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Impact of Strategic Initiatives on the Adaptation of Enterprise Architecture

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Abstract: Nowadays, companies are immersed in disruptive environments. To thrive in the 'new normal', they drive strategic initiatives resulting in changes with unpredictable frequencies and extents. These changes impact different elements of the company, which makes them a crucial matter for enterprise architecture. However, the traditional management operating models have become overstrained, which leads to existential threats. Therefore, the adaptation of enterprise architecture has emerged. It is an agile approach that continuously senses and responds to change without compromising the alignment in the enterprise. The management of the impact of strategic initiatives is pivotal to the success of companies. Overall, in the context of adaptation, contributions to the proactive assessment and monitoring of the impact of strategic initiatives on enterprise architecture are lacking. Therefore, this study aims to model this impact and evaluate it while focusing on the enterprise architecture structural components and their relationships. It proposes tools to support the analysis. Thereafter, it indicates the applicability of the suggested approach via a case study in a state urban planning agency.

Keywords: Adaptation, Change, Enterprise Architecture, Impact of Strategic Initiative

Introduction

Companies do not evolve alone in an empty space but in an environment that influences how they operate. Nowadays, they are facing an increasingly changing business environment mainly characterized by unpredictability and disruptions or as it is called in extant literature: A Volatile, Uncertain, Complex, and Ambiguous (VUCA) environment. To cite one recent example, businesses around the world have been caught off guard by the COVID-19 pandemic. The pandemic became a big challenge for micro to large enterprises in all industries as it spread rapidly in 2020; thus, a quick response was required. Some of the enterprises closed down and their digital transformation became a necessity, not an option.

In response to this environmental hostility, companies are required to navigate uncertainty and reassess growth opportunities. They need to develop dynamic capabilities to reconfigure their assets and proactively detect new opportunities. Thus, adaptation to this 'new normal' is compulsory. Enterprise Architecture (EA) can be leveraged as a catalyst for change (Lankhorst, 2013). EA first started in the eighties. It provides an overview of the systems of an enterprise and their relationships (Afriliana *et al*., 2022; Anthony Jnr, 2021). It supports the design of an enterprise at distinct levels by a set of principles and models. These levels are mainly business, organization, Information Technology (IT), and infrastructure (Lankhorst, 2013). EA ensures, by design, the alignment between the different structural components and their interrelations (Anthony Jnr, 2021). Traditional EA frameworks are heavy, lack agility, and are complex (Gong and Janssen, 2019; Masuda and Viswanathan, 2019). In current world dynamics, their adoption has refrained.

Several scholars have pointed to the adaptation of Enterprise Architecture (EA) as a tool that facilitates change (Hinkelmann *et al*., 2016; Mocker and Boochever, 2020), They call for the redesign of EA so that it is more adaptable to changes (Hinkelmann *et al*., 2016). In fact, to ensure a lightweight adaptation, EA should facilitate the

response to change. When moving from an 'As-Is' to a 'To-Be', EA should support continuous multi-level improvement to proactively address evolving requirements (Daoudi *et al*., 2021; Masuda and Viswanathan, 2019). The continuous response to change materializes as strategic initiatives impacting one or many layers of the EA and influencing the relationships between the components of their architecture (Daoudi *et al*., 2021; Kawtar *et al*., 2020).

Enterprises stepping out of their comfort zone, are confronted with numerous strategic proposals because of the high dynamic of their environment. Further, they face an increased risk of compromising the alignment between their EA components and the pre-established structural relationships. As previously stated, the accommodation to changes should be quick and effective while reducing complexity and cost (Beese *et al*., 2023; Masuda *et al*., 2021). In fact, adaptation EA projects that do not take into consideration the pace of change and the existing architectures are prone to failure or abandonment. They lead to a waste of time and effort. In addition, they lead to complex architectures, misaligned components, and maintenance issues. The enterprises, rather than focusing on their strategies, need to find workarounds to respond to changes. There is a gap in the literature on how to support enterprises to proactively assess and select their strategic initiatives. In addition, the quantification of the impact of strategic initiatives on the various pre-existing components and relationships that are already aligned is lacking (Daoudi *et al*., 2021). In the context of adaptation of Enterprise Architecture, the following questions occur:

- How to model strategic initiatives and their impact on Enterprise Architecture?
- How to evaluate the impact of these initiatives on Enterprise Architecture components and relationships?

The objective of this contribution is to model the impact of strategic initiatives on Enterprise Architecture and to support their implementation while considering the existing alignment. This study has the potential to support companies in their transformation journey to survive in the current highly dynamic environment. It helps them clearly understand the impact of their strategic initiatives on their current architecture. It supports them in choosing the strategic initiatives to implement while fully understanding the impact on their EA. They can also decide to proceed partially or fully with the implementation of an initiative.

In the following, the work related to the impact of strategic initiatives on EA, in a context of adaptation, is presented. The material and methods section highlights the methodology, the concepts, and materials adopted for our research. Moreover, the results section presents the modeling of strategic initiatives and their impact on the Enterprise Architecture. Furthermore, we highlight the approach to evaluate the studied impact, followed by a proposition of supporting algorithms and prototypes (a modeling tool and an impact evaluation tool). In addition, a case in a state urban planning entity shows the applicability of the work. In the last part, we discuss the results achieved. To wrap up the research, conclusions and perspectives are presented.

Related Work

Adaptation of Enterprise Architecture

EA is a catalyst to move from an Initial State (As-Is) to a future one (To-Be) (Anthony Jnr, 2021). It is a set of all those elements that evolve while ensuring an aligned coherent structure. It offers a view of the internal functioning of an enterprise (Winter and Fischer, 2006). There are several EA frameworks (Gong and Janssen, 2019). However, those traditional frameworks are heavy, lack agility, and are complex (Masuda and Viswanathan, 2019).

In current world dynamics, the adoption of traditional EA frameworks has refrained. Academics and practitioners explored the adaptation of EA frameworks (Daoudi *et al*., 2021; Masuda and Viswanathan, 2019; Van de Wetering, 2019). The actions taken to adapt the EA impact architectural components and their relationships (Alwadain, 2014; Moreno-Camacho *et al*., 2019). Adaptation responds essentially to change (Van de Wetering, 2019). It leads to adjustments to align the business with the strategy and the Information System (Alwadain, 2014; Moreno-Camacho *et al*., 2019). Conversely, change impacts various levels of an enterprise. It has external and internal sources (Kawtar *et al*., 2020). It can be triggered strategically or operationally (Hinkelmann *et al*., 2016). Thus, the adaptation of EA requires effective integration and alignment between adaptive strategy and operations. It fits into the value chain as a creator of value and supports alignment (Kotusev *et al*., 2022). Moreover, the adaptation of EA happens continuously over time. It is a set of EA projects that can be initiated through operational or strategic triggers. It impacts architectural layers, elements, relationships between components, and alignment in an EA (Hinkelmann *et al*., 2016).

Impact of Strategic Initiatives on Enterprise Architecture

Strategic initiatives define the priorities for a company. They constitute the overall strategy. Also, they are not static. They evolve continuously due to internal and external factors (Hanelt *et al*., 2021; Saunders *et al*., 2008). On the other hand, the main reasons that lead to the failure of implementation of strategic initiatives or projects are the lack of monitoring and the lack of impact evaluations

(Kawtar *et al*., 2020; Kitsios and Kamariotou 2019). The implementation of strategic initiatives requires Information systems and business capabilities (Saunders *et al*., 2008). Therefore, as a holistic approach, EA helps with the implementation of an enterprise strategy. This is achieved through the simplification of the system into interrelated components and the sharing of a common view of the enterprise. It plays the role of a mediator between the strategy and the operations.

