Enterprise Architecture: Projects and Goals alignment assessment

João Bernardo Antunes da Costa

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Supervisor: Prof. André Ferreira Ferrão Couto e Vasconcelos

Business Advisor: Bruno Fragoso

Examination Committee

Chairperson: Prof. Luís Manuel Antunes Veiga

Member of the Committee: Prof. José Luís Brinquete Borbinha

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Abstract

Although the alignment between organization’s projects and strategic objectives is a central competence for managing organizations, there are not available approaches to support this need in the enterprise architecture discipline. Since projects can be specified and implemented to meet specific strategic objectives, its implementation is expected to have an impact in the enterprise architecture, contributing or making harder to achieve the strategic objectives. Enterprise architecture existing approaches are expected to support the organization’s evolution from a current state to a future one. Although some researches address the identification of the alignment between projects and strategic objectives, the measurement and quantification of this architectural alignment, considering the information system architecture quality attributes, is not usually considered when defining or implementing projects. This dissertation contributes to filling this gap by extending ArchiMate enterprise architecture framework and proposing a 4-step approach for assessing the alignment between enterprise projects and goals: i) Identify the alignment between projects and strategic objectives; ii) Identify the quality attributes derived from the strategic objectives; iii) Identify applicable metrics to projects’ architecture; iv) Quantify the alignment level between projects and strategic objectives. With this research, we provide enterprise architecture discipline and organizations an approach that supports the assessment and improvement of strategies and projects portfolios misalignments. The approach developed is applied to a government-owned company. The results show that it is possible to use EA in supporting decision-making and in selecting projects that have higher impact on the company’s strategy.

Keywords

Alignment, strategic objectives, enterprise architecture, ArchiMate, projects, quality attribute.
Resumo

Embora o alinhamento entre projetos e objetivos estratégicos seja definida como uma competência para gerir organizações, não existem metodologias que suportem esta necessidade na disciplina de arquitetura empresarial. Na medida em que os projetos são especificados e implementados para cumprir objetivos estratégicos, é esperado que a sua implementação tenha um impacto na arquitetura empresarial, contribuindo para o cumprimento dos objetivos estratégicos. É esperado que as abordagens existentes da arquitetura empresarial suportem a evolução de AS-IS (estado atual) para TO-BE (futuro pretendido). Apesar de existirem pesquisas que abordem a identificação do alinhamento entre projetos e objetivos estratégicos, a medição e quantificação deste alinhamento, considerando os atributos de qualidade de uma arquitetura de sistemas de informação, não são consideradas quando a definição e implementação dos projetos. Esta dissertação contribui para cobrir essa lacuna, estendendo o ArchiMate, framework de arquitetura empresarial, propondo uma abordagem de 4 etapas: i) identificar o alinhamento entre projetos e objetivos estratégicos; ii) identificar os atributos de qualidade derivados dos objetivos estratégicos; iii) identificar métricas aplicáveis à avaliação desses atributos de qualidade na arquitetura dos projetos; iv) quantificar o nível de alinhamento entre projetos e objetivos estratégicos. Com esta pesquisa, providenciamos à disciplina de arquitetura empresarial uma abordagem que suporta a medição e desenvolvimento contínuo de estratégias e desalinhamentos de projetos do portfólio. A abordagem desenvolvida foi aplicada numa empresa do governo. Os resultados demonstram que é possível usar arquitetura empresarial para suportar a tomada de decisão e escolher projetos que tenham um maior impacto na estratégia da organização.

Palavras-chave

Alinhamento, objetivos estratégicos, arquitetura empresarial, ArchiMate, projetos, atributo de qualidade.
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<th>Description</th>
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</thead>
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<tr>
<td>DSRM</td>
<td>Design Science Research Methodology</td>
</tr>
<tr>
<td>EA</td>
<td>Enterprise Architecture</td>
</tr>
<tr>
<td>UML</td>
<td>Unified modelling language</td>
</tr>
<tr>
<td>TOGAF</td>
<td>The Open Group Architecture Framework</td>
</tr>
<tr>
<td>FCEO</td>
<td>Framework CEO</td>
</tr>
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</table>
## Glossary

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<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic objective</td>
<td>Equivalent to goal ArchiMate element. A goal represents a high-level statement of intent, direction, or desired end state for an organization and its stakeholders.</td>
<td>(The Open Group, 2012)</td>
</tr>
<tr>
<td>Strategic orientation</td>
<td>Equivalent to driver ArchiMate element. A driver represents an external or internal condition that motivates an organization to define its goals and implement the changes necessary to achieve them.</td>
<td>(The Open Group, 2012)</td>
</tr>
<tr>
<td>Strategic plan</td>
<td>Management technique that helps organizations set future goals and objectives to achieve more stable and predictable growth.</td>
<td>[2]</td>
</tr>
<tr>
<td>Viewpoint</td>
<td>A specification of the conventions for constructing and using a view. It is a means to focus on particular aspects and layers of the architecture determined by the concerns of a stakeholder.</td>
<td>(The Open Group, 2012)</td>
</tr>
<tr>
<td>UML</td>
<td>Modelling standard for OO software development.</td>
<td>[3]</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Quality characteristics of an architecture (e.g. reliability, safety).</td>
<td>[4]</td>
</tr>
<tr>
<td>Application/Information/Technology</td>
<td>Elements of application/Information/Technology architecture.</td>
<td>[4]</td>
</tr>
<tr>
<td>components</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business engineering</td>
<td>Development and implementation of business solutions, from business model to business processes and organizational structure to information systems and information technology.</td>
<td>[5]</td>
</tr>
</tbody>
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1 Introduction

This chapter introduces the alignment challenge. Firstly, the main goal of this dissertation is described, followed by the research methodology, the research problem and the possible applications of this work. Finally, we describe the outline of the document.

For business success, organizations must master the definition and implementation of their strategies. However, the best strategies can be useless without the proper implementation [6]. When formulating the organization's strategy, Quiros [7] highlighted the importance of the organizational alignment. Organizational alignment requires the knowledge about the organization's goals and objectives [8].

Projects must add value to organizations and the expected return on investment. It is consensual to consider a project completed when delivered within time and with the budget stipulated. Projects tend to have a weak alignment with the business strategy because most of them were conceived to solve urgencies in operations or to answer to senior managers' specific requirements [9]. There are many models of business strategy, for instance: balanced scorecard, and business motivation model [10], [11]. Few of them define project initiatives. Additionally, there is no balance in the project portfolio based on the alignment with business strategy. This misalignment results in weak strategy execution.

Enterprise architecture (EA) provides the insight needed to translate corporate strategy into daily operations. EA provides a path between strategy and execution. It allows understanding how projects help to achieve the organization's strategic objectives [12].

To measure the alignment level between the organization's projects and strategic objectives, we will use ArchiMate and EA. ArchiMate is the standard language for the modelling of EA. It also enables enterprise architects to describe, analyze and visualize the relationships among business domains in an unambiguous way [1]. This dissertation will help organizations to quantify the alignment between their projects and strategic objectives, in order to efficiently manage their resources and focus.

The methodology applied in this dissertation is the Design Science Research Methodology (DSRM). This method solves the domain problem and has six steps: problem identification, goal setting, design and development, demonstration, evaluation and communication [13]. DSRM aims to create and evaluate technological artefacts to solve organizational problems. Such artefacts include constructors (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instances (implemented and prototypes).
This methodology is the most adequate for this research because it aligns the proactiveness in the solution design and the organizational context.

Section 2 describes the related work that identifies crucial concepts to the definition of the proposed solution. It is focused on the following main concepts: EA, organizational alignment, ArchiMate, and metrics. In the first concept, we address EA by defining an organization’s structure, business processes, and information systems. About the organizational alignment, we get down to the importance of the alignment between an organization’s strategy and projects. ArchiMate provides tools to model it. In the last concept, we attend to metrics that allow us to measure the quality attributes in an EA.

Section 3 presents our solution to quantify the alignment between projects and the strategic objectives. It consists in a four steps method: i) identification of the alignment between an organization’s projects and its strategic objectives, ii) identification of the quality attributes associated to the strategic objectives, iii) identification of applicable metrics to measure the quality attributes in the project architecture and iv) quantification of the alignment between the projects and strategic objectives.

Section 4 proves our proposed solution in a government-owned company, named Democorp. Section 5 provides the evaluation of our work. Section 6 describes conferences/journals where our work has been published. Section 7 describes the conclusion of this dissertation and the future work that needs to be addressed.

1.1. Research problem

The problem we propose to address in our dissertation concerns the expectation to quantify the alignment level between the projects, regarding their business processes and application components, i.e. software systems that support the business processes, and the strategic objectives of an organization.
We will look for an answer to the following questions:

- **Will we be able to measure the alignment between projects and strategic objectives?**
  - Is it possible to measure quality attributes in EA?
  - Can EA’s contribution to meeting strategic objectives be measured through architectural qualities?

To summarize, this research focus on how an EA contributes to the fulfillment of the defined strategic objectives. We use ArchiMate as the modeling language since it supports the relationship between the strategic and the core aspects of an organization, and also, supports enterprise’s methods and value changes [1].
2 Related work

2.1. Organizational alignment

Many researchers sought to find an explanation and a definition for organizational alignment. It has several perspectives: employees’ motivation, improvement of effectiveness and organizational performance [17].

