A PROPOSAL TO A FRAMEWORK FOR GOVERNANCE OF ICT AIMING AT SMART CITIES WITH A FOCUS ON ENTERPRISE ARCHITECTURE*

Sergio Akio Tanaka
Centro Universitï£¡rio Filadï£¡lfia - UNIFIL
Universidade Estadual de Campinas - UNICAMP
Brazil, Londrina
sergio.tanaka@unifil.br

Rodolfo Miranda de Barros
Universidade Estadual de Londrina-UEL
Brazil, Londrina
rodolfo@uel.br

Leonardo de Souza Mendes
Universidade Estadual de Campinas - UNICAMP
Brazil, Campinas
lmendes@g.unicamp.br

ABSTRACT

This paper presents a proposal for a framework for Information and Communication Technology governance aiming at smart cities with a focus on enterprise architecture. A case study in the area of education was chosen to present a view of the modeling in archimate language. Five enterprise architecture implementation methodologies were reviewed. Eleven axes were recognized and compared with other methodologies to evaluate the maturity level of city governance. This led to a questionnaire of diagnostic assessment to identify the maturity level in city councils. This method generated the score of each axis, which allowed visualization of the maturity model of council governance. The results showed that the organizations diagnosed in relation to the eleven defined axes are between 11.43% and 58.22%, with the objective of reaching 100% for a high-performance rate in relation to the enterprise architecture.

KEYWORDS

Maturity model, enterprise architecture, framework, smart cities.

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1 INTRODUCTION

We live in the convergence of two relevant phenomena in the history of mankind: the acceleration of global urbanization and the digital revolution. The complexity of sustainable urban development management demands solutions in the areas of education, health, safety, transportation, energy, sanitation and other challenging sectors, such as population growth in the coming years [3].

Sustainable city planning, management and governance, maximizing economic opportunities and minimizing environmental damage are major challenges that countries will be presented in this new century. Therefore, turning traditional cities into smart cities is an increasingly important demand.

A smart city is an innovative city that uses Information and Communication Technology (ICT) and other means to improve the quality of life, the efficiency of urban operations, and services and competitiveness [15]. Enterprise Architecture (EA) is a discipline that helps companies analyze, design, plan and implement their actions using ICT to obtain satisfactory development and execution of their strategies [11].

This paper aims to present the proposal of a framework for EA aiming at smart cities. The creation of this framework was based on the study of several other models. Based on the best practices of these models, a new framework with a greater scope in relation to its architectural elements was proposed. Among all the researched frameworks, two were selected to complement the proposed framework, The Open Group Architecture Framework (TOGAF) and Archimate Modeling Language.

Having defined the EA model, it is necessary to ensure it is executed the way it has been planned. ICT Governance (ICTG) provides the support for this execution. ICTG can be defined as the specification of decision-making rights and the framework of responsibilities to stimulate desirable behaviors in ICT.

ICTG is not the decision-maker itself in the ICT process, but it determines the ones responsible for the decisions according to the organization?s policies, determinations, goals and culture. ICTG covers the organization in its entirety, not only in its ICT assets, but all stakeholders as well [11].

2 RELATED WORK

2.1 Comparison EAIMs

It is essential to discuss architectural frameworks when it comes to EA. These frameworks are models that assist in the development, creation and implementation of EA. The frameworks covered in this work are as follows: The Open Group Architecture Framework (TOGAF), the Federal Enterprise Architecture (FEA), Enterprise Architecture Planning (EAP), Department of Defense Architecture

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Framework (DODAF) and Gartner. Table 1 presents a comparison that was made by [5] and [12] in relation to the enterprise architecture implementation methodologies (EAIM), such as: TOGAF, FEA, EAP, DODAF and Gartner.

The axes used in the framework comparison were as follows: concepts, modeling and process. The notation H is used for a high level of detailing, M is used for a medium level of detailing and L for low level of detailing.