The pace of change of strategic initiatives is linked to the world dynamics. In current highly changing environments, adaptation over time of an EA results in many strategic initiatives that impact one or various layers of the enterprise (Hinkelmann *et al*., 2016; Masuda and Viswanathan, 2019). This disturbs the coherence and alignment required in an EA. Conversely, the complexity of the architectural model depends on the complexity of its underlying modules. In fact, without proper monitoring of the impact of strategic initiatives, the adaptation of EA can lead to complexities as new elements and relationships are created (Gong and Janssen, 2019). This causes the failure of EA adaptation projects and the absence of alignment with the strategy. It also creates ad-hoc components and relationships in the operational models making them difficult to maintain and align with each other. This challenges the EA as a supporting tool for decision-making (Tamm *et al*., 2022).

Consequently, an impact evaluation of strategic initiatives is required to support management in the selection and tracking of EA projects. The literature is poor on how to proactively assess the impact of strategic initiatives (Daoudi *et al*., 2021). Further, before undertaking any adaptation EA project, the initiating strategic initiative should be clearly defined and modeled. Also, their impact on the enterprise layers should be quantified and closely monitored. Most importantly, it is necessary to model the impact on the relationships between the layers. The impact engendered by those initiatives should be assessed proactively and reactively. This supports decision-making, ensures the right success rate, and minimizes the waste of resources. This impact analysis, also, ensures a quick and effective implementation of initiatives while reducing complexity and cost.

To achieve this, a modeling approach of the impact of strategic initiatives on the adaptation of enterprise architecture is presented. Further, this study suggests an evaluation approach to this impact. It is supported by tools and algorithms.

Materials and Methods

This section presents the material and the methods used in this research. It is based on a qualitative design. It uses an inductive conceptual methodology presented in the form of stages. The materials and the concepts used in each stage are detailed in below paragraphs. This helped identify research gaps and gain an in-depth understanding of the research problem of this study. To address this problem via a novel and adequate methodological approach, a four stages research methodology was defined. Figure 1 highlights the steps of the methodology.

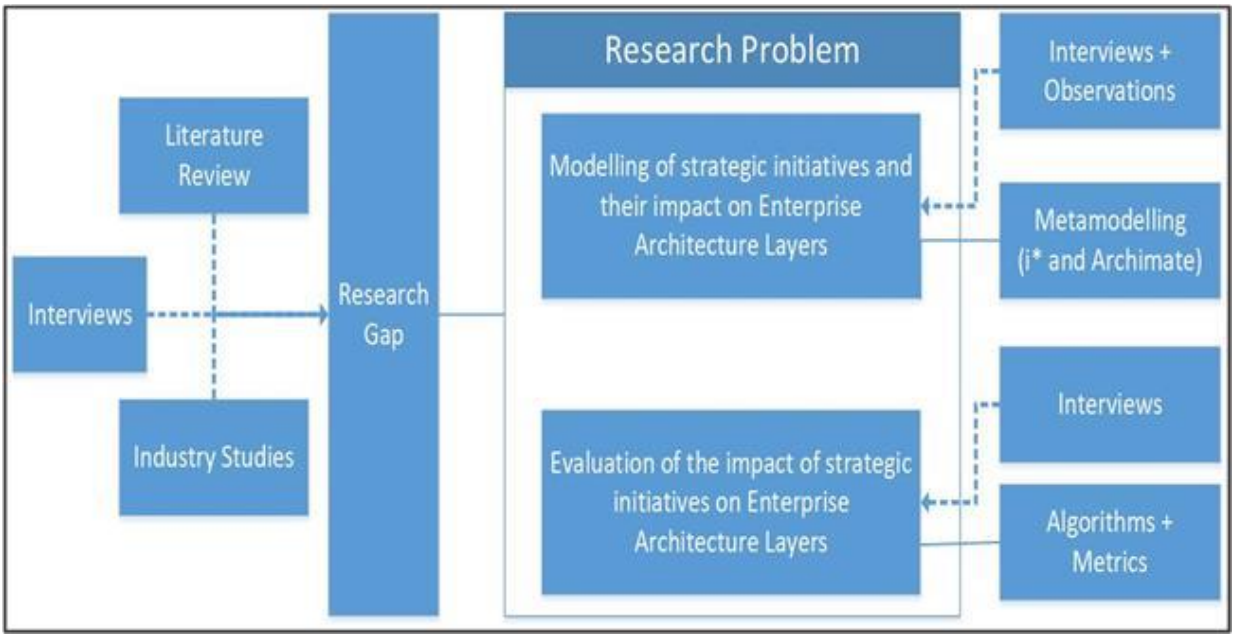

Fig. 1: Stages of the research methodology

Literature Review and Analysis of Industry-Leading Studies

The analysis of the literature was done through scientific databases: IEEE Explorer, Web of Science, ACM Digital Library, Science Direct, Springer, Scopus, DBLP, and Google Scholar. To narrow down the search scope, we focused on a set of keywords: "Adaptation", "enterprise architecture", "strategy", "strategic initiatives", "Impact", "Influence", "agile" and "dynamic". On top of this, industry-leading studies were explored. The search was limited to English and French publications (Thesis, journals, chapter books and conferences). The explored papers ranged from 2015-2023. This range was selected to cover the most recent publications and the research stream of "adaptation of Enterprise Architecture" (Anthony Jnr, 2021). The First screening helped with the identification of research gaps and limitations (Daoudi *et al*., 2021; Kawtar *et al*., 2020). On top of the language, the type of articles, and the publication date range, we selected the following inclusion and exclusion criteria:

- Inclusion: Include articles on the adaptation of enterprise architecture for companies and public entities, the impact of changes, and the change implementation
- Exclusion: Exclude articles that focused only on business/Information System alignment or strategic planning, without delving into the correlation between the two. Also, country frameworks were out of scope due to their specificities. Similar studies were excluded while retaining only the most recent versions

Research Problem

Enterprises are continuously evolving in their environment during their lifetime. In the current highly dynamic environment, they need to adapt their strategies to address various requirements, which impact different layers of the enterprise. Moreover, the changes create and/or alter architectural relationships and components. This disturbs the alignment required in an EA. Without a proactive analysis of the impact, companies fail their EA projects and waste effort and time. Also, without proper monitoring, the architecture becomes more complex and difficult to maintain. Based on the literature review and industry studies, the research problem formalizes into two main questions: How to model strategic initiatives and their impact on Enterprise Architecture? How to evaluate the impact of these initiatives on Enterprise Architecture components and relationships?

Description of Strategic Initiatives and their Impact on Enterprise Layers

The existing literature highlights the layered representation of EA. It shows the common layers or domains of EA: Organizational, strategic, business, information system, and technical aspects (Open Group, 2019; 2018; Winter and Fischer, 2006). The EA is represented through cartographies of each layer. In an effort to adapt to Enterprise Architecture, the identification of the chosen strategic initiative that would be considered requires the gathering of existing architectures through interviews and observations.

