Application Portfolio Management

A method to improve the Application Portfolio Management decision-making process through stakeholder involvement

By

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Abstract

Organizations struggle with historically grown application landscapes and the sharp increase of their application portfolio complexity. The challenges faced with the application portfolio, lead to difficulties to respond quickly to the dynamic business changes and to conduct well-founded decisions. This might be caused by a large amount of available data, limited support for decisive facts aggregation and the lack of a structured decision-making process. Thus, senior management bases their decisions on unreliable or incomplete information.

Therefore, this master thesis focuses on the following challenges. First, there is a need for a method that could help organizations improve their decision-making process. This issue is addressed by integrating a data modeling approach and Application Portfolio Management (APM). The use of data-driven workflows and dashboards is expected to improve the APM decision-making process by addressing the data complexity issue. Moreover, structured and transparent decision-making requires a diversity of knowledge and perspectives. To address this, stakeholder involvement is seen as a necessary approach for identifying the stakeholders and assess their needs throughout the process.

This master thesis is expected to support organizations to improve their decisions regarding APM by addressing the needs of the stakeholders involved in the process. The research aims to develop a design method that helps organizations to achieve better decision-making capabilities to support their business objectives. This approach should enrich the collaboration between the stakeholders within an organization and provide them a personalized viewpoint that aligns their needs. Moreover, the goal of this research is to provide a better understanding of the data flow between the stakeholders and how it contributes to support the business objectives.

This research can be considered a design science problem based on the definition by Wieringa(2014), since the goal of this research is to solve a specific problem, the APM decision-making problem, by designing an artifact, the proposed method in Chapter 3. Therefore, as a design science research, this thesis will adopt the Design Science Research Methodology (DSRM) proposed by Peffers et al.(2007) to structure the chapters of this master thesis report.

As a result of this research, the proposed method is expected to support organizations to improve their decisions regarding APM by addressing the needs of the stakeholders involved in the process. The proposed method consists of six sequential steps that need to be carried out. Besides, several key attributes are identified, classified and operationalized for contributing to a thorough application inventory and a reporting capability for each of the stakeholders involved through the use of the data-driven workflows and dashboards.

To conclude, some key findings from each chapter in this report is presented as follows:

- **Chapter 2** answers questions relating to the state of the art for APM and available methods for the assessment of an application portfolio. It is found that the APM decision-making process can be enhanced by two important concepts, namely Enterprise Architecture (EA) and Data Modeling (DM). The main key findings in this chapter are the APM methods and the information required throughout the process.

- **Chapter 3** presents the development process of the proposed method. The key outcome is the proposed method itself, along with detail steps and activities that must be followed.

- **Chapter 4** describes the demonstration of the proposed method. It shows that the proposed method is applicable in an organizational setting and the APM decision-making process can be improved if an EA model exists as well. Moreover, it demonstrates that

stakeholder involvement is critical to the APM decision-making process and its implementation requires a strong commitment from the senior management.

- **Chapter 5** presents the evaluation of the proposed method, along with the result of the evaluation workshop. The results show the most positive feedback for facilitating conditions, thus the participants are confident that they have the necessary knowledge to use the method and the method is compatible with their organization. Overall, the method is agreed to be helpful and expected to be used when addressing customer needs.
- **Chapter 6** concludes this master thesis report followed by contributions for both theory and practice, limitations, and possible future work. One of the limitations is this research uses literature study and expert interviews as a foundation for assumptions regarding the stakeholders. Thus, one of the future research discussed could focus on a real-life context with an expanded selection of stakeholders. Furthermore, more attributes from the stakeholder analysis can be used for the customization of the dashboard design.

Acknowledgement

Writing my master thesis has been an emotional roller coaster and represented my biggest challenge. This challenge represented nothing less than an opportunity to grow and learn, and the completion of this master thesis report is proof of how badly I wanted to achieve my dream of studying abroad and how hard I was willing to work for it. Choosing to pursue this master's at the University of Twente (UT) has been my best decision and the overall experience was beyond my expectations.

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About BiZZdesign

According to the Gartner Magic Quadrant for Enterprise Architecture tools 2017', BiZZdesign stands out as a leader in this industry based on completeness of vision and ability to execute. Founded in 2001 by Henry Franken, Harmen van den Berg, and Harm Bakker, BiZZdesign is a Dutch enterprise architecture and BPM software-development tools vendor and consultancy company.

Their position as a leader stands out as a result of their improved customer experience focus which brought the company a growing customer base and an expanding geographical coverage. Introducing a jointly owned and planned implementation roadmap with their customers, BiZZdesign empowers companies worldwide to drive simplicity, which is also their motto. They support their customers by improving the quality and the speed of the decision-making process on their journey of continuous improvement and transformational changes.

One of their most known products is BiZZdesign Enterprise Studio, a collaborative design platform, which provides powerful, integrated modeling across multiple disciplines. Through its capabilities to plan, track and execute change in a single software platform it provides a high value for its users, especially for business management. Their latest product is HoriZZon, an online platform offering a highly personalized environment, which provides real-time insights in changing projects through the use of architecture models, business design capabilities and analyses to a broad audience of business stakeholders. The main benefit is that it can support the improvement of the decision-making process by facilitating collaboration between business and IT teams and enabling a wide range of stakeholders to be informed about the current state of the enterprise.

In this research, BiZZdesign Enterprise Studio supports the enterprise architecture modelling and creating the application inventory. Moreover, the metrics functionality helps the quantification and visualization of the analysis result through personalized dashboards. This research investigates how the above-mentioned tools can be better used for creating capabilities to enrich Application Portfolio Management.

Although BiZZdesign is a leader in the field of Enterprise Architecture, with a focus on modeling and management, their expertise covers also fields like business process management, portfolio management, business model and strategy, governance, risks and data management This research study focuses on Application Portfolio Management and investigates how Enterprise Architecture and Data Modeling can enrich its practice in enterprises.

This research study aligns with BiZZdesign vision of building an adaptive enterprise that can deal with the opportunities and demands of a challenging business environment and their research interest in developing and improving software tools and methods that support stakeholders in their daily decision-making process.

Contents

1 Introduction

The success of an organization is built upon its capability of adapting to the changing business environment. Investments in information systems (IS) and information technology (IT) are being made to facilitate and improve their internal operational processes. Acquisitions and the rapid growth have resulted in a complex IT portfolio that organizations struggle to manage for delivering modernized, secured and cost-effective applications on time, on benefit and aligned to their business.

IT is constantly driven to improve business agility, increase their response time to new demands and "do more with less". This requires companies to remove inefficiencies in existing portfolios and better manage the portfolio applications that support key services and strategic projects. However, in most of the cases, the application landscape is poorly understood, leading to organizations storing redundant data and implementing similar features.

In addition to that, executives find themselves in the position of deciding which are the best solutions or approaches to support their business goals. To meet this requirement, IT leadership requires complete visibility across their applications deployed in the enterprise, along with critical information, to increase their efficiency in the decision-making process.

Application portfolio management (APM) supports businesses to achieve the required visibility to leverage their existing application portfolio and align technological assets with business goals, by taking into consideration the need and the value of the current application portfolio.

A thorough definition of APM is given by Simon et al. (2010) and identifies APM as a structured and continuous decision-making process intended to support the evaluation of an organization's applications. This evaluation should include various perspectives so that stakeholders gain appropriate knowledge to weigh various actions for future improvements and provide solutions for identified issues. The promise of APM lies primarily in reducing the complexity of the application landscape by having a holistic approach.

Providing a holistic view, APM provides a launching pad for change. An application portfolio assessment yields directional and future recommendations, and aims to lead the organization along the best transformational path (Cognizant, 2014). To drive change in evolving business scenarios, an Enterprise Architecture (EA) needs to be created, as it can play a pivotal role of managing the application portfolio by tracking the organization's transition and ensuring relevance with the changing business environment.

Defined as a discipline for proactively and holistically leading enterprise responses to disruptive forces, EA identifies and analyzes the execution of change toward desired vision and outcomes (Gartner, 2017a). The signature-ready recommendations, such as road-maps, for adjusting policies and projects, are one significant contribution provided by EA for stakeholders which supports them to achieve target business outcomes that capitalize on relevant business disruptions. Moreover, an EA institutionalizes a governance model that enables change along the pathway by enforcing compliance with the plan and capturing core organizational values (Cognizant, 2014).

The APM decision-making process requires accurate data and real-time access. Regularly updated data requires continual data entry, data integration, and error checking. This need for continuous data management places an extra burden on organizations. To address the continuous changes, new methods for tracking, comparing and archiving different versions of data should be implemented to support the APM decision-making process.

Moreover, since stakeholders often join the ongoing decision-making process at different stages, a method is needed to consider the new contributions, while still allowing the impact of the process as a whole to be tracked. Therefore, to reduce delays, a strategy for managing large amounts of updated data should be created for ongoing data entry, versioning, archiving and documentation.

To address these issues, data-driven workflows are used for enriching the APM approach by supporting the data collection process, the identification and the representation of how stakeholders collaborate and their impact on the data flow.

Leading to a foundation that can complete broad-scope initiatives, an improved data quality and a high-end view over its processing contribute to lowering the support cost and increase the reusability opportunities, thereby reducing the costs of building new applications.

Moreover, the use of the data-driven workflows supports creating the data models, used to communicate data requirements from business to IT and within IT from other stakeholders of the organization. In addition to that, combining various data sources provides an opportunity to create scalable, flexible and tailored analytics over the key performance indicators. Therefore, common challenges faced when implementing an APM, like outdated data, lack of responsibility for data changes or inconsistency in data can be addressed, leading to the improvement of the decision-making process (Fabrice Vila, 2012).

The challenges faced with the application portfolio, such as the increased size and complexity, lead to difficulties to respond quickly to the dynamic business changes (Cognizant, 2011) and to conduct well-founded decisions (Khosroshahi et al., 2016). The findings of Riempp and Gieffers-Ankel (2007) indicate the unfounded and speculative decisions as a common struggle, caused by the flood of information and the limited support for decisive facts aggregation. Another research study strengthens the same idea by indicating the general lack of a permanent approach to the application landscape that draws on structured and rational methods for making decisions about application investments on a portfolio-wide basis(Simon et al., 2010). The stakeholders' involvement has been regarded as being an important practice (Riempp and Gieffers-Ankel, 2007; Cantor, 2011; Khosroshahi et al., 2016). Their contribution to the decision making process is required for data collection (Cantor, 2011), evaluation and analysis (Weill and Vitale, 1999).

However, research dealing with APM is mostly dedicated to how to assess the health of a portfolio, how to classify applications and initiatives to improve the application landscape (Zelt et al., 2013a). Little or no attention is being given to the stakeholders and their needs throughout the APM decision making process(Riempp and Gieffers-Ankel, 2007).

Thus, there is a need for research on identifying the stakeholder needs in the APM decision-making process and how to support them. Under this consideration, the main aim of this thesis is to investigate the stakeholders, their needs for taking decisions related to APM and the tools that can support them.

Integrating different perspectives could help organizations facilitate relevant decision making by allowing access to important information by taking into account the entire range of constraints.

Therefore, for developing an environment where relevant stakeholders can have real-time access to the information they need and collaborate, the assessment of both capabilities and the needs of the main stakeholders for APM will be integrated along with the adoption of some analytical tools to perform the assessment.

This chapter aims at providing background information and the motivation for conducting this research. Section 1.1 provides an overview of the problem statement that leads to conducting this research, followed by the research objective in Section 1.2. The research questions are formulated subsequently in Section 1.3 as the foundation of this study. The research methodology is presented in Section 1.4.

1.1 Problem Statement

Nowadays, companies struggle with historically grown application landscapes that are burdened with obsolete IT systems, unfinished or long-lasting applications that no longer meet the business requirements (Zelt et al., 2013b). More than maintaining their applications which are fundamental for their business(Smith and McKeen, 2003), companies are also trying to prioritize their investments to drive operational efficiency and minimize the costs with maintenance (Cognizant, 2011).

Complex application landscapes require a comprehensive portfolio understanding of the inherent relationships and dependencies between applications (Zelt et al., 2013b). APM has, therefore, become an important issue in the enterprise IT's strategy (Sun et al., 2016), aiming to reduce the complexity of the application landscape, such as its heterogeneity, lack of transparency and vast scope (Simon et al., 2010; Khosroshahi et al., 2016).

Having as a main goal to reduce the application portfolio complexity through simplification and harmonization, APM aims at managing the application portfolio as a business (Simon et al., 2010) and relies on understanding application compatibility with business priorities, strategies and processes (Kotani and Iijima, 2008). Moreover, it is also focusing on gaining knowledge about the data types that exist across the organization and their source (Erwin, 2017). The gathered information provides a starting point for identifying problems and opportunities for better coverage of the business needs (Weill and Vitale, 1999).

In the past, business strategies were focused on good management of their assets and limitations in the present, such as constraint management and resource allocation optimization. Nowadays, strategies focus on future business planning, such as payoff maximization and choice of execution timing, where the progress can be measured through well-defined systems due to the emerging IT services. Therefore, developing and implementing an effective APM requires significant attention from the senior management to ensure success (Kotani and Iijima, 2008).

Recent studies reveal that the complexity of APM and the application clutter overwhelms the senior management in the decision-making process (Kotani and Iijima, 2008; Simon et al., 2010; Schneider et al., 2015; McKeen and Smith, 2010). Most of their decisions are based on unreliable or incomplete information (Simon et al., 2010) and sometimes the data is unavailable or outdated (Planview, 2015). Project managers usually depend on people to respond to the outputs and benefits that they deliver, however, the responses are not always offered (Erwin, 2017). This is mainly caused by the fact the team members are not engaged and held accountable (Planview, 2015). To address this issue, senior management must change the decision-making process (Zelt et al., 2013b).

A recent study states that although IT professionals have the necessary knowledge about the existing connections across applications and data, their perspectives are not considered during the strategy discussions and the decision-making process (Erwin, 2017). Organization stakeholders are defined as "any group or individuals who can affect or is affected by the achievement of the organization's objectives" and a change towards a stakeholder viewpoint is demonstrated to improve the efficiency of an APM (Simon et al., 2010).

In the last decade, grey literature recommends the stakeholders' involvement as a best practice for assuring data consistency in APM related decisions (Erwin, 2017; Fabrice Vila, 2012; Cognizant, 2014). Nevertheless, most of the existing academic papers regarding APM take a technical approach, focusing on the metrics and the analytics that can be deployed (Khosroshahi et al., 2016; Kotani and Iijima, 2008; Zelt et al., 2013b).

The most effective APM solutions can deliver value with sets of significant data based on the needs of the stakeholders. Thus, it becomes critical to have an overview of the data required to satisfy their needs and support them to achieve the business goals through well-informed decisions. Moreover, stakeholders need to perceive the data as being trustworthy so they can use it in their daily routine for decision making, therefore data ownership is also important.

Taken into consideration the aforementioned statements, stakeholder involvement can arguably be considered the most important factor for developing and implementing an effective APM, and it should not be regarded as a trimming activity.

Hence, the purpose of this research *is to articulate a method for an APM solution to help organizations improve their decision-making process.* The input for the proposed design will be derived by identifying the stakeholders and their needs and creating a data structure model that will reinforce their experience. The output should enable improvement for the decision-making process.

1.2 Research Objective

The research aims to develop a design method that integrates a data modeling approach and APM, to help organizations to achieve better decision-making capabilities to support their business objectives. This approach should enrich the collaboration between the stakeholders within an organization and provide them a personalized viewpoint that aligns their needs.

Moreover, the goal of this research is to provide a better understanding of the data flow between the stakeholders and how it contributes to support the business objectives. To achieve the above-mentioned objectives, the following steps are taken to create the designed method based on stakeholders needs:

- Conduct a literature review regarding the APM practice and the opportunities to enrich it through EA and by using data-driven workflows
- Mapping the stakeholders needs with data and the architecture capabilities
- Develop the data-driven workflows
- Apply the proposed data workflows to a case study
- Evaluate the conceptual model
- Discuss the limitations, further research, recommendation, and the results

1.3 Research Questions

This subsection will present the research questions for this thesis. The main research question will be explained in the first subsection, while the sub research questions will be explained subsequently in the next subsection.

1.3.1 Main Research Question

Based on the problem statement and the objective of the thesis, the main research question is formulated as follows:

"How can the APM decision-making process better support different stakeholder needs with the help of data-driven workflows?"

1.3.2 Sub Research Questions

The following sub-questions are formulated to offer background knowledge for answering the main research question:

1. What is the state of art in Application Portfolio Management (APM)?

2. What kind of methods are available for the assessment of an organization's application portfolio?
3. How can the practice of APM better address stakeholder needs?
4. How to use data-driven workflows to make the process of APM executable?
5. How can dashboards support different stakeholders in the APM decision-making process?

1.4 Research Methodology

A literature study will be conducted for answering the first two sub-questions, while others will be answered through the design method. Both academic and grey literature will be considered by following a systematic literature review presented in Chapter 2.

Although the first research questions are knowledge questions, this research study aims to provide different capabilities for improving the decision-making process, which can be perceived as addressing a design problem. A design problem intends to create a change in the real world and requires an analysis of actual or hypothetical stakeholder goals. The solution is a design, and many different solutions can be given (Wieringa, 2014). This research will follow the Design Science Research Methodology (DSRM) guidelines by Peffers et al. (2007). The DSRM Process Model is presented in Figure 1.1.

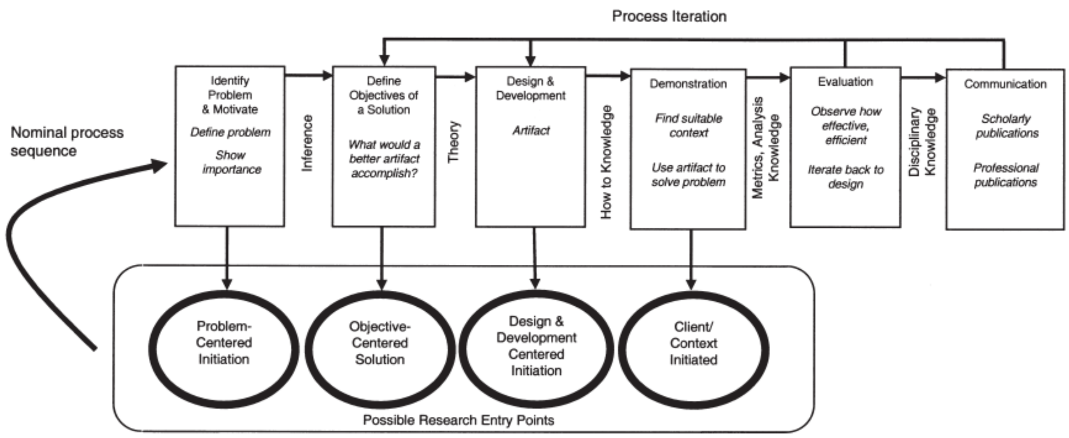

Figure 1.1: DSRM Process Model (Peffers et al., 2007)

The research process will be mapped into the DSRM Process Model activities and a brief description of how this process is distributed in the report of the thesis will be given as follows in Table 1.1.

Table 1.1: Research process following the DSRM Process Model

Activity	Description	Chapter(s)
Problem identification and motivation	The problem will be identified and a solution will be proposed. The motivation of the research and the research questions are presented.	1
Define the objectives for a solution	The objectives of this research are presented and a road map is created accordingly considering the literature in reference disciplines. This will result in a template for a structure of the research output.	1 & 2
Design and development	This activity includes determining desired functionality and the architecture for each element of the solution. The process includes defining the required input and the necessary activities for reaching the desired output.	3
Demonstration	This process will be performed in a case study. The visualization of the demonstration will be presented in this step.	4 & 5
Evaluation	In this process the solution will be observed and measured, involving comparing the objectives of the solution with the result of the proposed model.	6
Communication	The final process will be done in the master thesis defense after the submission of the thesis report.	

1.5 Research Structure

This study follows the DSRM, therefore, the structure of this research is divided into 5 parts, namely the Literature Review, Design and Development, Demonstration, Evaluation, and Conclusion.

Chapter 2 presents and discusses the existent knowledge and related research on the topics already introduced in the previous sections. This part aims to collect more information about the research topic so that a theoretical foundation can be provided for better understanding of the topic and to support the problem statement.

The design and development of the method are presented in Chapter 3, which is the main activity of this thesis. The knowledge gained from the literature review is considered as a basis for the design and development part. In this part, a detail presentation is given for the chosen approach and the decisions made for the development of the data-driven workflows and dashboards.

Chapter 4 describes the demonstration which can be related to the testing part in software development. This demonstration is conducted through a case study by using the information provided from an American software company, which will further be referred to as the Client due to privacy issues.

Chapter 5 includes the evaluation of the proposed approach and models presented in the demonstration. The evaluation is conducted using a survey that adapts the UTAUT concept proposed by Venkatesh et al. (2012). Before the survey, a workshop is held and participants are expected to give feedback by using the survey.

Chapter 6 presents a discussion over the feedback provided in the evaluation part together with the contributions of this research for the scientific work and practitioners. In this chapter, the limitation of the research and future work are also presented.

2 Literature Review

This chapter aims to provide background knowledge about the main concepts of this research study. Section 2.1 presents relevant literature review existent on Application Portfolio Management (APM). Furthermore, Section 2.2 presents why stakeholders' needs should be considered and how their knowledge can bring value to the APM decision-making process. Sections 2.3 and 2.4 will discuss the concepts of DM and EA in detail. The relationship between the main concepts is summarized in Section 2.5.

The research method for this paper was the Systematic Literature Review (SLR) following the research activities guideline proposed by Rouhani et al. (2015). As described by Budgen and Brereton (2006), a systematic review is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest. What differentiates a systematic review from the other existing forms consists of creating a review protocol which considers the research questions addressed by defining a documented search strategy. This would benefit from having a clear set of procedures to follow while reviewing the material considered for research and identify where this could support or conflict with the study.

SLR process was done mostly by searching in scientific databases, however, gray literature was included, as in white papers. There is sometimes a long lag time between the submission and publication of scientific papers, therefore, gray literature may help ensure the most current picture of what is happening within a body of evidence or area of practice (Paez, 2017).

The scientific databases selected for the searching process are presented below:

- Scopus
- IEE
- Science Direct
- Google Scholar

Literature was selected based on the relevance to the addressed research question presented in the introduction of this research. Different keywords were selected to identify the relevant studies by looking at the title, author's keywords and abstract for answering the proposed research questions.

Keywords associated with the research questions were used to identify relevant papers. However, not all of them offered relevant results, therefore we present the meaningful key terms used as it follows:

- K1: "application portfolio management" OR " portfolio management"
- K2: "application portfolio management" AND ("method" OR "analysis" OR "literature review" OR "technique")
- K3: ("application portfolio management" OR "application landscape" OR "application rationalization")
- K4: ("application portfolio management" AND ("data management" OR "complexity"))
- K5: "application portfolio management" AND ("stakeholder" OR "decision-oriented" OR "decision oriented" OR "viewpoint")

- K6: "stakeholder " AND ("application portfolio management" OR "APM")
- K7: "data architecture" AND "model" AND ("stakeholder" OR "viewpoint" OR "landscape" OR "portfolio management")
- K8: "application portfolio management" AND ("cost reduction" OR "IT landscape" OR "application retirement" OR "total cost ownership")
- K9: ("data driven workflows" OR "workflow") AND ("application portfolio management" OR "application portfolio")
- K10: "designing dashboard visualization" AND "user experience")
- K11: ("application landscape" AND ("visualization" OR "dashboard"))

Analyzing the number of published articles identified on Scopus using the keyword "("application portfolio management" OR "application landscape" OR "application rationalization")" regarding APM shows that the topic gained importance starting with 2000, and a significant increase was noticed in 2007.

The decision-making process on whether a study should be included or not in this research is going to be explained through the usage of the inclusion and exclusion criteria.

