for the maximum efficiency in any organization. This thesis focuses on the problem of developing a solution to model the evolved metamodel the Public Administration, which will be used as a tool to improve the efficiency of the different organisms of the Public Administration.

A metamodel is the foundation for that we’ll built architecture. It describes the background of an organization pointing out what is relevant and what level of detail we should be working.

Currently, the different organisms of the Public Administration are using a low-performance and outdated architecture. They require different models for solving different problems. However it is important that these models are compatible with each other, allowing a better articulation and integration.

It should also ensure that the final metamodel will be aimed to the achievements of each body of the Portuguese Services as well as done in real-time with the least possible intervention of humans to cause the minimal impact on the services.

After clarifying the context of the problem, we take place by defining the set of objectives associated with this work. In terms of objectives, this work will aim at answering to the two main questions Q1 and Q2 and their sub-questions:

**Q1: How can we model the evolved metamodel of the Public Administration?**

In order to answer this question, we had first to study which enterprise architecture modeling language we should use. Within the process of answering the problem, we determined that the architectural framework ArchiMate 2.0 was the more accurate for this work, given the good versatility and uniformity of his metamodel.

To provide a uniform representation for diagrams that describe enterprise architectures, the ArchiMate enterprise architecture modeling language offers an integrated architectural approach that describes and visualizes the different architecture domains and their underlying relations and dependencies.

ArchiMate is a lightweight and scalable language in several respects:
Its architecture framework is simple but comprehensive enough to provide a good structuring mechanism for architecture domains, layers, and aspects.

The language incorporates the concepts of the “service orientation” paradigm that promotes a new organizing principle in terms of (business, application, and infrastructure) services for organizations, with far-reaching consequences for their enterprise architecture.[2]

Given that we have a starting metamodel from our Public Administration, we had to proceed to a requirement elicitation of problems that the outdated metamodel had. Once we finished the requirement elicitation we undergo maintenance to evolve it.

All the modeling was done using the tool Archi\textsuperscript{1} from the Institute of Educational Cybernetics, since it is intended to provide a low cost entry (i.e. free) solution to users or even organizations that can’t afford expensive modeling tools.

Nonetheless, one problem arose with the maintenance of the metamodel. This problem was:

\textbf{Q1.1: How can we maintain track of the versions without using multiples models?}

Nowadays, this is one of the biggest issues that most companies have. They fail to have a tool that can organize the multiples models and therefore, leads to an effort greater than what should be required.

“…the truth is that companies fail to have such maps, claiming that update costs are simply too high given the rate of changes of the organization artifacts…” [3]

To keep this problem at bay, we used the tool EAMS from Link Consulting that allow the generation of blueprints, thereby clustering several models into one model using a timeline to visualize older modifications.

With both this tools, a solution was possible but it brought another problem:

\textbf{Q1.2: How can we transit models from the tool Archi to the EAMS?}

To overcome this problem, a parser had to be made that could translate all the information from the Archi models into information that could be read by the database from the EAMS. The database used was the EADB and the language used was the EALang, both developed by Link Consulting and its unit directed by Prof. Pedro Sousa.

Which it bring us to the second question regarding the automation of this work:

\textbf{Q2: What primitives are needed to make an evolutionary maintenance on the current metamodel of the Public Administration?}

In order to answer this second question, we had to resort to the primitives from the conceptual database modeling. Primitives are the building blocks which are used for design methodologies. They should be applicable to a variety of situations and environments, backed up by strategies that are applied in order to enhance them [4].

A set of primitives have been created in order to respond to this question. Which bring us to the sub-question:

\textbf{Q2.1: What strategy is the most efficient to apply during the evolutionary maintenance?}

\textsuperscript{1} http://archi.cetis.ac.uk/, accessed on 03-07-13.
Between the four strategies: *Top-Down, Bottom-Up, Inside-Out, Mixed*; a obvious question arises: *Do the four strategies always lead to the same final schema?* Of course the answer is negative, since each strategy follows a specific design philosophy. Indeed, even adopting the same strategy, we may happen to model the same requirements in very different ways [4].