In addition, a thorough knowledge of the strategy of the company, industry trends, and strategic initiatives of the enterprise is needed. To gather this, the methods used are observations and in-depth discussions in small groups. On top of these qualitative data collection methods, the description of the chosen strategic initiative and of the existing architecture requires the use of metamodeling. In fact, models are pivotal in the description of structures and behaviors. They add an abstraction layer to concrete concepts allowing their explicit manipulation. Metamodeling is the use of a model to describe another model as an instance. It allows the analysis and creation of structures, rules, models, and characteristics to address a class of problems. The representation of models and metamodels requires the use of a language that provides syntax and sometimes semantics. The use of computerized visualization tools with palettes and rule validations allows the representation of these models and their manipulation. According to (Kitsios and Kamariotou, 2019), there is a large variety of EA modeling techniques.

The existing literature advocates a layered design of EA. The common layers or domains are generally expressed in the form of architectures (Winter and Fischer, 2006). The researchers often refer to the organizational, strategic, business, information system, and technical aspects (Khabouze, 2022). Several proposals, ranging from three layers to five layers, generally, are present in the literature (Open Group, 2019; 2018; Winter and Fischer, 2006). This study considers that EA can be formalized in three layers: Strategy layer, business layer, and Information System (IS) layer composed of application and technology sub-layers. The application and technology are combined into the IS layer to facilitate communication with the stakeholders while executing the approach. In fact, there is a proximity between application and technology actors and processes. The strategy perspective defines the target strategy, its vision, mission, and goals. The business perspective describes the processes that support

goals and functional requirements. Further, it helps to define the IS requirements that are aligned with the business. Thereafter, the IS layer describes the systems, their interaction, the data organization, and the storage. Further, it includes the technology perspective that shows the network technologies and hardware infrastructure.

In the following, the supporting architectural languages used in this study are presented. They are used to model the impact of strategic initiatives on the adaptation of EA. A strategic initiative highlights crucial changes impacting the long-term direction of a company (Saunders *et al*., 2008). According to Kitsios and Kamariotou (2019), there is a large variety of EA modeling techniques used by researchers and practitioners; however, only a few of them are frequently used, mainly ArchiMate and i* framework. ArchiMate was published in 2009 as a solution to EA modeling. Its core framework has three layers: Business, application, and technology (Open Group, 2019). Further in this study, ArchiMate is used in the business and IS layers. Figure 2 shows the metamodel of the concepts used in each layer (Open Group, 2019). For strategy modeling, researchers focus on improving ArchiMate to model business strategy. ArchiMate 3.1, as the latest iteration (Open Group, 2019), shows that some elements were added to create a full ArchiMate framework, mainly motivation and strategy elements. However, there are many strategy concepts. The main ones are mission, vision, strategy, and objective (Anir *et al*., 2019). The main limitation is that those concepts have various levels of abstraction, some of them are quantifiable and others are vaguer. However, when using the same concept to model all of them, as in Archimate, we cannot differentiate between them anymore (Kitsios and Kamariotou, 2019). ArchiMate language shows limitations when conceptualizing strategy elements with the 'goal' concept. Thus, the i* framework is explored. i* is a modelling framework that uses four central concepts. The first one conceptualizes the strategic goal. It is called a 'soft goal'. The second one is 'hard goal', which is operationally well refined. Further, there is a 'plan', which is the method to fulfill a goal. Finally, there are 'resources', which are the means to reach a goal. Further, i* defines dependency and intentional links (Zhu and Li, 2022). Figure 3 shows the metamodel of i* (Zhu and Li, 2022).

In this study, the chosen languages are i* (Zhu and Li, 2022) and Archimate (Open Group, 2019). In order to model strategic initiatives, Archimate concepts can be enriched with i* ones. Strategic initiatives are parts of the strategy layer.

Analysis of the Impact of Strategic Initiatives on Enterprise Layers

For this stage, we require the operationalization of the gathered data regarding the impact of the chosen strategic initiative on the architectural layers. To ensure this, a quantitative method is proposed. The idea is to generate metrics from the models discussed in the previous step. The translation of qualitative concepts into numbers allows an in-depth analysis and the definition of metrics. To perform this, the method proposed is based on algorithms and matrixial representation.