Alignment is one possible approach to explain organizational efficiency. It focuses on the need for coherence among cultural, structural and strategic components of an organization. The organization and its components are means to implement strategy and, the interactions between components imply a mutual influence on each other. There is a need to adapt them to achieve adequate results. Strong alignment requires agreement rather than conflict between the strategic, structural, and cultural variables. There are two types of organizational alignment: vertical and horizontal or lateral. Vertical alignment refers to the configuration of strategies, objectives throughout the various levels of the organization. Horizontal alignment can be defined as concerning cross-functional and intra-functional integration. Alignment is vital as it enables a business to respond to its external environment and perform effectively. Alignment is hard to measure but misalignment is easier to see. Current models that incorporate the concept of organizational alignment offer simplicity and common sense, but they do not explain why alignment works, how it can be measured or improved [7].

A company without organizational alignment is similar to a group of people travelling to a location without having a map. They might have an idea of what the ultimate goal is, but they do not know how to achieve it and different people can have a different path or perception. It is essential for all companies to have organizational alignment. To accomplish this target, it is crucial that employees walk towards the same direction, at the same speed, rhythm, leaning on each other. All business processes, including values, strategy and information systems must work together to produce ideal results [18]. Organizations must know if they are doing what they had planned to do [6].

2.1.1. Strategy models

A strategy is a plan, an attitude, and it is a way to win a business challenge. In general, there is not an exclusive definition. Jogaratnam, Tse, & Olsen [19] defined strategy as how to better deal with competition and to achieve the desired state, and for Kippenberger [11] it is how to win the competitive advantage as he explains in his three generic strategies: cost leadership, differentiation, focus.

Many researchers tried to explain the concept of strategy, but the most consensual definition is the: concern with the overall purpose and scope of the organization to meet the expectations of owners or major stakeholders [20].
According to Maria de Fatima [20], creating an organization’s strategy comprises the definition of the following concepts:

- **Mission** – describes what the organization is, what it stands for and its purpose. It explains the organization’s existence and their wanted path.
- **Vision** – describes the organization’s future state, providing long-term direction of the organization.
- **Goal** – what an organization wants to achieve. They tend to be long-term and defined qualitatively.
- **Objective** – measurable steps to achieve a strategy and should be in line with the mission.

The existing strategy models connect all these concepts and provide strategic management with a mechanism to align resources and actions with the organization’s mission, vision and strategy. Regarding the strategic models familiar to organizations, we focus on the Balanced Scorecard (BSC) [21]. We address this model in this dissertation since we will use their elements and relations to help design our proposed solution.

**Balanced Scorecard**

The balanced scorecard is a strategic planning tool developed by Kaplan and Norton as a response to the assumption that organizations only exist to satisfy stakeholders needs [22]. It is based on four perspectives: financial, internal processes, customers and learning and growth. Each perspective represents a different set of stakeholders. The figure below illustrates the four perspectives.

![Figure 2 - BSC four perspectives](image)

**Customer perspective**

Customer perspective helps the company to address the important concerns of the customers. Their concerns tend to fall into four categories: time, quality, performance, service and cost [23].
Internal business perspective

The internal business perspective aims to identify and improve the critical internal business processes that bring competitive advantage and result in greater customer satisfaction [23]. These processes also embrace the activities necessary to create customer value and consist of activities such as product design, brand and market development, sales, service, operations and logistics [24].

Innovation and learning perspective

Innovation is a key driver in the knowledge economy. A competitive market expects the ability to continually innovate and bring value in the internal business processes. A company’s ability to innovate and improve comes down to creating more value for customers. Improving operating efficiencies can increase revenues which increases shareholder value [23].

Financial perspective

Financial perspective relates actions and results. Financial performance measures if the company’s strategy implementation is resulting in the earnings improvement [23]. The financial dimension describes the financial objectives of a company, for instance: profitability, sales growth, market value and cost reduction [24].

This framework provides a top-down approach by defining an organization strategic element and connecting it to its projects. It has four elements: objectives, measures, targets and initiatives. Strategic objectives are used to decompose strategy into actionable components that can be monitored using Performance Measures. These measures are often referred as key performance indicators (KPI) and are quantifiable, allowing the organization to track results against objectives’ targets [21].

Finally, strategic objective has strategic initiatives associated, defined as actions that translate strategy into a set of high-priority projects that contribute to the achievement of the organization’s objectives [21].

Projects may be designed and implemented to meet strategic objectives [15]. By implementing the organization’s strategic objectives with projects, it becomes clearer to which extent the planned strategy is accomplished and also whether the implementation of projects has indeed value for the business.

2.1.2. Strategic initiatives

In this section, we aim to explore in what way projects and programs can be associated to strategic objectives.

Organizations can have projects, programs and portfolio. Sanchez [25] defines portfolio as the collection of projects or programs grouped to facilitate effective management and meet strategic objectives. Program is the group of projects managed in a coordinated way to obtain benefits and control. Finally, a project is a temporary endeavor undertaken to create a unique product, service or result.
Project management office (PMO) is a management structure that standardizes the project-related governance processes and facilitates the sharing of resources, methodologies, tools, and techniques. PMO may act as a key decision maker throughout the life of each project, making recommendations, or terminating projects or taking other actions, as required, to remain aligned with the business objectives. In addition, the PMO may be involved in the selection, management, and deployment of shared or dedicated project resources.

It is not enough that projects come in on time and within the budget. They must be synchronized with the strategy. Each project’s expected, measurable value can be in line with one or more of the company’s strategic goals. The definition of value will certainly differ in accordance with the organization’s focus, strategies and types of projects [26].

The value criteria identifies what is important to the organization’s customers and what financial benefits does a project bring to the organization.

Financial aspect is one of the most used criteria to prioritize projects in organizations. However, it is not always the highest-scoring projects that make it. According to Levine [27], even though the financial value is the primary factor for project prioritization, further aspects should be considered, such as the alignment with the organization strategy and tactical plans. Associating the value of a project with the organization’s business objectives may also help decide if a project is worth or not.

2.2. EA

There are many definitions for EA. According to Institute of Electronics and Electronics Engineers: "An Architecture is the fundamental organization of a system embodied in its components, their relationships with each other, to the environment, and the principles guiding its design and evolution." [14].

The Open Group’s Architectural Framework (TOGAF) stated that: "the purpose of EA is to optimize across the enterprise the often-fragmented legacy of processes (both manual and automated) into the integrated environment that is responsive to change and supportive of the delivery of the business strategy. (...) providing a strategic context for the evolution and reach of digital capability in response to the constantly changing needs of the business environment." [15].

On the other hand, the ArchiMate Foundation defines EA as a: "coherent whole of principles, methods, and models used in the design and realization of an enterprise’s organizational structure, business processes, information systems, and infrastructure." [16].

The variety in these definitions indicates that the field of enterprise architecture is still in its infancy. However, all these definitions have a standard reference to structure and relationships combined regarding a set of governing principles that provide guidance and support for directions and decisions. EA focuses on shaping and governing the design of the future enterprise using principles to stipulate future direction and models to visualize future states [28].
For our dissertation’s purpose, EA is a coherent set of principles, methods, and models used in the
design and realization of an enterprise’s organizational structure, business processes, information
systems, and infrastructure [16].

2.2.1. FCEO
FCEO is a framework that allows to model organizational concepts defined. Goals are considered
business objects, for the strategy; processes, for the business processes modeling; resources, for the
business resources modeling; and extended components, for the information systems modeling. FCEO
supports two levels - Business and Information Systems and Technologies (TSI) - and several sub-
levels:

At business, there are three sub-levels:

- Strategy - described through business objectives. These goals can be achieved by completing
  one or more business processes.
- Business processes - has to meet one or more objectives and interact with the various entities
to give a better performance of the work.
- Entities - handled by business processes and represent all the relevant concepts in a specific
  business context.

At information systems and technologies (TSI), FCEO defines two sub-levels:

- At the application level, SIs are defined by a set of components whose main purpose is to
  support business processes and ensure that information entities are available.
- At the technological level, the primary goal is the specification of the technologies and
  infrastructures which allow the implementation of the application components defined at the
  higher level.

This framework is supported and formalized in UML. FCEO’s primitives have attributes that allow the
characterization of the architecture and inference on architectural quality characteristics. It is possible
to identify a global set of quality attributes to analyze an architecture (e.g. reliability, safety, alignment).
Still, we decide not to use this framework because it presents a set of limitations that in our view prevents
us from following this option:

- It does not identify perspectives (proposed measure in the IEEE 1470 standard).
- It does not define primitives or constrains attributes for the Architecture specification at the
  application or technology level.
- It does not define an approach or method that guides the design, evaluation and construction
  of the architecture aligned with the business.

[29]
2.2.2. ArchiMate

ArchiMate is a modelling language for EA that provides helping mechanisms for architects to build models to describe the organization’s structure and obtain different views (viewpoints) according to the stakeholders [1], [29]. The essential elements of ArchiMate are: active structure, passive structure, and behaviour element. Active structure elements can perform some action and behaviour. The passive structure consists of elements where the active elements perform their actions and behaviours. The behaviour elements are actions and behaviours which active elements perform [1].

The Open Group [1] split ArchiMate into three layers: i) Business, where business processes and their actors are defined, ii) Application, services that support business processes and applications that perform them, and iii) Technological, technological services, such as processing, storage, and required communication services to run applications. The Open Group added Physical elements to model physical equipment, materials, and distributed networks for this layer.

Despite the core aspect, there are two more layers in the ArchiMate 3.0.1: motivation and migration and Implementation.

The motivation’s extension is used to model the motivations or reasons that guide the design or change of EA. It has the following concepts: meaning, value, driver, assessment, goal, outcome, principle, requirement and constraint. Migration and implementation extension include concepts for modelling implementation programs, projects to support program, portfolio, and project management, and a plateau concept to support migration planning [1].

ArchiMate allows us to add attributes to its elements with a name and associated value [30].

In this dissertation, we model the strategic elements and the EA projects of an organization to validate our solution.