Table 1: Comparison EAIMs

	EAP	TOGAF	DODAF	Gartner	FEA
Concepts					
Alignment	L	M	M	M	L
Artfacts	M	H	M	M	M
Governance	M	H	M	M	L
Repository	M	M	M	M	M
Strategy	H	H	H	M	H
Modeling					
Easy to use	M	L	M	M	M
Easy to learn	M	L	M	M	M
Traceability	M	H	L	L	M
Consistency	M	H	L	L	M
Different Views	M	M	M	L	M
Complexity	L	L	L	L	L
Dynamic	L	L	L	L	L
Process					
Requirement	L	H	L	L	L
Step by Step	M	M	M	M	M
Detailed Design	M	M	M	M	M
Implementation	M	M	M	M	M
Guidelines	M	H	M	L	H
Maintenance	L	M	L	L	M
Continual	M	H	L	L	L

Notation: H: high consideration or detailed and clear description M: medium consideration or little description L: low consideration or low level description

2.2 The relationship between the Archimate Language and the TOGAF

The Open Group Architecture framework TOGAF [8] was the model used in the development of the proposed framework. This paper focused on the business architecture layer. Figure 1 shows a simplified mapping of how the archimate language can be used in relation to the phases of the TOGAF [8, 9].

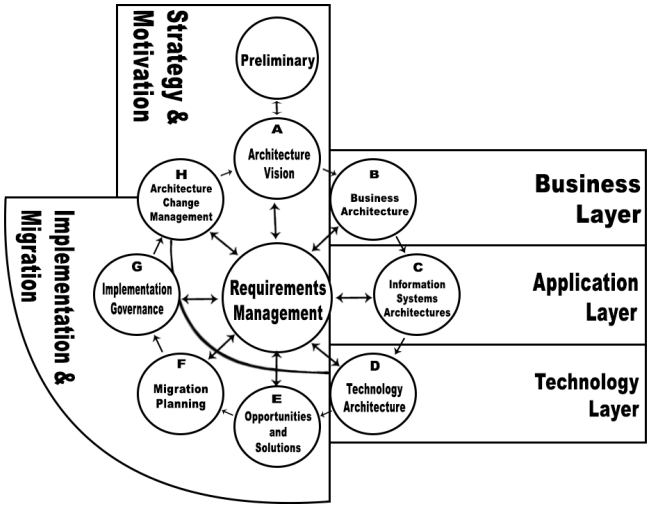

Figure 1: The relationship between the ArchiMate Language and the TOGAF ADM

> "The role of the archimate specification is to provide a graphical language for the representation of EA over time (i.e., including strategic, transformation, and migration planning), as well as the motivation and rationale for the architecture.
>
> The business, application, and technology layers support the description of the architecture domains defined by the TOGAF framework (business, information systems, and technology, as well as their inter-relationships)" [10, p. 15].

Figure 2 shows the archimate framework that was used for modeling the case study presented in section 3.2. Archimate is an open independent modeling language which provides a body of knowledge to support any organization that uses EA.

Figure 2 shows the aspects of the framework, such as the passive structures, behavioral elements, active structures and motivation. These aspects combined with the six layers mentioned form a framework of nineteen cells. This is known as the archimate full framework [9].

The motivational aspect deals with the interests of the organizations stakeholders, their motivations and project goals based on the results and evaluations, listing their requirements, principles and constraints.

The strategic layer is responsible for listing the organization's action plans, capabilities and resources. The business layer is responsible for listing all functions, services and processes in order to deliver a product within an organization.

The application layer covers all systems within an organization, as well as their functions, processes, and services. The technological layer has the role of mapping all the technology of the organization. The physical layer does the whole infrastructure project of the organization.

This work modeled the view of the motivational elements and the six layers. It presents only a partial view of the motivational

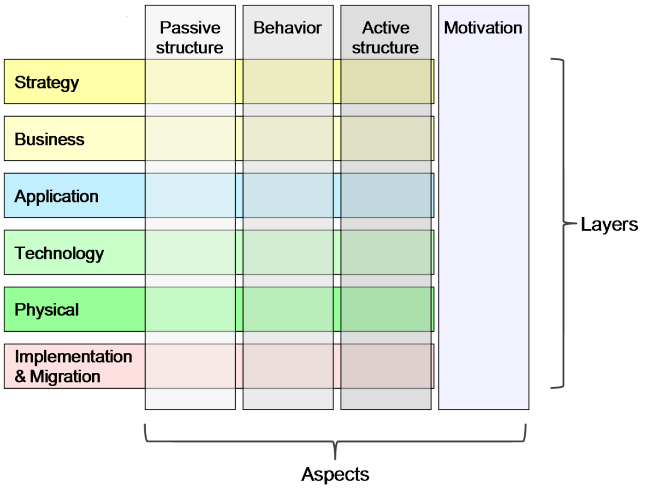

Figure 2: Archimate full framework

aspect and the modeling of the layer implementation and migration [9].