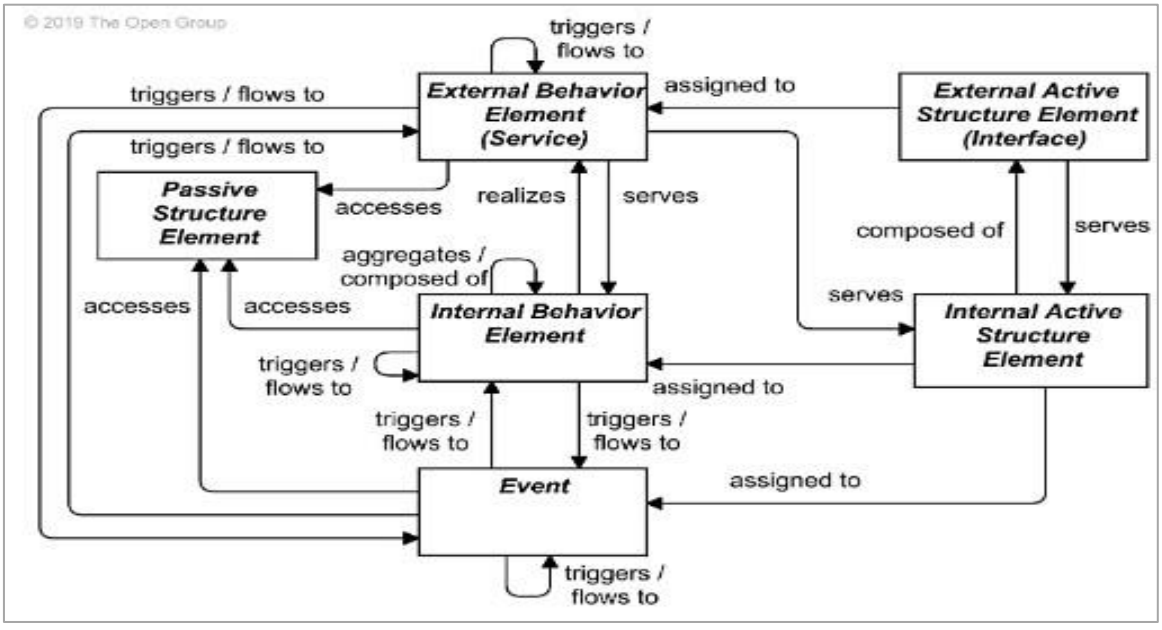

Fig. 2: Archimate core meta-model for each layer

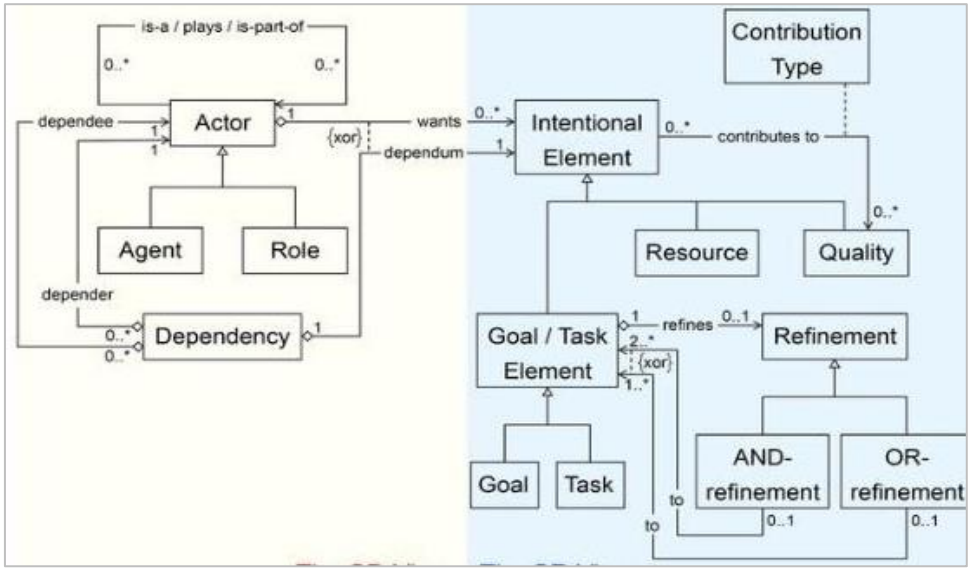

Fig. 3: I* meta model

The use of algorithms to calculate impact metrics provides a set of well-defined and rigorous instructions. It also ensures the readiness to inject these steps into a computer program to perform the calculation. It clearly states the inputs needed and the outputs generated. We use pseudocodes to present the algorithms. In addition, matrices are linear maps. They allow explicit computations in linear algebra. The impact of strategic initiatives on the architectural layers is simply a mapping between each strategic initiative and the components of each layer. The algorithms and the detailed matrices are presented in the following parts.

Based on this methodology, the resulting approach to address the research problem is presented. Moreover, a real case study involving enterprise stakeholders (architects and management) shows the applicability in the real context of the proposed approach. It validates the models presented. In other contexts, the set of stakeholders is narrowed down depending on each company's organizational structure.

Results

This section is organized into three parts. The first part presents the identification of strategic initiatives for Enterprise Architecture adaptation. The second section deep dives into the modeling of the impact of a strategic initiative on the layers of an Enterprise Architecture. It also presents the analysis of this impact. The last part presents a case study that supports the applicability of the work.

Identification of Strategic Initiatives for Enterprise Architecture Adaptation

When adapting to the dynamic environment, enterprises continuously move their EA from an 'As-Is' architecture to a 'To-Be' architecture. This transition can be chunked into a succession over time of small projects constituting 'elementary EA adaptations', namely EA_i (i is an integer not null). The transitions over time are shown in Fig. 4.

The elementary EA adaptation is initiated by a strategic initiative, and it drives the changes in the business and IS layers. The identification of a strategic initiative allows having a clear view of the foundations of the adaptation EA project. It, also, ensures an alignment between the enterprise architect and the different stakeholders. Moreover, it sets the grounds for the impact assessment of the strategic initiative on the Business and IS layers.

The first step is the modeling of the strategic initiatives using the soft goal concept from i* and its refinement into 'hard goals'. To ensure the readiness of the company for this elementary EA adaptation, an assessment of factors that influence the studied strategic initiative is suggested. These factors fall under four categories that show the strengths and the opportunities. According to Anir *et al*. (2019), the analysis of resources and capabilities of an enterprise highlights the company's strengths and weaknesses. In Archimate, resources are assets related to a business and capabilities use resources to achieve a goal. In addition, opportunities and threats are external factors. To model them the driver concept from Archimate is used. In Archimate, drivers are internal or external elements that impact a business (Kitsios and Kamariotou, 2019). Thus, the initiative of the elementary EA adaptation project is defined. It is modeled using the concept of 'soft goal' from i*. Figure 5 highlights the modeling concepts used in this step and their relationships.

Fig. 4: Elementary Enterprise Architecture adaptations

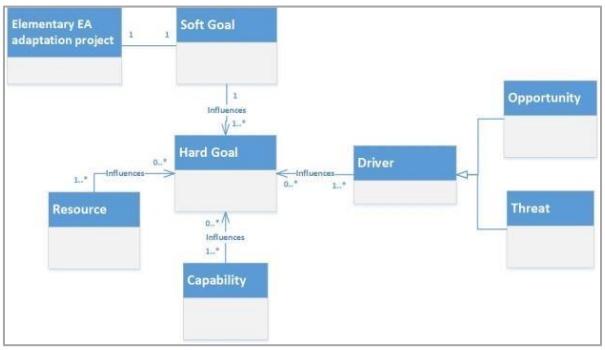

Fig. 5: Metamodel of the identification of a strategic initiative for an elementary EA adaptation

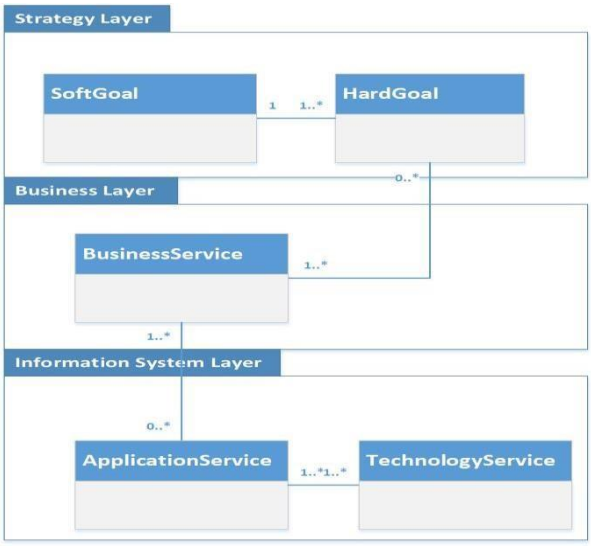

Fig. 6: Metamodel of the impact of strategic initiatives on EA layers

Impact of a Strategic Initiative on Enterprise Architecture Adaptation

In the following, the impact of strategic initiatives on the layers of the EA architecture is modeled. The impact analysis shows the changes caused by the strategic initiative on the business and IS layers. In the first part, this impact is modeled. In the second part, an evaluation algorithm is presented.

Modeling the Impact of a Strategic Initiative

This step ends with the presentation of the cartography highlighting strategic initiatives and their impact on the business and the IS.

In this study, ArchiMate concepts are used in business and IS layers. They have enriched with i* concepts for strategy modeling: Soft goals and hard goals. This is done by adding specialization to the concept 'goal' of Archimate.

The ArchiMate language offers basic components that are used in generic modeling. To address specific demands, ArchiMate offers two customization mechanisms: Adding attributes or 'profiling' specialization (Open Group, 2019). The second mechanism is adopted because it best serves the approach in this study. A specialized element or relationship is quite similar to the 'stereotype' in UML. It has the same properties as the generalized elements it is inheriting from.

To conduct the impact analysis, the following i* concepts are used in the strategy layer: Soft goals and hard goals. As previously stated, a soft goal models the strategic initiative of the elementary EA adaptation. The hard goal operationally refines the strategic initiative. Then, in the business and IS layers, the Archimate service concept is used. In this case, the concepts used are business service, application service, and technology service. The service concept reflects the function that a system exposes to the other systems and layers. It hides the internal details of the system.

The relationship used between different layers and in the same layer is the 'influence relationship' with weights (Default Value 1).

Figure 6 is a UML class diagram that presents shows the classes and their relationships. The classes are grouped depending on the layer they belong to.

To support the implementation of the presented method, the i*AM tool (i* ArchiMate modeling tool) was developed. It is the extension of the ArchiMate modeling tool to support the hybrid modeling method.