2.3. Quality attribute (QA)

A QA is a measurable property of a system that is used to indicate how well the system satisfies the needs of its stakeholders. QAs have been of interest to the software community since the 1970s. There are many definitions for it:

1. The definitions provided for an attribute are not testable. It is meaningless to say that a system will be “modifiable”. Every system may be modifiable with respect to one set of changes and not modifiable with respect to another. The other quality attributes are similar in this regard: a system may be robust with respect to some faults and brittle with respect to others [31].

2. Discussion often focuses on which quality a particular concern belongs to. Is a system failure due to a denial-of-service attack an aspect of availability, an aspect of performance, an aspect of security, or an aspect of usability? All four attribute communities would claim ownership of a system failure due to a denial-of-service attack. All are correct. But this does not help us, as architects, understand and create architectural solutions to manage the attributes of concern [31].
3. Each attribute community has developed its own vocabulary. The performance community has “events” arriving at a system, the security community has “attacks” arriving at a system, the availability community has “failures” of a system, and the usability community has “user input.” All of these may actually refer to the same occurrence, but they are described using different terms [31].

ISO/IEC 9126 [32] defines a quality model, quality characteristics and related metrics. These constituents can be used to both evaluate and set goals for the quality of a software product.

Our dissertation’s scope is to measure the impact of a project architecture on the strategic objectives. For that, we need to evaluate the QAs of an architecture. There is a primary set of QAs adapted from software qualities and new ones proposed by Vasconcelos [33], that are measurable in an EA:

- **Functionality** – a set of information systems’ ability to provide services meeting business objectives and strategies.
  - Adequacy – no changes.
  - Interoperability – set of information systems’ ability to interact with themselves.
  - Security – access to information/service is granted only to authorized subjects.
- **Reliability** – a system’s ability to keep operating over time.
  - Fault tolerance – no changes.
- **Efficiency** – no changes.
  - Behaviour against resources
- **Maintainability** – no changes.
  - Analysability – no changes.
  - Changeability – ability to make changes to a system quickly and cost-effectively.
  - Testability – degree which a system or service facilitates the establishment of test criteria and the performance of tests to determine whether those criteria have been met.
- **Portability** – no changes.
  - Adaptability – no adaptability.
- **Alignment** – architecture components’ ability to operate in accordance with requested requirements at other architecture levels.
  - Business/Application alignment – application components’ ability to operate in accordance with business architecture requirements.
  - Information/Application alignment – application components’ ability to operate in accordance with information architecture requirements.
  - Information/Technology alignment – technology components’ ability to operate in accordance with information architecture requirements.
  - Application/Technology alignment – technology components’ ability to operate in accordance with application architecture requirements.
- **Dimension** – no changes.

[34]
2.4. Metrics

According to Vasconcelos, Sousa and Tribolet [29], the term measure is a process by which numbers, i.e. metrics, are assigned to real-world entities to characterize their quality attributes through clearly defined rules. The authors describe the metric as a quantitative reality interpretation, based on observable measures of an architecture.

2.4.1. Architecture metrics

There are no consolidated metrics to measure information systems architectures, but extensions to measure the quality attributes of software architectures [32]. We use the metrics proposed by Vasconcelos, Sousa, and Tribolet [29] based on case studies [35]. These metrics were proposed to be applied in FCEO (Organizational Engineering Center Framework for modelling information systems architecture). A framework which allows to model organizational concepts, supported in UML (Unified Modelling Language).

Regarding our choice of using ArchiMate as the modelling language, we study the possibility of adapting or taking advantage of those metrics. As stated in section 2.3, we focus on the three architectural levels: Business, Application and Technology.

We follow a set of nine principles to guarantee the consolidation of metrics, for the information systems evaluation [29]. Next, we select the metrics attending our dissertation’ scope – table 1.

Table 1 - Metrics

<table>
<thead>
<tr>
<th>Quality attribute</th>
<th>Sub-quality attribute</th>
<th>Metric</th>
<th>Architectural level</th>
<th>Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Adequacy</td>
<td>BSRPF - business service factor required and made available</td>
<td>Business Applicational</td>
<td>Yes</td>
</tr>
<tr>
<td>Interoperability</td>
<td></td>
<td>DIIEF - the factor of different implementations of an information entity</td>
<td>Informational</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DTISSF - the factor of technologies in which IS services are made available</td>
<td>Applicational Technology</td>
<td>Yes</td>
</tr>
<tr>
<td>Security</td>
<td></td>
<td>SCBITABF - the factor of security components between IT application block</td>
<td>Technology</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IASF - the factor of security informational – applicational</td>
<td>Informational Applicational</td>
<td>No</td>
</tr>
<tr>
<td>Reliability</td>
<td>Fault tolerance</td>
<td>ITRF - the factor of technology redundancy factor</td>
<td>Technology</td>
<td>Yes</td>
</tr>
<tr>
<td>Dimension</td>
<td>Business/technology alignment</td>
<td>Information/technology alignment</td>
<td>Application/technology alignment</td>
<td>Efficiency</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------</td>
<td>----------------------------------</td>
<td>--------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td></td>
<td>Maintainability</td>
<td>Changeability</td>
<td>Testability</td>
<td>Portability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alignment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Business/application alignment</td>
<td>CPMIF – critical process</td>
<td>Information/application</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>misalignment factor system</td>
<td>alignment alignment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information/technology</td>
<td>LIEITBDTMF – data type misalignment low level informational entity – technological block</td>
<td>Applicational technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>alignment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As table 1 illustrates, we do not consider information level metrics. Our solution only focuses on business, application and technology level.

There are three more metrics proposed by Vasconcelos, Sousa, and Tribolet [29]: Business/application, measures the alignment between business processes and application systems, Business/information, measures the alignment between business processes and information entities, Information/application, measures the alignment between information entities and application systems.

We have only considered business/application since the others are out of scope. Moreover, the equation to quantify the business/application alignment is:
Align AN AA = \frac{(1 - \frac{nASwBP}{ntS}) + (1 - \frac{nBPwAS}{ntP})}{2} \tag{2.1}

Where:

- \textit{Align AN AA}, corresponds to business and application alignment
- \textit{nASwBP}, represents the number of applications components without a business process associated
- \textit{ntS}, corresponds to application components’ total number
- \textit{nBPwAS}, represents the number of business processes without application component’ support
- \textit{ntP}, corresponds to business processes’ total number
3 Using EA to align projects and strategic objectives

We propose to determine the alignment level between projects and strategic objectives. Inês Garcia [8] argues that there is a dependent relationship between projects and the implemented strategy. It is possible to quantify what each project contributes to the strategy. Therefore, we analyze the projects of an organization and assess their impact on the strategy, making it possible to understand if the organization’s path is the correct one or not.

ArchiMate 3.0.1 provides tools to analyze and visualize the relationships among business domains and extensions. We use the following ArchiMate viewpoints to support our proposal: outcome realization viewpoint, motivation viewpoint and a proposed generic viewpoint. The concepts in motivation viewpoint allow us to have a perception of the company’s motivation [1], [8]. Whereas, those in outcome realization viewpoint allow us to get an overview of the organization’s architecture and its outcomes. It can also represent all the layers of the architecture in a single diagram and used as a support for impact analysis against changes in EA, including dependencies between layers [1].

We propose to merge both viewpoints and create a generic viewpoint, whose goal is to support and measure the alignment following a method based on the next four steps: i) identify the alignment between projects and strategic objectives; ii) identify quality attributes associated with strategic objectives; iii) identify applicable metrics to projects’ architecture; iv) quantify the alignment level between projects and the strategic objectives. The figure below provides the big picture of our solution, including inputs and outputs of each process.

3.1 Step 1 - Identify the alignment between projects and strategic objectives.

**Input:** Projects architecture and outcomes and the strategic objectives’ outcomes.

**Output:** Projects aligned with strategic objectives.

At this stage, we aim to identify the alignment between projects and strategic objectives. For this, we
follow the steps present on the next sections:

1) Identify the strategic objectives;

2) Represent objectives’ outcomes and expected values;

3) Represent projects and their expected values;

4) Identify projects aligned with the organization’s strategic objectives.

Regarding the inputs and outputs of this sub-sections, we present the follow diagram.

**3.1.1 Identify organization’s strategic objectives**

We look forward to identify and model the organization’s strategic objectives, using ArchiMate as the modelling language. To accomplish this, we analyze documentation of the organization’s strategy, where the organization’s goals and objectives, its mission, vision and values and strategic analysis are defined. This information is presented in the strategic plan. The strategic plan also describes its drivers, strategic objectives and other essential motivational elements [8].

1. We use the ArchiMate motivation metamodel (Figure 5) to support this step.
We use an already proposed generic viewpoint (Figure 6) to model the strategic orientations (driver), strategic objectives (goal) and its outcomes (outcome) using ArchiMate as the modelling language [8].

With this viewpoint, we are able to identify and model its strategic orientations (drivers), represented with the driver element that, by definition, is an external and internal condition that motivates the organization to define goals. When all strategic orientations are represented, we are able to identify the strategic objectives defined to measure them. For every strategic objective, a target is defined that, when achieved, becomes an objective outcome that realizes the associated strategic objective [8].

### 3.1.2 Represent objectives’ outcomes and expected values

Value is a motivational element that denotes the relative utility, or importance of a core element or an outcome. The value represents the importance of the strategic objective to the organization. This value can be identified from the analysis of documentation regarding the organization’s strategy, namely, the definition of strategic objectives and strategic orientations.