2.3 A Comparison of the axes in relation to the Maturity Level of the EA

The mechanism of analysis developed is based on the axes of ICT governance efficiency presented by [4]. These axes define characteristics that must be met in order for the GTIC to be properly developed. The analysis takes place in two moments. Initially by the application of a questionnaire and, in a second moment, by the qualification of the organization with respect to the axes of efficiency. Eleven axes were defined to compose the proposed framework, which were: infrastructure, training, models, business process, deliverables, strategic alignment, metrics, perception, risk management, digitalization and organizational culture.

The questionnaire proposed for conducting the analysis has the objective of extract-ng information about the organization and how the operation of its ICT takes place. With this purpose, it relates aspects relevant to ICT governance with everyday situations in organizations, so that the answers are always objective. Since no preexisting questionnaire was found with these characteristics, one was prepared based on the CobIT and ITIL v3 models. In order to achieve effective ICT governance, which meets the defined axes, mechanisms should be used to support its implementation [14]. Based on this study, eleven axes were defined to compose the proposed framework.

To validate the defined axes some comparisons with other models were made. Table 2 shows a comparison of the axes in relation to the maturity level of the EA [4, 6, 13]. The objective of the comparison was to verify the existing axes used in the GTIC as a way to complement new axes as it happened in this work.

Table 2: Comparison between the Axes

Gartner (2013)	Brigano (2015)	Minodora (2012)	Designed Framework
Support and Involvement	-	-	Infrastructure
Team Resources	IT Resources		Training
Development Method	-	-	Framework (Model)
Process Integration	Responsibilities	Internal processes	Business Process
Deliverables	Value of IT		Deliverables
Governance	Strategic Align	Learning and development	Strategic Alignment
Metrics	Performance	Key Performance Indicators	Metrics
Perceptions	-	-	Perceptions
-	Risk Management	Financial	Risk
-	-	-	Digitalization
-	-	-	Organizational Culture

3 MODEL VALIDATION

In order to reach the objectives and to succeed in the use of EA, it is necessary to know the level of ICT maturity in city councils. The digital government maturity model can be used as a key framework to both set and manage the direction of the digital government transformation program which consists of five levels: initial, developing, defined, managed and optimizing [7].

A questionnaire with twenty four questions about EA was developed and applied in seven city councils (Municipal Administrations, MA) with the aim of understanding their level of maturity. After the mapping was done by the Gaia project algorithm [4], Table 3 was generated with the maximum and minimum possible values in the efficiency axes.

For each questionnaire question, weights P were attributed to each axis, ranging from 0 to 4 which represents the impact of the question generated in the axis. For example, weight 0 represents minimum or non-existent impact, while weight 4 represents maximum impact.

As well as in the axes, multiple factors F were defined for each alternative. Each question has a variable quantity of alternatives. Each alternative has a multiplicative factor that indicates if it implicates in a positive or negative result in the axes. The multiplicative factor ranges from -3 to 3. Table 3 represents the minimum and maximum scores of each axis.

These scores were defined by solving the questionnaire at its worst (minimum) and best (maximum) case. For example, for each question the alternative with the smallest multiplicative factor is chosen for the worst case, whereas for the best case the alternative of a larger multiplicative factor is used.

Each question has an individual score for each axis. This score is obtained by multiplying the axis weight by the multiplicative factor of the chosen alternative.

At the end of the questionnaire, all the scores collected for each axis are summed up. Thus, a general score of the axis is obtained between the minimum and the maximum values.