Table 2.1: Inclusion Criteria

Number of criteria	Inclusion Criteria
1	The study is reported in English
2	The study is published between 2008 and the present
3	The study answers to at least one of the research questions
4	The study is relevant to the search term defined previously

The inclusion criteria, presented in Table 2.1, were used to decide upon including a specific study in our research. Mostly, the English written papers that addressed the research questions and were identified with the search term presented in the previous sections were considered. The second inclusion criteria were selected because papers published in the last ten years were considered significant for answering the research questions.

Table 2.2: Exclusion Criteria

Number of criteria	Exclusion Criteria
1	The study does not meet the inclusion criteria
2	The study is not related to the defined search terms
3	The study is not properly addressing the research questions (insufficient information)
4	The study is duplicated by title or content
5	The study is not reliable

The exclusion criteria, presented in Table 2.2, were used for rejecting the unnecessary papers. Mostly, the papers were excluded based on the year of their publishing and their irrelevance for this study. Therefore, several papers were excluded from the candidate papers. The results of the searching process and the number of selected papers are presented below.

Analyzing the keywords mentioned in the selected papers the only significant connection identified was between APM and EA, based on the number of terms that could be clustered together,

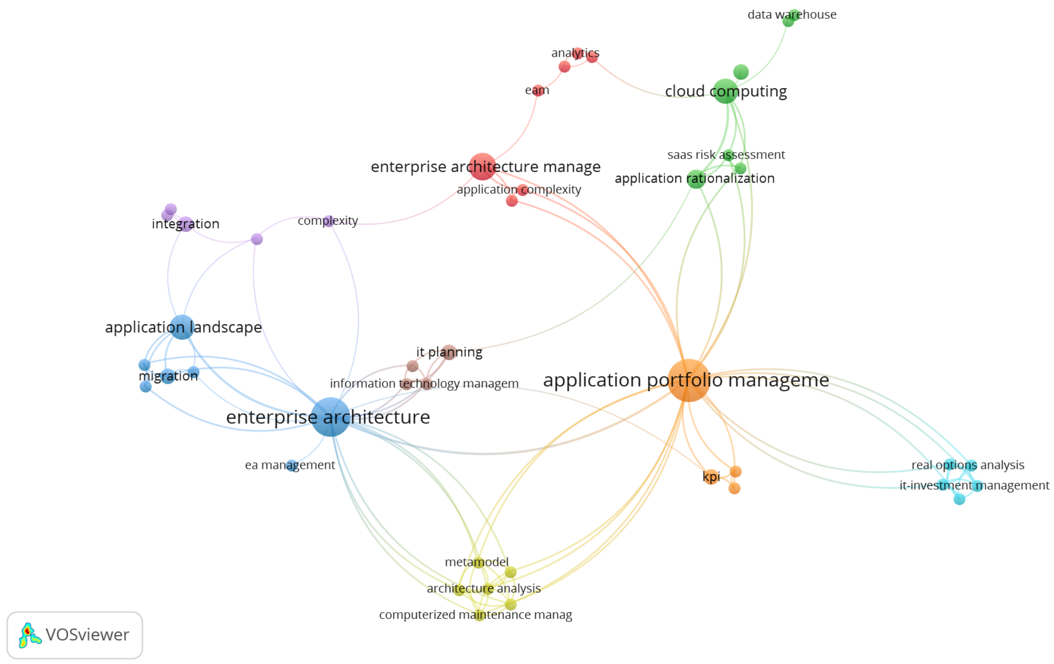

Figure 2.1: Keywords Analysis

as presented in Figure 2.1. This supports the idea that EA can enhance the APM decision-making process.

Another noticeable aspect is that the only term related to DM is "data warehouse". Looking at identified papers, even there APM and DM concepts have been researched leading to numerous papers found, the combination of the two concepts is quite limited. This leads us to believe that analyzing APM through a DM perspective is unexplored, therefore leaves us space for conducting this study to tackle new research opportunities. Most of the literature also lacks a stakeholder perspective over these concepts, therefore gray literature has been analyzed to justify these findings.

An elaborate search was conducted using Google Search and Google Scholar for identifying significant gray literature, such as white papers published by trusted and renamed companies in this field. Several articles and reports were found exploiting a practical perspective from practitioners.

Table 2.3: Searching Process Summary

Keywords Indicator	Scopus	IEE	Science Direct	Google Scholar	Number of selected papers
K1	3950	3706	7220	19000	7
K2	14	1895402	28	667	14
K3	182	2925	166	3870	8
K4	8	215563	21	414	6
K5	2	0	17	282	13
K6	89	525	12	7110	11
K7	9	579	516	6650	4
K8	1	3652	11	140	4
K9	8	169	21	1260	1
K10	1	2085	67	987	5
K11	1	2	0	1	1
K12	1	1166	52	746	1

The search process, depicted in Table 2.3, has led to identifying a total number of 75 book chapters, academic papers, and articles that contributed to the literature review, which is presented in the following sections.

2.1 Application Portfolio Management

Nowadays, organizations face a growing number of opportunities to expand their business due to technological progress. These opportunities, however, come along with challenges that require that IT services and functions need to become business-aware in their operations while delivering capabilities that can efficiently execute their strategy and support day-to-day operations.

In this context, organizations need to align their business and IT strategies to create value or to improve business performance from its IT investments (Nakakawa et al., 2010). Thus, the investment decisions regarding IT should be based on the organization's needs and oriented towards the business demands (Wittenburg et al., 2007). Therefore, the quality of the IT environment is directly related to the value of the business (CGI, 2014).

The increasing complexity of their application landscape and the benefits that can be achieved, had lead organizations to increase their efforts for efficient management of their applications. In this chapter, the concept of APM is presented. The definitions and the related concepts are presented in this chapter, along with the available methodologies and available techniques for the APM analysis.

2.1.1 Definitions and related concepts

There are many available definitions of application portfolio management and relevant terms. Therefore, a brief explanation for the relevant terms is given for settling a common understanding of them.

An **application** can be regarded as a special class of software that provides direct support for business processes (Riempp and Gieffers-Ankel, 2007). They are designed to perform a specific task and they have a very wide variety of types, such as word processors, databases, browsers, development tools and so on. An application can also be seen as a system or an executable software which can process data for a specific business purpose (Fabriek et al., 2007).

Applications can differ in several manners, including their scope and the way they were developed. At the same time, applications can be used simultaneously and interconnected to enable information sharing and assure the desired functionalities leading to more complexity. Since business requirements are in continuous change, the applications have to be changed and maintained. Due to their importance for the business and their complexity, practitioners recommend managing them as a portfolio.

A portfolio can be defined as a collection of items, such as projects, programs, sub-portfolios or operations, that are managed for achieving strategic objectives (Simon et al., 2010; Grobbelaar, 2018). Therefore, an application portfolio simply describes the sum of all applications run by a specific organizational body (Simon et al., 2010). Adopting a "portfolio" perspective implies evaluating new and existing applications collectively on an ongoing basis and determine the value that they provide the business (McKeen and Smith, 2010). Using this information, practitioners can provide detailed reports on the performance of the IT infrastructure compared with the ownership costs and the business value-added.

This method also emphasizes the linkage between the set of existing applications, referred to as the application portfolio, and the set of the potential applications, as project portfolio, therefore providing a point of comparison (McKeen and Smith, 2010). The components of a portfolio can be independent or interdependent, having related objectives. They are also quantifiable, which allows organizations to measure, rank and prioritize them (Larson and Gray, 2015).

This categorization is used within centralized management of their existent portfolios, practice which is regarded as portfolio management, and supports organizations to achieve their strategic objectives. As an example, for making better-informed decisions and achieve better overall outcomes, investments are managed as a portfolio (Lankhorst and Quartel, 2010). An important element of portfolio management is the valuation of IT projects and assets in terms of their costs, benefits, risks, and contribution to strategic objectives.

This research study focuses on the valuation of the current application portfolio and the improvement of the decision-making process regarding its alignment with the business goals within an organization.

Existent literature offers a variety of views with regards to the APM definition (Simon et al., 2010; Khosroshahi et al., 2016) caused by different ways of adoption, differing interpretations and different emphasis on the benefits (Information Balance, 2009). A thorough definition of APM is given in a paper by Simon et al. (2010) and since it provides a sharper focus on the process and goal-related aspects, it is used as a reference for this study.

The author defines APM as a continuous process in which stakeholders need to take well-founded decisions regarding the existent applications of an organization. The decision-making process should be "systematic and structured", consisting of all critical elements, in such a way that the stakeholders own the necessary knowledge for grounded decisions. To address the complexity of individual applications and application portfolios, an application should be evaluated along various dimensions, such as technical, architectural and also from an operational view and classified accordingly. This evaluation creates a foundation that "can support weighing various scenarios for the purpose of optimization" in which costs and risks are being considered, "leading to the implementation of appropriate actions".

The processes, services, and methodologies that support the maintenance, enhancement and management of applications are regarded as APM. Its aim lies primarily in reducing the complexity of the application landscape, which is approached from a holistic viewpoint (Simon et al., 2010).

APM sustains continuous improvement and transforming the portfolio to address evolving business needs (CGI, 2014). As nowadays a life-cycle approach is required (Zelt et al., 2013a), considering the lifetime of an application, APM supports organizations to acquire an in-depth understanding of their applications, including their functions and their interdependencies(Fabrice Vila, 2012). For this reason, various studies argue that APM should be regarded as a sub-process of IT governance for achieving alignment(Zelt et al., 2013a; Riempp and Gieffers-Ankel, 2007).

Through the business and IT alignment, APM aims at decreasing costs (Cantor, 2011; Zelt et al., 2013b), reducing application portfolio complexity (Fabrice Vila, 2012; Zelt et al., 2013b; Khosroshahi et al., 2016; McKeen and Smith, 2010), managing better the risks and the compliance (Fabrice Vila, 2012) and improving the decision making process and future investments(Simon et al., 2010; Fabrice Vila, 2012; Zelt et al., 2013a; McKeen and Smith, 2010). Moreover, APM can significantly improve communicating the contribution of IT to the overall organization (McKeen and Smith, 2010).

Portfolio decisions deal with uncertain information and require a long term vision, therefore they should be based on individual characteristics, the context of the whole portfolio and the achievement on strategic goals(Kester et al., 2009). Three wide-ranging goals for obtaining strong portfolios have been identified: strategic alignment, maximization of value and balance.

While the focus of this research study concerns the APM, it can be argued that the effective management of the application portfolio enhances the effectiveness of the project portfolio as well(Grobbelaar, 2018).

2.1.2 APM transformation strategies

A comprehensive evaluation of a portfolio provides support for decisions regarding the IT infrastructure and applications future (McKeen and Smith, 2010; Simon et al., 2010), which, in turn, can benefit organizations. Several different decisions can be taken regarding an application portfolio. In research, different alternatives are being given for the existing strategies.

Simon et al. (2010) presents them as "Optimization options", while in other research studies they are referred differently, such as "Categories of impact results" or as a "TIME model" (Sun et al., 2016; Jochem Schulenklopper, 2018). However, they all refer to the possible transformation scenarios of an application, a group of applications or a portfolio.

The "TIME" model includes the options "Tolerate", "Invest/Innovate", "Migrate" and "Eliminate" (Jochem Schulenklopper, 2018). In a different research, the alternative options are "Retain", "Revision","Replace", "Outsource", "Remove" (Sun et al., 2016). Fatimah et al. (2016) refers to these alternatives as "Tolerate", "Migrate", "Invest" or "Eliminate".

More complex actions regarding the possible transformations are presented by Simon et al. (2010) who categorizes the application portfolio options in "Create", "Modify" and "Delete", indicating specific alternatives for each category:

1. **Create**: "Investment" and "Replace"
2. **Modify**: "Functional Enhancement", "Outsourcing", "Service-oriented Architecture(SOA)", "Integration", "Integration Optimization" and "Reengineering"
3. **Delete**: "Disposal" and " Consolidation".

Looking at the alternatives proposals, the first difference that can be identified is that there is no option to keep an application as it is in the model proposed by Simon et al. (2010). The author emphasizes that stakeholders should always aim for a change for optimizing the portfolio, thus taking no corrective actions is not considered desirable. However, this strategy might involve a modified resource allocation.

Another difference would be that Simon et al. (2010) and Sun et al. (2016) differentiate between the scenarios where new applications are created and the ones where changes have to be done for existing ones. The other strategies from the literature consider all these decisions under "Investment" as all of them require an allocated budget (Jochem Schulenklopper, 2018; Fatimah et al., 2016).

Creating new applications is suggested when business processes have changed significantly and existing ones don't align with the requirements. Replacements can be considered when existent applications are not compliant from a technical or business perspective or when their maintenance requires too much effort.

When applications require improved functionalities, the "Functional Enhancement" strategy should be considered, while when technological enhancement is required, such as code optimization, "reengineering activities" are recommended.

Strategies like "Service-oriented Architecture(SOA)", "Integration", "Integration Optimization" refer to the improvement of the existent EA aimed to improve collaboration between applications, or its creation when EA is not in place. These strategies benefit the maintenance of the applications and provide better insights into the process and resources involved.

A decision to outsource or migrate an application can be beneficial from a strategic, financial and technological perspective. Recent advances in technology, like cloud computing, have made possible application outsourcing. This offers the option to delegate the work of the development, design, testing or maintenance of the applications to a range of third-party vendors and service providers. This decision is also regarded differently in the scientific literature, as this option is included under the "Modify" category, while others have a different approach because the responsibility is given to a third party (Simon et al., 2010).

The difference between the two corrective strategies "Disposal" and "Consolidation" is that in the first one the application is no longer used, while in the other indicates a reduction of various overlapping applications that support the same process into one single application.

Although the presented alternatives are used with different names, they indicate the same direction of transformation, the retirement or the further investment (Zelt et al., 2013a). In practice, companies might adopt their own transformation strategies.

Even though the transformation strategies are not part of the scope of this research, they can benefit this research by offering a broad view of the knowledge that is required in the decision-making process. An agile approach is required for APM and should enable fast identification of applications that represent the greatest opportunity. This will lead to a great business impact through modernizing and migrating the selected applications.

To achieve this, stakeholders need to be aware to what extent the applications are compliant from a technical perspective, and how efficient they satisfy the architecture compliance and provide the necessary functionalities. Depending on this information, they can decide if the existent applications can be improved or new ones are required.

The costs and the risks involved are significant in prioritizing the applications and deciding if they can be managed within the company or they should be outsourced to a third party.

Moreover, decisions such as investing in a new application or a new platform lead to new project proposals, therefore complex scenarios have to be created beforehand for weighting the benefits.

Therefore, to guarantee the efficiency of these decisions, a thorough assessment and evaluation of the applications have to be done beforehand.

2.1.3 Assessing the application portfolio health

The valuation of an IT Portfolio has been regarded as a controversy for decades. Several research studies addressed this topic to prove the value that IT can bring to an organization (Weill and Vitale, 1999; Quartel et al., 2010). In particular, findings of Weill and Vitale (1999) indicate that the health of an organization's application portfolio can be the cause of the continuous debate over the years.

According to Weill and Vitale (1999), the application portfolio health is based on an evaluation by senior managers of a business unit's portfolio of information systems. The assessment should be done based on five attributes of each system in the portfolio: importance, investment, technical quality, use, and management value, which are described in Table 2.4.

Table 2.4: Application Health Assessment

Attribute	**Description**	**Method used**
Importance	Alignment between the system and business goals	Questionnaire using a five point scale
Investment	Investment in the system: provision, operation and maintenance	Financial reports
Technical quality	Technical compliance	Based on six aspects: source code quality, data quality and reliability, system reliability, ease of use, output quality and portability
Level of use	Usage or amount of users of an application	Frequency of usage
Perceived management level	Usefulness of application	Questionnaire using a five point scale

For reporting the IS application portfolio health assessment to the management organization "Health Grids" were used as a visualization tool. The Health Grids consist of four quadrants that indicate different management actions that can be taken, namely Nurture, Upgrade, Consolidate or Eliminate and Question.

In the first category, systems that are essential in the daily activities, therefore representing the core of the business operation, are included. Systems that are highly valued by the users and require technical improvement are included in the Upgrade quadrant. The systems that are properly functioning, however not valuable for the management are included in the Question quadrant, while in the last quadrant the systems which don't provide value and not functioning properly are mapped as they need thorough revision.

The Health Grids are regarded as an efficient tool for displaying the required information for the management so that appropriate measures can be taken. Nevertheless, they just indicate the state of the IS at a specific point in time. Moreover, they don't assess the health or the flexibility of the underlying infrastructure. Therefore, more factors should be considered in the assessment phase for adding complexity to the presented approach.

Therefore, the assessment of the portfolio itself is not enough for making grounded decisions and more information is required regarding the applications. A better understanding and streamlining of the many applications and their impact on the portfolio consolidates the evaluation of their effectiveness. For this reason, the assessment and evaluation of the application are critical in building the portfolios.

2.1.4 APM methods

The APM process provides a common reference for organizations and practitioners. They benefit through a thorough assessment of the capabilities of an organization across all of its functions and enables senior management to plan accordingly.

In the literature, scholars have proposed several APM methods (Wittenburg et al., 2007; Fabriek et al., 2007; Simon et al., 2010). Moreover, in practice, several frameworks are developed.

From the scientific literature, two methods were identified as being complete and addressing the complexity of APM application in organizations.

Application Portfolio Rationalization (APR)

The first method chosen is one presented by Fabriek et al. (2007) who introduces the practice of APM under the name of ***Application Portfolio Rationalization (APR)***. The redefined method is defined as aiming to " analyze and restructure the complete set of applications in an organization".

In its definition, APR is being described as an evolutionary process which implies that an application inventory should be created and maintained continuously by allocating the necessary resources. The core of this process stands in gathering information about the existent applications. This method requires to be conducted by both business and IT units for assuring the applications are compliant to the business needs. As goals, on short term APR aims at improving the usability, while on the long term aims at reducing the total cost of ownership.

The proposed method consists of three main steps: the assessment phase, the evaluation phase, and the planning phase(Fabriek et al., 2007). Two previous research studies serve as a foundation for the proposed method which indicates that applications should be evaluated both individually and as a part of the application portfolio (Weill and Vitale, 1999; Sarissamlis, 2006).

The Assessment phase aims at gathering all the information about the application portfolio. Before the assessment, the scope of APR should be determined. To achieve this, applications should be matched with the processes that are being performed. This approach is preferred over a more technical one as it reduces the complexity and can be better understood by the management.

This phase consists of two processes. First, applications are assessed using the five attributes presented in Table 2.4. Then, they are categorized by depicting the applications on certain dimensions from a technical perspective or depending on their value. The categorization can be influenced by the scope. For example, a technical categorization can be made when operational issues need to be fixed, such as an outdated programming language. Different categorization examples were given, among them, the Health Grids presented in the previous subsection.

In this phase, a lot of emphasis lays on the different values that an application can provide to an organization. Several perspectives are being considered both in the assessment and categorization, from how an application supports the business process to how relevant it is from a financial perspective.

The Evaluation phase requires a review of the assessment and the categorization with managers from different departments for preventing potential bias. The next step is to evaluate the underlying patterns, which implies an investigation of the current problems through analyzing the business strategy, the IT strategy, EA, culture and communication patterns.

Several misunderstandings between the IT department and business unit might raise problems, therefore an organization should investigate the causing root of their problems and redefine their strategies if necessary.

The Planning phase consists of determining the required actions for reducing the application portfolio complexity and allocating resources. The actions can be determined through the application transformation strategies. The author proposes APR as an iterative process for continuous improvement and emphasizes that investments should be made both for short-term and long-term goals. A time plan needs to be developed for the planned actions.

Although the presented method indicates that aggregated information should be used for the assessment and the evaluation of the applications, no specific details are being given regarding the stakeholders that should be considered in each step of the phases.

APM Framework

The second method is the ***APM method*** proposed by Simon et al. (2010) and it consists of four phases, namely Data Collection, Analysis, Decision Making, and Optimization. These four phases form the foundation of the APM framework. An application inventory is created in the first phase, followed by a thorough analysis of the inventoried applications. The third phase is where the decisions are being taken regarding the future, which are implemented in the last phase. This last phase also implies updating the application inventory. The author acknowledges that APM should not be regarded as a one-time effort, but a continuous process.

The first phase of this method consists of *Data Collection* where an application inventory is being created. This phase encompasses three levels of understanding the application portfolio: the existing and planned applications of the organization, the general characteristics of the applications and the key attributes of these applications. Some examples are being given, such as application name, release version, implementation data, and application owner. Three types of data collection methods were mentioned for creating the inventory: automatic data collection, semi-automatic data collection, and manual data collection.

The Application *Analysis* is the phase where the "as-is" portfolio is being evaluated, using the application inventory created in the previous phase. Several aspects should be considered for identifying how compliant is an application with the organization's needs from a business, technical and strategic perspective. For this matter, the following dimensions are mentioned as being relevant for this evaluation: Business Process Support, Strategic Fit, Value/Benefits, Costs, Risks, Life-cycle, Regulatory compliance, Functional Wealth, Technical Health, Operational Performance, Relations and Dependencies and Vendor Information.

The third phase presents the *Decision-Making* process. In this phase, the "to be" portfolio is planned based on the previous analysis and involves determining budget allocation for further investments. Several decisions are taken and they might involve the creation of new applications, changes to the existent ones or to eliminate their usage. A concrete action plan, such as a "road map", is expected as the result of this phase. The "road-map" is intended to support the business cases that justify the decisions. Moreover, a model of the future landscape is expected as well to illustrate the intended resulting portfolio.

The last phase is the *Optimization*. The decisions taken in the previous step should be strengthened with more concrete and detailed strategies, such as selecting certain products or vendors. The author notes that significant changes in the application portfolio might require new projects, therefore the actions need supervision along the whole process and alignment with the business case should be assured.

Three processes were common in the identified methods, namely the creation of an application inventory, the analysis of the portfolio and the decision making.

In the APR method, the collection of the application characteristics for creating the application inventory has to be decided depending on the scope of the application analysis(Fabriek et al., 2007). This would imply, that for every new change regarding the application portfolio, another assessment has to be created, stakeholders involved and new resources allocated. Thus, creating a thorough assessment is recommended for making the method more efficient.

The literature indicates several characteristics that should be considered when building an inventory. This should contain more than general characteristics(Simon et al., 2010) and aspects related to risks and costs are significant, especially for their analysis and evaluation. The literature indicates several methods can be used for their collection.

It should be noted that each method is based on other previous research studies, which implies that they strengthen other methods and bring more value to the organizations. Therefore, this enhances the choice of considering them complete and insightful for this study.

The term APM is not consistent in scientific literature, some referring to it using the term "APR" (Fabriek et al., 2007), however, the identified methods resemble each other. APM is considered as a continuous process (Fabriek et al., 2007; Simon et al., 2010). Applications require to be assessed and categorized individual and also as part of the broader portfolio. While the methods present similarities, the steps are quite different.

In addition, gray literature provides several best practices for APM. Two methods for APM were selected from the gray literature to identify if best practices align with the previous research studies and identify the differences.

APM as a governance tool

The first method regards APM as a governance tool for the CIO and consists of a simple and recurring process of three steps (Fabrice Vila, 2012).

In the first step, a comprehensive *inventory* of the existing applications is created. A clear definition of reference data is necessary for consolidating application information together with associated management rules and controls for the data collection.

The information model should be addressing business lines, technology, processes, core systems, user and business capabilities. Moreover, the regular updating of the information must involve all necessary stakeholders and the complexity of multiple deployments should be addressed in the process. Several stakeholders are mentioned for this step, such as application managers, users, business owners, IT managers and technical architects.

In the second step, an *evaluation* of the applications is performed based on the business value, maintenance, and support costs and risk acceptance. Furthermore, it is recommended to create a short-term and mid-term classification for the life-cycle of the applications.