Due to the nature of the strategies, we had to choose the one with more flexibility in order to enhance the set of primitives used.

Since we had access to the initial version of the Public Administration metamodel and after the requirement elicitation, we had all the means necessary to perform the evolutionary maintenance. All that was left was to create and apply the set of primitives to this metamodel.

By answering all these questions we successfully address the problem underlying, and are able to evolve the metamodel for the Public Administration.

2 Related Work

This section is aimed at providing a formal definition of the concepts that served as a starting point of this work. We will start by the theoretical concepts; the Public Administration and enterprise architecture, since they are the most connected to this work. Afterwards, we will approach the practical concepts since this work resolves around the usage of these specific concepts, with the objective of achieving an evolutionary maintenance.

2.1 Public Administration

Whenever people co-operate to achieve some ends, the activities which they have to perform to achieve the goal in view, it is administration. Public Administration is a particular area of the broader field of administration. It is administration of the governmental affairs. It includes activities like the collection of tax by the Income-tax Officer, the arrest of a criminal by the police, construction of public roads, highways, bridges, canals, etc.

The Public Administration can be described as the management of public programs. Public Administration as we know it today began as the study of Government Administration, and that study began as part of late-nineteenth-century efforts to reform governmental operations.

Even though work in public and nonprofit organizations is guided by commitments to democratic ideals, it is also involved with management, and, for that reason, Public Administrations is often confused with business management. Indeed, such confusion has occasionally been prominent in the field of Public Administration. Certainly, there are some similarities between business and public administration. Managers across all sectors - public, private, and nonprofit - are involved in questions of organizational design, the allocation of scarce resources, and the management of people. [5]

It is distinguished from other forms of administration by the fact that its ultimate purpose is general interest and public good. It is the activity of the State in the exercise of its political powers. In a narrow sense, it is the activity of the executive departments in the conduct of the Government. Thus Public Administration is primarily concerned with the implementation of public policy laid down by representative of political bodies. Its main task is the implementation and enforcement of public policy and the law of the State.
Therefore, a system of public administration is the composite of all the laws, regulations, practices, relationships, codes and customs that prevail at any time in any jurisdiction for the fulfillment or execution of public policy. [6]

2.2 Primitives

The design of a conceptual schema is the result of a complex analysis of user requirements. As a consequence, the schema is usually produced by an iterative process. During such a process, we start from some draft version of the schema and perform a set of schema transformations that eventually produce the final version. The situation is similar to what happens in software design, where the final program is usually produced by performing a set of transformations that enrich, in a series of steps, a first-draft version of the program.

Primitives are classified in two groups, top-down and bottom-up. Top-down primitives correspond to pure refinements; that is, refinements that apply to a single concept (the starting schema) and produce a more detailed description of that concept (the resulting schema). By contrast, bottom-up primitives introduce new concepts and properties that do not appear in previous versions of the schema. [7]

2.3 Archi (Institute of Educational Cybernetics)

After a careful analysis, the chosen modeling tool was Archi\(^2\) from the Institute of Educational Cybernetics\(^3\). There were three main factors leading to this decision.

Archi is a free, open source, cross-platform tool and editor to create ArchiMate models. Archi is targeted toward all levels of Enterprise Architects and Enterprise Modelers. One of the main factors of this work was to provide the most cost-efficient solution to organizations with low budgets that are looking for a cross-platform ArchiMate modeling tool.

Archi fulfills the needs of most Enterprise Architects and associated stakeholders, but it can also be regarded as an introductory ArchiMate tool for those wishing to engage with the language before committing to a commercial solution. Since Archi is an easy tool to use and to model ArchiMate solutions, it will be easy for organizations to adapt it.

Since its introduction, Archi has been widely adopted for real-world use in the commercial and educational sectors and is used in-house by major global companies and consultants. It is rapidly becoming the de facto open source ArchiMate modeling tool. Another reason is due to its fully alignment with TOGAF\(^4\).