Table 4 presents the percentage values obtained by each axis according to the answered questions. The percentage values indicate

Table 3: Maximum and minimum possible efficiency axes

Axis	Min	Max
Infrastructure	-74	84
Training	-170	180
Framework	-210	228
Business Process	-216	234
Deliverables	-207	225
Metrics	-144	159
Strategic Align	-192	210
Perceptions	-187	201
Digitalization	-106	117
Risk Management	-118	129
Organizational Culture	-235	252

Table 4: Search application results

AXIS	MA1	MA2	MA3	MA4	MA5	MA6	MA7
Infrastructure	47,47%	48,10%	50,63%	56,33%	18,99%	46,20%	44,30%
Training	21,71%	36,00%	50,29%	53,71%	11,43%	32,00%	22,86%
Framework	24,66%	42,92%	47,49%	54,79%	13,70%	35,62%	21,92%
Business Process	29,78%	46,67%	49,78%	58,22%	15,11%	40,00%	22,89%
Deliverables	28,24%	43,06%	47,92%	53,94%	13,89%	35,19%	23,38%
Metrics	26,07%	43,89%	45,54%	47,52%	17,82%	40,59%	28,05%
Strategic Align	27,86%	49,25%	54,48%	58,21%	16,92%	44,78%	24,38%
Perceptions	29,64%	47,42%	57,47%	57,99%	18,56%	48,20%	25,77%
Digitalization	34,98%	38,12%	51,57%	47,53%	19,73%	52,91%	32,29%
Risk Management	35,22%	48,18%	50,61%	55,47%	21,86%	53,85%	34,41%
Organizational Culture	28,75%	45,79%	51,95%	56,67%	14,78%	43,53%	21,56%

the relevance level given by the city councils to the axes according to their strategies.

In order to obtain these percentage values, the general score of the axis is applied to a Value Range (VR) that equals maximum value of the axis (MVA) subtracted by its minimum value. For example, with a minimum = -74 and a maximum = 84, the value range would have 158 values, as 84-(-74) = 158. Therefore, the value 158 represents the quantity of values the general score of the axis may take.

Figure 3 presents a bar chart comparing the seven city councils (MA) based on the percentages showed in Table 4.

3.1 An EA Framework for Smart Cities

Figure 4 presents a framework for EA for smart cities.A framework for EA is the mapping of the whole process of the company's development and how it interacts with the company's mission, provides the corporation with the ability to understand and analyze weaknesses and inconsistencies in their processes and also solve them [1].

The advantages in terms of its use are organizing the initiatives of a corporate architecture, standardizing the terms and language, accelerating the operation and reducing the complexity, integrating solutions, suppliers and different teams in a more harmonic and structured way, facilitating communication of the vision and of the plans for the entire corporation and identifying ICT alignment with business guidelines.

To validate the developed framework, the same was applied in one of the city councils with the objective of identifying the situation of its ICT governance and seeking solutions to improve it.

Initially, it is necessary to define the business strategy. Compliance, legal aspects and risk management are then specified. Based on these specifications, society and capability are modelled.

Society is composed by citizens, government, companies and organizations. Society today has demanded more control, monitoring and transparency in planning and management from organizations with a view to improving services and reducing bureaucracy. Compliance, legal aspects and risk management integrate the processes in the organization, which makes business strategies unified and transparent.

The capability map enables the Business Architect to create a framed overview of the capabilities of the enterprise. This map shows two or three levels of capabilities across the entire enterprise. Areas requiring investments can be identified by a heat map [2].

After defining the previous elements, the business, information, application, infra-structure and program/project architecture are then planned. These elements are collections of interconnected architectonic domains.

Business architecture defines the results, functions, resources and business processes of the organization, and its relations with external entities necessary to execute the business strategies. Information/data architecture corresponds to the structure and utility of the information into the organization and its alignment with strategic, tactical and operational needs.

Application architecture specifies the structure of software systems based on defined technological standards. Technological architecture defines the environment of technology and infrastructure in which all the IT systems operate.

Portfolio is a collection of projects and programs that are grouped with the purpose of facilitating effective work management to meet the strategic organizational objectives. While the programs and projects are temporary, portfolios are continuous. An organization may have more than one portfolio, which in turn refers to specific areas or objectives. There must be a comprehensive portfolio covering the organization as whole.

The EA must be projected into digital models and with security so that the society can safely have access to all service areas. As for digital government, organizations must develop their digital strategies so as to add value to services provided to clients. Technologies such as social medias, portable devices, big data, cloud computing and Internet of things have caused disruption to business.

Society has developed digital habits. Citizens and companies need to learn about the government organization in order to access the digital services. The democratization of public access to services provided by digital media is an urgent demand in all governmental spheres.