To model the objectives’ outcomes and expected values, we use a generic template (Figure 7) already proposed, using ArchiMate as the modelling language [8].
3.1.3 Represent projects and their expected values

In this step, we analyze projects’ documentation and represent their architecture and their expected value to the company. We do not consider projects without information concerning its scope, purpose or project owners and that are unable to identify its processes, services, application components, outcomes and expected values.

We use the outcome realization viewpoint to model the organization's projects, its processes, stakeholders, services, outcomes, expected values. Archi also allows us to represent the properties or attributes of each element that we will use for the metric application [30].

Inês Garcia [8] identified the alignment between the projects and strategic objectives at motivational, implementation and migration level. It is a good starting point but that is not enough. We aim to measure the impact of the projects’ architectures on the organization’s strategy.

Figure 8 - Relationships between motivation elements and core elements [1].

3.1.4 Identify projects aligned with the organization’s strategic objectives

We propose a generic viewpoint to the alignment between projects and strategic objectives.
Every project has an outcome expected value to the organization (output of the previous step), defined according to a business rule: it is mandatory that each outcome value is defined by precisely one transitive verb followed by the direct object that complements the verb [8]. Every strategic objective has an outcome expected value, which is also defined according to that business rule. If the value that a project brings to the organization is similar to the outcome value defined for each strategic objective, then both values are in line and, consequently, that project is aligned with that strategic objective.

If a project value does not correspond in any way to a strategic objective outcome value, there is no alignment. Therefore, we will not consider both projects and strategic objective for our demonstration.

3.2 Step 2 - Identify quality attributes associated with strategic objectives

Input: Documentation related to organization’s strategy and management’s commitment.

Output: Quality attributes associated with strategic objectives.

In this step, we identify the quality attributes associated with strategic objectives.

We seek to identify and model those quality attributes after analyzing documentation pertaining to the organization’s strategy, which compiles the objectives, mission, vision, values and strategic analysis of its products, customers and business in general. Also, we suggest reaching a consensus with one or more stakeholders to understand which quality attributes interfere with the objectives’ achievement, as this dissertation’s purpose is to measure the alignment and not to derive quality attributes.

Each quality attribute has a weight associated that represents its relevance to the strategic objective – real type value between 0 and 9. Moreover, each strategic objective also has an importance value to the company – real type value between 0 and 9. The organization’s stakeholders define these values.
3.3 Step 3 - Identify applicable metrics to the projects’ architecture

Input: Quality attributes.

Output: Metrics.

Given the quality attributes, we aim to identify appropriate metrics to measure them in the projects’ architecture. These metrics must be measurable and unambiguous in the architecture. We will consider metrics that have already been formalized by [29] to evaluate a project architecture. Since these metrics were formalized in FCEO, we propose to map them into ArchiMate.

The proposed metrics are organized according to the quality attributes desired for EA (indicated in section 2.6).

3.3.1 Methodology for defining metrics

The metrics described in the following sections were developed in an iterative way. This work was based on researches carried out by specialists. Our option was the extension of FCEO metrics (Appendix J: FCEO to ArchiMate) into ArchiMate. This option allowed us to reuse some of consolidated knowledge of ASI evaluation, reducing the effort of starting from scratch development. This approach was not only at the metrics level, as well as for quality attributes to be considered in EA. The application in practical cases of the metrics helped verifying and consolidating the same. The metrics proposed respect the principles for the creation of metrics, since they were already revised, tested in previous researches [29] and formalized in OCL. We do not propose to change their computation, but the elements used.

Table 1 fits the set of metrics proposed from section 3.3.3 to 3.3.9.

<table>
<thead>
<tr>
<th>Quality attribute</th>
<th>Sub-quality attribute</th>
<th>Metric</th>
<th>Architectural level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>Adequacy</td>
<td>BSRPF – business service factor required and made available</td>
<td>Business Applicational</td>
</tr>
<tr>
<td></td>
<td>Interoperability</td>
<td>DTISSF – the factor of technologies in which IS services are made available</td>
<td>Applicational Technology</td>
</tr>
<tr>
<td></td>
<td>Security</td>
<td>SCBITABF – the factor of security components between IT application block</td>
<td>Technology</td>
</tr>
<tr>
<td>Reliability</td>
<td>Fault tolerance</td>
<td>ITRF – the factor of technology redundancy factor</td>
<td>Technology</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Behaviour against resources</td>
<td>SITPLBF – the factor of stateful IT presentation block and its logic block</td>
<td>Technology</td>
</tr>
<tr>
<td>Dimension</td>
<td>Analysability</td>
<td>SCCF – the factor of cyclomatic complexity of services</td>
<td>Business/Technology Application</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------</td>
<td>-------------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td></td>
<td>Changeability</td>
<td>NOISF – the factor of number of operations in IS block</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>Testability</td>
<td>RSF – response factor for a service</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>Portability</td>
<td>Adaptability</td>
<td>Technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>POSF – the factor of possible operating systems</td>
<td>Technology</td>
</tr>
<tr>
<td></td>
<td>Alignment</td>
<td>Business/application alignment</td>
<td>Business application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CPSMF – critical process misalignment factor system</td>
<td>Business application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Application/technology alignment</td>
<td>Application technology</td>
</tr>
<tr>
<td></td>
<td>Dimension</td>
<td>Business/Technology Application</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NA – number of applications</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NITB – Technological blocks number</td>
<td>Technology</td>
</tr>
</tbody>
</table>
3.3.2 Model for the characterization of metrics

The metrics proposed in this section are described according the model presented in the table 2.

Table 2 - Model used for the metrics description.

<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Metric name</td>
</tr>
<tr>
<td>Computing</td>
<td>Description of the metric value calculation mode</td>
</tr>
<tr>
<td>Architectural level</td>
<td>Architectural level(s) that may be affected by the metric</td>
</tr>
<tr>
<td>Element(s) and Attribute(s)</td>
<td>ArchiMate elements and attributes used in the metric computing</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Indication of the &quot;architectural qualities&quot; (or quality characteristics) that relate to the metrics in question and the meaning of the metric values (discrimination), in relation to these quality(s)</td>
</tr>
<tr>
<td>Substantiation</td>
<td>Justification supporting the proposed metric and its influence on the indicated quality(s)</td>
</tr>
<tr>
<td>Example</td>
<td>Presentation of simple EA evaluation examples, using the proposed metric</td>
</tr>
</tbody>
</table>

3.3.3 Functionality metrics

This section introduces a proposed set of metrics to enable the measurement of quality attributes related to functionality in an EA, namely adequacy, interoperability and safety. 3.3.3.1 BSRPF – Business Service Factor Required and made available.
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>BSRPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>business service factor required and made available</td>
</tr>
</tbody>
</table>
| Computing   | \[1 - \frac{\sum_{i=1}^{#Business\ process} #Business\ service\ RNI_i}{\sum_{i=1}^{#Business\ process} #Business\ service\ R_i}\]  
\=#Business\ service\ RNI_i - number of business services required to support the process I and not implemented  
\=#Business\ service\ R_i - number of business services required to support the process i  
\=#Business\ process – number of business processes |
| Architectural level | Business and application |
| Element(s) and attribute(s) | Elements: business process, business service and application component  
Attribute: implemented (business process attribute) Appendix B: Attributes (BSRPF) |
| Quality attribute | Adequacy and business/application alignment |
| Substantiation | This metric measures the alignment between business and application, and its adequacy. This analysis is done by accounting for all services that the processes require and are not matched by business services, or being matched by business services, they are not implemented in any application component. |
Example

EA A:
\[ BSRPF = 1 - \frac{1+1}{2} = 0 \]

EA B:
\[ BSRPF = 1 - \frac{0+1}{2} = \frac{1}{2} \]

3.3.3.2 DTISSF – Distinct Technologies for IS Services Factor
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>DTISSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Distinct Technologies for IS Services factor</td>
</tr>
</tbody>
</table>
| Computing   | \[1 - \frac{\sum_{i=1}^{\text{application service}} \text{technology service integration}_i}{\text{application services}}\] Where: 
\[\text{technology service integration}_i\] – number of technology services, where serviceType attribute = “Integration Service”
\[\text{application service}\] – number of application services |
| Architectural level | Application and technology |
| Element(s) and Attribute(s) | Elements: application services
Attribute: serviceType
(Appendix C: Attributes (DTISSF)) |
| Quality attribute | Interoperability and portability |
| Substantiation | The interoperability and portability of an EA is proposed to be seen as the average of the technologies in which each application interface is made available. |
Example A:

\[ DTISSF = 1 - \frac{1}{1} = 0 \]

Example B:

\[ DTISSF = 1 - \frac{1}{3} = \frac{2}{3} \]

3.3.3.3 SCBITABF – Security Components between IT Application Block Factor
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>SCBITABF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Security Components between IT Application block Factor</td>
</tr>
<tr>
<td>Computing</td>
<td>$\frac{\sum\limits_{i=1}^{#\text{System Software}} \sum\limits_{j=1}^{#\text{System Software}} \text{MIN}(#\text{SITB}_{ij})}{#\text{System Software} \times #\text{Node}}$</td>
</tr>
<tr>
<td></td>
<td>Where:</td>
</tr>
<tr>
<td></td>
<td>$\text{MIN}(#\text{SITB})$ – minimum number of Node with securityElement = TRUE in the connection between two Nodes</td>
</tr>
<tr>
<td></td>
<td>$#\text{Node}$ – number of Node elements</td>
</tr>
<tr>
<td></td>
<td>$#\text{System Software}$ – number of system software elements</td>
</tr>
<tr>
<td>Architectural level</td>
<td>Technology</td>
</tr>
<tr>
<td>Element(s) and Attribute(s)</td>
<td>Elements: node, system software</td>
</tr>
<tr>
<td></td>
<td>Attribute: Security</td>
</tr>
<tr>
<td></td>
<td>Appendix D: Attributes (SCBITABF)</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Security</td>
</tr>
<tr>
<td>Substantiation</td>
<td>The security of the application components is increased by the supporting security elements such as IDS and firewalls. Thus, this metric is not limited to accounting for the number of security elements, but to counting, for each application component, the number of security elements that separate it from other components.</td>
</tr>
</tbody>
</table>
Example A:

\[ SCBITABF = \frac{(1 + 2) + (1 + 1) + (1 + 2)}{3 \times 11} = \frac{8}{33} \approx 24\% \]

Example B:

\[ SCBITABF = \frac{(1 + 1) + (0 + 1) + (0 + 1)}{3 \times 10} = \frac{4}{30} \approx 13\% \]
3.3.4 Reliability metrics

In this section we describe the proposed metric for the quantification of the quality attribute related to EA reliability, namely the fault tolerance.