More details are given for assessing the business value of an application. Practitioners indicate the necessity of having a business view as being critical for a thorough evaluation that would support identifying redundancies, the level of alignment with the business processes and providing the information required for further decisions.

As for the technical value, it is recommended to depict infrastructures and technologies and map them to the existing data models for identifying the relationships. A cost model is also required for assessing the financial value. An emphasis is made on the importance of integrating different perspectives into a consistent framework that facilitates the decision-making process.

The last step refers to the *transformation* and implies the creation of a road-map for the application management. The transformation strategies should be included and scenarios should be developed based on the planned transformations.

Moreover, the authors recommend that this method has to be integrated into the IT governance framework. When new strategic and business objectives are established, they can impact the application transformation strategies and the project directions. An integrated framework can provide a high-end view and informed decisions can be taken accordingly.

The steps for this method are similar to the ones identified in the scientific literature, strengthening its complexity through more specific details about how data should be managed for an efficient APM. Moreover, the stakeholders are mentioned together with several examples of best practices that would improve their decision-making process.

Application Portfolio Framework

Another method indicates the importance of considering the changing business trajectory for the application assessment (Cognizant, 2014). The proposed application portfolio framework is built upon two foundational pillars. The first one refers to the fact that industries follow distinctive change trajectories, such as radical, creative, intermediating and progressive. These changes are defined by two types of threats, namely the industry's core activities, and the core assets. The second one indicates that organizations need applications with long and useful life to serve as their IT foundation.

The framework they propose consists of the following steps:

- **Enterprise Application Portfolio Segmentation**: Based on their intent, different categories of applications are subject to different types of treatment. For building an adequate focus for each application, it is required to identify the capabilities and processes that the application addresses regarding the organization's growth and effectiveness. Therefore, processes and capability are first categorized into three types:

    1. Common: processes and capabilities are common and change very slowly, such as those meant to support daily activities.
    2. Differentiated: these processes and capabilities are meant for competitive differentiation and change at a moderate pace.
    3. New: capabilities and processes that allow businesses to quickly try early-stage concepts, potentially through several iterations. They can become common if they are adopted for long-term.

- **Application Segmentation**: Applications are mapped to the capabilities and the processes they support. Furthermore, based on the nature of the processes and capabilities, the applications are grouped into three segments: System of innovation, System of differentiation and System of record.

- **Evaluating the Business and Technical Value of Applications**: Business processes and capabilities are rated based on their maturity, rated on a scale from 1 to 3. An application's maturity is evaluated by summing up the maturity of the linked capabilities and processes. A matrix is being used for visualizing the results.

- **Additional Assessment and Recommendation**: For making future decisions, firstly the business trajectory has to be identified. Based on that, vehicles of change have to be determined, such as processes, capabilities or just optimization, and their expected levels of maturity. The last step is assessing the implications and generate appropriate recommendations. An example is shown in Figure 2.2.

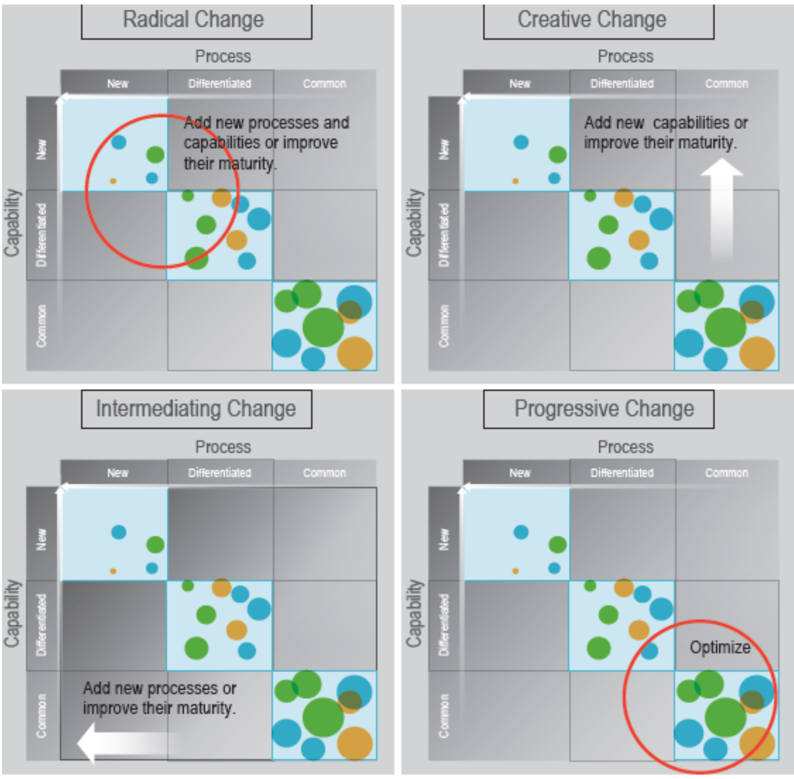

Figure 2.2: Assessment Recommendation based on business trajectory (Cognizant, 2014)

However, for ensuring the successful implementation of APM, the authors recommend that the transformation program should be driven and governed by senior management. Moreover, the creation of an EA is considered substantial.

Compared to the previous methods, the latest suggests that an inventory of the application is already in place and not many details about its construction are being given. However, the focus on the analysis and the evaluation of the application indirectly indicates the aspects that should be considered beforehand. Since the applications need to be mapped with the capabilities and process they support and their relevance for the strategic value, it is assumed that an inventory should contain information about the intended purpose of their usage.

A striking difference from the previous methods consists of the decision-making process, where the industry is considered when deciding the transformation strategies for the application. For this, stakeholders need to have the knowledge not only about the internal organization but also about the market and be able to foresee potential opportunities.

Along the time, the methods evolved and practitioners suggest that APM can be enhanced through mapping applications to existent resources, processes and data models. For achieving that, strong enterprise architecture could facilitate the method by offering more insights from a holistic perspective.

All the presented methods present a common approach: assessing the state of the application portfolio, conducting its evaluation and derive actions for rationalization. The decision-making phase receives more attention in the gray literature, regarded as being one of the struggles that organizations face. Although aligned, the methods proposed by the practitioners include more details about how each step should be performed. Moreover, little emphasis exists on the involved stakeholders and their needs and concerns.

In three of the methods, an inventory is presented as the foundation of the APM, while one refers to it indirectly through the assessment of the application portfolio. While scientific literature indicates that applications should be assessed and categorized individually and as part of the portfolio, practitioners recommend strengthening the assessment by categorizing them based on the nature of the processes they support. While all the methods agree on evaluating the value of applications from different perspectives, the characteristics suggested by each research are slightly different.

2.1.5 Application Characteristics

This section describes the use of characteristics to conduct an assessment of software applications, also involving the related costs and the infrastructure supporting the applications.

Identifying solutions and creating various scenarios for further investment decisions require that stakeholders should be capable to understand and measure various aspects of the applications(Riempp and Gieffers-Ankel, 2007). For achieving that, relevant characteristics have been investigated for offering a foundation for multi-criteria analysis.

When evaluating an application, Mocker (2009) proposes that its complexity can be differentiated in four types:

- interdependency refers to the interconnectedness of the applications in terms of the interfaces they have with each other
- diversity related to the number of the different technologies involved for creating the application
- deviation from the standard looks at the compliance of the application with the standard technology set through existing policies
- overlap/ redundancy describes the degree to which an application covers certain functionalities that are already covered by other applications.

The findings of this paper showed that only interdependency related characteristics impact the complexity, as older applications and those with more complex business requirements also exhibit more interfaces. At the same time, interdependent applications incur higher IT costs. Therefore, in this case, stakeholders would be advised to either maintain the growth or reduce the number of interfaces.

The diversity, deviation, and overlap might not influence the complexity of an application (Mocker, 2009). However, it might be relevant on aggregate levels, such as the application landscape and for this scenario, IT architecture can be investigated in order to understand the impact that a group of applications can have in contrast with just one.

Mocker (2009) proposes that along with application characteristics, the level of activities that address the application complexity should be considered, such as the integration measures, standardization efforts, and consolidation efforts.

Scanning the literature, several characteristics were regarded as being important during the APM process for the assessment, evaluation and making further decisions. Numerical and ordinal characteristics were identified.

From an architectural perspective, different aspects have been found as being relevant. As stated in the previous subsection, enterprise architects need to support organizations to maintain a sustainable level of IT operating and to constantly improve according to external requirements (Riempp and Gieffers-Ankel, 2007; Khosroshahi et al., 2016). Thus, they require an understanding of the dependencies between business application characteristics and related efforts of their operation. The identified characteristics and their description are presented in Table 2.5.

Table 2.5: Architectural Characteristics

Characteristics	Description	Reference
Deviation from standard	Provides information on whether the application or parts of it deviates from organizational standards	(Khosroshahi et al., 2017), (Schneider et al., 2015)
Number of information flows / interfaces	Describes the number of connections of one application to other.	(Khosroshahi et al., 2016), (Khosroshahi et al., 2017), (Schneider et al., 2015), (Wittenburg et al., 2007)
Architectural standard compliance indicator	Describing an application degree of standardization	(Riempp and Gieffers-Ankel, 2007)
Number of applications	Describes the number of existing applications related to a specific domain	(Schneider et al., 2015)
Number of infrastructure elements	Describes the number of the infrastructure elements used to realize an application.	(Schneider et al., 2015)

One of the most important metrics from an architectural perspective is the architectural standard compliance indicator. A possible approach is demonstrated in a case study by analyzing the underlying components to applications, so the relevant interdependencies can be identified (Riempp and Gieffers-Ankel, 2007). Each metric can be evaluated on a scale from 1 to 5. On this scale, 1 indicates that the application is compliant, 2 that is compliant, but not tolerated,3 for not compliant, but minor use, for example just in some business units, and 4 indicates that is not compliant and is a major issue. The value 5 is indicated when the compliance is undecided.

The complexity of enterprises can be significantly impacted by the complexity of the business processes and interfaces(Khosroshahi et al., 2016). Therefore, an increased number of the supported process can lead to more interdependencies causing difficulties in its maintenance and greater costs. For this reason, characteristics addressing those should be considered.

Business requirements have been identified as one of the cases of the application complexity leading to cost increase (Khosroshahi et al., 2017). Therefore, in a cost reduction scenario, characteristics related to business compliance and functionality should be carefully investigated as they are critical in identifying each application and its role (Simon et al., 2010). Several characteristics were identified from the literature and presented in Table 2.6.

An outstanding characteristic is the business standard indicator, which describes the extent to which an application is compliant to the business standards (Riempp and Gieffers-Ankel, 2007). In a case study, one method of appreciating the value of this metric was on a scale from 0 to 4, where :

- 0: not yet classified
- 1: has been declared an organization-wide business-standard,
- 2: has been declared a business standard in selected parts of the organization
- 3: is tolerated
- 4: is violating other business standards.

Table 2.6: Business Characteristics

Characteristics	Description	Reference
Functional scope	Indicated the scope for each application	(Schneider et al., 2015)
Operational excellence indicator	Describes the degree of an application operational status from an aggregated IT operational viewpoint	(Riempp and Gieffers-Ankel, 2007), (Wittenburg et al., 2007)
Number of supported business processes	Describes the number of supported businesses.	(Khosroshahi et al., 2016)
Number of supported business data objects	Describes the number of data objects used	(Khosroshahi et al., 2016)
Business standard indicator	Describing the alignment of the application to the business standards.	(Riempp and Gieffers-Ankel, 2007) , (Wittenburg et al., 2007)

Also, the operational excellence indicator is quite significant. For evaluating this metric, (Riempp and Gieffers-Ankel, 2007) indicates that applications and components should firstly be clustered according to services and operation dimensions, and then assessed and rated using performance indicators, benchmarks, and expert judgment.

A research study identified the age and the alignment with the business requirements as the main causes of the IT complexity (Mocker, 2009). Therefore, for addressing them, technical aspects should be considered in application assessment so that stakeholders can easily identify the areas which can be improved. The technical characteristics should help to identify the interdependencies, the diversity of the technology and the deviation from technology standards. Moreover, they can support tracking the technical compliance and operational performance of an application.

The technical metrics take the perspective of the developer or reviewer of an application program, however, they are insightful for application managers, IT managers and project managers for future investments. These are presented in Table 2.7.

A thorough evaluation of the technical complexity should consider the proposed characteristics together and not individually. For example, analyzing just the age of an application is not sufficiently and it should be supported by information which identifies the degree of the customization during its lifecycle.

Table 2.7: Technical Characteristics

Characteristics	**Description**	**Reference**
Functional readiness	Describes the degree to which an application's required functions are available in the required quality.	(Riempp and Gieffers-Ankel, 2007), (Simon et al., 2010)
IT project status indicator	Defined to capture the status of scheduled and running projects.	(Riempp and Gieffers-Ankel, 2007), (Wittenburg et al., 2007)
Expected development date	Indicates the date when the development spend begins for an application.	(Cantor, 2011)
Lifecycle state	Describes the lifecycle state of an application.	(Riempp and Gieffers-Ankel, 2007), (Saskia Zelt, 2013), simon
Application Lifecycle Duration	Indicates the lifecycle duration of applications	(Cantor, 2011), (Weill and Vitale, 1999)
Utilization indicator	Describes the percentage of the operational time that a resource is busy.	(Lankhorst and Quartel, 2010)
Application Age	Describes the amount of time since the initial release of an application.	(Khosroshahi et al., 2016), (Khosroshahi et al., 2017)
Technology diversity	Indicates the number of technologies an application is based on.	(Khosroshahi et al., 2017), (Simon et al., 2010)
Documentation quality	Describes the availability and extent of documentation.	(Khosroshahi et al., 2017)
Application failure	Indicates the number of application downtimes in a specific period.	(Khosroshahi et al., 2017), (Simon et al., 2010)
Application size	Indicates the function points or lines of code of an application.	(Khosroshahi et al., 2017)
Number of incidents	Indicates the number of incidents for an application in a time frame.	(Khosroshahi et al., 2017)
Number of users	Indicates the number of registered users on each application.	(Khosroshahi et al., 2017)
Incident processing time of an application	Describes the amount of time that was required for solving an incident.	(Khosroshahi et al., 2017)
Expected retirement date	Indicated the date when an application is expected to be retired.	(Cantor, 2011)
Functional redundancy	Indicates the number of functional redundancies of an application.	(Khosroshahi et al., 2017), (Schneider et al., 2015),(Simon et al., 2010)

The last category of identified characteristics is related to investment decisions, capturing the costs, risks and strategic alignment and they are presented in table 2.8. Operation costs directly contribute towards the TCO and they involve all the expenses required to maintain the usage of the applications. Several examples of such expenses are the costs for licensing, the database storage and the server handle, required upgrades, support services and the operation of the server environments (Khosroshahi et al., 2016). Important to mention is that in the planning phase, stakeholders might not have the real costs, so they need to propose a budget or estimate the costs(Cantor, 2011). To keep track of such assumptions, it is important to implement a method to check if the provided financial aspects are estimations or real costs.

Table 2.8: Investment related characteristics

Characteristics	**Description**	**Reference**
IT investment indicator	Describing the investment estimated for an application.	(Riempp and Gieffers-Ankel, 2007), (Wittenburg et al., 2007), (McKeen and Smith, 2010)
Revenue per User	Describes the income per user	(Khosroshahi et al., 2016)
Operating costs	Indicates the amount of operating costs for an application in a given time frame.	(Cantor, 2011), (Khosroshahi et al., 2017)
Investment value	Describes the financial value of the investment for a specific period of time.	(Cantor, 2011)
Net present value	Describes the value in the present of an application in contrast to future value.	(Cantor, 2011)
Future value	Describes the estimation of a future value of an application.	(Cantor, 2011)
Estimated savings	Describes the estimated savings for an application.	(Cantor, 2011)
Cost efficiency	Describes the ratio between development, costs and revenue.	(Wittenburg et al., 2007)
Return on Investment	Measures the amount of return on an investment, relative to the investment's cost.	(Wittenburg et al., 2007), (Cantor, 2011), (Mocker, 2009)
Return on Asset	Indicator of how profitable a company is relative to its total assets.	(Wittenburg et al., 2007)
Security status indicator	Describes the degree of alignment to the security standards.	(Simon et al., 2010)
Investment risk	Describing the risk of investing in a specific application	(Cantor, 2011)

While for some of the identified characteristics, their description is quite straightforward, others might require more effort for understanding or calculating (Riempp and Gieffers-Ankel, 2007). For example, a complex method for calculating the Return on Investment metric is presented in (Cantor, 2011), however in practice might have different methods of calculating it(Fabrice Vila, 2012; Cognizant, 2014).

Moreover, there are different approaches for calculating the same metric for a specific characteristic. For example, the strategic importance indicator is calculated manually and involves more stakeholders in one of the case studies (Riempp and Gieffers-Ankel, 2007), while (Lankhorst and Quartel, 2010) and (Khosroshahi et al., 2017) present more complex and automated methods. In practice, stakeholders can have different opinions regarding the importance of an application, therefore for assessing the real value, all opinions should be considered in the process (Fabriek et al., 2007; Riempp and Gieffers-Ankel, 2007).

Some extra characteristics which should be included when consolidating an application inventory such as application name, release version, implementation data, and application owner, however, these are not necessary for evaluation, but for a historical tracking of the application development (Fabrice Vila, 2012). However, it can strengthen the evaluation of technical and business value. Moreover, keeping track of the stakeholders who interacted with an application, such as developers or engineers, is beneficial for IT managers, so they have information about whom to contact when more questions arise about an application evolution in a given time frame (Simon et al., 2010).

It has been noticed that in gray literature, the characteristics that were presented were consistent with the ones identified in the scientific literature. Moreover, in the scientific literature, more complex methods and description were given.

In portfolio management **a metric** is a characteristic of an organization, such as business value, cost, and customer satisfaction, used to score elements in portfolios (BiZZdesign, 2010). In the definition of a metric, not only a name is set, but also the measurement unit of the metric and the way of being measured.

When metrics are being defined, a distinction should be made between base metrics and aggregate metrics. The first one delivers directly measured values, while the latter is calculated using other metrics. The aggregation formula shows how the values of the underlying metrics are combined into a single value in the aggregate metric.

These characteristics, seen as potential metrics, can be used for creating an application inventory that provides all the information needed for assessment and evaluation. Moreover, they can serve further at creating a foundation for KPI development following the guidelines provided by (Khosroshahi et al., 2017).

2.2 Stakeholder Involvement

APM represents a continuous, structured and systematic process, which stakeholders need to follow for making decisions regarding the existent applications of an organization. This chapter presents why their needs should be considered and how their knowledge can bring value to the process.

The complexity and the dynamic nature of the APM approach require structured and transparent decision-making that embraces a diversity of knowledge and perspectives. Ensuring that stakeholders involved in a decision-making process have the power to influence the decision and the technical capability to engage effectively with the decisions is regarded as **stakeholder involvement** or stakeholder engagement (Pandi-Perumal et al., 2015).

For this reason, stakeholder involvement in the APM decision-making process has been increasingly sought and seen as a necessity in the organizational culture of organizations (Riempp and Gieffers-Ankel, 2007). Practitioners argue that linking together different perspectives and cross-referencing information allows understanding the real issues and support making the right decisions (Fabrice Vila, 2012). The literature argues that stakeholder involvement needs to be underpinned by a philosophy that aims towards empowerment, equity, trust and learning (Reed, 2008).

The key focus in the process of stakeholder involvement is the stakeholder, defined as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Pandi-Perumal et al., 2015). Therefore, any individual or group of individuals interested, able to influence or is affected by the decision-making process and its outcome, can be considered as a stakeholder.

The process of encouraging stakeholder involvement is referred to as stakeholder management and consists of four steps (Pandi-Perumal et al., 2015). Figure 2.3 presents the four steps and their key outputs.

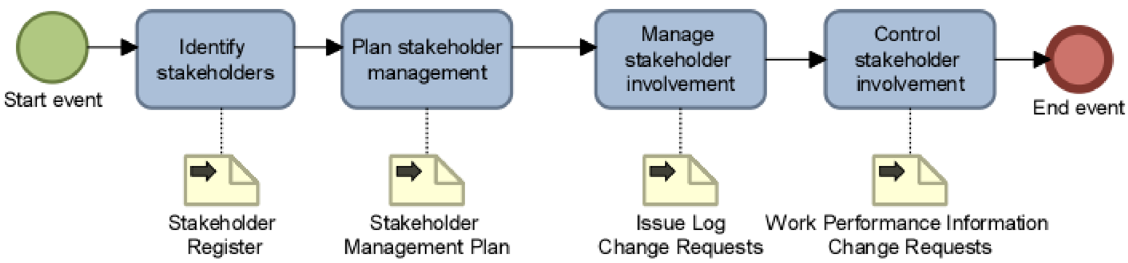

Figure 2.3: Stakeholder Management steps and key outputs(Pandi-Perumal et al., 2015)

Identification of stakeholders

The first step requires the identification of all the stakeholders and documenting relevant information regarding their interests, expectations, involvement, and influence.

The techniques used for this step are the stakeholder analysis, expert judgment, and meetings. The stakeholder analysis is however identified as the most common approach by both academic literature and practitioners (Simon et al., 2010; Reed, 2008; Cognizant, 2014; Khosroshahi et al., 2016).

Analysis of stakeholders can be used to generate knowledge about the relevant actors to understand their behavior, intentions, interactions and their interest in a given context and the influence or resources that they can bring to the decision-making process (Brugha and Varvasovszky, 2000). The stakeholder analysis aims to evaluate and understand stakeholders from the perspective of an organization and to highlight the importance of actors and interest groups in the decision-making process (Pandi-Perumal et al., 2015).

Conducting a stakeholder analysis involves three steps according to Pandi-Perumal et al. (2015), namely:

1. identifying potential stakeholders and relevant information,
2. identifying potential impact and support,
3. assessing each stakeholder's attitude or likeliness to react.

The identification of the stakeholders should be conducted through brainstorms, interviews and organizational documents (Jepsen and Eskerod, 2009; Pandi-Perumal et al., 2015). A downside of using only organizational documents is the generality of the interaction and the lack of details for specific cases. Therefore, interviews and brainstorm sessions bring more value through specific information (Jepsen and Eskerod, 2009).

The characterization of the stakeholders should include the assessment of needed contributions, expectations concerning regards for contributions and the power concerning the decision that needs to be taken.

The data collection method for the characterization is the use of face to face interviews with stakeholders. The reason behind the approach lays in the significant value provided through the level of details and accuracy per each stakeholder (Jepsen and Eskerod, 2009).

A possible outline for the characterization of the stakeholders can include attributes like Interest, Contribution, Expectations, Power, Strategy, and Responsibilities (Jepsen and Eskerod, 2009). The contribution is regarded as a specific deliverable such as a positive attitude or specific behavior, such as making a supportive decision. Expectations are rewards that stakeholders expect in exchange for their work, the authors indicating that usually external stakeholders put more emphasis on that. Some examples mentioned in the article are influence, access, publicity or attention.

The power of stakeholders in decision-making is critical and it can be assessed based on their knowledge and the context of the decision. The attitude has a significant role in future decisions regarding their involvement. This is because the stakeholders labeled in some level of opposition would require more attention than the ones which are supportive(Pandi-Perumal et al., 2015).

Another study indicates that characterization could be done through two common approaches, namely a top-down approach, where an analytical categorization is created, and a bottom-up one where reconstructive methods are used (Reed, 2008). The top-down approach implies that stakeholders are classified by researchers based on their observations of the system in question and assumptions made on the way it should function. The bottom-up approach allows the categorization and parameters included in the analysis to be determined by the stakeholders themselves, so the analysis reflects the perceptions of the stakeholders.

The output of this step should be a stakeholder register that needs to contain details related to the stakeholder classification, their identification information, and assessment.