Conversely, the extension description ArchiMate uses the Ecore language of the Eclipse Modeling Framework (EMF) to define its metamodel. E-Class, EReference, and EAttribute constitute the main elements of Ecore. The representation of similar model entities is regrouped in the EMF metamodel element:

- E-Class: Each E-class has E-Attributes. Unidirectional relationships between two E-Classes are done through E-References. The specialization applied is on E-class

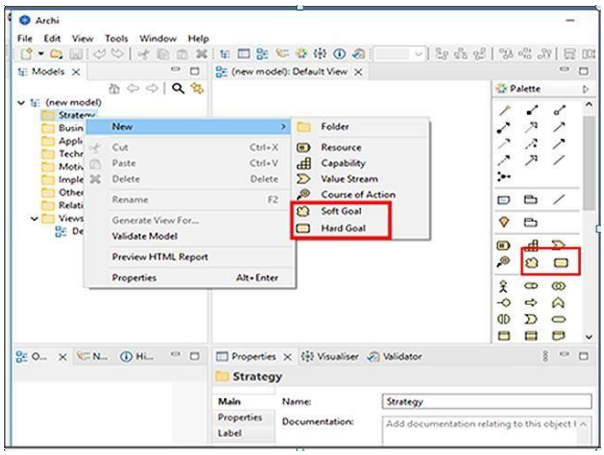

Fig. 7: I*AM tool modeling palette

```
Function impact_of_strategic_initiative_on_a_layer(A, B, max_impact, max_weighted_impact):
  n = number of rows in A
  m = number of columns in A (which is equal to the number of rows in B)
  p = number of columns in B

  impact_sum = 0.0
  weight_sum = 0.0

  for i = 1 to n do
    for j = 1 to p do
      dot_product_impact = 0
      dot_product_weight = 0

      for k = 1 to m do
        dot_product_impact += A[i][k].impact * B[k][j].impact
        dot_product_weight += A[i][k].weight_of_impact * B[k][j].weight_of_impact

      impact_sum += dot_product_impact
      weight_sum += dot_product_weight

  resulting_impact = (impact_sum / (n * p)) * max_impact
  resulting_weighted_impact = (weight_sum / (n * p * 5)) * max_weighted_impact

  return (resulting_impact, resulting_weighted_impact)
```

Fig. 8: Algorithm used to calculate the impact of a strategic initiative on a business and Information System layers

Archi® (Beauvoir and Sarrodie, 2022; Open Group, 2019) is the modeling tool on which the authors performed their extension. It is an open-source tool that supports modeling activities using ArchiMate. It is developed using the Eclipse Integrated Development Environment (IDE). First, they worked on the prerequisites (development tools, plug-ins, version) necessary to run Archi on Eclipse. Using the eclipse modeling framework plug-in, they modified the Archi meta-model and model to support i* concepts. Thereafter, they generated the model code. Further, the relations between concepts are defined. Regarding graphical notation, the authors reused the 'influence relationship' in ArchiMate, and for the soft and hard goals, they used designs for the two concepts based on the original notation in i* modeling.

In ArchiMate, the color used for the strategy layer is brown. The authors worked on the interface code using Eclipse graphical plug-in. Figure 7 shows what the Archi palette looks like after enriching it with i* concepts.

Evaluation of the Impact of a Strategic Initiative

This step consists of the quantification of the impact and its analysis. The main metrics considered in each layer (business and IS) are presented below:

- Number of elements: Count of the elements composing the layer
- Number of intra-relations: Count of the relationships between the elements of the layer
- Average weight per intra-relation: Sum of weights of intra-relations divided by the number of interrelations
- Impact and weighted impact of a strategic initiative on a specific layer: The supporting algorithms are presented in the following

As for the quantification of the impact of a strategic initiative on each layer, an algorithm is proposed based on matrices. The matrices are composed of the value of the integer couple that corresponds to the weighted links between the components. The rows and columns are the projections of different layers. The first part is '1' if there is an interaction between the corresponding row and column, or it is '0' if no relationship exists. The second part is the weight of the link. It is an integer between '0' and '5'. The matrices used to quantify the impact of a strategic initiative on the business and Information System layers are below:

- SH represents the relationship between soft goals and hard goals
- BA represents the relationship between business and application services
- AT represents the relationship between application and technology services
- HH, BB, AA, and TT represent the relationships in the same layer respectively hard goals, business services, application services, and technology services

The method used in calculating the impact of a strategic initiative on a layer is based on the matrix notation. The two main metrics that are suggested are the impact of a strategic initiative and the weighted impact of a strategic initiative on each layer.

The calculation used to have the impact of a strategic initiative and its weighted impact on a layer is performed using the algorithm in (Fig. 8).

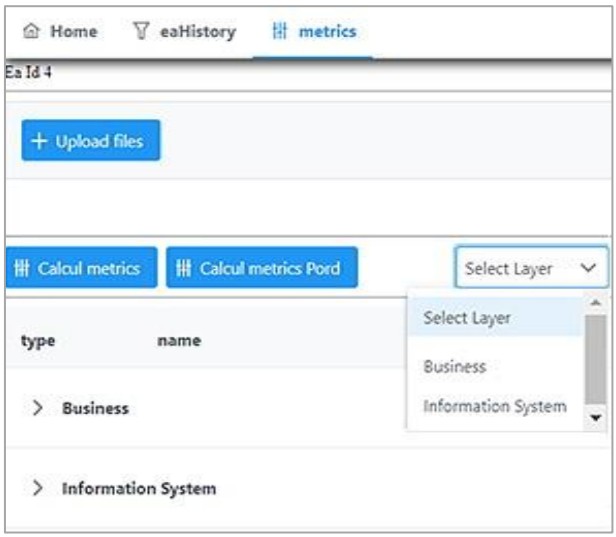

Fig. 9: The second interface of the T Strategic Initiative Impact Evaluation Tool (SIE)

```
function UploadFile(path):
    // Open the CSV file for reading
    file = open(path, 'r')
    // Parse the header row to get column names
    header = file.readline().strip().split(',')
    // Generate a unique name for the table
    table_name = generateTableName()
    // Create a table with the same columns as the CSV file
    createTable(table_name, header)
    // Insert the data into the table row by row
    for line in file:
        values = line.strip().split(',')
        insertRow(table_name, values)
    // Close the file
    file.close()
    // Return the name of the table
    return table_name
```

Fig. 10: Algorithm to upload a file in the SIET tool

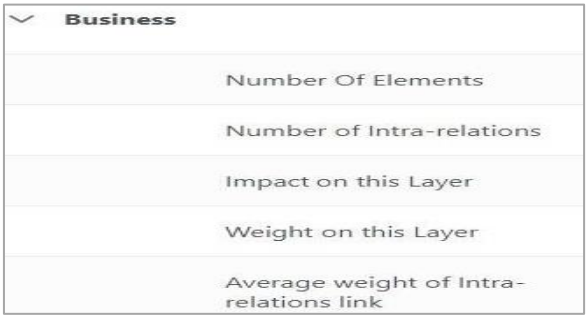

Fig. 11: Details of the metrics in each layer in the second

The algorithm ensures the multiplication of the representative matrices. The coefficients of the resulting matrix are 2-tuples. The first part reflects the existence of impact and the second part shows the weight of the impact on a layer. The algorithm then sums the coefficients of the resulting matrix to extend the resulting coefficients to the entire layer interpretation. Finally, the scaling of the resulting matrix brings the numbers to an interpretable scale by the enterprise architect.

The impact on the business layer is the result of the chain multiplication of the following representative matrices: SH, HB, and BB. Moreover, the impact of a strategy initiative on the IS layer is the result of the chain multiplication of the following representative matrices: SH, HB, BB, BA, AA, AT, and TT.