3.3.4.1 ITRF – IT Redundancy Factor
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>ITRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>IT Redundancy Factor</td>
</tr>
</tbody>
</table>
| Computing   | # redundantElements  
# Technology Elements |
|             | Where: |
|             | # redundantElements – number of nodes whose redundantElement attribute value = True |
|             | # Technology Elements – number of nodes |
| Architectural level | Technology |
| Element(s) and Attribute(s) | Elements: nodes  
Attribute: redundantElement |
|             | Appendix E: Attributes (ITRF) |
| Quality attribute | Fault tolerance |
| Substantiation | The availability of an EA will tend to increase through the use of redundant elements. This metric reflects this fact. |
| Example     | Example A  
Example B |

Example A:

\[
ITRF = \frac{2}{3}
\]

Example B:

\[
ITRF = \frac{0}{3}
\]
3.3.5 Efficiency metrics

In this section we describe the proposed metric for the quantification of the quality attribute related to EA efficiency, namely scalability.
3.3.5.1 SITPLBF – Stateful IT Presentation Block and IT Logic Block Factor

<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>SITPLBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Metric name</td>
</tr>
<tr>
<td>Computing</td>
<td>[ 1 - \frac{# \text{SIT}}{# \text{IT}} ]</td>
</tr>
<tr>
<td>Where:</td>
<td>#\text{SIT} – number of IT elements where the attribute state = TRUE</td>
</tr>
<tr>
<td></td>
<td>#\text{IT} – number of IT elements</td>
</tr>
<tr>
<td>Architectural level</td>
<td>Technology</td>
</tr>
<tr>
<td>Element(s) and Attribute(s)</td>
<td>Elements: IT elements</td>
</tr>
<tr>
<td></td>
<td>Attributes: state</td>
</tr>
<tr>
<td></td>
<td>Appendix F: Attributes (SITPLBF)</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Scalability</td>
</tr>
<tr>
<td>Substantiation</td>
<td>Scalability is increased by the use of components that do not hold state.</td>
</tr>
</tbody>
</table>

Example

Example A:
\[
\text{SITPLBF} = 1 - \frac{1}{1+1} = \frac{1}{2}
\]

Example B:
\[
\text{SITPLBF} = 1 - \frac{0}{1+1} = 1
\]
3.3.6 Maintainability metrics

In this section we describe the proposed metric for the quantification of the quality attribute related to EA maintainability, namely analysability, changeability and testability.

3.3.6.1 SCCF – Service Cyclomatic Complexity Factor
<table>
<thead>
<tr>
<th><strong>Abbreviator</strong></th>
<th>SCCF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong></td>
<td>Service Cyclomatic Complexity Factor</td>
</tr>
</tbody>
</table>
| **Computing**  | \[
\sum_{i=1}^{\#\text{business service} + \#\text{application service}} |e_i - n_i + 2| \]
| Where:         | \#business service – number of business services |
|                | \#application service – number of application services |
|                | e_i – dependencies number between application component and service i |
|                | n_i – number of application components that supports service i |
| **Architectural level** | Technology |
| **Element(s) and Attribute(s)** | Elements: business services, application services, application components |
| **Quality attribute** | Changeability and analyzability |
| **Substantiation** | The complexity to support a given service is measured by accounting for the difference between the number of dependencies and the applications used in its support. |
Example A:

$$SCCF = \frac{1}{8 - 4 + 2} = \frac{1}{6}$$

Example B:

$$SCCF = \frac{1}{2 - 1 + 2} = \frac{1}{3}$$

3.3.6.2 NOISF – Number of Operations in IS Block Factor
### Abbreviator
NOISF

### Name
Number of Operations in IS Block Factor

### Computing
\[
\text{NOISF} = \sum_{i=1}^{\text{#business service application component } i} \frac{\text{#application component}}{\text{#application component } i}
\]

Where:

- \( \text{#business service application component } i \) – number of business services at application component \( i \)
- \( \text{#application component } i \) – number of application components

### Architectural level
Business and application

### Elements and Attributes
Elements: application component, business service

### Quality attribute
Changeability

### Substantiation
The ease of adapting the functionalities of an EA to new business requirements is maximized when the impact of changing each operation is confined to a given application component.

### Example

![Example A](chart1.png)

**Example A:**

\[
\text{NOISF} = \frac{1}{3}
\]

**Example B:**

\[
\text{NOISF} = \frac{3}{5}
\]

### 3.3.6.3 RSF – Response for a Service Factor
Abbreviator | RSF
---|---
Name | Response for a Service Factor
Computing | \[
\text{RSF} = \frac{\# \text{business service} + \# \text{application service}}{\sum_{i=1} \text{application component i}}
\]
Where:
\# \text{business service} – number of business services
\# \text{application service} – number of application services
\# \text{application component i} – number of application component that supports the service i

Architectural level | Application
Elements and Attributes | Elements: business service, application service, application component
Quality attribute | Testability
Substantiation | Count the number of application components that may be invoked to support a service.
Example

Example A:
\[ \text{RSF} = \frac{1}{4} \]

Example B:
\[ \text{RSF} = \frac{1}{1} = 1 \]
3.3.7 Portability metrics

In this section we describe the proposed metric for the quantification of the quality attribute related to EA portability, namely adaptability.

3.3.7.1 POSF – Possible Operating Systems Factor
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>POSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Possible Operating Systems Factor</td>
</tr>
<tr>
<td>Computing</td>
<td>$1 - \frac{#\text{system software}}{\sum_{i=1}^{#\text{system software}} NPOS_i}$</td>
</tr>
<tr>
<td>Where:</td>
<td>$NPOS_i$ – number of operating systems that system software supports</td>
</tr>
<tr>
<td></td>
<td>$#\text{system software}$ – number of system software</td>
</tr>
</tbody>
</table>

### Architectural level
Technology

### Elements and Attributes
- Elements: system software
- Attribute: OS (operating system)
- Appendix G: Attributes (POSF)

### Quality attribute
Portability

### Substantiation
The portability of an EA grows with the number of possible platforms where the components can operate.

### Example

<table>
<thead>
<tr>
<th>Example A</th>
<th>Example B</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="example.png" alt="My application A" /></td>
<td><img src="example.png" alt="My application A" /></td>
</tr>
<tr>
<td><img src="example.png" alt="My application B" /></td>
<td><img src="example.png" alt="My application B" /></td>
</tr>
</tbody>
</table>

Example A:

$$POSF = 1 - \frac{2}{3+1} = \frac{1}{2}$$

Example B:

$$POSF = 1 - \frac{2}{1+1} = 0$$

### 3.3.8 Architectural alignment metrics
In this section we describe the proposed metric for the quantification of the quality attribute related to EA alignment, namely business/application alignment and application/technology alignment.

3.3.8.1 CPSMF – Critical Process – System Mismatch Factor
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>CPSMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Critical Process – System Mismatch Factor</td>
</tr>
<tr>
<td>Computing</td>
<td>$1 - \left( \frac{# { P \subset AC \cap NC } + # { P \subset AC \cap NC }}{# P} \right)$</td>
</tr>
<tr>
<td></td>
<td>Where:</td>
</tr>
<tr>
<td></td>
<td>$# { P \subset AC \cap NC }$ – is the number of critical processes supported in application components that support other non-critical processes</td>
</tr>
<tr>
<td></td>
<td>$# { P \subset AC \cap NC }$ – is the number of non-critical processes supported in application components that support other critical processes</td>
</tr>
<tr>
<td></td>
<td>$# Process$ – number of processes</td>
</tr>
<tr>
<td>Architectural level</td>
<td>Business and application</td>
</tr>
<tr>
<td>Elements and Attributes</td>
<td>Elements: business processes, application components</td>
</tr>
<tr>
<td></td>
<td>Attributes: critical</td>
</tr>
<tr>
<td></td>
<td>Appendix H: Attributes (CPSMF)</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Business and application alignment</td>
</tr>
<tr>
<td>Substantiation</td>
<td>Critical business processes must be supported by different application components of non-critical business processes.</td>
</tr>
</tbody>
</table>
Example

Example A:

\[ C_{PSMF} = 1 - \frac{0 + 0}{2} = 1 \]

Example B:

\[ C_{PSMF} = 1 - \frac{1 + 1}{2} = 0 \]

3.3.8.2 CSTMF – Critical Process Technology Mismatch Factor
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>CSTMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Critical Process Technology Mismatch Factor</td>
</tr>
</tbody>
</table>
| Computing        | \[
\begin{align*}
1 & = \frac{\#\{application\ component\ c \in node\ NC\} + \#\{application\ component\ NC \in node\ C\}}{\#application\ component} \\
\end{align*}
\] Where:
- \#\{application\ component\ c \in node\ NC\} – is the number of application components considered critical supported on nodes that support other application components besides the critical ones (one application component is considered critical when it only supports critical processes)
- \#\{application\ component\ NC \in node\ C\} – is the number of non-critical application components supported on nodes that support other non-critical application components
- \#application\ component – number of application components |
| Architectural level | Application and Technology |
| Elements and Attributes | Elements: application components and node
Attribute: critical |
| Quality attribute | Application and technology alignment |
| Substantiation | In the same way that critical business processes must be supported by different applications than non-critical processes, these same applications must be implemented in technological components other than those that implement applications that support non-critical processes. |
Example A:

\[ CSTMF = 1 - \frac{0 + 0}{2} = 1 \]

Example B:

\[ CSTMF = 1 - \frac{1 + 1}{2} = 0 \]

### 3.3.9 Dimension metrics

In this section we describe the proposed metric for the quantification of the quality attribute related to EA dimension, namely application and technology architecture.