The element security describes the necessary requirements to provide all levels of organization ranging from processes, data/information to infrastructure level with security. The framework is supported by a layer of infrastructure and governance of ICT to guarantee that the EA is executed well.

TOGAF was the process used to approach the framework designed for EA, and archimate was the language used to document the content.

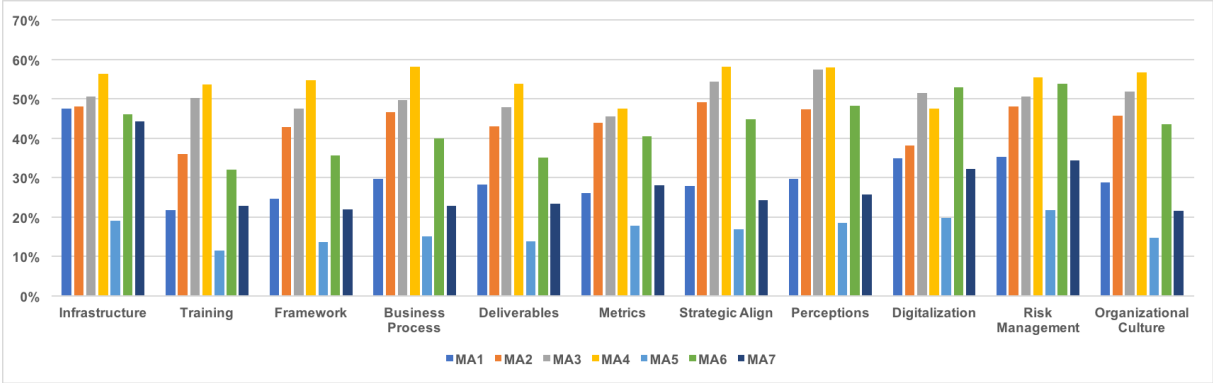

Figure 3: Comparison of selected results

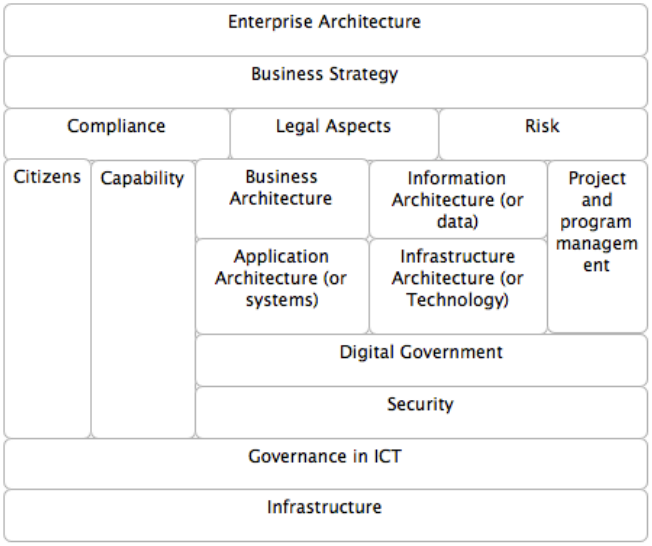

Figure 4: Framework designed for EA for smart cities

3.2 Modeling the Case Study

For the modeling of the framework the standard Archimate EA modeling language was used. This standard provides a set of entities and relationships with their corresponding iconography for the representation of architecture descriptions [9].

Among the various sectors of a city council such as education, health, safety, transportation, energy and sanitation, a case study in the area of education was chosen to present a partial view of using archimate language.

The information about the case study was extracted from the documents of a state school, Political Pedagogical Project (PPP) and the school rules. Meetings were held with the public school principals to construct the models presented at work.

One of the objectives of this work in relation to smart cities is to help improve the IDEB in Brazilian schools. The acronym IDEB refers to the Index of Development of Basic Education. It was created in 2005 by the National Institute of Educational Studies and Research Anï£¡sio Teixeira (INEP) with the objective of measuring the quality of basic education learning in Brazil. This measurement is made for three stages of education: initial years of elementary school, final years of elementary school and high school.