When identifying stakeholders, several challenges can arise. Firstly, managers can have difficulties in correctly identifying the stakeholders that should be considered (Jepsen and Eskerod, 2009). This mostly happens due to the fact that stakeholders have different contributions during the stages of a project, so in the early stages is hard to get an overall impression (Pandi-Perumal et al., 2015).

Another challenge consists in the difficulty to manage the stakeholder interviews (Jepsen and Eskerod, 2009; Reed, 2008). Therefore, high skilled facilitation is essential to maintain a positive group dynamic and to handle stakeholders that have a negative attitude.

Moreover, when the responsibilities are not clearly defined within a project, the contributions are hard to estimate (Jepsen and Eskerod, 2009).

In addition to this, managers are afraid to label stakeholders with a negative attitude Jepsen and Eskerod (2009). The reason behind this lays in the uncertainty of stakeholders that have access to the outcome of the analysis in future stages. The validity of the data is also put under question sign due to the fact that stakeholders can provide biased input, therefore expert judgement should be considered for more accuracy (Pandi-Perumal et al., 2015).

Plan Stakeholder Management

The second step defines an approach for managing stakeholders and building relationships that can benefit the goal and to minimize the influence of stakeholders that might have a negative impact.

A project management plan and the stakeholder register together with organizational process assets and enterprise environmental factors should be considered as inputs. For this step, the expert judgement, meetings, and analytical techniques can be used to determine the desired state of engagement of the stakeholders. The techniques take into consideration the sensitivity towards the project goals and personal orientations such as being unaware, resistant, neutral, supportive or providing leadership (Pandi-Perumal et al., 2015).

Stakeholders have different and unique perspectives, possessing capabilities acquired through their experience. Therefore, their engagement is critical. A good communication plan should be established with the stakeholders to minimize the gap between their desired level of engagement and the actual level. However, if the senior management remains unaware of either their skills or their knowledge for contribution can cause barriers to effective involvement (Pandi-Perumal et al., 2015). In addition, Jepsen and Eskerod (2009) also argues that decisions should be made based on the need to alter or support stakeholder's inclination to deliver results.

Another study indicates that other factors that can influence stakeholders' participation should be considered in this step (Reed, 2008). For example, Jepsen and Eskerod (2009) indicates the lack of knowledge as a possible factor, and trainings, or other interactive activities are suggested for educating stakeholders and providing them with more information. This way, stakeholders can meaningfully engage in the decision-making process.

The output of this step consists of a stakeholder management plan and project document updates. The stakeholder management plan is expected to include information about the stakeholders, communication requirements and accountable stakeholders, the required engagement level and the strategy decided.

Manage Stakeholder Involvement

This step is focused on meeting and exceeding the stakeholders' expectations through continuous communication and clarifying and resolving any issue that they might face. This aspect will significantly contribute to the improvement of project performance.

A project manager is expected to be responsible for conducting this process. The input expected consists of the stakeholder management plan and the communication strategy, a change log and organizational process assets. While the first two provide information on the stakeholders and how the communication with them should be conducted, the change log is a document where the stakeholders are expected to raise the challenges or struggles they face. The organizational process assets should assist the project manager in managing unexpected situations. Communication methods are really important and the project manager is expected to have good management and interpersonal skills.

The output is expected to be an issue log, where obstacles are documented together with accountable stakeholders for better monitoring progress. Moreover, change requests together with updates concerning the project management plan and project documents are expected as well.

Control Stakeholder Involvement

The last step consists of evaluating and monitoring the overall stakeholder relationships and ensuring their appropriate engagement throughout the project by adjusting plans when required. The input consists of a project management plan, an issue log, the work performance data, and the project documents.

For this process, a good information management system is required for capturing the information and used as a tool for communication and history tracking of changes. Examples of reporting techniques that can be used are spreadsheets, presentations, and graphics for visual representations (Riempp and Gieffers-Ankel, 2007). Expert judgement and meetings with stakeholders can also be conducted for this step.

The output of this step is expected to consist in work performance information, change requests, and updates related to the project management plan, related documents, and the organizational process assets.

The four steps aim to create a framework for adopting stakeholder involvement in an organization. Identifying the stakeholders has been indicated as the most challenging step in the literature (Jepsen and Eskerod, 2009; Reed, 2008).

Several best practices are suggested for addressing these challenges and presented as follows:

- stakeholder involvement should be considered as early as possible (Reed, 2008)
- the entire process requires clear objectives and should not overlook the need for highly skilled facilitation (Reed, 2008)
- an informal context should be created for enhancing participation in the brainstorm sessions, for example, organizing the interviews during lunchtime or offering meals during interviews (Jepsen and Eskerod, 2009)
- more persons should be involved as interviewers to avoid subjectivity (Jepsen and Eskerod, 2009; Pandi-Perumal et al., 2015)

In spite of the presented challenges, it is considered that stakeholder involvement can bring value through shading light on stakeholders' expectations. Moreover, the discussions support building a common vision on objectives and how they can be achieved. Active participation in these discussions has the capacity to transform adversarial relationships between the involved stakeholders and indicate solutions for better collaboration. Sharing common interests and concerns at an early stage can lead to better project design and increase the likelihood that local needs and priorities are successfully met. This can enhance the engagement of the stakeholders as it becomes clear that their work is valuable for a greater goal.

More than addressing stakeholder needs, the co-generation of knowledge can empower the stakeholders and it can increase their capacity of using this knowledge (Reed, 2008). This leads to an improvement of the decision-making process by providing higher quality information, anticipating and ameliorating unexpected negative outcomes before they occur.

While the literature emphasizes the positive benefits of stakeholder involvement (Reed, 2008; Simon et al., 2010), potential costs and risks with the adoption of a stakeholder perspective should also be considered (Pandi-Perumal et al., 2015). A big downside is the time constraint, as identifying stakeholders can take a lot of time and it can delay the start of a project (Jepsen and Eskerod, 2009).

The articles considered for this research mostly cover only the first two steps, namely the identification of the stakeholders and the planning, when adopting a stakeholder perspective. The conceptual framework introduced by Pandi-Perumal et al. (2015) addresses also the need for managing the stakeholders' engagement and monitoring their performance. Therefore, the lack of these two practices could represent a reason why practitioners still fail in addressing stakeholders' needs.

The quality of the decisions regarding APM depends thoroughly on the quality of the process that leads to it, therefore best practices regarding stakeholder involvement need to be considered for improving it.

The presented steps can significantly contribute to APM. Stakeholders can provide reality checks which aid in prioritizing investments, identifying potentially difficult issues and providing solutions to navigate around or to overcome challenges.

The following subsection presents the stakeholders that should be considered in APM.

2.2.1 Stakeholders in APM

Recent studies agree that organizations should change their organizational management thinking and the decision making processes (Pandi-Perumal et al., 2015). Stakeholder involvement is considered to be a must for a consolidated data foundation needed in the aforementioned phases of APM(Information Balance, 2009; Cantor, 2011; Cognizant, 2014).

This subsection presents the main stakeholders involved in the APM process as identified in the existent literature. These roles are presumed to be found in most organizations. Based on the scanned literature towards coverage of the APM, the identified stakeholders are summarized in Table 2.9.

Table 2.9: Identified Stakeholders

Entities	Stakeholders	Sources
Senior Management	CIO, COO, CFO	(Weill and Vitale, 1999), (Fabriek et al., 2007), (Cantor, 2011), (Zelt et al., 2013a), (Fatimah et al., 2016)
IT Management	Technical Manager, Application Portfolio Manager, Functional Manager, System Development Manager	(ASL BISL Foundation, 2000), (Erwin, 2017)
Business Leaders	Business Manager, Application Owner, Business Analyst, Business Consultant	(Weill and Vitale, 1999), (ASL BISL Foundation, 2000), (Simon et al., 2010), (McKeen and Smith, 2010), (Cantor, 2011)
Enterprise Architects	Chief Architect, Technology Architect	(ASL BISL Foundation, 2000), (Riempp and Gieffers-Ankel, 2007), (McKenzie et al., 2011)
Project Management	Project Manager	(Fabriek et al., 2007), (Lerch and Spieth, 2013)
Development Team	Developers, External ICT service providers	(ASL BISL Foundation, 2000), (Erwin, 2017)
Marketing Management	Marketing Manager, Product team	(Cantor, 2011)
Finance Management	Financial Manager, Financial Analyst	(Cantor, 2011)

With research targeting the technical aspects for adopting APM in organizations, most of the papers indicate the senior management and the IT professionals as the most important stakeholders in this process (Weill and Vitale, 1999; Fabriek et al., 2007; Zelt et al., 2013a). The primary reason for this choice is because of their impact on APM decision making, as they are responsible for the strategic decisions concerning their AP.

Literature indicates three positions from the senior management as being relevant for the APM, namely the Chief Information Officer (CIO), the Chief Operation Officer (COO) and the Chief Financial Officer (CFO). A CFO's main responsibility is the financial affairs of the organization. Concerning APM, his interest lays in answering questions related to the investment value and the impact on the return on investment (Cantor, 2011). A COO is concerned on the impact of the administrative and operational functions (ASL BISL Foundation, 2000; Cantor, 2011). However, none of these two actively participate in the decision-making process, the CIO being the only one active in the decision-making process regarding the future of applications, responsible with decisions related to the features and planning.

Among the senior management responsibilities, several were mentioned in the academic research:

- negotiating and approving budget related decisions (Cantor, 2011; Riempp and Gieffers-Ankel, 2007)
- handling decisions of strategic impact arisen from the business management (Fatimah et al., 2016)

- implementing a governance structure and rules to address APM (Riempp and Gieffers-Ankel, 2007; Fatimah et al., 2016)
- executing the organizational strategies (Simon et al., 2010)

It is argued that knowledge of IT professionals should be considered in the APM throughout the whole decision-making process (Simon et al., 2010; Fabriek et al., 2007; Erwin, 2017).

IT professionals are considered to be formed by three parts, namely technical management, application management, and system development and each part has its own interests and concerns ASL BISL Foundation (2000).

A technical manager is responsible for the availability and maintenance of the infrastructure, assuring its usage (ASL BISL Foundation, 2000).

An Application Portfolio Manager would be responsible for the maintenance and the enhancement of information systems that run on the infrastructure. Therefore, an Application Portfolio Manager also arranges the capacity for change and renovation projects, monitoring the results.

System development is described as the practice of building new applications. System developers are responsible for building new applications that involve highly innovative nature and aim towards radical transformations in an organization.

Analyzing the responsibilities of IT professionals in the APM decision-making process, best practices identify and make a clear difference between the positions that should exist in a company (ASL BISL Foundation, 2000). However, this is not always the case in companies. For example, a common practice is that the responsibilities of Functional Manager can come under those of an Application Portfolio Manager (ASL BISL Foundation, 2000) or not all the positions exist (Riempp and Gieffers-Ankel, 2007), when the company size is small or medium.

One research proved that more knowledge is required in the APM decision-making process (Riempp and Gieffers-Ankel, 2007). The findings indicated that senior management decision-making can be better supported through information aggregation of the following fields:

- IT strategy, defined and governed by central IT staff who directly report to the Chief Information Officer (CIO)
- Business and application needs, addressed by IT staff in charge of business requirements management
- IT architecture, usually developed and maintained by technical staff spearheaded by chief architects
- IT operation, managed by teams responsible for data centers, networks, and customer support
- IT project management, which is carried out by dedicated IT project offices
- IT investments, which are planned, negotiated and controlled by central IT staff.

Several papers indicated the importance of the business leaders for contributing to the assessment phase and during the optimization processes (Weill and Vitale, 1999; Simon et al., 2010; Cantor, 2011). Business leaders are mostly interested in the business value of an IT application, such as future internal value (Cantor, 2011; McKeen and Smith, 2010) and discussing business scenarios of the chosen optimization alternatives (Fabriek et al., 2007; McKeen and Smith, 2010). Some of the positions identified in the literature are Business Manager, Business Owner, Business Analyst, and Business consultant.

"Business manager" is a term that describes the person with overall responsibility for the business process in which the application or applications are used (ASL BISL Foundation, 2000).

For this purpose, the business manager has at his disposal resources and authority in all the management areas, such as production management, human resources management, supply chain management, financial management and also in the domains of ICT management. In practice, he places responsibility for his applications in the hands of internal providers, by delegating the steering function to the system or application owner and the functional managers, or external ICT service providers (ASL BISL Foundation, 2000).

The application owner is responsible for the functionality and the development of an application, being also the accountant for the budgets required for the maintenance, enhancement and renovation of the application (ASL BISL Foundation, 2000; Erwin, 2017). His knowledge should cover the supported business process and which relevant details are being used in the application, such as business rules and regulations. A functional manager is supposed to assure the functionality of the application, however, these roles can be filled by the same person.

The ownership of each application should be established and enforced by assigning a single person responsible for maintaining the information, who has knowledge of the accumulation of essential, current, correct and complete facts (Planview, 2015). However, this might not always come under the responsibilities of an application owner, but under the developer that has created it.

When the software applications are being used by external parties (Project One, 2013), business consultants should also be considered in the decision-making process.

A complete view of the data and enterprise architecture assets are required for providing a collaborative platform for the business and technical stakeholders (Erwin, 2017), therefore the importance of an enterprise architect is also highlighted as significant. The chief architect and his team plays a significant role in the future development of AP (McKenzie et al., 2011) as well as providing the information regarding the architectural compliance of an AP (Riempp and Gieffers-Ankel, 2007).

The decisions regarding APM are directly impacting an organization's projects as well, therefore project managers should also be engaged in the APM process (Lerch and Spieth, 2013). Thus, their decisions are expected to aim for better investments that support the growth, adding to and refining content, thus increasing the parameters of the benefit distributions and decreasing the parameters of the cost distributions.

One research indicates that the main responsibility of a project manager's focuses on a group, function or a process, therefore the view about a value of a system includes not only the direct value to the manager personally, but also implicitly the value gained through the usage of the system by employees within the manager's domain (Weill and Vitale, 1999). The value of the team is strengthened by the findings of Fabriek et al. (2007), where is indicated that application-related strategies are valuable for a manager, but in an indirect way as they provide value for his subordinates.

When it comes to the development phase of applications, several positions were identified as significant. The first one is the Application Portfolio Manager who has the responsibility of overseeing that everything goes as planned and making sure that the proposed budgets are respected. Moreover, the System Development Manager is responsible for managing the actual development and making sure that Developers are on track with the expected progress. Having one person accountable for the overall performance of a software application is regarded as a best practice, therefore the position of an Application Owner was also regarded as important. In some cases, however, for financial reasons, the development phase can be outsourced to an External Provider.

Looking at investment and cost-related decisions, Cantor (2011) illustrates that different stakeholders have the required information and insights for providing the foundation for cost and benefit streams. The author indicates that not only IT managers and the CFO should be involved, but also stakeholders like the development manager, the support unit and the product marketing team. Moreover, the author suggests that the systems manager should work closely with the financial managers for accurately assessing the value created through the previous investments. From a financial perspective, the most high-level decision-maker is the CFO and the decision depends on financial reports provided by Financial Managers. The Financial Analyst is responsible for various investment decisions concerning really specific applications.

Software applications can impact the services or the products that the company provides, therefore another department identified as relevant was the Marketing department (Cantor, 2011). Although the stakeholders from this department require to be informed, they don't necessarily have decisional power.

Significant differences were found in the gray literature regarding the stakeholder engagement and the explanation of their roles in the APM process (ASL BISL Foundation, 2000). Strong management commitment, as well as access and active participation of stakeholders, are some of the critical success factors for APM from a practical perspective (Cognizant, 2011, 2014). Thus, stakeholders' engagement is required as their involvement is regarded as crucial, especially in the data collection phase and the validation.

Stakeholders have different interests and therefore view problems and solutions differently (ASL BISL Foundation, 2000). Therefore, the data collection and the regular updating of the information must involve all necessary stakeholders, such as application managers, users, business owners, IT managers and technical architects (Cognizant, 2011; Fabrice Vila, 2012).

Collaboration among the aforementioned stakeholders for suggestions and reactions before the final decisions are made is considered as being valuable for the organizations (Erwin, 2017). Aligning with this, a case study demonstrates that a cross-functional team of consultants comprising highly experienced business consultants and technology architects leads to a successful application rationalization (Project One, 2013).

Findings from the literature are very interesting and they further support the information fields identified by Riempp and Gieffers-Ankel (2007) by indicating the stakeholders that should be involved. A striking difference between the gray literature and the academic papers consists of the stakeholders' involvement. While academics briefly mention the senior management and the IT professionals, practitioners offer a clear definition of their role and how each position can and should enhance the APM process.

2.3 Data Modeling and Visualization

Emerging technologies and increasing accessible data sources contributed to a massive volume of both structured and unstructured data that is so large it is difficult to process using traditional software tools. Regarded as big data, the term refers to the technologies, like tools and processes, that an organization requires for handling large amounts of data and storage facilities (International D., 2017).

Nowadays, APM has also become a big data challenge mostly because applications require integration with other business capabilities. Moreover, their performance relies on the software infrastructure, underlying hardware, and network connection, generating massive quantities of data (Khosroshahi et al., 2016). This chapter presents how the data complexity issue can be addressed through data-driven workflows and interactive dashboards.

Data is recognized as a vital enterprise aspect that can provide insights about customers, products, and services for an organization (International D., 2017). Therefore, data is a critical asset for an organization as it can be used for creating value. However, to provide information, significant efforts are required as data needs to be processed, organized, structured or presented in a given context.

In relation to technology, data can be understood as information that has been stored in digital form, therefore the definition of data is too wide to be captured. Even within a single organization, data can be represented in multiple ways, as it can be at the same time an interpretation of the object and an object that must be interpreted. Therefore, for data to become meaningful, the context must be given. Context can be regarded as a data representational system, and its documentation is referred to as metadata.

Managing data requires understanding the scope and range of the data within an organization. Good management involves that data should be organized in a structured way and the processes in which are used should be well documented.

In information technology, data architecture is composed of the models, policies, rules or standards that govern which data is collected, and how it is stored, arranged, integrated, and put to use in data systems and in organizations (International D., 2017). The structure of the data impacts the ability to analyze it, therefore organizations require a modern scalable architecture (Khosroshahi et al., 2016). In APM, data architecture supports a unified application architecture and organizing a decentralized data collection that provides the means of capturing, analyzing and visualizing relevant metrics about the application portfolio (Cognizant, 2014).

Regardless of the amount of data that has to be processed, two fundamental aspects need to be addressed, namely the identification of problems and how to address them.

To identify a problem, the underlying APM tools should support stakeholders to detect anomalies in the application's behavior and their infrastructure. More than identifying issues, stakeholders need to gain knowledge of the root cause. This implies that data has to be integrated from different sources so correlations can be established.

2.3.1 Data Modeling

Data Modeling is a core concept in dealing with large amounts of data and this subsection presents the basic concepts, the practice and why is it important within an organization.

Data modeling is defined as the process of discovering, analyzing, representing and communicating data requirements in a precise form called the data model (International D., 2017). This practice of usage and management of the data through structured and repeatable processes enables people and systems to create value and to achieve business goals within an organization.

Data models are critical to the effective management of the data. They can create the foundation for collaboration by providing a common vocabulary and serving as a primary communication tool. Data models capture and document explicit knowledge about an organization's data and systems, hence, it can provide a starting point for future transformations of applications (Khosroshahi et al., 2017).

Having a complete model of the data provides stakeholders access to a high-end vision and a thorough understanding of the value of their data assets. Therefore, it becomes extremely important that an organization has a data representation and a process representation. The practice of data modeling can help the improvement of business processes and data quality along with that.

The goal of data modeling is to confirm and document the understanding of different perspectives, leading to a better alignment between applications and business requirements. A proper implementation benefits the cost reduction through lowering the maintenance costs and increasing the reusability opportunities. Moreover, confirming and documenting the different perspectives facilitates data structures formalization, the scope definition, and knowledge retention (International D., 2017). In APM integrating different perspectives is a requirement as it provides better insights for executives and improves the quality of their decisions (Riempp and Gieffers-Ankel, 2007).

To illustrate a decision-making process, workflows are being used. A workflow represents a high-level specification of a set of tasks and the dependencies between them that must be satisfied to accomplish a specific goal in a determined time (Deelman et al., 2009). Workflow modeling focuses on structural aspects of the processes, indicating the order of execution of the component activities, using specification languages.

A good understanding and planning of the data life cycle is required for effective management of data assets. This implies a good understanding of processes that create or obtain data, move, transform, store and enable to share it. Throughout the life cycle, data can be cleansed, transformed, merged, enhanced or aggregated. The specific of the data life cycle within a given organization can be quite complex, as the data also has a lineage. This provides knowledge over the origin, the movement, and the transformations through the systems where the data was accessed and used. Therefore, both the life cycle and the lineage of the data have to be documented and maintained for good management.

A strategic organization should define both data content requirements and data management requirements, such as policies and expectations for use, quality, control, and security. Moreover, an enterprise approach for architecture and design should be implemented together with a sustainable approach for the infrastructure and software development.

The most common problems that can occur address the data validation, namely the redundancy of the data or when the data is lost, missing, mismatched, inconsistent or misdirected (Sadiq et al., 2004).

The continuous flow of data in organizations, provided by different systems, requires new workflow models. They need to capture the data perspective of these applications since data is produced constantly while the business process instances are limited. Good workflow tools provide automation of the processes of creating data and workflow governance.

When the availability of the data coordinates the processing in workflow it's called data-driven workflow (Wombacher, 2010). The data flow indicates which data are exchanged between which activities, therefore the data workflow approach aims to process and model data.

In this research study, data-driven workflows are used for two purposes, namely:

- to identify and to represent how stakeholders collaborate and impact the data modeling process
- to represent the data collection process for supporting decision making.

Another benefit of data-driven workflows is that they ensure the collaboration between different stakeholders that modify local data using conditioned or updating actions. Moreover, they allow stakeholders to reason, based on local observations, about the high-end state of the system and the actions taken by other stakeholders. This can be regarded as a strong foundation for monitoring, detecting and diagnosing the application portfolio leading to improved efficiency. With regard to APM, such an approach will address the challenge regarding the traceability of information regarding the application and its transformations.

At the level of representation and execution, a workflow is a computer program that can be expressed in any modern programming language, however, the task of creating it goes to a person and it should be not be seen as a one-time-only action.

The workflow representation can be done in numerous forms as they consist of several functional units, such as components, tasks, job or services. There are several representation languages for its representation such as graph variants, Perri nets, Unified Modelling Language (UML), Business Process Modelling Notation (BPMN) (Deelman et al., 2009).

BPMN intends to standardize a business process model and notation and provides businesses the capability of understanding their internal business procedures in a graphical notation and improves the communication of these procedures in a standard manner (Object Management Group, 2011).

BPMN describes the steps in a business process from the start to the end, which is a significant phase whether is it's used for documenting a process, analyzing possible ways of improvement or defining the business requirements for an IT solution to a problem.

One of the main benefits of the BPMN is that provides a simple means of communicating process information to other business users and process implementors. Therefore, it's easy to follow and understand by different kind of stakeholders which don't have a technical background such as customers or suppliers. Moreover, each BPMN shape and symbol are documented and precise which supports good communication between different stakeholders.

Adopting BPMN can be of tremendous use, as it supports process discovery and provides a thorough analysis for stakeholders, leading to time efficiency and cost reduction in the decision-making process.

Moreover, the visual language used by the business analysts to describe "To be" versions of the process is the same as the one used by developers to build the processes that lead to new business-empowered process solutions. The BPMN models can become executable when developers attach source-code or scripts by using workflow and business process management software. Therefore, the collaboration between the business units and IT becomes faster and agile. The execution of the BPMN models leads to the creation of the data models which can later be used in the EA approaches.