To support the implementation of the presented algorithm, we developed a tool Strategic Initiative Impact Evaluation Tool (SIET). It allows the evaluation and monitoring of the impact of a strategic initiative for each elementary EA adaptation project.

SIET is a Java web application developed using the framework spring web Model-View-Controller (MVC), which provides components that can be used to develop flexible and loosely coupled web applications.

Figure 9 constitutes the second interface of the SIET tool. It allows the calculation of the impact metrics presented in the previous section. Using i*AM, the impact of a strategic initiative is modeled on both business and IS layers. Thereafter, i*AM generates three Comma Separated Value (CSV) files, defining the elements, relationships, and weights of relationships. These files are imported to the SIET tool to calculate the impact metrics of the model uploaded.

The algorithm used to upload each of the files into the database of the SIET tool is presented in Fig. 10. It is used in the second interface of the tool. Figure 11 presents the metrics calculated in each layer.

Subsequently, the metrics are grouped in each layer and the management can deep dive into their respective values by selecting the layer in the interface.

The calculation of the impact of a strategic initiative affects the actual management of EA by improving how adaptation decisions are taken. The measurements of the impact and its weight help the studied company assess its readiness to undergo a specific adaptation project. The stakeholders can analyze the way the supporting business and information system architectures will change. If the impact and the weighted impact on a layer are high, it means that there will be significant changes that will operate. After doing the analysis on multiple initiatives, the enterprise architect can understand when to raise the red flags about a project. He can as well, decide whether to implement a strategic initiative, to replace or to delay it. Moreover, for each strategic initiative, he has the flexibility whether to implement or not a hard goal. He can as well prioritize them. On top of this, the average weight of impact of intra-relations in a layer refers to the strength of the relationship between components. The higher it is the more the changes need to

operate simultaneously and the riskier it is for the alignment between those components.

On top of this, the count of elements and relations in a layer helps the management to keep track of the evolution of this number. Thus, they can decide when to perform optimization and cleaning actions of the architectures.

Case Study

A case in a Moroccan urban agency is studied below. The urban agency conducts and operates development projects in the urbanization sector. It offers solutions for redevelopment, construction, studies, and consulting. It works with local/global partners. The agency has evolved in a complex context. Its core business involves continuous adaptation to the evolution of the market and regulations. Further, all these elements induce changes to the strategy, processes, activities, and organization of the agency, thereby impacting its IS.

With the advent of climate change and social challenges, Sustainability has become essential in the proposals. It is voluntarily led by organizations. It shows their ethics to make a positive impact in the world. Organizations are urged to take their responsibilities seriously regarding world sustainability.

The 2030 Agenda proposed by United Nations dedicates a specific goal to cities sustainability. In this sense, Morocco is taking many actions.

In 2018, the ministry in charge of urbanization urged the urban agencies to rethink their processes to incorporate sustainability. Thus, the studied Moroccan agency wants to move from its 'As-Is" to a "To-Be" state: Become a leader in sustainability for urban agencies.

At the start of the project, we assessed the 'As-Is' by defining a list of drivers, capabilities, and resources. We analyzed the elements from the monitoring systems and various business intelligence tools of the agency. Afterward, the soft goals were refined.

Following deep discussions with the main stakeholders in the urban agency, the main soft goals identified were as follows: 'Define the sustainability vision', 'highlight territorial sustainability', 'Reduce digital divide between rural and urban areas', 'Promote clean energy and the sustainable use of land' and 'ensure alignment with country guidelines'.

Multiple interviews with decision-makers and architects in the urban agency helped me gain more field insights, rich descriptions, and relevant observations. The main objectives were the understanding of the underlying architectures and the gathering of the expected changes of the chosen strategic initiatives. The interviews focused on the following points:

- Existing cartography of business layer
- Existing cartography of information system layers (applications and technology)
- Threats and opportunities
- Supporting capabilities and resources
- Weights of the relationships between components in business and information system layers
- Adopted architecture frameworks
- Critical architectural components
- Expected changes related to the studied strategic initiative

The focus was made on the following strategic initiative: 'Highlight territorial sustainability'. We already had the cartography of relations between the business and IS components. The As-Is model is represented in Fig. 12 using the i* AM tool.

Based on the As-Is architecture, the influencing relationships were added.

Below, we modeled the impact of this strategic initiative; the result is presented in Fig. 13.

Using the modeling tool, the soft goal and the corresponding hard goals were created. The studied hard goals were as follows:

- Hard Goal 1: Increase green projects and eco-cities
- Hard Goal 2: Certify projects and service
- Hard Goal 3: Incorporate sustainability claims into internal and external communications
- Hard Goal 4: Ensure environmental diagnosis in urban planning

To evaluate the impact of the studied strategic initiative, the CSV files are exported from the i*AM tool. The files are, then, imported into the SIET tool. The files were CSV files. Three files were exported from the tool. The first one highlighted the components, the second one highlighted the relationships and the third one comprised the weights. Notably, each component had a unique identifier, which allowed the enterprise architect to perform the analysis after the representation. Figure 14 shows a snapshot from the CSV file representing the components of the architecture. It is extracted from the i*AM tool. Figure 15 shows a screenshot of the CSV file representing the relationships between the components of the architecture.

The second interface of the SIET allowed the upload of those files to simulate the impact of the strategic initiative before adopting it as an intermediary architecture. The files uploaded are analyzed and the representative matrices are created as per the description in previous parts. The calculation of the metrics (count of elements, number of intra-relations, impact, and weighted impact) is performed using the algorithm presented in (Fig 8). For the calculation of the impact on a business layer, the inputs of the algorithm are the scaling thresholds and the representative matrices of the strategy and the business layers. The same logic applies to the impact on the Information System layer. The output of the calculations performed using the algorithm presented in Fig. 8 is presented in the figures below. First, Fig. 16 presents the calculated impact of the studied strategic initiative on the business layer. Second, Fig. 17 shows the impact of the studied strategic initiative on the information system layer.

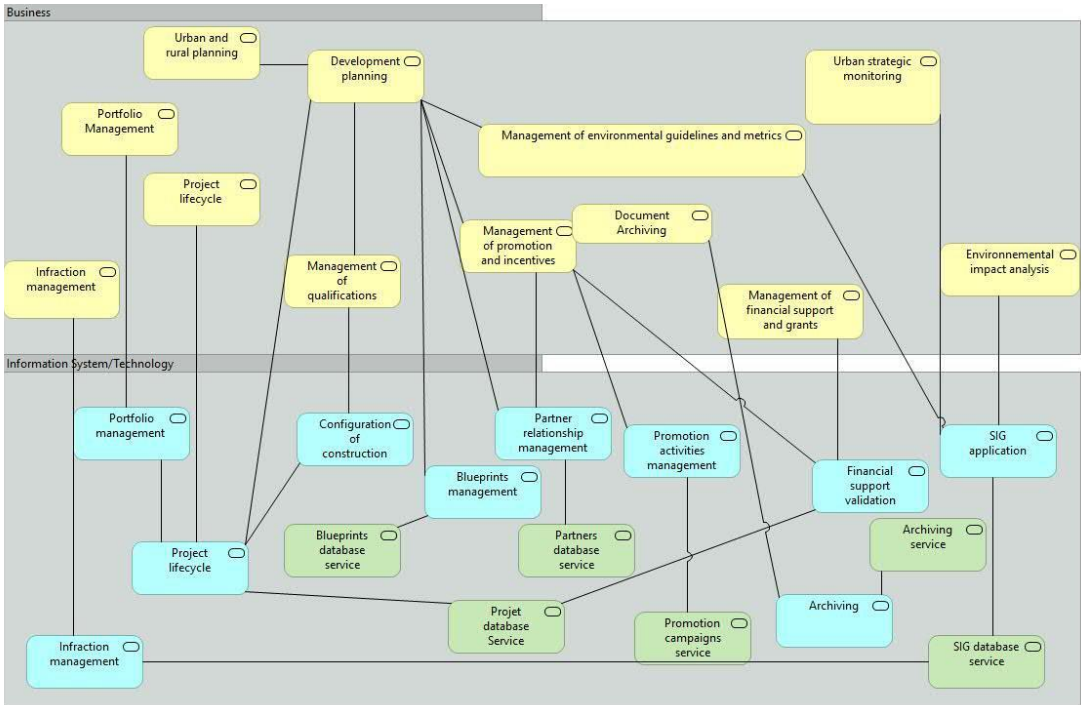

Fig. 12: As-Is modeling of the business and information system layers of a Moroccan urban agency