#### 3.3.9.1 NA – Number of applications
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Number of applications</td>
</tr>
<tr>
<td>Computing</td>
<td>#application components</td>
</tr>
<tr>
<td></td>
<td>Where:</td>
</tr>
<tr>
<td></td>
<td>#application components – number of application components</td>
</tr>
<tr>
<td>Architectural level</td>
<td>Application</td>
</tr>
<tr>
<td>Elements and Attributes</td>
<td>Elements: application components</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Dimension</td>
</tr>
<tr>
<td>Substantiation</td>
<td>With this metric it is possible to estimate the size of an EA, in application terms.</td>
</tr>
</tbody>
</table>

**Example**

**Example A:**

\[ NA = 4 \]

**Example B:**

\[ NA = 2 \]

3.3.9.2 NITB – Number of IT Blocks
<table>
<thead>
<tr>
<th>Abbreviator</th>
<th>NITB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Number of IT Blocks</td>
</tr>
<tr>
<td>Computing</td>
<td>#nodes</td>
</tr>
<tr>
<td></td>
<td>Where: #nodes – number of nodes</td>
</tr>
<tr>
<td>Architectural level</td>
<td>Technology</td>
</tr>
<tr>
<td>Elements and Attributes</td>
<td>Elements: nodes</td>
</tr>
<tr>
<td>Quality attribute</td>
<td>Dimension</td>
</tr>
<tr>
<td>Substantiation</td>
<td>With this metric it is possible to estimate the size of an EA, in technology terms.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Example A</th>
<th>Example B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Application server</td>
<td>Application server</td>
</tr>
<tr>
<td></td>
<td>Firewall</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data server</td>
<td></td>
</tr>
</tbody>
</table>

Example A: $NITB = 3$

Example B: $NITB = 1$

### 3.4 Step 4 - Quantify the alignment level between projects and the strategic objectives

**Input:** Metrics’ value used to measure quality attributes and the weighting of strategic objectives and quality attributes.

**Output:** Alignment level between a project and strategic objectives.

To quantify the alignment level between projects and strategic objectives, we need to measure the project’s impact according to quality attributes’ and strategic objectives importance provided in the previous section.
Firstly, we compute the metrics identified in the previous step. Then, we propose an arithmetic formula to quantify the alignment level between a project and strategic objectives:

\[
\sum_{i=1}^{n} \text{weighting} \ast \left( \sum_{j=1}^{m} \text{weighting} \ast \text{metricvalue} \right) \leq 1 \quad (3.1)
\]

Where:

- \( n \) = strategic objectives aligned with projects
- \( m \) = quality attributes
4 Demonstration

This section aims to prove the usefulness of artefacts to solve one or more instances of the problem. We apply our solution to a government-owned company that for confidentiality reasons we named “Democorp” (Appendix A: Democorp). To better address the problem and demonstrate the proposed solution, we selected two projects from the portfolio: Employee’s card project, and Newsletter project. We expect to compare two possible TO-BEs of each project and study which one has a higher impact on the Democorp’s strategy. The first project’s goal is to customize an employee card. The second is for clients to subscribe to the newsletter. With Democorp’s strategic plan, we were able to identify strategic objectives and its outcomes.

Our goal was to decide which implementation (TO-BE) of both projects is better aligned with the strategic objectives. The solution comprises of four methodological steps:

1) Identify the alignment between projects and strategic objectives;
2) Identify quality attributes associated with strategic objectives;
3) Identify metrics which can be applied;
4) Quantify the alignment level between projects and strategic objectives.

4.1. Step 1 – Identify the alignment between projects and strategic objectives

To identify the alignment between the selected projects and strategic objectives, it was imperative to:

4.1.1. Identify organization’s strategic objectives

The strategy definition of Democorp started by clarifying its mission and vision statements. These concepts are essential to the strategic plan, where strategic orientations and strategic objectives are also defined. The first tries to ensure the sustainability of the company’s activity and the creation of long-term value. The second potentiates and measures the achievement of strategic orientations and is the basis for the operational objectives’ definition.

We were able to identify its mission, vision and core values. These elements help stakeholders to define strategic orientations, strategic objectives, and the respective elements. We identified Democorp’s seven strategic orientations, twenty-one strategic objectives, and its outcomes. Each strategic orientation is numbered (from 1 to 7) and has strategic objectives associated (numbered from 1.1 to 7.3, according with the strategic orientation).

In Figure 10, we modelled the association between strategic orientations, strategic objectives and its outcomes.
Figure 10 - Association between Democorp's strategic orientations and strategic objectives.
Projects do not meet one strategic objective but contribute for its achievement. We used the above strategic objectives as input for the next step.

4.1.2. Represent objectives’ outcomes and expected values

In this step, we analyzed the documentation of Democorp’s strategy, namely strategic objectives and outcomes, to identify the expected value to the company. The value element represents the importance of the outcome and strategic objective to the organization. To represent the outcome value, we followed
the business rule proposed by Garcia (2017), using a transitive verb and a direct object that complements it.

We modeled the Democorp's objectives outcomes and their expected value, using the motivation viewpoint proposed in section 3.

Figure 12 - Strategic objectives outcomes and their expected value
In the Figure 13, we have identified the strategic objectives’ expected values according to the business rule defined in section 3.1.2.

4.1.3. Represent projects and their expected values

In this step, we analyzed documentation about the scope and purpose of each project to identify the most critical processes, applications they depend on, stakeholders, services, and their expected outcome value to Democorp. We used the outcome realization viewpoint to model it, as proposed in section 3.1.3. This viewpoint shows how underlying core elements produce business – oriented results [1].
Employees’ card TO-BE 1

Figure 14 – Employee’s card TO-BE 1

Figure 13 describes the employee’s card customization TO-BE 1. After receiving a request, the production process starts: validating employee’s data and printing card. Then, verifying the employee’s identity and, later, proceed to the customization itself. The outcome of this implementation is to increase response to failures, adding a specific value to the company: optimize process and infrastructure.

We added attributes to the Employee's card TO-BE 1 elements for further measurement, as explained in section 3. Those attributes are represented in the following table.

Table 2 - Employee's card TO-BE 1 attributes

<table>
<thead>
<tr>
<th>Element</th>
<th>Attribute Name</th>
<th>Attribute Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Customization</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Produce card</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Customize card</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Database Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Database</td>
<td>redundantElement</td>
<td>False</td>
</tr>
</tbody>
</table>
Employees’ card TO-BE 2

Figure 15 - Employee’s card TO-BE 2

Figure 13 describes employee’s card customization TO-BE 2. The objective of this implementation was to deploy an alternate site datacenter with synchronous system replication. In this way, any type of disruption that affects only one of the locations will not affect the continuity in the reception of requests.

The attributes of Employee’s card TO-BE 2 elements are described in the following table.

Table 3- Employee’s card TO-BE 2 attributes

<table>
<thead>
<tr>
<th>Element</th>
<th>Attribute Name</th>
<th>Attribute Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Feature</td>
<td>Type</td>
<td>Status</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Customization</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Produce card</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Customize card</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Database Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Database</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Internal Network</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Server</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Server Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Data Backup</td>
<td>redundantElement</td>
<td>True</td>
</tr>
<tr>
<td>Backup Server</td>
<td>redundantElement</td>
<td>True</td>
</tr>
<tr>
<td>DB management system</td>
<td>redundantElement</td>
<td>False</td>
</tr>
</tbody>
</table>

**Newsletter TO-BE 1**

![Diagram](image)

Figure 16 – Newsletter TO-BE 1
Figure 16 describes the Newsletter TO-BE 1 and has the objective to manage all the organization’s information regarding its business activities. This project allows the organization to increase product and service portfolio, by adding one new and innovative product.

The attributes of Newsletter TO-BE 1 elements are described in the following table.

Table 4 - Newsletter TO-BE 1 attributes

<table>
<thead>
<tr>
<th>Element</th>
<th>Attribute Name</th>
<th>Attribute Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membership management</td>
<td>critical</td>
<td>False</td>
</tr>
<tr>
<td>Content management</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Free consultation</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Subscription management</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Database Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Database</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Internal Network</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Server</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Server Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
</tbody>
</table>

Newsletter TO-BE 2
Figure 17 - Newsletter TO-BE 2

Figure 17 describes the Newsletter TO-BE 2. The objective of this implementation was to deploy an alternate site datacenter with asynchronous system replication. In this way, any disruption that affects only one of the locations will not affect the continuity in the reception of requests.

The attributes of Newsletter TO-BE 2 elements are described in the following table.