2.4 Enterprise Architecture Management System (Link Consulting)

Enterprise Architecture Management System (EAMS)\(^5\) is an enterprise architecture tool produced by Link Consulting\(^6\). EAMS was the tool used to visualize the models developed during this work.

Using the same modeling tool (Archi) to visualize the models was proven insufficient due to the common problem in most of the architecture tool – there isn’t an effective

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2 http://archi.cetis.ac.uk/, accessed on 18/07/2013
4 http://www.opengroup.org/togaf/, accessed on 18/07/2013
5 http://www.link.pt/eams/, accessed on 18/07/2013
6 http://www.link.pt/, accessed on 18/07/2013
way to see the changes (As-Is & To-Be) that are being made in the models. There is always the possibility to open simultaneous views in the same tool, but it’s not practical and not efficient enough.

EAMS give the possibility to visualize the As-Is and the To-Be through a life cycle bar, tackling the problem of having several files to see the changes made through time on the models. Given this terms, EAMS was the solution proven most efficient. Due to the environment which this work was developed and the full support from Link Consulting, there were no costs associated with the use of their tool.

During the course of this work, there were several implementations made, one of them was the possibility of integrating parsers with this tool (Fig. 6). Since we were using Archi as the modeling tool, we had to create a parser that would integrate with EAMS and could transform files from Archi to his data sources.

2.5 ArchiMate Framework 2.0

The unambiguous specification and description of enterprise architecture’s components and especially of their relationships requires an architecture modeling language that addresses the issue of consistent alignment and facilitates a coherent modeling of enterprise architectures.

The role of the ArchiMate standard is to provide a graphical language for the representation of enterprise architectures over time (i.e., including transformation and migration planning), as well as their motivation and rationale. The evolution of the standard is closely linked to the developments of the TOGAF standard and the emerging results from The Open Group forums and work groups active in this area. As a consequence, the ArchiMate standard does not provide its own set of defined terms, but rather follows those provided by the TOGAF standard [8].

A key challenge in the development of a general metamodel for enterprise architecture is to strike a balance between the specificity of languages for individual architecture domains, and a very general set of architecture concepts, which reflects a view of systems as a mere set of inter-related entities.

In this work, the metamodel from the ArchiMate 2.0 Specification was used as the foundation to perform the evolutionary maintenance on the metamodel of the Public Administration. It can be divided in three principal layers and two extension mechanisms. The core concepts of ArchiMate focus on describing the architecture of systems that support the enterprise. Not covered are the elements which, in different ways, motivate the design and operation of the enterprise. These motivational aspects correspond to the “Why” column of the Zachman framework [9]. Each of these layers have specific rules.

3 Proposal

In this chapter we present the different set of steps included in our proposed methodology for evolving the metamodel, which we followed during the execution of this work, whereas in the previous chapter we presented the scientific methodology used while developing this work. It is therefore imperative for the development of the solution to be aligned with the methodology in order to enable its application. Facing the problems identified on section 1.2, considering the related work on chapter 2 - particularly the Archimate Framework 2.0, and the evaluation methodology to be applied, we devised a coherent sequence of steps/phases that allowed the obtaining of a solution.
The development of the solution started with a transformation of the current metamodel aligning with the Archimate framework, from which resulted the solution of this thesis. During the next sections we provide further insight on each of the steps of the proposed methodology, as well as on the work realized in them.

3.1 Context

We aimed at defining which concepts of the public administration we want to target and what steps are needed to create the solution for this work. This includes not only the steps taken to evolve the metamodel of the public administration, which represent an important role of this work, but also the tools created and used directly related to the process of the evolutionary maintenance. The concepts served as basis for this work are enumerated as follows:

**Business Layer:**

Serviços de Negócio; Processos de Negócio; Entidades Informacionais; Localização; Organização; Contratos

**Application Layer:**

Soluções

**Infrastructure Layer:**

Comunicações; Software; Serviços Tecnológicos; Artefactos; Equipamento

For each of these concepts we proceeded to its representation using the ArchiMate Framework 2.0 from a set of gathered data, e.g., project documentation and meetings with people enrolled at AMA. Here, we were able to gather different sets of information that allowed us to create a vision of the As Is.