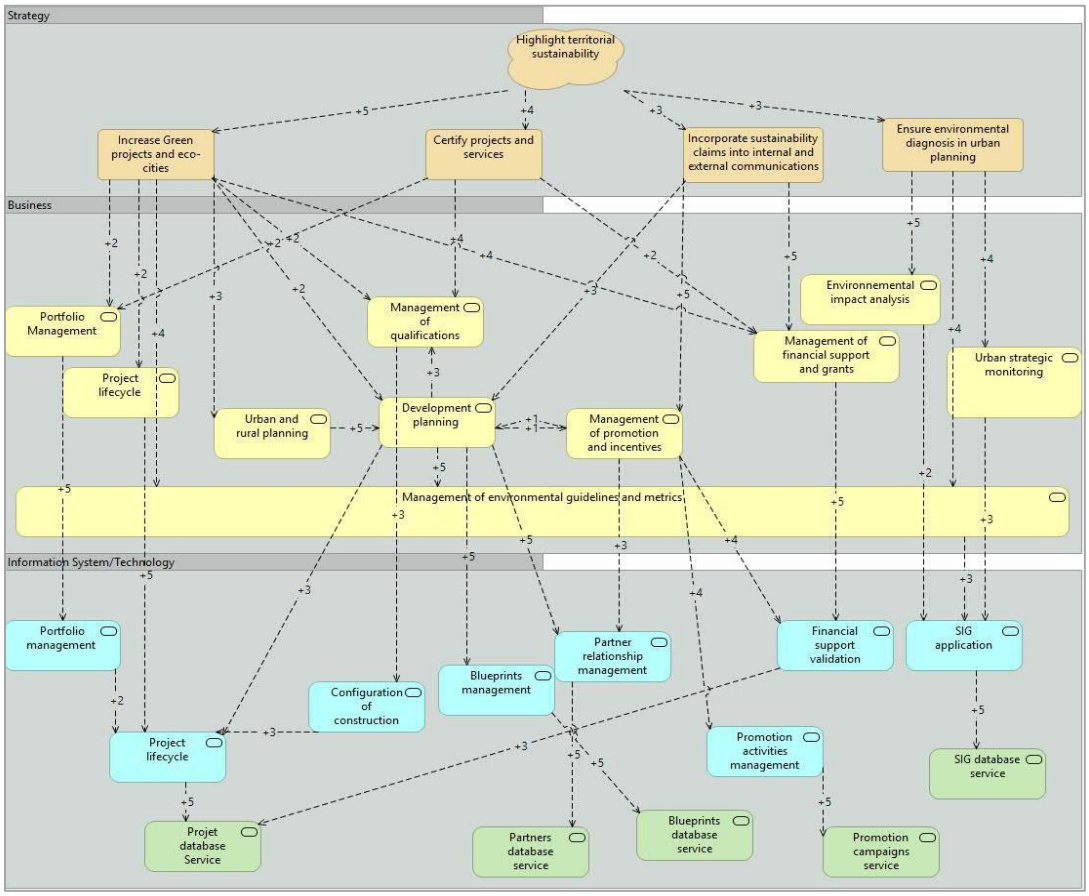

Fig. 13: Impact modeling of the strategic initiative; 'Highlight territorial sustainability'; of a Moroccan urban agency

ID	Type	Name
id-376c7c95d14d49c89c5c02a9468348a0	BusinessService	Business Service
id-7f2f832ed23f44c9be437ba6b76bfe1b	BusinessService	Development planning
id-9d8ff8586c374c7084ef7070f9101d12	BusinessService	Environnemental impact analysis
id-af3a1475d25d462ea242aeb20c25d2f3	ApplicationService	Partner relationship management
id-396f1398e06d4ef3a89e5c19229c3ab1	ApplicationService	Portfolio management
id-acef3cb807d445a89bf352d9b9a3afcd	ApplicationService	Project lifecycle
id-e9c65d08a31a46008fdf121c17a316b2	ApplicationService	Promotion activities management
id-015d221467944fd19f0f77717b8acefa	ApplicationService	SIG application
id-423096c2fe5a409594f2d931d806e1d8	TechnologyService	Blueprints database service

Fig. 14: CSV file of the components extracted from the tool i*AM

ID	Type	Source	Target
id-7072473e9b8745a08abfe	InfluenceRelationship	id-9e32db36994748e4a74	id-60f51e804be345
id-e2dc006528394bd086d2c	InfluenceRelationship	id-9e32db36994748e4a74	id-7b0952482d664l
id-2eaf53dfcdf6491b9569a6	InfluenceRelationship	id-9e32db36994748e4a74	id-54b530d43afb40
id-f146fb3baaba4ad5baa3c	InfluenceRelationship	id-9e32db36994748e4a74	id-c9f756cfe0df444
id-26f13483e8df4e9e8e5208	InfluenceRelationship	id-9e32db36994748e4a74	id-1f545b99c3d74b
id-47b22206f5f54b569dc36	InfluenceRelationship	id-9e32db36994748e4a74	id-7f2f832ed23f44c
id-7bd7376d08184e94be16	InfluenceRelationship	id-b7b0eedb2b9042b0a4f	id-7b0952482d664l

Fig. 15: CSV file of the relationships extracted from the tool i*AM

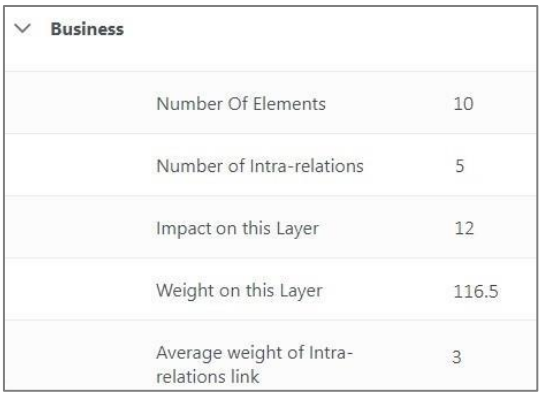

Fig. 16: Details of business metrics of the impact of the studied strategic initiative using the SIET tool

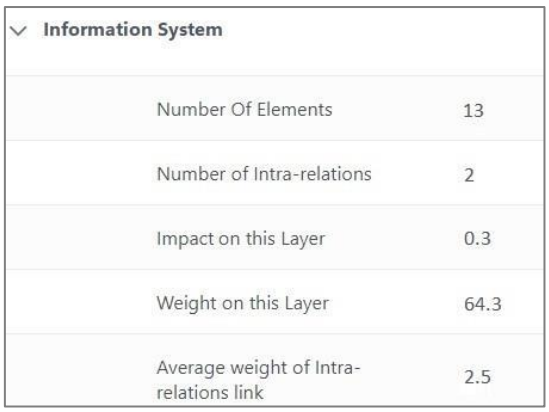

Fig. 17: Details of Information System metrics of the impact of the studied strategic initiative using the SIET tool