Table 5 - Newsletter TO-BE 2 attributes

<table>
<thead>
<tr>
<th>Element</th>
<th>Attribute Name</th>
<th>Attribute Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membership management</td>
<td>critical</td>
<td>False</td>
</tr>
<tr>
<td>Content management</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Free consultation</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Subscription management</td>
<td>critical</td>
<td>True</td>
</tr>
<tr>
<td>Database Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Database</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Internal Network</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Server</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Server Interface</td>
<td>redundantElement</td>
<td>False</td>
</tr>
<tr>
<td>Backup server</td>
<td>redundantElement</td>
<td>True</td>
</tr>
<tr>
<td>Data backup</td>
<td>redundantElement</td>
<td>True</td>
</tr>
<tr>
<td>DB management system</td>
<td>redundantElement</td>
<td>True</td>
</tr>
</tbody>
</table>

### 4.1.4. Identify projects aligned with the organization's strategic objectives

In this step, we identified the alignment between the selected projects in the section before and the strategic objectives, using the generic viewpoint proposed in section 3.

The project expected outcome value to Democorp can be in line with the outcome’s value associated with a strategic objective. By analyzing and comparing both values, we can identify the alignment between a specific project and strategic objectives.

Figure 18 provides the alignment between employee’s card TO-BE 1 and one strategic objective.
Figure 18 - Alignment between employee’s card TO-BE 1 and one strategic objective.

The project’s value is to optimize process and infrastructure and it is in line with the optimize process and infrastructure, that it is the value of the strategic objective.

Figure 19 provides the alignment between employee’s card TO-BE 2 and the same strategic objective. It is an improvement of the actual state (TO-BE 1) by adding security mechanisms and redundant elements.
Figure 19 - Alignment between the second employee’s card TO-BE 2 and strategic objective

Figure 19 displays the newsletter TO-BE 1 aligned with a strategic objective.

Figure 20 - Alignment between newsletter TO-BE 1 and the strategic objective
Figure 20 displays the newsletter TO-BE 2 aligned with a strategic objective. It is an improvement of the actual state (TO-BE 1) by adding security mechanisms and redundant elements.

4.2. Step 2 – Identify quality attributes associated with strategic objectives

In this step, we met with strategic objectives’ creators to understand which quality attributes we could derive from the strategic objectives. With quality attributes, it becomes possible to measure the project’s impact on the company’s strategy. Since our research’s scope is to measure the alignment between projects and strategic objectives, we do not consider strategic objectives that do not have any quality attribute associated and are not in line with a project.

After applying step 1, we gathered two strategic objectives that are in line with the two projects: rationalize and optimize the structure and increase service and innovate products and services portfolio.

As one of the objectives is to rationalize and optimize the structure, the creator considered the efficiency in the employee’s card customization processes and applications significant. We came up with two measurable quality attributes in the architecture: business/application alignment and fault tolerance.

While the second objective is to innovate products and services portfolio, the creator also defined two quality attributes: scalability and fault tolerance.

We also needed to get the importance of the strategic objectives and quality attributes associated. The strategic objective’s importance is a quantitative value between 0 and 10 for the organization’s
significance and the quality attribute importance is also a quantitative value between 0 and 10 but for the strategic objective significance.

Strategic objectives’ creator defined a similar importance for every strategic objective. Assuming that the importance of fault tolerance is higher than business and application alignment for rationalize and optimize the structure.

Table 6 - Mapping strategic objectives and quality attributes

<table>
<thead>
<tr>
<th>Strategic objective</th>
<th>Importance (0-10)</th>
<th>Quality attribute</th>
<th>Importance (0-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rationalize and optimize the structure</td>
<td>5</td>
<td>Business and application alignment</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fault tolerance</td>
<td>6</td>
</tr>
<tr>
<td>Innovate products and service portfolio</td>
<td>5</td>
<td>Scalability</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fault Tolerance</td>
<td>5</td>
</tr>
</tbody>
</table>

Assuming that we have only identified two strategic objectives for the alignment, their quantitative importance is 5.

4.3. Step 3 - Identify applicable metrics to projects’ architecture

In this step, we identified metrics in the correct condition to measure the quality attributes defined in step 2. The quality attributes that resulted from the previous step are: business and application alignment, fault tolerance and scalability. Consequently, we gathered metrics that allow us to measure these quality attributes in the architectures and to get deviations from TO-BE 1 and TO-BE 2.

Table 7 - Metrics to measure quality attributes

<table>
<thead>
<tr>
<th>Quality attribute</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business and application alignment</td>
<td>Alignment heuristics</td>
</tr>
<tr>
<td>Fault tolerance</td>
<td>ITRF</td>
</tr>
<tr>
<td>Scalability</td>
<td>SITPLBF</td>
</tr>
</tbody>
</table>

The metrics in table 11 were formalized in FCEO [4], but we proposed to adapt them into ArchiMate. help us to apply our solution, as explained in section 3.
4.4. Step 4 – Quantify the alignment level between projects and the strategic objectives

In this step, we quantified the alignment level between the possible implementations (TO-BEs) of projects and the strategic objectives considered before.

First, we needed to calculate the value of the metrics identified in the previous step.

**Employee's card TO-BE 1**

**Input:** business and application alignment and fault tolerance.

**Output:** metrics' value.

For business and application alignment, we applied the CPSMF metric:

$$CPSMF = 1 - \frac{1 + 0}{2} = 0.5$$

For fault tolerance, we applied the ITRF metric:

$$ITRF = \frac{0}{5} = 0$$

**Employee's card TO-BE 2**

**Input:** business and application alignment and fault tolerance.

**Output:** metrics' value.

For business and application alignment, we applied the CPSMF metric:

$$CPSMF = 1 - \frac{0 + 0}{2} = 1$$

For fault tolerance, we applied the ITRF metric:

$$ITRF = \frac{2}{9} = 0.22$$

**Newsletter TO-BE 1**

**Input:** scalability and fault tolerance.

**Output:** metrics' value.

For scalability, we applied the SITPLBF metric:

$$SITPLBF = 1 - \frac{1}{5} = 0.8$$

For fault tolerance, we applied the ITRF metric:

$$ITRF = \frac{0}{5} = 0$$

**Newsletter TO-BE 2**
Input: scalability and fault tolerance.

Output: metrics' value.

For scalability, we applied the SITPLBF metric:

\[ SITPLBF = 1 - \frac{1}{9} = 0.99 \]

For fault tolerance, we applied the ITRF metric:

\[ ITRF = \frac{3}{9} = 0.33 \]

Then, we applied the contribution formula (3.1) to quantify the alignment level between projects and the strategic objectives:

Employee’s card TO-BE 1

Input: metrics’ value and ponderation, strategic objectives’ ponderation

Output: alignment level between Employee’s card TO-BE 1 and the strategic objective.

\[ c = 0.5 \ast (0.5 \ast 0.5 + 0 \ast 0.5) = 0.125 \]

Employee’s card TO-BE 2

Input: metrics’ value and ponderation, strategic objectives’ ponderation

Output: alignment level between Employee’s card TO-BE 2 and the strategic objective.

\[ c = 0.5 \ast (1 \ast 0.5 + 0.22 \ast 0.5) = 0.305 \]

Thus, the employee’s card TO-BE 2 has a greater impact on the strategic objectives of the organization than TO-BE 1, regarding the quality attributes measured in both TO-BEs.

Newsletter TO-BE 1

Input: metrics’ value and ponderation, strategic objectives’ ponderation

Output: alignment level between Newsletter TO-BE 1 and the strategic objective.

\[ c = 0.5 \ast (0.8 \ast 0.5 + 0 \ast 0.5) = 0.2 \]

Newsletter TO-BE 2

Input: metrics’ value and ponderation, strategic objectives’ ponderation

Output: alignment level between Newsletter TO-BE 2 and the strategic objective.

\[ c = 0.5 \ast (0.99 \ast 0.5 + 0.33 \ast 0.5) = 0.33 \]

Thus, the newsletter TO-BE 2 has a greater impact on the strategic objectives of the organization than TO-BE 1, regarding the quality attributes measured in both TO-BEs.
4.5. Results discussion

To measure the quality attributes, each of the project’s architecture, TO-BE 1 and TO-BE 2 were assessed by quality metrics to determine which TO-BE can be more aligned with the Democorp’s strategic objectives.

At the level of the qualities to evaluate these TO-BE architectures (scalability, fault tolerance, business and application alignment), Figure 22 represents a comparative analysis of the qualities presented by the two projects developed.

![Comparative analysis of quality attributes](image)

Figure 22 - Employee's card comparative analysis
Figure 23 - Newsletter comparative analysis

It is possible to verify that employee’s card TO-BE 2 is more adequate than TO-BE 1 according the quality attributes – fault tolerance and business and application alignment. Therefore, newsletter TO-BE 2 is more adequate than TO-BE 1. We can observe that TO-BE 1 does not respect the quality attribute of fault tolerance.

It is possible to conclude that employee’s card TO-BE 2 and newsletter TO-BE 2 have a higher impact on the Democorp’s strategy. Consequently, these two TO-BEs should be implemented.

4.5.2. Summary

In this chapter, we propose to assess the impact of EA on the strategic objectives. Thus, using the multi-criteria approaches, using ArchiMate in EA modeling, with the definition of alternative TO-BEs in which its characteristics are evaluated (comparatively) by measuring their quality attributes and, consequently, identify which project(s) had higher impact on Democorp’s strategy.

The solution proposed in this dissertation, which helped the organization decide between TO-BE’s in accordance with its strategic objectives, was applied in two different projects: employees’ card and newsletter. The organization should then decide which TO-BE to adopt according to its strategic objectives.

The verified results allowed to validate the fulfillment of the objectives and contributions foreseen, namely with respect to: measuring the alignment between projects and strategic objectives.