Initially, the framework and modeling was applied in order to understand and document the process. It was observed that after the validation of the motivational aspect diagrams and the six layers it was possible to verify the flaws, inconsistencies, bureaucracy and problems that can be corrected in the day-to-day activities in the school.

Figure 6 presents a modelling made Market and how many had University Access respectively. The assessments enable the establishment of goals and its outcomes. For example, Improvement in the teaching quality is quantified by the Measure the number of graduates.

Principles are associated with goals and requirements. Principles, as well as requirements, describe properties of systems. However, principles are more abstract and broader in scope when compared to requirements.

A principle determines a general property that applies to any system in a certain context. A requirement defines a property that applies to a specific system as de-scribed by an architecture [10].

For example, the results associated with Improvement in the teaching quality and Improvement in the learning of the school are realized by Student must have access principle.

This principle consists of University, FIES, Prouni and Ciencias sem fronteiras, which in turn are controlled by the requirements Combating truancy and Teaching must be improved for them to be achieved.

Figure 5 presents the motivational aspect, the archimate language, the Stakeholder, Driver, Assessments, Goals, Outcome, Principle, Requirements and Constraints and show the IDEB motivational scenario.

In the scenario, the Ministry of Education (MEC) and the National Institute of Educational Studies and Research Anï£¡sio Teixeira (INEP) were defined as the stake-holders. These are motivated by the IDEB, which is evaluated by Saeb, which in turn, has three internal evaluations: National Evaluation of Basic Education (Aneb), National Assessment of School Income (Anresc) / Prova Brasil and National Literacy Assessment (ANA).