Once the workflows become executable, it is required to keep track of all the information related to the ongoing processes, such as the status of tasks, involved stakeholders and overall performance. Therefore, it is required that the organizations adopt a capability that provides the ability to view all this information in one place.

2.3.2 Data Visualization

The information required about the applications and the application landscape can result in a large amount of data. Therefore, the visual representation is critical to sense-making as stakeholders can process large amounts of data if presented in meaningful ways (Schwendimann et al., 2016). This subsection presents how a dashboard can facilitate this need and the features that should be included to provide valuable and customized insights to its users.

A dashboard is a visualization tool of data and information showing the latest condition about the achievement of organizational performance in the form of the main indicators. The ability to visualize everything in a single viewpoint and comprehensive reports helps optimize the effective execution of the organizational processes in a streamlined manner. Therefore, dashboards can be of tremendous use for complex organizations that involve multiple stakeholders with different needs and responsibilities.

Stakeholders such as decision-makers, executives, and senior leaders can establish targets, set goals, analyze the state of an application or a portfolio and track its history. A customized dashboard supports them by displaying data from multiple sources in the same view, showing historical data for different periods. Through their interactive features, dashboards can provide better understanding so stakeholders can use that information to implement appropriate changes.

Dashboards can be used for three purposes, namely monitoring, analyzing and for management (Heikkinen and Kostakos, 2012). At the monitoring level, key metrics are displayed to the user using graphical data and alerts should be created when thresholds are exceeded. At the analysis level, the information behind the metrics is explained. The detail level provides users the option to examine report results in depth before taking action.

A recent case study identifies several features that a dashboard should provide to facilitate stakeholder involvement (Orlando and Sunindyo, 2017) and has been identified as significant for this research. The methodology used and the findings of the research are be presented.

The methodology consists of five steps: identifying needs, planning, designing prototype, testing and evaluation, and implementation.

The first step starts by identifying organizational goals and conditions, followed by determining the organization KPI and stakeholder identification and analysis. The analysis should cover their primary needs, such as execution, supervision or decision-making, the activities undertaken. This output of analysis will be mapped for the dashboard features, with the use case and will support the estimation on the business intelligence level required for each type of stakeholder.

The planning step starts with creating an analysis of the KPI meta-information together with the design for the dashboard functionality used for determining the hierarchy for the information access. In this step, design should also be created for the communication hierarchy.

The output from the previous step is used for designing the prototype. In this step, design of the layout and the communications mechanism will be created, both serving as a map for control navigation. The last two steps involve prototype testing and evaluation until a certain level of agreement is reached and lastly the final implementation.

Throughout the proposed methodology, several features are mentioned for being significant for stakeholder involvement.

For creating customized dashboards, user roles are critical in the development of a dashboard. The business intelligence feature, based on a stakeholder type, will impact the design needs of the dashboard (Heikkinen and Kostakos, 2012). For example, a certain stakeholder type would not require new analytics creation as its concern is only to supervise based on a defined viewpoint. However, considering that stakeholders type can change over time, the feature should provide the option to be changed.

The dashboard should be able to help users identify and visualize trends. In a cost reduction scenario, an analytical dashboard would support monitoring financial expenses and investments over time and visualizing the changes. Heikkinen and Kostakos (2012) indicates some additional main rules that should be considered for a dashboard design:

1. it should not exceed the boundaries of a single screen
2. context should be appropriate for the data presented
3. the media should be chosen accordingly
4. highlights should be used only for important information
5. the design should be simple, not cluttered
6. colors should not be overused

Different types of visualizations can be created. The type of data should also be considered when deciding their construction. Different analytics can be used for different purposes, mainly focusing on identifying the relationship, distribution, composition or comparison of data.

Relationships between different numerical variables can be displayed by using scatter plots or bubble charts, for clusters. For distribution of values, column charts, scatter plot or box plots can be used, while a histogram can be chosen when on emphasis lays on the shape of the distribution. Pie charts and waterfall charts support the user to identify proportions of a whole.

Comparing data across can be visualized through tables and charts. A highlight table can support visualizing comparing categorical data using different colors. Visualizing a sequence of values for either analyzing a trend or forecasting future values can be done through line charts (Cantor, 2011). A bullet graph is a variation of a bar graph and can also be used for comparing the performance of primary measure to others. For data that include timestamps, GANTT charts and timelines can be used for showing the duration of events or activities.

Maps visualizations can be used when spatial questions need to be answered, such as identifying locations where the applications are being used. This kind of visualizations should be used for showing quantitative data for different locations, distribution of ratios, density, or identifying trends or clusters (Cognizant, 2014). Another benefit of using maps, such as spider maps or flow maps, is for tracking paths over time. However, a different types of visualizations, such as bar charts, can also be used to answer the spatial question, if there is a risk of users misinterpreting the data. Accuracy of representation is more important than creating an attractive visual.

Moreover, interactivity and context can be assured through filters, highlights, selections or other actions that provide the user with selective data.

The dashboard should be able to provide users with the latest and dynamic data. Therefore, this implies that the system allows data to be updated automatically to provide better access. In addition, features of the authentic data are of major importance to understand the usefulness of data visualizations from a user perspective.

Sharing activities should be also facilitated by the dashboard in order to support stakeholder collaboration, such as exporting the data in a specific format or providing other users real-time access. For a better development, the interaction can be predetermined when mapping stakeholder activities to use case process.

Findings of Schwendimann et al. (2016) indicate that the evaluation of a dashboard should be created using mixed methods. It should combine qualitative and quantitative techniques and address general constructs such as usability, usefulness, user satisfaction, changes in behavior of the user and the impact of the technology over the learning process.

A systematic review on learning dashboards identifies several challenges for dashboard development. The most important ones are focused on what and how information is displayed in order to provide valuable insights for its users in a timely and accurate way (Schwendimann et al., 2016). A significant mention was that although there is a rich variety of indicators that can be used, the literature regarding which indicators are most suitable for different user data literacy levels is limited.

Moreover, user experiences and usability issues also represent a challenge, more specific investigating particular requirements for different user groups, determining the granularity level of information being displayed and adopting proper visualizations techniques.

The common challenges identified from an user perspective are related to ethics and data privacy and making interpretations based on the presented information.

Data Visualization in APM

This subsection presents the current practice regarding data visualizations in the APM decision-making process.

A case study demonstrates how metrics can be integrated in an integrative APM dashboard for supporting the decision-making process (Simon et al., 2010). The author describes a dashboard as an integrated viewpoint. Several examples are being given for visualizing different types of information. For example, for ranking the applications, the information system orchestration language (ISOL), a modeling technique developed by the author, is being used.

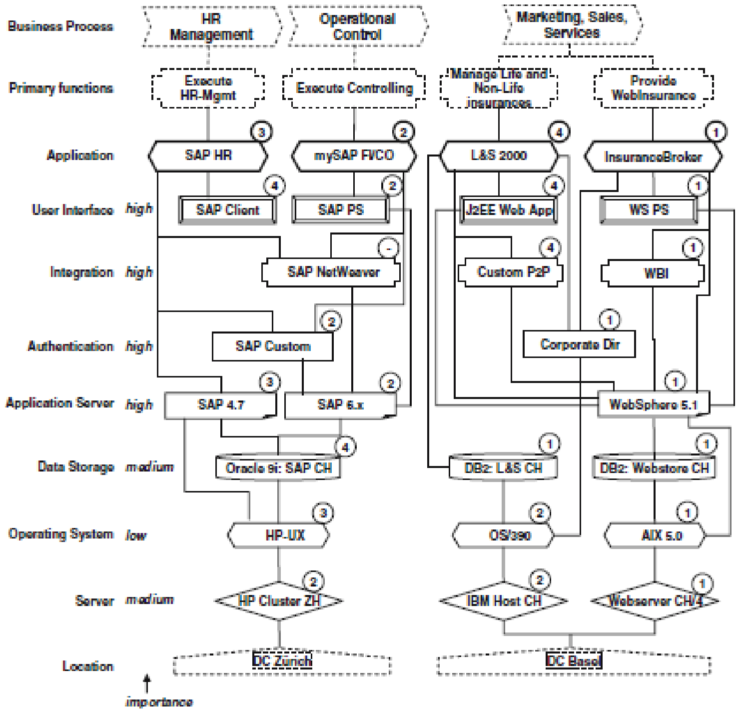

Figure 2.4: ISOL Diagram outlining application interdependencies (Riempp and Gieffers-Ankel, 2007)

Figure 2.4 illustrates the application interdependencies and their compliance to the standards, resulted by relating all the underlying components. It can also be regarded as a way of using the standard compliance indicator mentioned in the previous sections. In Figure 2.4 its value is shown in circles, indicating the compliance of each application. The proposed method proved its feasibility among the interviewed stakeholders and was perceived as easy to comprehend.

Another significant way of visualizing integrated application portfolio information was through a pivoted land-use plan, shown in Figure 2.5, that can be used as a basis for a detailed assessment of the stakeholder structures.

Module / Application	business standard	lifecycle status	strategic importance	functional readiness	architectural compliance	operational excellence	project status	operational cost	investment current year *	investment current year +1 *	investment current year +2 *	Invvestment current year +3*
Supporting Processes												
SAP HR	partial standard	being rolled out	3	4	2	5	2	0,7	2,1	1,3	0,5	0,5
SAP FiCo	partial standard	fully available	3	2	2	3	1	1,2	0,2	0,3	0,5	0,2
...												
Sales												
TopSales	corporate standard	fully available	1	1	4	1	2	0,5	0,1	0,1	0,1	0,1
SAP CRM	partial standard	being rolled out	1	2	2	2	3	1,3	0,5	1,2	0,7	0,7
...												
Production												
ProdPlan	violates standard	being phased out	2	4	5	3	5	0,3	0,3	0,5	0,3	0,3
ABOLT	tolerated	to be phased out	3	2	4	2	5	1,1	0,4	0,4	0,2	0,3
...												
Inventory Management												
InventOK	partial standard	fully available	4	3	3	3	3	0,3	0,5	0,3	0,2	0,3
Inventory Mgmt	tolerated	fully available	1	2	1	5	1	2,1	0,3	0,5	0,9	0,2
...												

* million €

Figure 2.5: Integrative APM View (Simon et al., 2010)

This example provides a holistic view of different kind of characteristic, which can support stakeholders to easily identify the areas that need to be improved. In a similar way, different values of the same characteristic can be shown to verify if different stakeholders share the same opinion about a given aspect, such as the technical value or any other.

Several other approaches exist for visualizations of the information in practice. Integrated information is usually visualized through heat maps, health grids and tables (Fabrice Vila, 2012; Cognizant, 2011). In a research study, business capability maps were used as a lens to provide a comprehensive overview about issues from different perspectives and identify opportunities to improve the portfolio health (Khosroshahi et al., 2016). The easiness of monitoring the application portfolio was enriched by using different colours depending on the actual value of characteristics in comparison with their benchmark.

However, literature indicates that visualization used in the decision-making process should be more interactive and should provide real-time information (Weill and Vitale, 1999; Fabriek et al., 2007). Moreover, the visualizations are created usually only for general purposes and not aligned with the specific information that each stakeholder needs.

One recent white paper in particular addresses some of the most relevant features of an efficient tool for APM (Cognizant, 2014). The recommendation is that firstly, the tool should be a Web based enterprise applications assessment tool, for effective data capture and faster analysis. That could benefit organizations especially in the case of large application portfolios with geographically separated stakeholders.

Practitioners recommend that the tool should provide support for the discovery and the analysis of the portfolio, the visualization of different scenarios and recommendations, consolidating the our findings regarding the APM methods. Several features should be contained, to provide the best assistance for the stakeholders and they are illustrated in Figure 2.6.

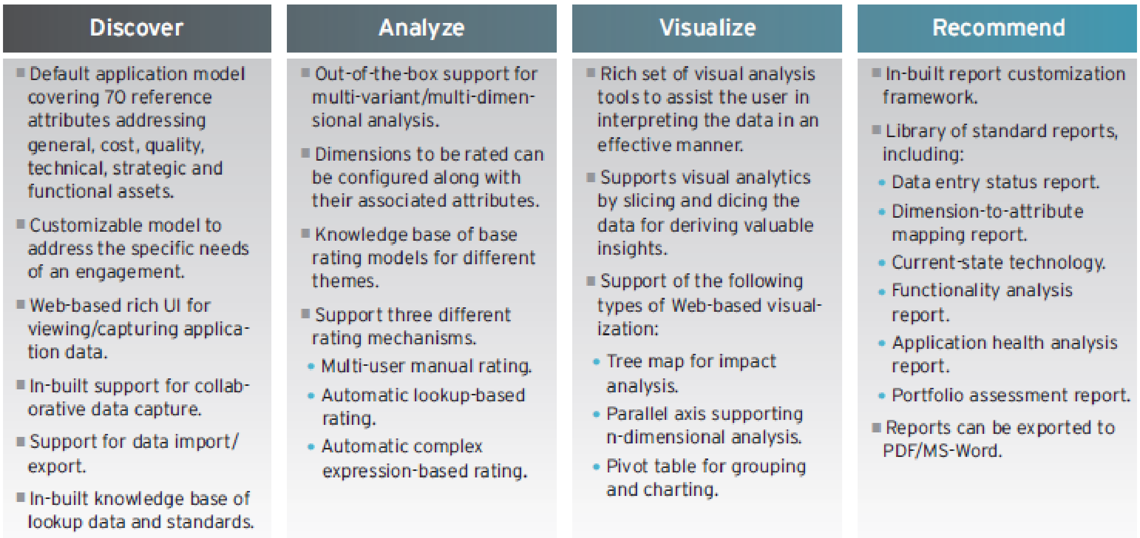

Figure 2.6: Key Features of an Web-Based Assessment Tool (Cognizant, 2014)

The idea of aggregating information for better decisions is consolidated by practitioners. For this purpose, dashboards are indicated as an efficient tool to monitor and analyze the health of an application portfolio (Cognizant, 2014). The easy customization supports the needs of different stakeholders, as the dashboard design can easily adapt for a fast customized analysis and informational awareness (Cognizant, 2011).

For anomaly detection, organizations are expected to rely on machine learning to build and continuously improve their own models of an expected normal behavior of the applications (Karl Freund, 2017). With the increase of Internet of Things (International D., 2017), the number of sources not only will increase but will provide different types of data which requires integration. Therefore it is expected that big data analytic tools will become essential for addressing the data complexity issue within organizations.

2.4 Enterprise Architecture

The emergence of technology and the complexity of IT in the organizations leans on **Enterprise Architecture (EA)** to manage the interrelationships and growing demands on business agility (Olsen and Trelsgård, 2016) and support strategical alignment in organizations. This chapter briefly introduces EA related concepts and presents how APM aspects are integrated in the most known existing EA frameworks.

Architecture, as a noun, represents a set of descriptive representations required for creating or managing an object, and, once created can be considered a baseline for improvements and it can also serve for a shared vision for all stakeholders (Kappelman and Zachman, 2013).

According to (The Open Group, 2018) **an enterprise** stands for the highest level of description of an organization and typically covers all missions and functions. Although there are many definitions for EA from different perspectives, there is a lack of general accepted definitions (Kappelman and Zachman, 2013; Olsen and Trelsgård, 2016).

Gartner defines EA as a discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analyzing the execution of change toward desired vision and outcomes (Gartner, 2017b). EA delivers value by presenting businesses and IT leaders with signature-ready recommendations for adjusting policies and projects to achieve target business outcomes that capitalize on relevant business disruptions.

The goal of EA is to optimize across the enterprise the often fragmented legacy of processes, both manual and automated, into an integrated environment that is responsive to change and supportive of the delivery of the business strategy (The Open Group, 2018). Four major benefits are the cost reduction and technology standardization, the process improvement and strategic differentiation (Gartner, 2017b). Moreover, withing the larger strategy of cost saving, sub-strategies focus on technology standardization and efficiencies, skills leverage and potential for terminating of aging and high-cost software assets.

Scientific literature indicates EA is a strong concept for coping with the complexity caused by large application portfolios. It offers a common and integrated understanding of the enterprise, proving transparency and a high-end view of the business processes and the data flow (Urbaczewski and Mrdalj, 2006). When senior management gains a better understanding of the processes, the governance can be improved and complexity reduced, contributing to a better decision-making process by enhancing cooperation and collaboration between different business units (Olsen and Trelsgård, 2016).

With regards to APM, practitioners implement EA for collecting the status of current assets, create a vision of future enterprise strategies and govern technologies. Relevant characteristics per applications are aggregated through EA models and integrated into dashboards to support stakeholders to gain a holistic view over the portfolio. These practices are critical for building capabilities, such as the application inventory, business process models or road maps, and creating possible transformation scenarios through structured processes (Simon et al., 2010).

The practice of APM allows transparency in the architecture process by having a centralized management of their existent portfolios which can be used for sound decisions. When EA is integrated with APM, the alignment with architecture road maps and business views improves the overall results for business and IT.

An EA framework can be defined as the instrument used by stakeholders for developing a broad range of capabilities that capture the necessary information from an enterprise (Urbaczewski and Mrdalj, 2006). There are several existent frameworks built for a specific purpose, some being enterprise-oriented while others focus on the development of the IT system only. This study focuses on the latest category and the evaluation investigates on how the APM concept is integrated. Four frameworks are selected for an analysis regarding how APM is integrated:

- Zachman Framework (Zachman, 2002)
- The Open Group Architecture Framework (TOGAF) (The Open Group, 2018)
- Federal Enterprise Architecture (FEAF) (Urbaczewski and Mrdalj, 2006)
- Dynamic Enterprise Architecture (DYA) (Wagter et al., 2005)

An efficient EA should consider the needs of a broad range of stakeholders. As identified in the previous section, stakeholders present interest in the creation, maintenance or replacement of the EA elements due to their importance in the APM decision-making process.

EA views can support the APM decision-making process by addressing the needs of the involved stakeholders and providing specific information. These viewpoints enclose one or several concerns of stakeholders allowing a faster comprehension streghtening decisions and increasing stakeholders engagement.

In general, the existing architecture frameworks support mapping the existent applications to related enterprise aspects which helps stakeholders to identify interdependencies, redundancies and opportunities for improvement.

2.4.1 Zachman Framework

The Zachman framework was introduced as the first enterprise architecture in 1987. Providing the ability to develop a descriptive logical structure of the enterprise creates value for the management of the enterprise and the development of the IS (Zachman, 2002). The framework raises significant awareness of the EA and defines it by providing a complete description of the enterprise, as it can be seen in Table 2.10 .

Table 2.10: Zachman Architecture

	DATA What	FUNCTION How	NETWORK Where	PEOPLE Who	TIME When	MOTIVATION Why
SCOPE (Contextual) Planner1	List of significant aspects for the business	List of performed processes	List of locations in which the business operates	List of significant organizations for the business	List of significant events	List of business goals/strategies
Business Model (Conceptual) Owner	Semantic Model	Business Process Model	Business Logistics System	Work Flow Model	Master Schedule	Business Plan
SYSTEM MODEL (Logical) Designer	Logical Data Model	Application Architecture	Distributed System Architecture	Human Interface Architecture	Processing Structure	Business Rule Model
TECHNOLOGY MODEL (Physical) Builder	Physical Data Model	System Design	Technology Architecture	Presentation Architecture	Control Structure	Rule Design
DETAILED REPRESENTATION (Out-of-context) Sub-contractor	Data Definition	Program	Network Architecture	Security Architecture	Timing Definition	Rule Specification
FUNCTIONING ENTERPRISE	**DATA**	**FUNCTION**	**NETWORK**	**ORGANIZATION**	**SCHEDULE**	**STRATEGY**

Generic perspectives have been defined for the architecture in general, and they are described below:

- **Planner**: the person defining an organization's scope
- **Owner**: the business owner defines the nature of the organization, along with the structure ad the processes, also regarded as a business model
- **Designer**: the person defining the detailed version of the business model, including IS, identified as a system model
- **Builder**: the person defines the necessary technology to support the needs defined by the designer, creating the technology model
- **Subcontractor**: the person defines a detailed design and the enterprise elements, such as implementation language, by creating detailed representations

Each of the cell identifies a potential deliverable and the corresponding perspective by asking the "what","how", "who", "where". As an example, an Application Architecture can be a potential deliverable for answering the "how" by taking a designer's perspective. The advantage of this framework consists in its ease of usage, the fact that is comprehensible and that provides a holistic view of the enterprise (Zachman, 2002). Due to this aspects, the framework provides an ideal set of rules for the management of complex and evolving IT organizations from a senior management perspective. Moreover, the practice of asking the same questions every time for tackling the problems makes the conceptual model quite straight forward for its users.

The framework provides a means to investigate an organization architecture and represents a tool for modeling existing functions, process and elements. When the APM aspect is investigated, the framework provides examples of deliverables related to applications, referring the application inventory as a necessary input for the EA. The perspectives considered in each phase align with the stakeholders identified as being relevant for the APM approach.

However, the simplicity of the model can also be encountered as a limitation. Even though the framework can be used for any system, the major disadvantage is the lack of detail. The proposed framework doesn't provide guidance on sequence, process, or implementation for the stakeholders involved, but rather focuses on ensuring that all views are well established, ensuring a complete system regardless of the order in which they were established (Urbaczewski and Mrdalj, 2006). This creates difficulties for practitioners in its implementation.

2.4.2 The Open Group Architecture Framework (TOGAF)

TOGAF has been created as a framework and methodology for the development of technical architectures, with more focus on digital trends and business tranformation beyond IT. The framework consists of the following components:

- **Architecture Capability Framework** aims at the EA capabilities improvement
- **Architecture Development Method (ADM)**: defines the process of creating an enterprise architecture and provides details through each phase. The ADM cycle represents the core of TOGAF
- **ADM Guidelines and Techniques**: provides the guidelines and the techniques for supporting the usage of the method
- **Architecture Content Framework**: provides a model of the architectural deliverables and the other artifacts

- **The Enterprise Continuum and Tools**: provides taxonomies and tools for categorizing and storing deliverables in a repository
- **TOGAF reference Materials** provides a reference library which contains guidance for establishing and operating an architecture function.

A representation of the framework is given in Figure 2.7.