Furthermore, to be possible to relate each concept to the process of being born or death, in the tools developed, we had to create a set of rules so that the users could easily define the birth date and death date. Thus, some properties types had to be associated to the modeling tool Archi.

Each of these property types is read by the tool created in this work and transformed in the language EALang, which is read by the data source of the visualization tool used. This process can be seen in figure 1:

![Figure 1: Process of the work of this thesis](image-url)
3.2 Analysis

Next, in analysis, we reunited and cross-reference the information gathered from the previous step and, using Archi as the modeling tool, proceeded to the representation of the concepts gathered and their properties, in a structure manner. Also, after further gathering information and with the start of the development of the parser, this triggered the end of the definition of the As Is, and started the processes of definition of the To Be. Each of the specific concepts of the public metamodel was represented using a specific concept of the Archimate Framework, and for each concept, the corresponding properties were assigned.

The same procedure was followed to deal with the more detailed concepts, this time by creating elements for each corresponding concept of the metamodel. Once the model was finished, we would proceed to his validation with the Archimate 2.0 metamodel, so that in the future, all the instances created would follow the rules established by this framework. At this point, we had enough information about each concept, a representation and a structured evolution of the metamodel. None the less, we had already developed work around the subject of traceability, and identified the relations inside the concepts analyzed. This was a necessary step towards understanding the relations between each of the concepts.

Once the parser was finished, and all the rules for implementation in EADB were met, we could initiate the process of the work of this thesis.

4 Demonstration

4.1 As-Is

As described earlier, this work was developed in collaboration with AMA, the agency responsible for the execution of the project of the metamodel for the Portuguese Public Administration. Despite the fact that this metamodel is currently being used, it is not organized, not perceptible and can induce a lot of errors. There is no division between the business, application and infrastructure layer. This metamodel provided us the initial basis to work on.

This architecture aims at providing a basis for each organization to develop its own architecture, giving the necessary support, and facilitating the use of common code and language through the different organizations [10]. The presented architecture gave us a formal basis to work on, providing us with a perspective into the problem, and allowed us to use it as starting point towards evolutionary maintenance, with the objective of accomplishing our work's goals and contributions already defined.

4.2 Proposed Changes (To-Be)

In this section we present the proposal of the evolutionary maintenance of the public administration metamodel to integrate with the ArchiMate metamodel entities. All the proposed changes are implied in the sheets provided by the organization AMA in conjunction with the propositions made during the meetings.

In order to assess the list of modifications proposed to the actual version of the public administration metamodel, we must first consider the methodology our work was based on, the type of work developed, the intermediate results achieved, and the context of the work. Hence the evolution of the metamodel was based on the ArchiMate 2.0 framework. This option allowed us to add the concepts that were necessaries to the importation of the existing information. In the current metamodel there are several concepts that may mislead information as referred in section 5.1. ArchiMate divides the
metamodels in 3 main groups - Business Layer, Application Layer, and Infrastructure Layer. Each of these layers is compromised by several concepts (chapter 2, section 2.3.2). Since our goal was to evolve the metamodel into a more clear, rule-based and well-constructed metamodel, we started by analyzing the main concepts that were fundamentals to the public administration. We divided, as the ArchiMate metamodel, into the three main groups and created the respective concepts. Afterwards, we specialized each of the main concepts, going one level lower, allowing us to be more detailed. Finally, in the infrastructure layer, some concepts needed even more detail, requiring going one more level lower. In the end, the evolved metamodel is simple with a well-built structure and rule-based. The primitives were used in order to make a part of this work the more automated as possible. After the information is parsed and added to the database, the primitives will transform the information from the current metamodel to the evolved metamodel. In this section we will demonstrate the types of primitives used and the operations they will perform.