The results of the practical cases allowed the verification of the various hypotheses of scientific investigation delineated.
5 Evaluation

This section corresponds to the evaluation of DSRM process model’s activity. The evaluation activity aims to observe and measure how well the artifacts support a solution to the research problem. It intends to compare the objectives of a solution to observed results from use of the artifacts presented in Section 4.

The evaluation of this work was accomplished by using the demonstration scenario at one government owned company, named Democorp.

We used the following approach to evaluate our solution:

• Analyze Democorp’s alignment between its projects and strategy before and after applying the proposed solution;
• Compare both scenarios identified in the analysis above, in order to establish if, with the proposed solution, we were able to add or improve quality and quantify the alignment information between Democorp’s projects and strategic objectives.

The two selected projects represent a sample of Democorp’s ongoing projects in the portfolio. Although restrictive, this sample has proven to be sufficient to verify the applicability of our proposed solution’s by presenting the scenario: projects were aligned with at least one strategic objective. Therefore, when evaluating the proposed solution, we used two projects selected as Democorp’s ongoing projects in the portfolio.

5.5.1. Comparative analysis of EA assessment methodologies

In order to allow a better discussion of the proposal developed in this dissertation with other reference work in this area, a comparative analysis was performed. Given the research objectives of this dissertation, we will focus on the level of architecture vision, business architecture, application architecture and technology architecture.

In this analysis, we will consider the following concepts of comparison:

• Framework - indicates whether the research under consideration makes it possible to recognize and relate business and organizational concepts, technologies and information systems (at the application and technological level) and software (regardless of whether they propose specific concepts for each of these areas or not).
• Concepts - indicates whether the research under analysis proposes a set of architectural primitives and concepts, including a notation, at the business and organizational levels, of information and software technologies and systems.
• Approaches - indicates whether the research under analysis provides some methodological support or concepts in the construction of architectures and their evaluation (such as metrics, quality attributes and evaluation methodologies).
• Industry - the use by the industry.

For this analysis, we will consider ArchiMate and FCEO.

Table 8 summarizes the evaluation of the various approaches analysed, by assigning scores with a value from 0 to 5, where 0 corresponds to total non-compliance and 5 corresponds to total compliance with the criteria.

<table>
<thead>
<tr>
<th></th>
<th>ArchiMate</th>
<th>FCEO</th>
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<tbody>
<tr>
<td><strong>Framework</strong></td>
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<td><strong>Concepts</strong></td>
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<td>Business primitives</td>
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<td>2</td>
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<td>Information systems primitives</td>
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<tr>
<td>Software primitives</td>
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<td><strong>Approaches</strong></td>
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<td>Building</td>
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<tr>
<td>Used by industry</td>
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</tbody>
</table>

These two languages are closely related to the objectives that our research intends to achieve. The facts that took us to choose ArchiMate as the modelling language were: the increased involvement of industry, about 40 organizations use ArchiMate for modelling its concepts; and more graphic and visual concern on the part of ArchiMate, namely by using colors and a set of usability guidelines to understand the models developed. We bore in mind that FCEO is an already formalized language in UML.
For those reasons we applied our solution in Democorp using ArchiMate as the modelling language and adapted important concepts of FCEO, for instance, metrics and quality attributes.

There are other researches in this area of architecture evaluation by measuring quality attributes: [36], [8] and [29]. However, there was a gap between EA and the strategy that our work proposed to address.

5.5.2. Hypotheses of the scientific research

The validity of the research hypotheses, proposed in section 1.1, is analyzed in the light of the results obtained in this chapter (according to the research-action methodology that supports this research). Thereby, the question “Is it possible to measure quality attributes in EA?” was verified in the two case studies, using metrics to measure quality attributes already formalized in FCEO that we adapted into ArchiMate. The question “Can AE’s contribution to meeting strategic objectives be measured through architectural qualities?” was verified, as we got the quality attributes associated with the strategic objectives and, consequently, measured in EA.

Finally, the question “Will we be able to measure the alignment between projects and strategic objectives?” was also verified. We proposed a contribution formula to assess the impact of the projects on the strategic objectives.
6 Communication

The communication section corresponds to the communication activity of the DSRM process model [13]. In this Section, we aim to communicate the problem and its importance, the artifact, its utility and novelty, the rigor of its design and its effectiveness to researchers and other relevant audience [13]. Moreover, this communication activity tests the acceptance of the research work outcomes, which provides information about the proposed work, the problem’s importance, the solution objective’s viability, the artifact’s utility and the outcomes’ value.

This research work was applied in Democorp, the field study company, by having the proposed method applied to its particular case.

To communicate our work, we have submitted one paper to the 21st International Conference on Enterprise Information Systems (ICEIS 2019). The paper proposes our method to measure the alignment between an organization’s projects and its strategic objectives using ArchiMate as the modelling language.
7 Conclusion

The alignment between projects with an organization’s strategy is crucial in today’s competitive market as it is nowadays. Without the right projects, even the most prepared strategies can fail. Organizations use strategy models, templates, frameworks tools to analyze strategies, goals and objectives, based on KPI’s. These tools only measure whether strategic objectives are accomplished or not, leaving apart initiatives that can contribute for it.

The related work provided information concerning key concepts relevant to the research problem, such as: organizational alignment, enterprise architecture and ArchiMate to model the proposed solution.

Enterprise architecture offers different perspectives of the organization’s AS-IS and TO-BE and operations that must be executed to meet the strategic objectives. Also, it provides different viewpoints that focus on specific aspects of the architecture, allowing the representation of our proposed solution in a coherent way.

After analyzing the related work, the research problem was formulated: a solution for quantifying the alignment between projects and strategic objectives using ArchiMate as the modelling language.

ArchiMate allows the modeling of an organization’s strategic objectives, projects and their expected value to the organization. It also allows us to model relations between these concepts. In section 3, we described the proposed solution steps and its viewpoints.

The proposed solution was applied in Democorp, a government owned company. We modelled Democorp’s strategic elements and three selected projects and the expected value of a project using ArchiMate as the modelling language. Additionally, we identified the correlation between Democorp’s projects architecture and its strategic objectives. We provided an arithmetic solution to quantify such alignment.

We conclude that the proposed solution helps organizations identifying which projects can contribute more to the achievement of the strategic objectives.

7.1 Contributions

Throughout this research a number of contributions in the field of EA have been produced. Below we list these contributions, considering the specific problems of this dissertation.

The main contribution of this dissertation is the proposed adaption of FCEO metrics into ArchiMate to evaluate the quality attributes of an information system architecture.

The metrics were proposed in order to estimate the quality characteristics of the IS, being organized in metrics of Functionality, Reliability, Efficiency, Maintainability, Portability and Alignment.

The proposed metrics, based on the quality characteristics reference, are supported in FCEO architectural primitives and were formally defined in OCL, avoiding any interpretation or application ambiguities. For each metric, the form of computation is described (informally and mathematically), its
rationale is presented, the levels and architectural attributes involved in its calculation are identified and the estimated quality attributes are identified.

In the two practical cases where the metrics were applied (Employee’s card and newsletter), it was verified the correction of the estimated quality characteristics and the impact they have on Democorp’s strategy was verified.

As proposed in the main objectives, this research contributes to fill a gap that previous researchers left: a methodology to quantify the alignment between projects and strategic objectives.

This research also has additional contributions: exploratory mapping work between FCEO and ArchiMate, evaluation of alternative architectures according to quality attributes using ArchiMate as the modelling language.

Our solution was validated in Democorp, a government-owned company. Contributing to the continually identifying an ongoing or starting project is in line with the strategic objectives and between different implementation of projects (TO-BEs), which one has a higher impact on the company’s strategy.

7.2 Limitations

This dissertation has some limitations that need to be addressed.

The main limitation is that the solution is not a stand-alone tool, it requires knowledge about the organization’s strategy, projects and about the language used to model every step.

Our method does not provide a direct relation with other tools. Only that the used metrics to measure the alignment were adapted from those already created for FCEO. And it was not possible to use all metrics, because some are not supported in ArchiMate.

There is no rule or methodology to derive quality attributes from strategic objectives, but only stakeholders’ knowledge.

7.3 Future work

There is plenty of work that needs to be done based on this dissertation.

Having established a way to measure the alignment between projects and strategic objectives, a possible future work should be to automatically derive quality attributes from strategic objectives, rather than depending on stakeholders’ knowledge.

Another possible future work would be to translate FCEO metrics or create new ones for ArchiMate, in order to support and expand our starting work to quantify the alignment.

Also, developing a dashboard or a tool that is able to monitor the real value of the alignment could be another possibility.
Moreover, it would be valuable to demonstrate and evaluate the solution in more than one government owned company and comparing the results.

7.3.1 Using BSC to support the connection between quality attributes and strategic objectives

We have started the possibility of mapping BSC’s perspectives and quality attributes, in order to improve the measurement of the alignment between EA and the strategy. However, we could not deepen this aspect due to a lack of technical support and referenced work, but we believe it is a hypothesis that can facilitate and support the work in this area.
References


8 Appendixes

8.1 Appendix A: Democorp

Example A:

8.2 Appendix B: Attributes (BSRPF)
8.3 Appendix C: Attributes (DTISSF)

Example A:

Example B:
8.4 Appendix D: Attributes (SCBITABF)

Example A:

Example B:

8.5 Appendix E: Attributes (ITRF)

Example A:
Example B:

8.6 Appendix F: Attributes (SITPLBF)

Example A:
8.7 Appendix G: Attributes (POSF)

Example A:
Example B:

8.8 Appendix H: Attributes (CPSMF)

Example A:

Example B:

8.9 Appendix I: Attributes (CSTMF)

Example A:
### 8.10 Appendix J: FCEO to ArchiMate

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