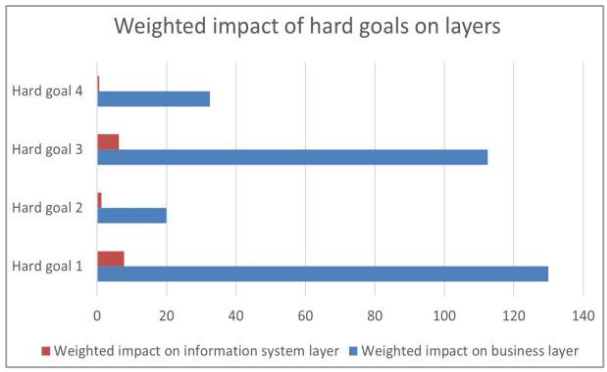

Fig. 18: Comparison between the weighted impact of studied hard goals on business and information system layers using the SIET tool

In this case study, the management had to decide to implement partially or totally the hard goals of the studied strategic initiative. To support them with this analysis, the weighted impact of each hard goal on the business and the information system layers was calculated using the SIET tool. Furthermore, the data exported as a chart helps with the interpretation by the management stakeholders of the impact of the chosen strategic initiative. Fig. 18 shows a comparison between the four hard goals.

Based on the comparison in Fig. 18, the decision-makers compared the weighted impact of each hard goal on the various layers. They concluded that the highest impact came from hard Goal 1 and Hard goal 3. The changes and modifications would affect various components of the business layers. This would require

high effort to rethink some of the business processes. Combined with the model in Fig. 13, they identified clearly the most critical components and discussed whether to implement the changes or not. Due mainly to budget constraints and other risks, management decided to implement Hard goal 2 (certify projects and services) as a first adaptation project. Thanks to the analysis, this goal impacts the least the architecture layers. Also, based on Fig. 13, some changes required by this goal would prepare the architectural components for the future adaptation projects. In fact, there is an intersection of impact between the three first hard goals. In addition, the calculation of the weight of intra-links shows the dependency between components in each layer.

The modeling of the impact of the chosen strategic initiative allows the alignment between different stakeholders from strategy, and business, to IS before undergoing the elementary EA adaptation. Further, it allows the prioritization of EA adaptation projects, while knowing the impact on the aligned structure and relationships between the components. In this case, it allowed the management stakeholders to choose the hard goals to pursue, delay, or remove from the strategy implementation roadmap.

Discussion

The adaptation of EA leads to adjustments to align its components. It happens continuously over time through a set of EA projects that can be initiated through operational or strategic triggers. The alignment required in an EA, as a mediator between the strategy and the operations, is impacted by many strategic initiatives (Masuda and Viswanathan, 2019).

The literature presents methodologies and guidelines to adapt enterprise architecture. Nevertheless, it lacks focus on the proactive assessment of the impact of strategic initiatives before undergoing these adaptations (Daoudi *et al*., 2021). This shortfall pushes decision-makers to undergo fastidious adaptation projects for which they are not ready. It also complexifies the operational models making them difficult to maintain. The absence of monitoring of these initiatives leads to the abandonment of projects and a waste of effort and time (Kawtar *et al*., 2020; Kitsios and Kamariotou, 2019).

The proposed approach allows companies to have clear visibility on their adaptation initiatives and the impact on the established EA. This helps them track the evolution of architectural elements and relationships. They can make informed decisions whether to undergo the changes partially, totally, or not at all. In fact, it helps identify the initiating strategic initiative of an adaptation EA project. Its modelling is supported by EA modelling languages. This helps the achievement of a common view of the targeted initiatives by all management stakeholders. In addition, the use of quantitative metrics and algorithms ensures a quick and effective analysis and simulation of the implementation of initiatives. It minimizes the risks of direct implementation of the strategic initiatives on the existing architectures.

Moreover, in a context where enterprises use multiple frameworks of Enterprise Architecture, the proposed approach is agnostic to Enterprise Architecture Frameworks. This helps its applicability into various segments and verticals.

The replication of the proposed approach is highly recommended. This will help improve the efficiency of the algorithm and assess its limitations depending on the industries. The steps required for the replication are the following: The identification of the strategic initiatives and their translation into i* concepts; the analysis of the drivers (opportunities and threats), the resources, and the capabilities supporting each strategic initiative; the modeling of the impact of strategic initiatives on business and Information System layer using the modeling tool; the export of the data from the modelling tool and the upload of the files generated using the SIET tool. Finally, the impact on the layers using the presented algorithm is calculated. The enterprise architect or the lead of the implementation of these projects can compare the data and decide which initiative to implement.

Conclusion

Companies, that are trying to survive in the current highly dynamic environment, rethink their strategies and transform internally. They undergo adaptation projects of their architectures. This study allows the modeling and evaluation of the impact of strategic initiatives when adapting an Enterprise Architecture. The identification of strategic initiatives needs to be in accordance with the requirements of the environment where a company evolves. Also, these initiatives need to have enough support through internal capabilities and resources. We conclude that the strategic initiatives impact the alignment in the established architectures and the relationships between the components. The impact on the alignment has different weights.

The contribution to the current literature is an approach that ensures the adaptation of companies while ensuring an aligned coherent architectural structure. As a consequence, management can choose the strategic initiatives to implement, assess the evolution of their impact, and monitor the transformation of their architecture. To address the modeling of the strategic initiatives and their impact on the established architectures, which is the first aim of this study, we propose a hybrid modeling method based on i* and Archimate languages. Also, the modeling of the studied impact is done through influential relationships coming

from strategic initiatives and directed to business and Information Systems. A weight is affected by each relationship showing the level of impact. To support this modeling method, a tool was developed (i* the ArchiMate modeling tool). Moreover, understanding the extent of the impact of the strategic initiatives on the overall architecture helps companies estimate their readiness to undergo the adaptation projects. It allows them to keep control over their architectures and to prioritize enterprise architecture projects. To support this, we propose, as a second objective in this study, the measurement of the impact of a strategic initiative on the EA components and relationships. The quantification of this impact is done via an algorithm based on representative matrices of the EA layers. It allows the evaluation and monitoring of the impact of a strategic initiative for each elementary EA adaptation project. Our contribution helps companies undergo the required existential changes while maintaining alignment between strategy, business, and information systems. It is agnostic to enterprise architecture frameworks.

In subsequent work, the integration of a machine learning approach to analyze the impact of strategic initiatives on enterprise architecture is suggested. This will bring architectural and business intelligence to support decision-making while moving to a target enterprise architecture. Moreover, we propose to enrich the evaluation of the impact of strategic initiatives with additional metrics that are specific to the domain of the enterprise.

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Author's Contributions

Wissal Daoudi and Kawtar Imgharene: Substantial contributions to the conception of the work, acquisition, analysis, and interpretation of data, drafted and critically reviewed.

Karim Doumi: Substantial contributions to the conception of the work; interpretation of data, and critical review.

Laila Kjiri: Substantial contributions to the conception of the work, final approval of the version to be published, accuracy and integrity of the work.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all the other authors have read and approved the manuscript. No ethical issues are involved.

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