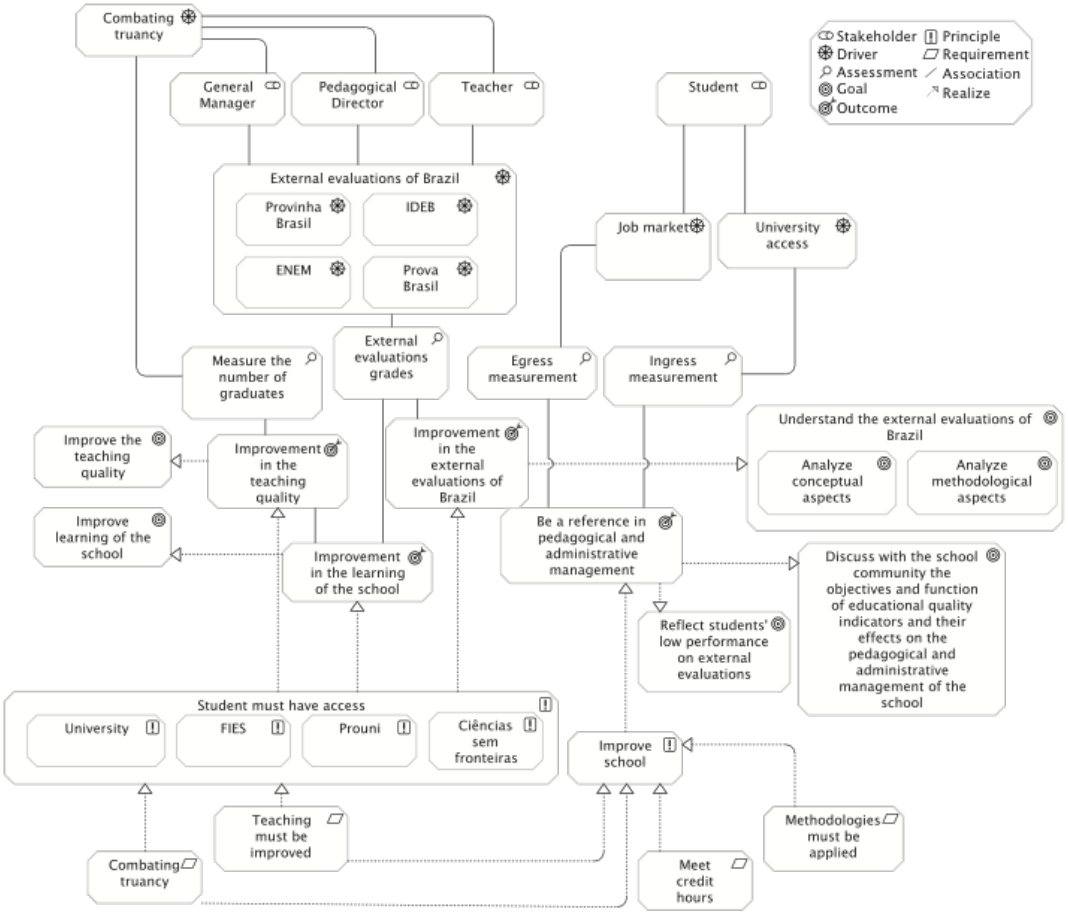

Figure 5: Modeling the Case Study

Education Development Plan (PDE), which is associated with the National Education Plan (PNE), aims to ensure adequate learning at the right age, which is carried out by using the principle of using national IDEB averages according to the PDE .

PDE has the following goals: Achieving an IDEB equal to 6.0 until 2021, Defining IDEB in public school and Defining IDEB in private school. The last two are associated with IDEB National goals, which in turn is composed of Early years of elementary education (1st to 5th year), Final years of primary education (6th to 9th grade) and High school. The IDEB national goals are based on the principle Average of developed countries members of the Organization for Economic Cooperation and Development (OECD).

Achieving an IDEB of 6.0 to 2021 results in the IDEB national average, which is composed of the results of the Early years of elementary education (1st to 5th year), Final years of elementary education (6th to 9th year) and High school.

As a result, the IDEB observed and the IDEB Projected were obtained from the IDEB National Average, the IDEB National Goals as well as the Search Parameters requirement. These Search Parameters consists of the requirements Defining result, Defining school, Defining the state, Defining education network, Defining municipality and Defining level/year.

The Search Parameters that are required to Generate observed IDEB and projected goals, Age distortion rate/level, school performance, School truancy and Teacher training, finally as Insufficient Number of participants in Prova Brasil for the results to be disclosed, Absence of average in Prova Brasil test 2015: did not participate or did not meet the necessary requirements to have the performance calculated and Calculated from the average proficiency of the students in the state assessments, due to the loss of the tests and the impossibility of the calculation of proficiency for Prova Brasil.

Figure 7 shows the implementation and migration diagram of the archimate language, the case study of a state school through milestones (Plateau), Gaps, Deliverables, Work Package and Events. It shows the scenario of the evaluation project of the Basic Education Development Index (IDEB) within the state school.

The implementation and migration layer is comprised of the Assessment, Preparation and Study, Test (Brazil Test or Basic Education Evaluation System (Saeb)), Result of IDEB, Planning phase after IDEB. In order to change milestones it is necessary to meet the