4.3 Archi2EALang

The solution Archi2EALang is a real-world implementation of this thesis subject. The solution was developed by the author as a collaboration of Link Consulting. Some of its capabilities and functionalities go beyond the scope at hand and are the result of collaboration with other colleagues and students. The descriptions here addressed concern only designs and implementations done solely by the author.

5 Evaluation

In order to evaluate our proposal [11] and to get some feedback on our design decisions, we used semi-structured interviews [12]. These interviews and questionaries’ are presented in the appendix 1. In the next two sub-sections we explain how we conducted those interviews and present the main results.

5.1 Interviews

We conducted a total of six interviews. During those interviews we explained our proposal and collected the interviewees’ overall evaluation and feedback.

These were the main conclusion of our interviews:

The vast majority agreed that the evolved metamodel was much more organized and of simple perception. The evolved metamodel is substantially better, more organized, more perceptible, with the correct division between the various layers (Business, Application, Infrastructure).

Most agreed that all the process starting from Archi and finishing at EAMS was simple and efficient. There were no misunderstandings of what each step of the process do and if needed, how to change it to be more aligned with the goal of the user.

Lastly, the solution provided fully attended the request of low-budget. Any plan to change the process of how the solution parse the information or if the solution is updated in the future, should be handled with extreme caution, so that the current implementations still continue aligned and working with the several goals of the users.

6 Conclusion

This chapter will look at some of the ways in which the knowledge-making demands of the research.[13] It will summarizes our thesis’ main contributions, limitations and lessons learned. The results we obtained during our Evaluation step were quite positive
and encouraging. Taking into consideration these results, we consider that our solution met its initial objectives.

The Portuguese Public Administration is being target of a modernization initiative which, among other aspects, contemplates the development of a metamodel. This action aims at addressing the incompatibilities existent between different information systems, on different departments, and their inefficiency in terms of dealing with information. There is a need for developing a metamodel with a good set of rules based on a respected framework, so that it can be perceived which are the entities and departments enrolled in the manipulation of the several concepts associated with business, application and infrastructure. Therefore, this will improve the work efficiency as well as the experience perceived by all the departments of the Public Administration.

With this work, we began by clarifying the problem and establish the motivation towards the solution. Then, we researched on the themes of the enterprise architecture, information parsing, state of the art languages and frameworks that allowed us to develop a coherent work. We researched on the scientific investigation methodologies that we used to support our work on scientific basis, and therefore guarantee its validity and continuity. The Design Science Research Methodology (DSRM) methodology has proven to be useful since an early stage of this work, and the solution's architecture is also aligned with its steps. After having a sense of perspective into the context of the work and the approaches to be taken, we devised a methodology for working towards a solution, with support on activities and objectives defined for each step. By using the knowledge gathered under this phase, and by applying it into the further development of the work, we were able to analyse and process the different data gathered and ultimately provide a revised version of the existent architecture, with improvements based on the entire work we developed. Finally, and after achieving our objectives, we adopted a critical perspective and made considerations about the work developed and eventual opportunities of improvement in future work around the subject. The subject and context of this work, as well as the people with whom we worked, were a sincere motivation towards its realization and completion. None the less, the fact that we integrated a project of significant dimension, already on the move, with multi-disciplinary teams and organizations involved, and for which there is a real need, put us in a position where we had the means and level of participation of the different intervenient that allowed us to perform the planned activities and with relative flexibility. Sometimes the elevated dimension of the project also proved to be a problem, especially while shifting between organizations. As we know, with sensitive materials there is always a pipeline of approvals that need to be granted and all that consumes a valuable resource: time.

We always had the notion that this was an ambitious work. In this case we were capable of developing relevant work for both the academic community and the professional world, for who we hope that our contributions prove useful. Finally, and on that note, we would like to leave the challenge open to anyone who continues working on this theme, to attempt to evolve and enrich this solution. We are positive that its contribution to the related work on the area would be enormous, as well as a very differentiating factor and solid base to develop similar future work.
References