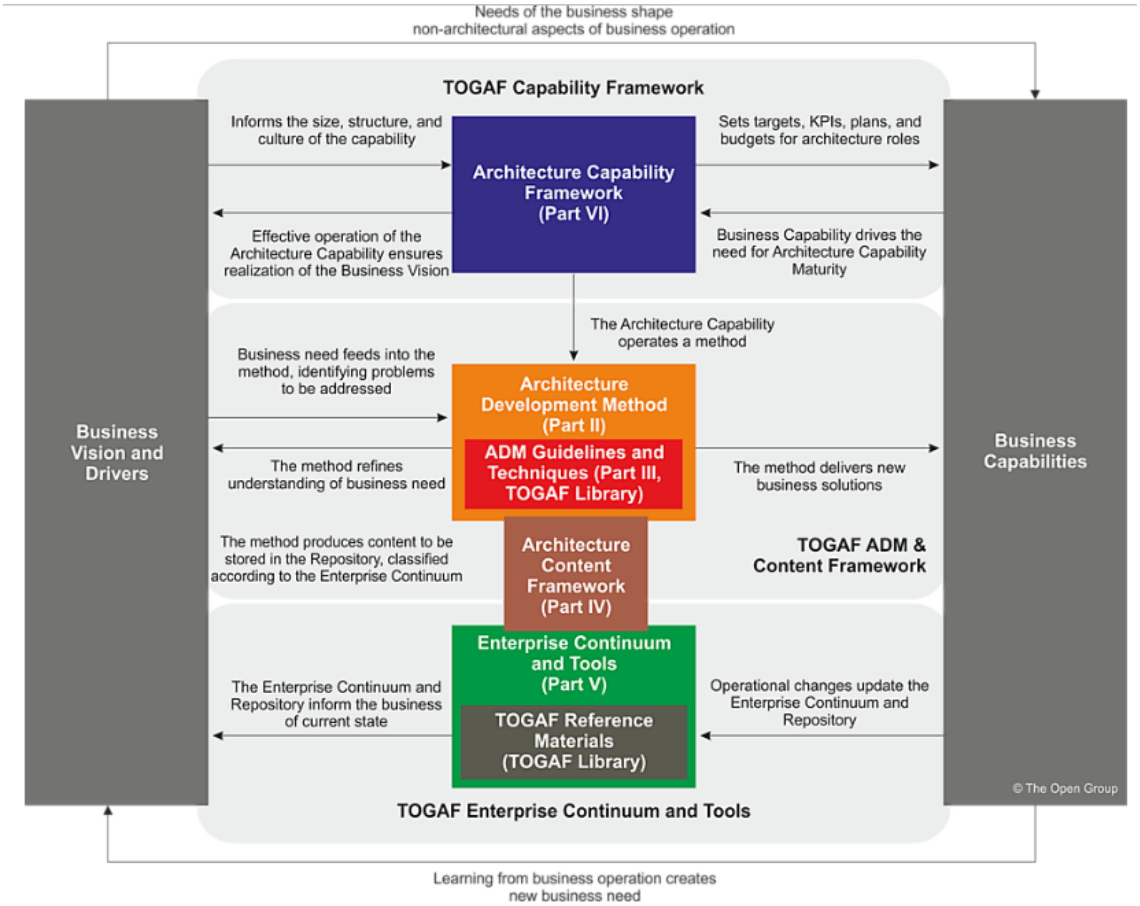

Figure 2.7: TOGAF (The Open Group, 2011)

In the ADM cycle, "Information Systems Architecture" represents the phase C where applications modeling is being described, addressing both data and application architecture. This phase aims at developing the target application architecture that would enable the Business Architecture and the Architecture Vision while considering the requirements for the architecture and the stakeholders concerns. In this phase, a baseline and target architecture should be identified and road maps should be created for analyzing the gaps.

Out of the nine phases of ADM, the first one encounters the same steps as in the APM methods, namely " Select reference model, viewpoint and tools". Several activities are suggested, among them understanding the list of applications and removing duplicate functionalities, however no indication of creating a characteristics list is being given (Desfray and Raymond, 2014). Models selection is also recommended to be chosen based on each viewpoint identified, through stakeholders. TOGAF suggests developing matrices that can map logical applications to business services, processes and data.

The benefits of ADM is that enable establishing a process with multiple check points, therefore supporting stakeholders to easily determine issues when the wider architecture is implemented. This aspect can make a significant difference when new technology is being implemented and a lot of changes have to be done, which can happen quite often considering how fast technology changes.

With regards to APM, TOGAF is one of the most comprehensive considering the actual process involved (Urbaczewski and Mrdalj, 2006). Definitions are provided of catalogs, matrices and diagrams for the Application Architecture development, however the framework doesn't suggest or provide guidelines on rating applications from a technical or a business perspective (The Open Group, 2018).

2.4.3 Federal Enterprise Architecture (FEAF)

The Federal Enterprise Architecture Framework was developed and published by the United States Federal Chief Information Officers (CIO) Council to provide a common approach for technological acquisitions and their development (FEA, 2013). The FEAF specifies the framework in a matrix illustrating architecture types using the same perspectives and some of the architecture types from the Zachman framework. Although, the rows of the FEA matrix correspond with the Zachman framework, they don't indicate the approach for developing the products for each of the cells (Urbaczewski and Mrdalj, 2006).

A representation of the framework is provided in Figure 2.8.

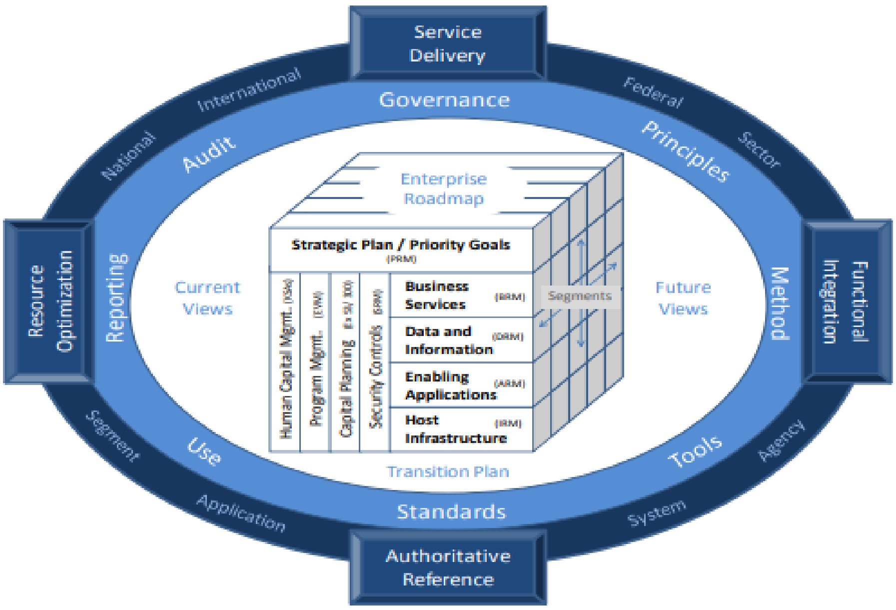

Figure 2.8: FEAF Framework (FEA, 2013)

Six sub-architecture domains are recognized in FEAF and they indicate the type of analysis that has to be conducted for addressing the stakeholder requirements. The most important for this research is the "Applications", in which the Application Interface Diagram represents the core artifact which is required.

With regards to the APM, the Application Reference Model (ARM) provides the basis for categorizing applications and their components, and it is structured in systems, application components and interfaces used in the organization. This model is intended to be used for IT cost reduction and IT and business alignment, aligning with some of the goals from the APM approach.

The advantage of this framework is that roles and responsibilities are clearly specified in general, even they are not for each activity. However, the framework is focused more towards enterprise architectures rather than IT architectures. Moreover, it is focused on the US Federal Government therefore some reference models present really specific details.

2.4.4 Dynamic Enterprise Architecture (DYA) Framework

The DYA model is one of the newest approaches for enterprise architecture and is built around three distinct processes (Wagter et al., 2005):

- Strategic Dialogue: business objectives are determined and further defined as project proposals
- Development with Architecture: IT solutions are implemented
- Architectural Services: supports the other two processes with principles, guidelines and models. Here another scenario is present, where the architectural framework can be lacking due to special circumstances.

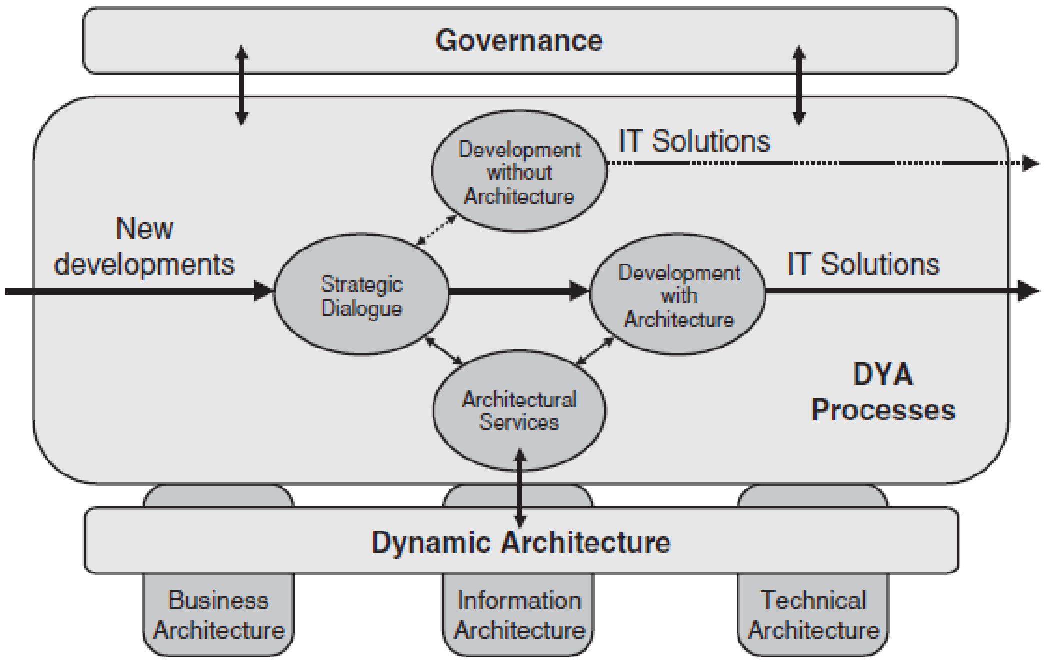

Figure 2.9: DYA Framework (Wagter et al., 2005)

This framework supports achieving an architecture which is agile and facilitates change, referred as "dynamic architecture". The Dynamic Architecture, presented in Figure 2.9, is the content layer, while the YA Processes and Governance represent the process layer. The content approach aim to break down the IT support into autonomous building blocks that are easy to develop, maintain or improve independently. The business processes are crucial for gaining agility and they address the main principles that support stakeholders to develop an architecture. These principles address the ways in which data is manipulated, who has the authority to access the data and the physical locations where it is stored, and how the control and execution mechanisms are implemented.

The approach for using the DYA model is by understanding the purpose of the architectural improvement. The possible reasons consist of creating new channels for product delivery, shortening manufacturing lead time, IT outsourcing, cost reduction or better investments, goals that align with the APM benefits.

Depending on the goal, the framework can be used for determining the level of architectural awareness and the level of integration of the architecture within the organization. The framework provides insights on how to measure the EA maturity. The current state of the architecture is established by evaluating if the IT solutions are aligned with the business strategy and developed with architecture, as in there is a defined, structured and permanent process or solution.

With regards to APM, the framework emphasizes the process of creating the EA capabilities providing best practices, the challenges based of the EA maturity. However, the framework is briefly described and no guidelines and definitions are provided. For example, information architecture is broadly defined and considered to consist of data architecture and application architecture, without any further specifications.

The analysis on frameworks revealed that there are different ways on how APM is being integrated. The Zachman framework offers a holistic view of the enterprise and how IT is related to other capabilities, however the APM concepts are not clearly visible. A major importance of the applications has been identified in TOGAF and FEAF, and both of them suggest the application inventory as an useful deliverable for assessing application. In comparison with these two, the DYA framework is more focused on governance and provides best practices on a high level, although same layers are identified.

With regards to APM, the ADM method from TOGAF is what makes this framework more efficient and significantly better than the other frameworks. The steps offer guidance for practitioners to evaluate the current state of the enterprise and plan future improvements. However, none of the frameworks mention the APM methods discussed above and provide similar practices under the concept of EA (Hafner and Winter, 2008; Zelt et al., 2013a). Moreover, the frameworks focus more on the holistic view, capturing the interdependencies and relations between the different layers, in order to facilitate innovation.

Even with a successful implemented framework failures can still happen, therefore key stakeholders and senior management need to set up possible transformation scenarios, by considering key performance factors, and choose the most appropriate ones for the given situation.

2.5 Relationship between the main concepts

A survey held among chief information officers showed that organizations are starting to understand the IT valuation for their business and consider it essential for innovation, gaining market differentiation, business profitability, which will lately support them in achieving a leadership role in their market (Capgemini, 2016). However, with the expansion of the IT portfolios, organizations face even more complex challenges to rationalize their portfolio (Fabrice Vila, 2012). As a consequence, more than optimizing their IT architecture, organizations have to improve the poor management of the application portfolio (Cognizant, 2014).

Different methods have been identified for conducting an efficient APM to improve the poor management and they were described in Section 2.1.4. These describe a decision-making process that stakeholders need to follow in order to make informed decisions regarding the application portfolio. The methods involve three steps, namely creating an inventory, conducting an assessment of the application portfolio and making decisions about the transformation strategies. The assessment of the applications should include information related to their costs, the value for the business, and the alignment with the infrastructure from different perspectives.

Within an organization, data is the most important asset, as it represents the core foundation of information and knowledge for future decisions and actions (International D., 2017). In the

APM, data represent facts about the software applications and the portfolios, the processes, the systems, and the involved stakeholders. Accurate and consistent data creates the foundation for efficient analysis enhancing the process of decision-making and supporting the organization to be proactive in their field (Cantor, 2011; Cognizant, 2014). This makes data crucial in the decision-making process. It is therefore important, that the data gathering process is well-structured and includes aggregate information.

To address the complexity of the APM decision-making process, organizations need to establish an enterprise architecture for gaining a holistic view of the organization, its processes and the data flow (Riempp and Gieffers-Ankel, 2007; Quartel et al., 2010; Zelt et al., 2013a). Seen as a key skill and support area for portfolio management, an integrated EA can deliver valuable information to support organizations with strategic and operational decision-making (Fabriek et al., 2007; Simon et al., 2010). The architecture model provides a strong structure for organizational assets and related information. This simplifies the decision-making process by improving data accessibility and reliability.

This practice is recommended for institutionalizing a governance model that can enable change along the proper pathway by enforcing compliance with the plan and capturing core organizational values (Cognizant, 2014; The Open Group, 2011). Several other benefits can be achieved by establishing an enterprise architecture (Närman et al., 2012).

APM requires a clear business strategy on a more detailed level consisting of well-defined goals, which should be created by considering the opinions of different stakeholders. More than that, the stakeholders involved in the decision-making process need to be capable of understanding the complexity of the data for making sound decisions. Literature indicates different roles in the decision-making process which involve different needs. However, little emphasis is made on stakeholder involvement in the current practices. To address this issue, stakeholder involvement has been analyzed. Best practices indicate that stakeholder involvement can improve the APM decision-making process by identifying potential problems at an early stage and possible solutions to avoid them. Moreover, it increases the likelihood that local needs and priorities are successfully met.

The data complexity creates several challenges for organizations when implementing APM. To address these challenges, a new approach will be defined for addressing the needs of the stakeholders throughout the APM decision-making process. For this matter, data-driven workflows and the use of dashboards are considered as potential solutions.

Data-driven workflows have the potential to improve the collaboration between different stakeholders while addressing all the data concerns that can appear. Its alignment with architecture assets within a central repository enables relevant parties across merging companies to work from a single source of information. It provides insight to make better decisions by offering the ground for complex trustworthy business scenarios (Zelt et al., 2013b; Project One, 2013). At the same time, the information captured can reveal the location of data that might otherwise have been unwittingly discharged with the elimination of an application, enabling it to be moved to a lower-cost storage tier for potential future use (Erwin, 2017). It is believed, therefore, that using data-driven workflows supports gaining business-wide visibility of data flow and provides a history of stakeholders who contributed in the process.

Dashboards are considered useful tools for communication with stakeholders, where relevant information can be presented in various forms to support the user to make better decisions or gain knowledge over different processes. With means that allows the user to explore data interactively, dashboards provide good analysis capabilities and weighting different business scenarios.

While APM requires an initial investment of time and effort, when executed correctly, with an understanding of the full enterprise portfolio, it delivers long term benefits, like minimized costs, increased business effectiveness and reduced risks (Zelt et al., 2013b; Khosroshahi et al., 2017). The aforementioned factors are therefore expected to support organizations and their stakeholders to successfully implement a governance process that ensures that the APM approach will be maintained as the organization changes and develops its applications.

3 Design Method

This chapter presents the proposed method for improving the APM decision-making process through stakeholder involvement. Firstly, a brief introduction and an overview of the method is explained. The following sections will provide a comprehensive explanation of the steps constituting the method and discuss the tools that have been chosen for this research. At the end of the chapter, a summary of the method suggested is discussed together with its expected outcome.

Organizations are required to take decisions regarding the future of their application portfolio. For these decisions, academic literature indicates that applications should be evaluated both individually and as part of the application portfolio. The information required for their individual evaluation is related to the technical, architectural and business complexity, and their strategical importance. Moreover, practitioners indicate that decision regarding transformation strategies should consider their industry and the changing business trajectory. It is concluded that an aggregated view has to be created so that stakeholders have the aforementioned knowledge.

The goal of this research is to develop a design method that integrates data-driven workflows and dashboards to support companies to reduce the complexity of their application landscape and related costs. This approach aims at providing guidance for organizations to improve their APM decision-making process, which can help organizations to better support the stakeholders needs.

As described in the previous chapter, data-driven workflows and dashboards can support the APM process by addressing the data complexity issue. The APM decision-making process requires interrelating and balancing information from multiple data sources. These two capabilities can provide value, when an EA model is created within the organization to support mapping the applications to related capabilities and process, thus providing a high-end perspective over the application landscape. With data being a critical asset, data-driven workflows provide knowledge about the origin, the movement and the transformations throughout all the related processes and their structure.

Moreover, most of the existing APM solutions lack the aggregated information according to stakeholder needs. According to the findings of the literature review, an effective APM solution can deliver value only if it provides a set of significant data based on the needs of stakeholders. Thus, the proposed approach emphasizes on the criticality of having an overview of the data required to satisfy each of the involved stakeholder's needs and support them to achieve the business goals through well informed decisions.

The key focus in the proposed approach lays on the stakeholders. The proposed method supports the four processes required for stakeholder involvement presented in Section 2.2 through the use of data-driven workflows and dashboards. A summary of the proposed method is presented in the flowchart shown in Figure 3.1, modelled with BPMN.

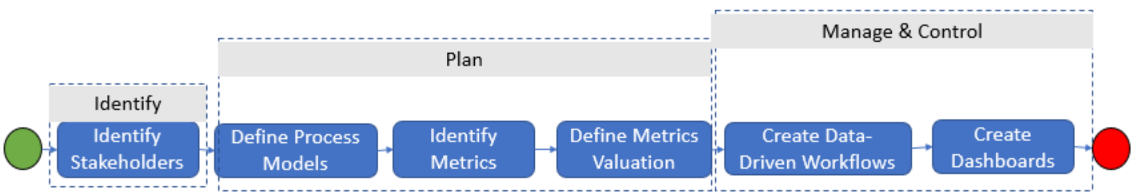

Figure 3.1: Design Method Steps

The first step aims to identify the stakeholders which would be engaged in the decision-making process and conduct their assessment. In this step, both qualitative and quantitative information is gathered and analyzed, thereby determining whose interest should be taken into account throughout the decision-making process.

The following three steps of the designed method intend to support the planning process. Firstly, the expected collaboration and interactions between the stakeholders in the decision-making process are defined. The next two steps emphasize the stakeholders' need for aggregated information, their ability to understand and identify critical metrics for APM and derive measures for optimization. For this matter, the approach investigates the metrics that demonstrate the health of the application portfolio and can assist stakeholders on the APM decision-making process. The steps provide guidance on how to identify the required information and how the representation should be created to facilitate better and faster understanding.

The last two steps provide the means to support the last two processes of stakeholder management, namely to manage and control the stakeholder performance, by enhancing the APM approach through self-executable workflows and customized dashboards.

Each of the following sections will explain a step from the proposed approach and the underlying reasoning why particular methods are used. It also includes the description of theoretical concepts that involve the choice of methods within the more general nature of academic work, and reviewing its relevance in examining the research problem.

3.1 Identifying and classifying the stakeholders

In the first step of the proposed approach, the focus is mainly on identifying the stakeholders that should be involved in the APM related decisions and their classification. It is assumed that an organization already has a good overview on the decision-making process and who are the stakeholders involved in the process.

In this situation, the high-level goal is to identify the stakeholders which should be a part of the decision-making process due to their knowledge and responsibilities and assess their involvement in the actual process.

Thus, the input for this step will be gathered through interviews, organizational documents and brainstorming. The findings will support the selection of the stakeholders that need to be involved.

An organizational structure is expected to outline how certain activities are directed for achieving the goals of an organization. These activities are expected to include the roles and the responsibilities of the involved stakeholders and their collaboration rules. Other documents can also be used if they exist in the company and serve the same purpose as described above.

A potential list of people that should be interviewed will be created based on the documents. Two key stakeholder groups need to be included, namely the users of the output and owners and stewards of data that is required as input for the metrics.

In the interviews, questions should be asked about the responsibilities, decisions that have to be made and the information required for them, interactions with other colleagues and other aspects related to the necessary resources.

The interviews provide knowledge about stakeholders' needs in the APM decision-making process and the related concerns or problems faced by the stakeholders. Other potential stakeholders can be identified during interviews. Moreover, the interviews can be used to validate if the collaboration rules are respected on a daily basis and are followed every time.

Findings from interviews and the organizational documents will serve as a foundation for brainstorming. The brainstorming sessions are used for improving the existent APM decision-making process. This builds involvement and increases interaction among stakeholders as they decide on possible improvements. Moreover, these sessions will shed light over practical matters and remove subjectivity and biased answers provided through one-on-one interviews.

The next step is to organize the stakeholder data according to their influence and salience in order to understand their support in the decision-making process (Jepsen and Eskerod, 2009).

For this matter, a close look is given to their type, internal/ external, the power they have in the decision-making process, their interest, attitude and the interaction with the other stakeholders. The chosen attributes can signal the capability of each stakeholder to reject or accept an idea or a proposal.

Literature identifies several ways to assess the power of a stakeholder. One of the most common method is to categorize the power in categories like none, low, medium and high (Bryson, 2004; Jepsen and Eskerod, 2009; Pandi-Perumal et al., 2015). For this research, a decision is taken to assess the power of a stakeholder by the type of their involvement in the APM-decision making process (Cantor, 2011; Cognizant, 2014). This decision would further support on deciding the business intelligence level for using the dashboards (Heikkinen and Kostakos, 2012). Three different categories are defined to assess the power of a stakeholder:

- Decision Maker is regarded as a stakeholder who can directly influence the vote on major decisions regarding transformation strategies
- Data Supplier is regarded as a stakeholder who has the responsibility of managing a subset of data items and assures the accuracy and consistency of the data sources
- Informational Stakeholder is regarded as a stakeholder which is not directly active in the decision making process but is interested in the data and output for their external implications

Attitude of stakeholders should always be assessed in relation to the end goal, therefore the objective should always be established before conducting the stakeholder analysis. This aspect is quite difficult to assess without a direct interaction with the stakeholders. The attitude of a stakeholder can easily be influenced not only by the context, but also by other stakeholders or the personality of the stakeholder itself. Stakeholders with an open mind will treat challenges with a good attitude, while narrow-minded people can become negative, therefore in this context interviews are highly recommended.

The interest of the stakeholders is categorized as Low, Medium and High based on the interest they have regarding the goal of the intended change (Jepsen and Eskerod, 2009).

For assessing the attitude, the following classifiers are used according to (Pandi-Perumal et al., 2015):

- The stakeholder is 'unaware' of the project's impact or potential
- The stakeholder is 'resistant' to any changes to the project
- The stakeholder is 'neutral' about the project, therefore no resistance or support will be shown
- The stakeholder is 'supportive' to change and is aware of the potential of the project
- The stakeholder is 'leading', more than being supportive, he/she will take the lead to assure the success of the project.

Stakeholder interaction plays a significant role in the selection phase. A better understanding of the interaction and the relationships among the stakeholders may assist in developing more effective implementation programs, which should in turn bring about more effective outcomes.

The decisions on whether to involve stakeholders should be based on two aspects: whether the stakeholders have the power to influence a final decision or they have the technical capability to engage effectively with the decision (Reed, 2008).

Therefore, a classification of the selected stakeholders and a collaboration diagram are expected as an output. A collaboration diagram is a visual presentation that shows how various software objects can interact with each other within an overall IT architecture and how users can benefit from this collaboration (Object Management Group, 2011).

In the next steps, the collaboration diagram can be transformed into a governance model. This can support the access to various type of information and can serve as a check method for data entry.

A summary of the first step is presented in Table 3.1.