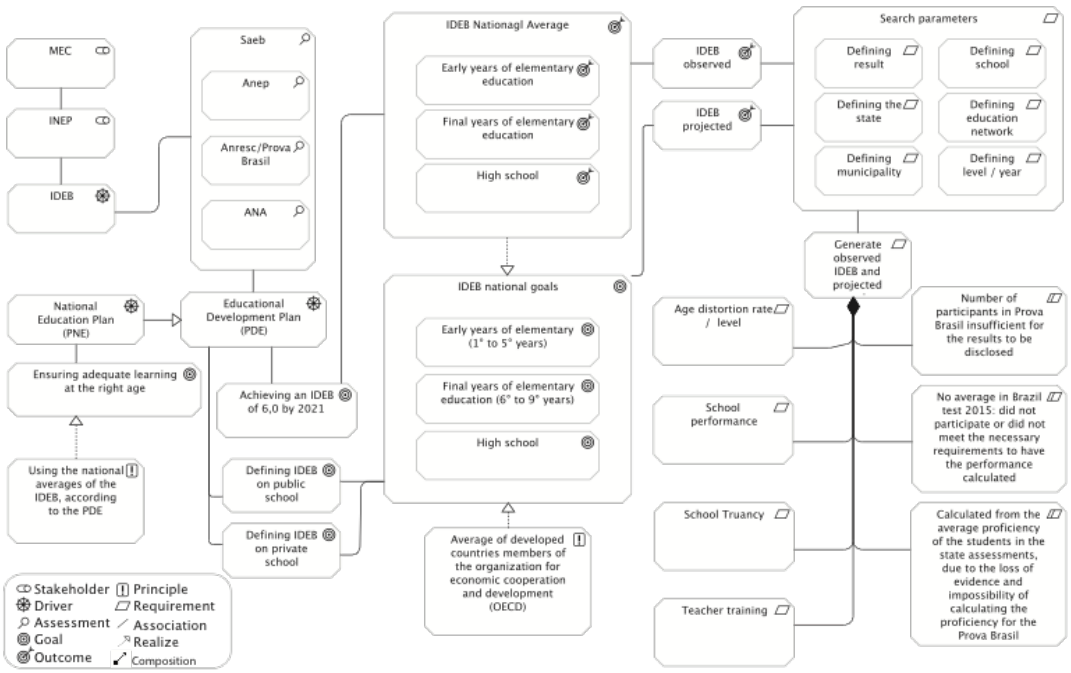

Figure 6: Modeling of the Motivational Layer in relation to IDEB

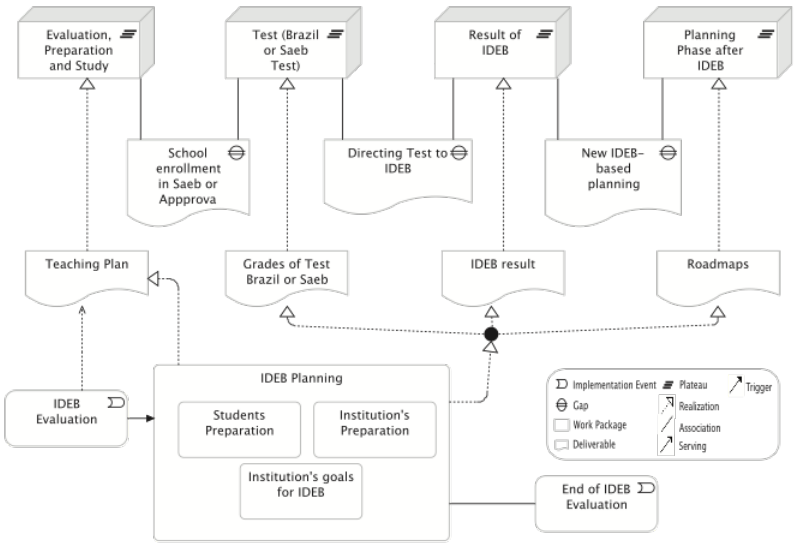

Figure 7: Modeling of the implementation and migration layer of the state public school

gaps such as School enrollment in the Saeb or AppProva, Direct-ing Test to IDEB and New IDEB based planning.

At the end of each milestone, their deliverables are generated, such as the Teaching Plan, Grades of Test Brazil or Saeb, IDEB results and the Roadmaps (goal map of the organization).

Based on the deliverables, tasks are then listed in the IDEB Planning, which is composed of multitasking Students Preparation, Institutions Preparation and Institutions goals for IDEB. These in turn, start from the IDEB Evaluation event and end in the event End of the IDEB evaluation.

4 CONCLUSIONS

The application of the questionnaire in city councils showed that processes, systems and services are built in silos in a non-integrated and unshared way. The systems of city councils are not reused and are mostly not integrated leading to effort duplicity, fragmented

and non-standardized information which causes waste of time and resources.

The use of ICT is a necessity for organizations, but when an EA is not implement-ed it is difficult to guarantee satisfactory results.

The framework presented in this paper is a direct result of the conducted research. The research includes a mechanism to analyze the maturity level in relation to the defined axes of city councils in regard to ICT governance and EA. The result of this analysis aim to improve the governance of smart cities.

The TOGAF systematized and planned the EA process of the proposed framework. The archimate was used to document this process. Thus, it was possible to present an integration of the TOGAF and archimate with the proposed framework.

It is concluded that in order to achieve satisfactory results in the implementation of the EA, it is necessary to automate the modeling by observing the best practices of other frameworks, as the case of TOGAF and archimate.

A case study in education was selected to present a partial view of the use of archimate language. Therefore, other government areas can be modeled by using the same pattern. The results presented in the study demonstrated that organizations analysed according to the eleven defined axes are between 11.43% and 58.22%, with the goal of reaching 100% for a high-performance rate in relation to the EA.

Therefore, the analysis of the data collected in the city councils in relation to the axes will allow new measures of performance rates after the application of the proposed framework aiming at smart cities.

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