Table 3.1: Identifying and classifying the APM stakeholders

Step:	*Identifying and classifying APM stakeholders*
Objective	To identify and select which stakeholders are important in the APM decision making process
Input	Organizational structure Collaboration rules
Activities	Identify potential stakeholders Assess stakeholders based on interviews and brainstorming Classify stakeholder based on decision role Select relevant stakeholders
Technique	Interviews with stakeholders and local experts Brainstorming BPMN modeling
Output	Classification of stakeholders Collaboration diagram based on stakeholders classification

3.2 Defining process models

The second step in the proposed approach is defining the process models. The aim of this step is to identify and analyze the decision making process and to propose improvements.

The inputs required in this step are the stakeholder classification and the collaboration diagram created in the previous step. In this step, the collaboration diagram is used to identify and improve the main decisions that have to be taken regarding the APM.

Critical phases need to be identified along the decision-making process and check if the standard procedure is followed. For each phase, following investigations have to be carried out: which stakeholders contribute, what data they need for making a contribution, the sources and availability of that data, what is the contribution and if it's expected in a certain format and their expectation. Potential causes for the delays in the decision-making should be identified as well.

Once the information is gathered, process models can be designed for understanding the current practice. Processes are described using activities, events, gateways, and flows and their graphical representation is shown in Figure 3.2 which presents the process execution of a potential order.

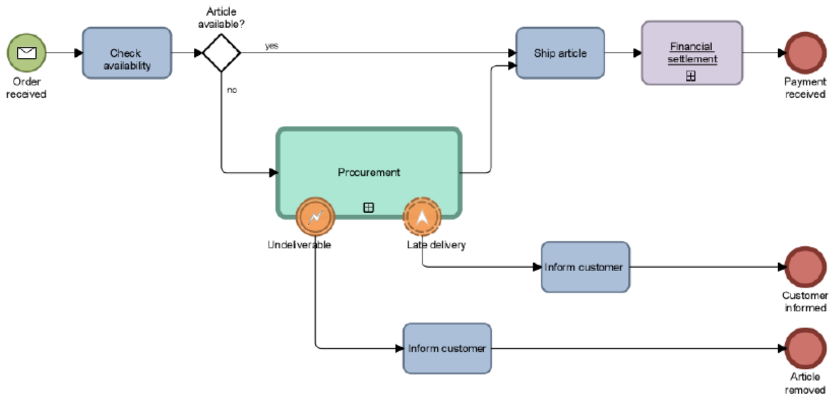

Figure 3.2: A BPMN process (Object Management Group, 2011)

Events represent something that can occur at the begging of the process, within it or at the end. It's usually triggered by a condition, such as a message, or a timer, or a signal, and can provide different outputs. For example, in Figure 3.2, "Order received" is the event that triggers the execution of the process, while the events "Payment received", "Customer informed" and "Article removed" show different possible ends of this process.

An activity stands for a task that has to be done by a person or an existent system in a business process. In our example, the activities that can be identified are: "Check availability", "Ship article" and "Inform customer".

Gateways are the graphic representation of the decisional points, which control the direction of the sequence flow within the process. In our example, the availability of the product is the decisive point of the process. In case the product is available, the article will be shipped, otherwise, a procurement might take place.

Moreover, processes can be modeled from different perspectives, using diagram styles, such as processes, collaborations, and choreographies. An example of integrating different perspectives is shown in Figure 3.3 which represents the process of ordering a pizza.

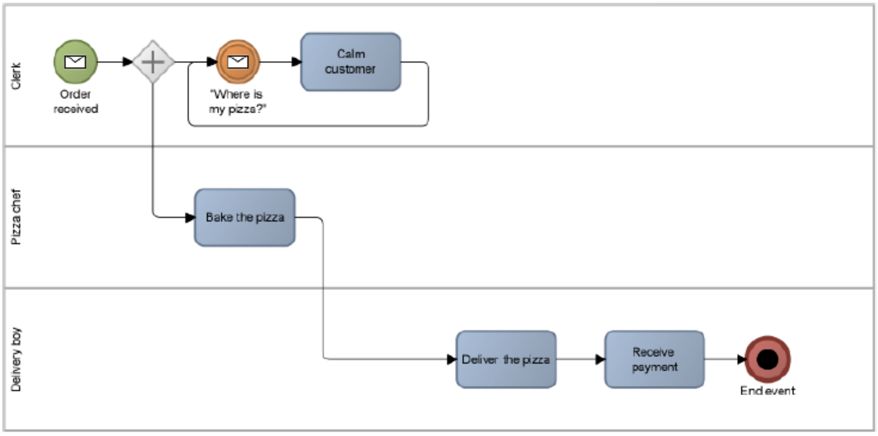

Figure 3.3: A BPMN process with integrated perspectives (Object Management Group, 2011)

The lanes are used for identifying the three perspectives, namely the clerk, Pizza chef, and the delivery boy. In this example specific persons are being represented, however, lanes can also be used for identifying a group of people, such as business units or departments, or systems. The lanes support keeping accountability for the tasks.

Adopting BPMN can be of tremendous use, as it supports process discovery and provides a thorough analysis for stakeholders, leading to time efficiency and cost reduction in the decision-making process. The resulted BPMN models can be related to models from other domains, such as entity-relationship models or UML models. The models can be automated, where the data input is provided by other applications or other resources, or manual when input is expected from a real user.

The models will furthermore help to detect misalignment, resolve redundancies or spot missing integration. The findings should be discussed in a brainstorming session where stakeholders can indicate if the current practice is efficient and improvements should be suggested for an ideal case.

For improving the models, it is required that all the selected stakeholders are included in the decision process accordingly based on their knowledge and concerns. Furthermore, an analysis will be conducted with a focus on the enhancement of the collaboration between the stakeholders and the consistency of the data flow.

Changes will be proposed and discussed with local experts. The agreed changes will be implemented in the models.

The decision-making processes will be illustrated through process modeling and they will represent the output of this step. In addition, the required information will be identified in this step. A summary of the second step is presented in Table 3.2.

Table 3.2: Defining process models

Step:	*Defining process models*
Objective	To identify and analyze the decision making processes and to propose improvements
Input	Classification of stakeholders (from step 1) Collaboration diagram
Activities	Define existing decision making process model Analyze required information for stakeholders Analyze efficiency in stakeholder collaboration Propose changes Conduct interviews with local experts Implement changes in the process models
Technique	Interviews with local experts Process modeling
Output	Workflows Information requirement

3.3 Identifying and classifying metrics

The third step consists of identifying and classifying the metrics for the APM decision-making process. The end goal is to assess their importance for the involved stakeholders.

This step requires to first identify the metrics by analyzing the information requirement and conducting additional interviews, if the information is not conclusive enough. Once the metrics are identified, their usefulness for each of the identified stakeholders is assessed by local experts.

For measuring the local experts attitudes, a research study recommends the Likert scale (Boone and Boone, 2012) as they represent the most reliable way to measure opinions, perceptions and behaviours. The Likert scales are widely used to measure attitudes and opinions with a greater degree of nuance than binary questions. The method supports identifying possible area of improvement and a better understanding of perceptions. The survey scale consists of a set of close-ended questions, where respondents are presented with pre-populated answer choices. The scale ranges from one extreme attitude to another, and they also include a neutral midpoint.

The Likert scales are used to measure agreement, frequency, the quality, likelihood or the importance (Boone and Boone, 2012). There are many types of Likert scale response alternatives, such as:

- Strongly Agree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree
- Highly Dissatisfied, Dissatisfied, Neutral, Satisfied, Highly Satisfied
- Never, Almost Never, Neutral, Almost Every Time, Every Time
- Very important, Fairly Important, Important, Slightly Important, Not at all Important

In this approach the importance of the metrics will be measured and the assessment will be made using a Likert scale from 1 to 5, where 1 is the "Not at all important" and 5 is "Very important".

For their assessment, a framework is created as illustrated in Table 3.3. The framework contains the metrics and their description on the rows, while the columns indicate the list of the involved APM stakeholders. The values, illustrated with an "X" in Table 3.3 indicate the assessment of the usefulness of the metric for a specific stakeholder. The assessment is conducted with local experts.

Table 3.3: Framework Example

Metric	*Description*	*Stakeholder 1*	*Stakeholder 2*	*Stakeholder 3*
Metric 1	Explanation	X	X	X
Metric 2	Explanation	X	X	X
Metric 3	Explanation	X	X	X
Metric 4	Explanation	X	X	X
Metric 5	Explanation	X	X	X

For each metric, the local experts need to assess the importance of the metrics for each stakeholders in the decision making process. Since the findings of the literature have shown that different position names are being given to stakeholders with the same responsibilities, the local experts are provided with a brief explanation of the positions and responsibilities.

The results will be gathered and analyzed and a list with selected metrics per stakeholder will be the output of this step. A summary of this step is presented in Table 3.4.

Table 3.4: Identifying and classifying metrics

Step:	*Identifying and classifying metrics*
Objective	Assess the importance of the metrics for each stakeholder
Input	Information requirements for the decision-making processes
	Classification of stakeholders (from step 1)
Activities	Identify metrics
	Create matrix with metrics and stakeholders
	Interview local experts
	Analyze results
	Assess importance per each stakeholder
Technique	Interviews with local experts
	Likert scale
Output	List with selected metrics per stakeholder

3.4 Defining metrics valuation

The fourth step consists of defining the metrics valuation. The aim of this step is to understand the best way to reflect information through values, so that stakeholders can easily make decisions using them.

The input required for this step consists of the output from the previous step, together with the information requirement obtained in the second step. While the output of the third step shows the importance of the metrics for specific stakeholders, other metrics are essential for the general decision-making process, such as an id that can help identify the object of discussion or an indication of where the information is stored. Therefore, the information requirement is also crucial in this step.

When defining metrics, a distinction is made between base metrics, directly measured values, and aggregated metrics which are valued based on other metrics. The relationship between an aggregate metric and the component metrics is called a parent-child relation, where the aggregated value is a parent.

For the aggregated metrics, a formula shows how the values are combined into a single value in the aggregate metric. For example, in order to assess the business value of an application considering opinions from different stakeholders, an aggregate metric can be created as an average of all the scores provided.

Together with the metric type, the way of scoring is also important. The metrics can be scored manually, by different stakeholders or automatically by means of a script or based on an attribute, by mapping values.

Different methods of valuation for each of the metrics will be proposed according to best practices and literature. The selection will be made based on a benchmark, local experts and stakeholders interviews. A summary of the fourth step is presented in Table 3.5.

Table 3.5: Defining metrics valuation

Step:	*Defining metrics valuation*
Objective	Define metrics valuation
Input	List with selected metrics (step 3)
	Information requirement (step2)
Activities	Identify and analyze how the information should be valued
	Propose methods of valuation for metrics
	Select methods based on benchmarks
Technique	Interviews with local experts
	Benchmark
Output	Methods of valuation for selected metrics

3.5 Creating the data-driven workflows

The fifth step is creating the data-driven workflows. The aim of this step is to model and configure fully executable process through the data-driven workflows.

In this step, the input consists of the selected stakeholders (step 1), the process models (step2) and the metrics with their valuation methods (step 4). Along with these, an enterprise architecture model will be required from the company, so the sources of the data objects can be easily identified and mapped with the data-driven workflows.

A typical workflow model is defined through a directed graph consisting of nodes and flows, which indicate the control flow of the workflow. Coordinator nodes support building the control flow structures for managing the coordination requirements of the business processes, as in the necessary conditions in which the workflow can become executable.

To illustrate decisions taken along the process by different entities, such as systems or stakeholders, several structures can be used in the workflow representation and their graphical representation is shown in Figure 3.4.

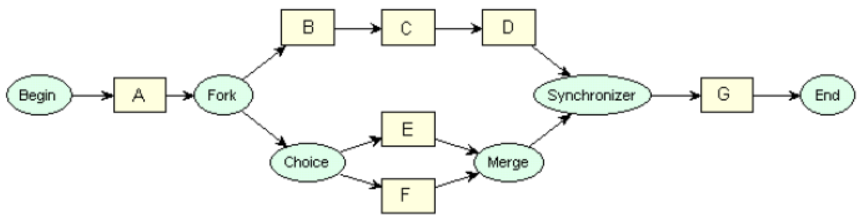

Figure 3.4: Basic Workflow Constructs (Sadiq et al., 2004)

The basic structures supported through these coordinators include Sequence, Exclusive OR-Split (Choice), Exclusive OR-join (Merge), And-Split (Fork) and the And-Join (Syncronizer) (Sadiq et al., 2004). The And-Split can be used when two different activities can be done at the same time, without any existing constraints and the And-Join is used for merging the information from different sequences of activities. The Exclusive-OR differentiates between two or more possible sequences which are determined by a predefined condition, and the Exclusive-Join merges the data input created only if a predefined condition is checked. An instance within the workflow graph is one particular case of the process.

The composition of the workflow has to be created through several means of representations, such as text, graphical and semantic. During this step, a new workflow can be created or an existing one can be improved using workflow components and data models. The process models are used as a starting point for the design of the data-driven workflows.

Since not all the processes from the workflow can be automated, a differentiation has to be made across the type of tasks required, namely: manual, automated and user tasks.

The workflow components have to be mapped to the underlying resources, followed by its execution. Therefore, user tasks need to be mapped with the selected stakeholders and the decided methods for metrics valuation are implemented and mapped accordingly with the data objects.

The activities in the workflow model need to provide the necessary data to their underlying application components and users for correctly identifying the context of the work which they are supposed to execute. At the same time, the users and the applications may return some data to the workflow model which might be required in the next steps of the workflow model (Sadiq et al., 2004).

Therefore, the data flow is crucial, and its mechanism should have the ability to manage the input and the output, to ensure that the required data is available and to provide a mechanism to ensure the consistent flow of the data from one activity to each other. All the execution properties need to be included for achieving the designed behaviour. Activities regarding the improvement of the workflow can take place for correcting the expected behavior.

Moreover, the metadata and information regarding the data changes regarding the execution of the workflow will be recorded in a database. Data recording can also occur during the execution phase if the workflow is designed this way.

The design of the workflows is created iteratively based on feedback from local experts. A summary of this step is presented in Table 3.6.

Table 3.6: Create data driven workflows

Step:	*Create data driven workflows*
Objective	Transform the defined process models into self-executable workflows
Input	Classification of stakeholders (from step 1)
	Process models (from step 2)
	Selected Metrics and valuation methods (from step 3)
	Enterprise architecture model
Activities	Design data driven workflows
	Operationalize metrics
	Execute process instances
	Test efficiency and accuracy of expected output and behaviour
	Improve the design
Technique	BPMN modeling
	Software design
	Agile design
Output	Executable workflows

3.6 Creating the dashboards

Different types of visualizations are required to help stakeholders understand the information easier and faster so they can make better decisions. Therefore, the aim of the final step is to create customized dashboards for each type of users.

The dashboards are meant to improve the usage of the platform, and to provide stakeholders the information they need in order to improve the quality of their decisions.

The main idea is that once the stakeholder type is indicated, based on the defined model, the stakeholder would be sent to a page personalized accordingly. For example, if the type of stakeholder is a Data Supplier, then the main page shown to him should be his tasks sorted by the type of their urgency instead of the customized dashboard. However if the stakeholder is a Decision Maker, then the landing page should be a dashboard where metrics identified as being important for his position would be shown. The focus on this study however is on how the dashboard should be created.

The dashboard provides custom-made reports that will display significant information to each of its users, eliminating the practice of generating irrelevant reports no one uses.

The input for this step consists of the stakeholder classification (step 1), lists with selected metrics per stakeholders from the third step and the data-driven workflows (step 5). The data required for the dashboard is provided using the data captured through the data-driven workflows.

The power attribute from the stakeholder classification will be mapped with the business intelligence level required for each type of stakeholder according to Heikkinen and Kostakos (2012). The levels for the business intelligence are the following:

- Prenatal level is intended to be used for all users interested in what happened
- Infant level is aimed at analysts interested in forecasts
- Child level is aimed at power users and should provide an interface for interactive reporting. The users at this level are expected to be interested in understanding the "why".
- Teenager level is intended to be used for managers for performance monitoring in real time. This implies that the dashboard should allow the use of charts as well as interaction between them.
- Adult level is aimed at executives for performance management purpose. The dashboard should provide a high-level interface for monitoring KPIs, with a simple and informative design aimed at showing business forecasts
- Sage level is aimed for customers or external parties where the information provided should be about the products or services offered

The data-driven workflows are the main data stream for the dashboard. In this case study, different stakeholders are mapped to several metrics. Based on the metrics they are mapped, a custom dashboard will be created.

A summary of the last step is presented in Table 3.7.

Table 3.7: Create dashboards

Step:	*Create dashboards*
Objective	Create customized dashboards for each type of user
Input	Classification of stakeholders (from step 1)
	List with selected metrics per stakeholder (from step 3)
	Data driven workflows (step 5)
Activities	Business intelligence mapping
	Create design layout
	Implement designs
	Evaluate dashboards
Technique	Software design
	Agile Design
Output	Customized Dashboards

3.7 Tool selection

Several tools can be used for delivering the expected outputs from each step of the method described in the previous section. In this section the selected tools for this research are presented.

3.7.1 Process Modeling

The output required in the first two steps can be delivered by using any software which supports BPMN modeling. There are many software applications in the market which can satisfy this criteria (Recker, 2008).

Enterprise Studio is a stand-alone modeling tool which supports BPMN and a wide range of visualization techniques and features to highlight important information. The tool enables its users to switch between different levels of details for process diagrams, allowing to chose the most appropriate visualization for targeting the right audience.

Although Enterprise Studio provides the capability to represent stakeholders and their interaction, the icons used in the design does not provide a wide range of options to support the variety of stakeholders. Therefore, for creating the collaboration diagram, a decision is taken to use a different tool which provides a better flexibility for modeling the links between the stakeholders and a better representation for their diversity.

The chosen tool is Creately, a web platform that supports modeling of all types of diagrams and allows users to collaborate in real-time. The platform is logical, intuitive and accessible for use, even for non-technical users. The tool is quite straightforward for unexperienced users as learning materials, such as tutorials and blogs, are provided. Moreover, unexperienced users can benefit by using existent examples and templates when starting to model. However, Creately can only support the designing phase and not the execution of the process models.

Enterprise Studio provides better support for process improvements, with a powerful set of analysis instruments, such as value stream mapping and an option to make the process diagrams executable. The tool can also be regarded as a modeling environment for HoriZZon, a web portal meant to bring value by enabling a wide range of stakeholders to gain insights across the enterprise. The web portal is expected to provide better visualization, analysis and collaboration capabilities.

3.7.2 Workflow Modeling

In order to shift from conceptual process models to executable ones, a software application which provides an execution engine is required. Powerful execution engines for BPMN workflows require to be paired with essential applications for process automation projects.

For this matter, the software used for this research is Camunda Modeler, an open-source workflow and decision automation platform which supports BPMN modeling (Camunda, 2015). The tool provides an environment where process and decisions models can be designed and allows users to execute workflow tasks assigned to them.

The process models that require to be automated can be documented graphically by using the tool and directly executed in Camunda without further transformation. Operationally, the processes can be viewed directly, together with their source code of the process. Therefore, the processes can easily be understood by technical and non-technical people.

Moreover, Camunda is an open-source framework that can be easily be embedded into another existing technical environment, facilitating integration with other applications.

3.7.3 Dashboard Construction

The last step of the method implies creating a dashboard in which relevant information can be displayed. Therefore, according to the findings presented in Section 2.3.2, the tool should be a business intelligence platform that can provide capabilities that support comprehensive analytical workflow, from data preparation to visual exploration and insight generation.

The tool used for this research is Tableau, a business intelligence platform which provides powerful, secure, and flexible end-to-end analytics. Comprising features that enable data manipulation and visual exploration in an intuitive and interactive way, the tool can also be used by people without technical skills.

The transformation program for the APM decision-making process, namely the implementation of this method, should be driven and governed by senior management. Depending on the maturity of the EA and the business processes, the number of organizational resources required can differ. Capabilities that are required for this program are presented in detail throughout the method. The creation of an EA is considered substantial.

Different stakeholders are also expected to be involved in the process of implementing the method, as explained throughout the steps that have to be performed. It is expected that the leader of this transformation program is an Application Portfolio Manager.

The first step of the method provides an opportunity to communicate the APM strategy and to establish a common ground with all the stakeholders. This supports the articulation of a strategy including goals, deliverables and a set of governance procedure for guiding the APM decision-making process. Best practices for stakeholder analysis are identified through the literature study and considered in this step.

The second step, namely the definition of the process model, could be avoided due to the fact that the same information is addressed in the fourth step of this method. However, the simplified way of representing the same information is beneficial when dealing with stakeholders who don't have a technical background. The representation of process models presents less complexity than data-driven workflows, therefore they are convenient to use for receiving feedback on the desired state of future collaboration in decision-making.

Key attributes are being identified for the APM decision-making and a classification of their usefulness is investigated for each of the stakeholders involved. This not only supports the creation of a thorough application inventory for monitoring the application portfolio but also contributes to a personalized analysis and reporting capability for each of the stakeholders involved in the the application landscape rationalization through the use of the data-driven workflows and dashboards.

The output of this design method enhances a faster and more accurate APM decision-making process. Throughout the phases of the process, stakeholders' needs are identified and addressed by providing custom-made solutions based on dynamic links created between the data assets, business process, applications and the infrastructure by the use of the data driven workflows.

The capabilities created throughout following the design method are closely interrelated and build on each other. With automation as a part of the EA practice, a framework for a better APM decision-making process is created and can support the APM management in becoming more strategic and impactful.

4 Case Demonstration

The objective of this chapter is to provide a demonstration of the proposed approach in a real case. Applying the approach to a case is mandatory to prove that the proposed approach is applicable in a real situation which exists in organizations.

For this matter, a case study of a client from BiZZdesign is provided. However, due to data limitation, some assumptions and additional information are added by the author while implementing the case study. In a real case, all the required information should be determined from related stakeholders or documents in the organization.

A brief description about the case along with the assumptions made is given in Section 4.1. A detailed explanation regarding the application of the proposed approach is presented in the subsequent sections.

4.1 Case Description

The Client is a multinational technology company which supplies devices related to communications and computing. These products are used by industry members to create advanced computing systems. The aim of the company is to be a leader in the technology innovation by continuously focusing on customer satisfaction and significantly contributing to the worldwide digital economy.

To improve its position on the market, a recent acquisition of a smaller business has been made. After a transition period of one year, several challenges regarding the IT investment decisions are noticed by the senior management. Among others, the transition resulted in significant changes to the application landscape. The delay in a proper integration caused a misalignment between the information systems used for daily operations, such as coordinating transactions, managing operations and supporting the sales.

To successfully complete the integration, new decisions regarding the application landscape need to be taken. So far, the senior management had only limited support for strategic decisions due to a lack of consolidated and integrated data regarding the influencing factors. Their decisions were based on limited knowledge, therefore some of them lead to inefficient investments, such as allocating funds for several applications which were not longer required.

The recent acquisition contributed to new opportunities, increasing the work load for the existent employees, who are now handling the demands of many teams at once concerning different project. While this aspect is a good approach since their knowledge is shared where is the most needed and avoids costly downtime, in practice this is stressful and less productive. Moving between teams implies adjusting different roles changing the level of their accountability and their ability to manage resources, sometimes ending to do repetitive work and not growing.

Moreover, in all the units, employees are being given more tasks than they can manage, which they accept because they want to be considered as collaborative team members. This behaviour is causing resources to be over-allocated and overworked, leading to inappropriate time and efforts allocation. For example, when two or more applications need to merge due to similar functionality or optimization, previously assigned developers might share different opinions regarding the necessary changes, such as architecture, database or security, therefore new developers have to be considered for leading the development. When new people are assigned, the project manager who required the merge, has to supervise closely for keeping track of accountability and deciding future ownership. Secondly, the exhaustion caused by the overwork makes employees feel disengaged, tired, or overwhelmed which results in suboptimal execution of their tasks. The aforementioned challenges lead to employees working extra hours for finishing their daily tasks, contributing to a significant increase with costs required for maintaining the application landscape and its development.

For this matter, several goals were defined by the senior management to support their vision and a clear interest was identified in simplifying the IT landscape and improving their decision-making process regarding investments.

The initial driver for APM efforts was cost reduction. Along with that, an interest was shown in enabling a data driven decision making culture that could support them to innovate the business models, solutions and their services in the market on the long term.

To address these problems, an enterprise architecture model was provided for illustrating the current state of their resources and to explore potential ways of improvement. The architecture model will serve as a significant input in our approach.

4.2 Identifying and classifying the stakeholders

The local branch of the Client doesn't have a defined approach for APM and decisions are being taken by considering the opinions of certain stakeholders. Due to the limited number of employees and their limited time, individual interviews could not be conducted. Therefore, assumptions about possible stakeholders, their responsibilities and the role in the decision-making process were created based on local experts' knowledge and literature study.

The concerns of a CIO are expected to come from the arising complexity of their application landscape. This complexity leads to a lack of a high-end overview and could affect the data security and quality, but most important could decrease the agility and responsiveness to the needs of the core business processes. Moreover, all these challenges need to be addressed from a financial perspective as well, as a CIO is responsible for taking decisions on how the budget should be allocated. An assumption was made that the cost evaluation of the application landscape within the company is performed twice a year. Another important struggle expected from a CIO is the lack of perspective on the future of the application landscape.

The Application Portfolio Manager is expected to have as his primary responsibility the management of the application portfolio and to oversee their transformation strategies. For this matter, an assumption is made that every quarter an evaluation of the application landscape takes place. For this evaluation, different knowledge would be required. The applications should be evaluated based on their functionality, business relevance and their dependencies within the other system. Therefore, an assumption was made that stakeholders such as an IT Manager, Business Analyst and the Enterprise Architect would be involved in the process. Moreover, the Application Portfolio Manager is expected to be also responsible for deciding which new applications should be created. An assumption was made that possible struggles can arise from the lack of updated information regarding the current state of the application portfolio, which would cause delays in the decision-making process.

The Project Manager is expected to correctly execute projects and choose the projects which bring the most value to the business. Moreover, is expected that this responsibility would require to ensure that there are sufficient resources to deal with the required changes for optimization. Therefore, when new applications are required for a project, an assumption is made that the Project Manager would be responsible to send a proposal to the Application Portfolio Manager for new applications. For this task, it is expected that a list of prerequisites exists for checking the necessary information before sending the proposal. An expected struggle is the confusion regarding the accountability for progress updates in the application functionalities. This could be caused due to possible changes of assigned software developers, as their required knowledge for the development phases of the application might change in time.

An IT Manager is expected to assure the technical functionality of the IT landscape. In the decision-making process, an assumption is made that his responsibility is to review the technical value of an application. Possible concerns are expected to be the poorly documented applications that can slow down the decisions he would be responsible for. An assumption is also made that due to the recent acquisition, multiple applications provide similar and overlapping functionalities leading to an increased cost of the IT landscape.

The poorly documented applications could be an issue caused by differences between different stakeholders. Other stakeholders expected to be involved are the Application Portfolio Manager and developers. An assumption is made that a possible cause for the delay consists of the lack of employees. An Application Portfolio Manager is expected to prioritize existent tasks and to allocate the available developers accordingly. An assumption is made that applications intended for innovation of the business are set on highest priority and developers would dedicate more time to those projects. It is expected that poorly documentation can impact the work of the developers. An assumption is made that when assigned to an application, developers require a lot of time for understanding the source code in order to modify it. This could cause delays in completing tasks and delivering according to the deadlines. Moreover, an assumption is made that the possibility of outsourcing the development of the application landscape for reducing the costs would make developers feel afraid of losing their job. For addressing the poor documentation issue, an application inventory is expected to be created over the past year of transition and that several would be involved in the data collection phase.

Employees from the Business department and Enterprise Architects are also expected to be involved in the decision-making process. While managers are expected to be responsible for overseeing the tasks performed by their employees, individual employees are expected to be directly accountable for supplying the necessary data for evaluating the business value and the architectural dependency. An assumption is made that the application inventory would be considered of value, as aggregated information can be found in the same place. A possible struggle that stakeholders could face is the data collection, which can be time-consuming due to the possibility of different sources. An assumption is made that the Business Manager could be concerned about the impact on their regular software caused by acquisition. The reason would be the necessity of organizing new activities to train the employees, which would demand extra planning.

It is expected that costs evaluation is usually performed by a Financial Analyst. The common concerns are expected to be related to data inaccuracy, caused by many values that could be submitted as estimations. Therefore possible delays are expected in this process, as each of the costs submitted beforehand has to be individually investigated for identifying the real values and the assumptions made. An assumption was made that once the estimations are identified by the Financial Analyst, meetings would take place for updating the cost evaluation.

Based on the assumptions created for this case study, an analysis has been created on the existent positions and their contribution to the decision-making process and is reflected in Figure 4.1.

Stakeholder	*Type*	*Power*	*Interest*	*Attitude*	*Interaction*
CIO	Internal	Decision Maker	High	Leading	Requests cost evaluation twice a year
IT Manager	Internal	Decision Maker	High	Supportive	Analyzes technical value of application
Application Portfolio Manager	Internal	Decision Maker	High	Supportive	Assesses the application portfolio every quarter Has the final decision on new application proposals
Developer	Internal	Informational Stakeholder	Low	Resistant	Improves the functionality of applications
Business Manager	Internal	Informational Stakeholder	Medium	Resistant	Interested in the business value of applications
Business Analyst	Internal	Data Supplier	Low	Supportive	Supplies data for assessment and evaluations of applications
Enterprise Architect Manager	Internal	Informational Stakeholder	Medium	Supportive	Interested in the architectural complexity of applications
Enterprise Architect	Internal	Data Supplier	Low	Supportive	Supplies data for assessment and evaluations of applications
Project Manager	Internal	Decision Maker	Medium	Supportive	Identifies requirements and sends new application proposals
Financial Manager	Internal	Informational Stakeholder	Medium	Supportive	Interested in the costs related to application landscape
Financial Analyst	Internal	Data Supplier	Low	Supportive	Providing the financial status of the applications

Figure 4.1: Stakeholder Classification

The power of each stakeholder in the APM decision-making process is established in accordance with their responsibilities and general tasks that they are engaged with.

The power of the Developer is in this case identified as Informational Stakeholder, due to the face that his contribution impacts the source code development of the application, not the functionality of the application. Several managers are classified as Informational Stakeholders due to their interest in the output and lack of a direct contribution to the decision-making process.

While the CIO and the responsible managers concerning the application landscape are expected to show a high interest in creating a structured decision-making process, several other managers are expected to show a medium interest. The lowest interest is assumed to be among the employees which might consider this initiative as another change that they need to handle along with their usual tasks.

The assessment of the attitude is made based on their expected interactions and how the goal can affect the responsibilities of each stakeholder. The attitude is considered overall supportive, only two stakeholders are expected to show resistance. One of them could be the Developer due to his fear that this initiative could lead to a decision of outsourcing the IT development to an external party. The other stakeholder could be the Business Manager, who is expected to be resistant to the new changes regarding the software application introduced in the last year for the daily activities. The CIO is expected to show a leading attitude based on the expectation of the outcome of this initiative.

For the next steps of this approach a selection of the stakeholders is made. The stakeholders which are not expected to directly contribute to the decision making process have been therefore excluded. The list of the selected stakeholders is presented in Table 4.1, together with their responsibilities.

Table 4.1: Selected stakeholders and their responsibilities

Function	*Responsibilities*
CIO	Primary responsible for the information technology and computer systems that support enterprise goals.
Project manager	Responsible for project scoping, scheduling and approvals regarding the resources and budget management.
IT Manager	Responsible with the management of the IT landscape and services.
Application Portfolio Manager	Responsible for managing the application software implementation and upgrades and other activities related to its usage.
Business Analyst	Responsible with the analysis of the business processes and their constant improvement by the use of technology.
Financial Analyst	Responsible with the management and analysis of the financial statements in order to determine a company's value and future earnings.
Enterprise Architect	Responsible with the alignment of the application portfolio with the business strategies.

Figure 4.2 presents the high-end collaboration diagram of the selected stakeholders. A high-end perspective of the interaction between the stakeholders in the APM decision-making process and data sources that are being used for the knowledge required.

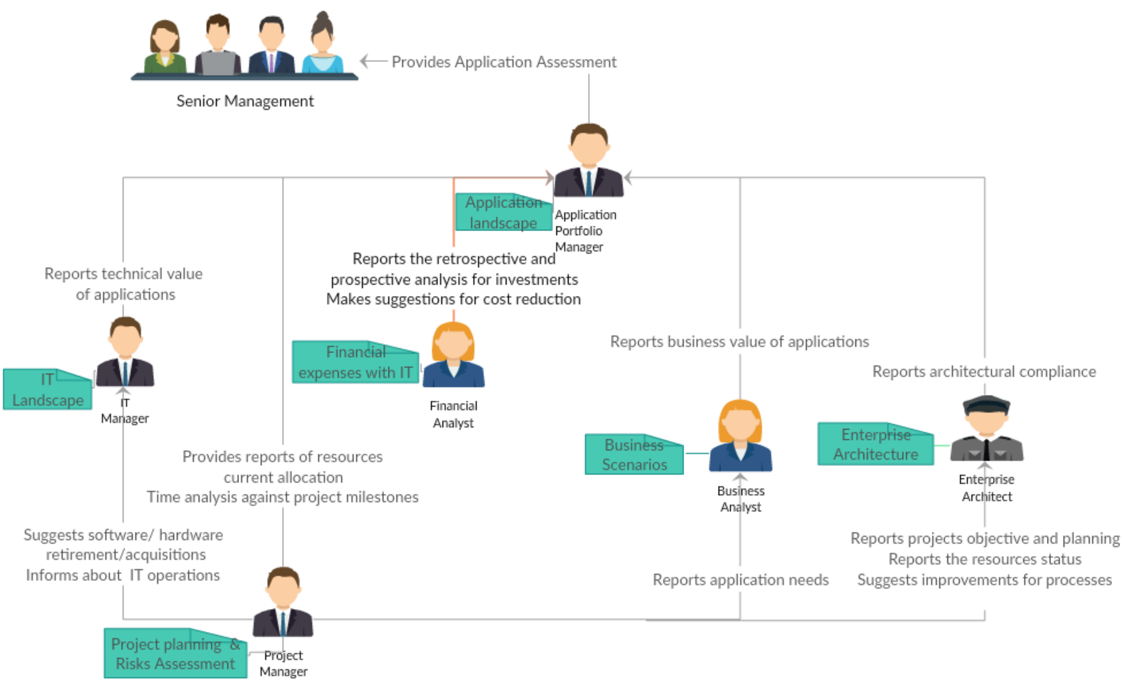

Figure 4.2: Collaboration Diagram

The next section presents in more detail the expected interaction between the stakeholders and the critical phases identified in their decision-making process.

4.3 Defining process models

Three main steps are expected to be critical in the APM decision-making process:

- creating a application inventory
- assessment of the application portfolio
- cost evaluation of the application portfolio.

The creation of an application inventory is expected to be the first step due to its usefulness for further phases. However, it is necessary to have a clear overview of the information required in the next steps, so that the inventory captures useful data in order to better support stakeholders in their decisions.

The assumptions regarding stakeholder's interactions, along with findings from literature and the knowledge of local experts serve as a basis for an ideal scenario for the APM decision-making process. The process models reflect how the stakeholders should collaborate in this ideal scenario.

Scenario 1: Application assessment

In this step that assessment of the compliance of an application portfolio is expected to take place. For this matter, the following stakeholders are expected to be involved in this scenario: the Application Portfolio Manager, the IT Manager, the Business Analyst and an Enterprise Architect.

The Application Portfolio Manager is expected to be the one who initiates the assessment for the application landscape. The assessment has to be conducted from three perspectives: technical, business and architectural. An assumption is made that, in this case, the assessment on these perspectives are not dependent.

After the initiation, each of three other stakeholders are expected to receive a task for reviewing the current value. For creating these assessments, the stakeholders are expected to have access to updated information. This information should be clear and straightforward so that the assessment can be fast and based on accurate information.

Once their assessments are completed and gathered, the Application Portfolio Manager is expected to decide if the overall assessment requires any other revision. If the assessment requires any changes, he is expected to take action, otherwise the assessment is considered completed. Figure 4.3 presents the process model for this scenario.

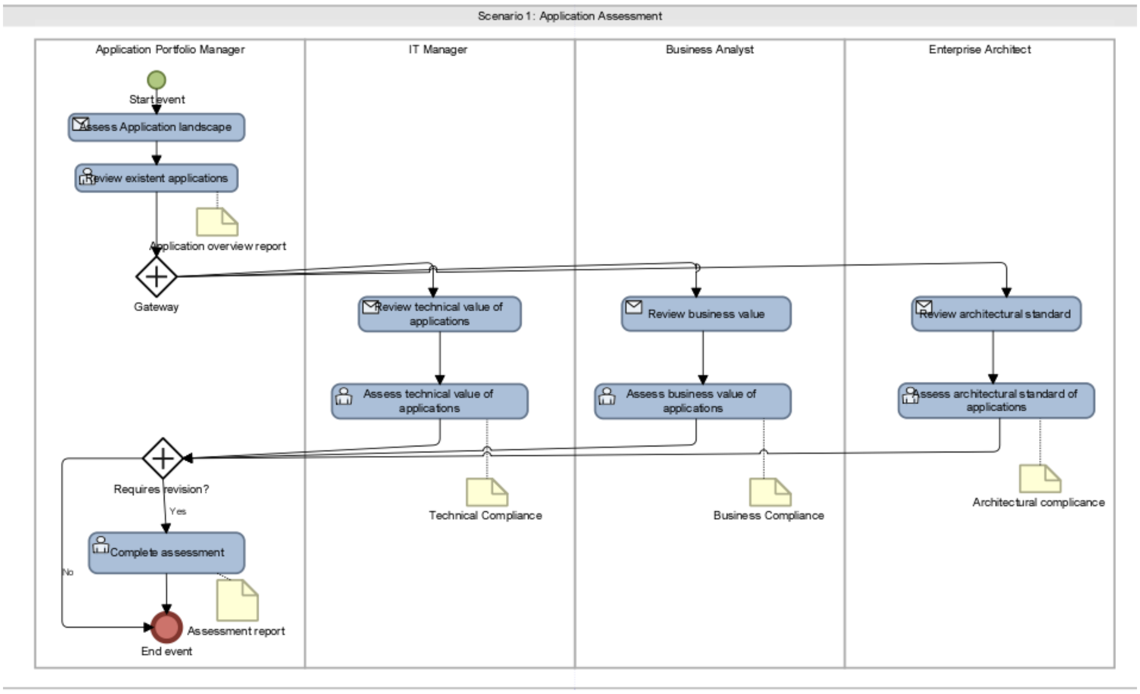

Figure 4.3: Scenario: Application Assessment

In this step, estimated values are expected. If an application inventory is used for the assessment, it is assumed that stakeholders would update the data. Therefore, an application inventory should include features for a fast evaluation of the data accuracy. Moreover, for keeping stakeholders accountable, reminders should be given in defined period of time to assure this aspect.

Scenario 2: Cost evaluation

The second step is expected to be the cost evaluation. In this step, stakeholders are expected to evaluate the finances from a retrospective perspective and also a prospective one. The main questions expected to be answered at this stage are "Has the organization earned ROI for the money invested to date" and " Is the organization likely to earn ROI for money invested today and in the future?".

Financial values are calculated by indicators such investment value, cost efficiency and net present values, such as return on investment or return on asset. Therefore, both the costs and benefit streams are expected to be considered. Additionally, non-financial values like risk or strategic values are assumed to supplement the financial value. Therefore, for this scenario the following stakeholder are expected to be involved in this phase: the CIO, the Application Portfolio Manager, the IT Manager, the Business Analyst and a Financial Analyst.

The CIO is expected to be the initiator of this evaluation. The request is assumed to be forwarded to the Application Portfolio Manager, responsible with evaluating the development costs of the applications. The IT Manager and the Business Analyst are expected to provide the maintenance cost, respectively the benefit streams. When both evaluations are completed, the Financial Analyst is expected to provide a financial analysis.

Once completed, the financial report is expected to be sent back to the CIO, and it can be used for the cost evaluation and future investment decisions. Figure 4.4 depicts the process model of this scenario.

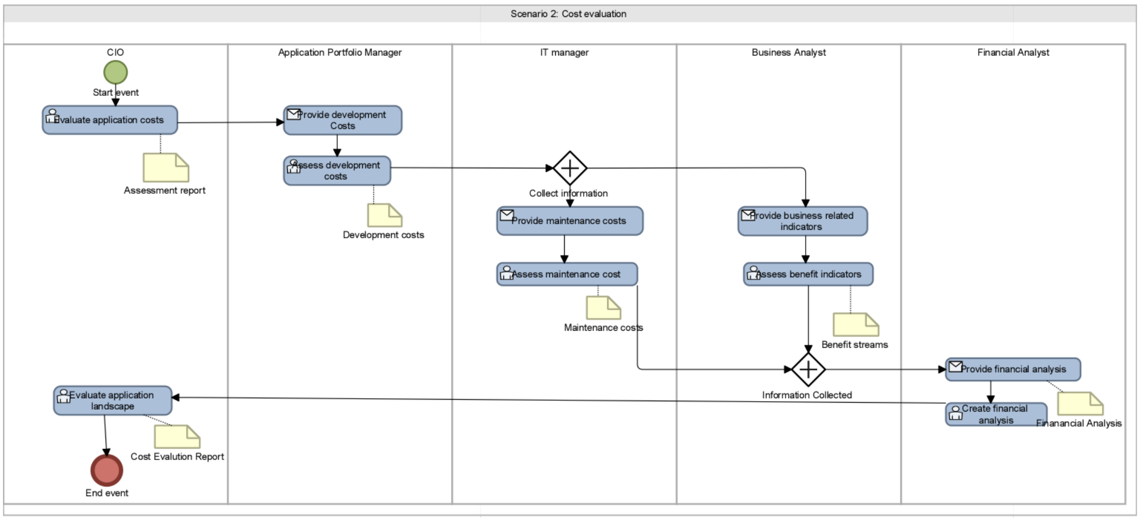

Figure 4.4: Scenario: Cost evaluation

Scenario 3: Application Registration

In this step, an application inventory is expected to be created, a critical phase that creates a basis for all the upcoming decisions regarding APM. This step is expected to be an entry point for new IT initiatives, more specifically, new software applications. When a new demand arises, its documentation should be created in a standardized way containing the information described in the following paragraphs.

The initiator of a demand is expected to provide enough information for explaining the need of the new initiative, to link it to supported strategies and addressed objectives and define a contact person to achieve traceability. Additionally, architecture elements affected by the new software are expected to be mentioned. A new application can lead to the retirement of other applications or it might overlap other existing applications. In this case, this information is important so stakeholders can decide if a new application should be built or older ones improved.

For this scenario, the initiator was assumed to be the Project Manager, who identifies a need for new applications. The request is expected to be sent to the Application Portfolio Manager. Once received, the Application Portfolio Manager is expected to review the submission.

Based on the completeness of the request, the Application Portfolio Manager is expected to ask for more information or move forward with taking a decision. Once the final decision is taken, the Project Manager will receive the answer. Figure 4.5 shows the process model of this scenario.

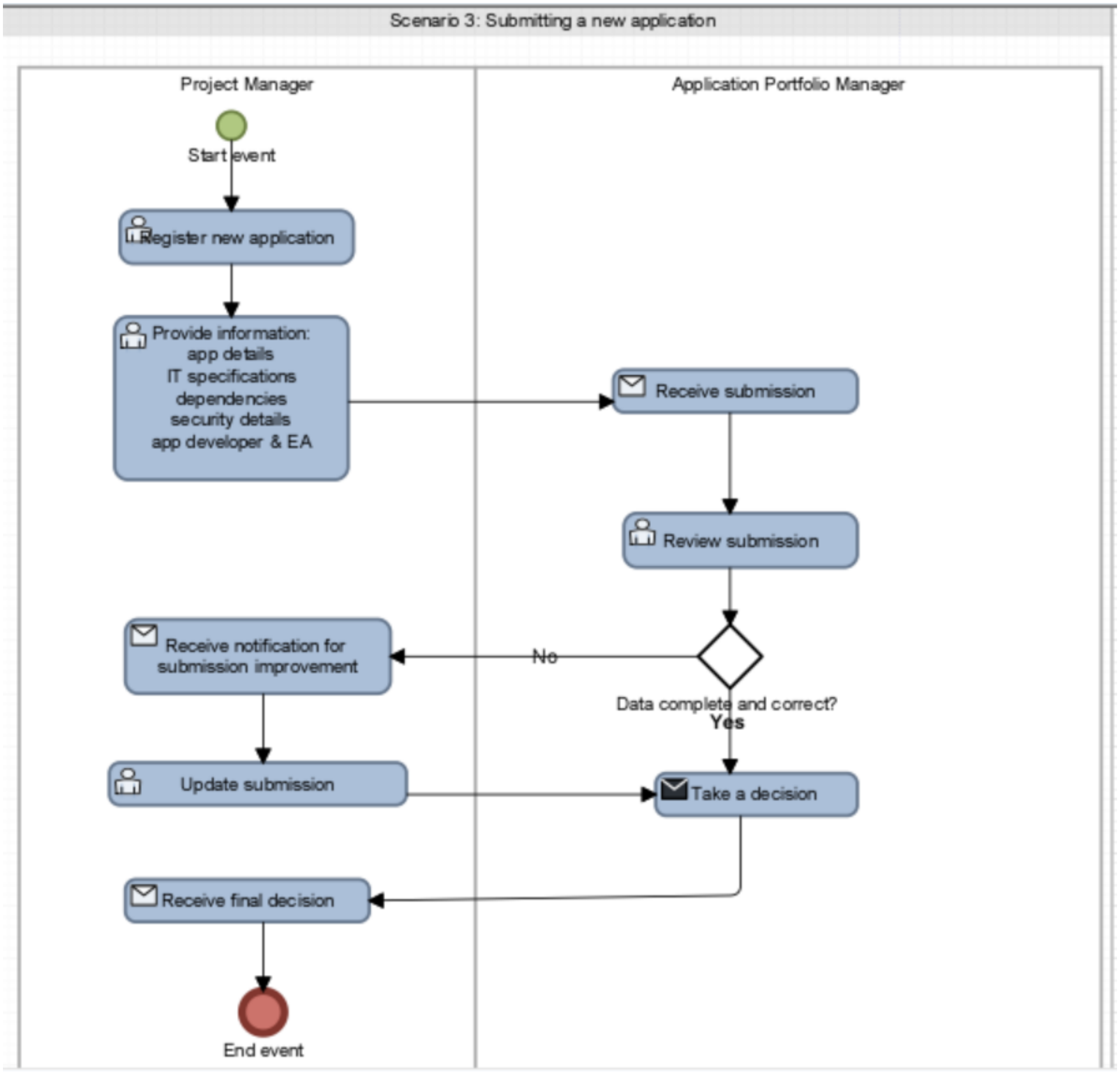

Figure 4.5: Scenario: Application Registration

4.4 Identifying and classifying metrics

From the literature study, a number of forty metrics related to APM decision making process are included in the framework.

Four local experts are involved in assessing the importance and usefulness of the metrics for each of the considered stakeholders. The positions of the local experts are different within the company, namely:

- E1: Research Consultant
- E2: Chief Technology Officer
- E3: Medior Consultant
- E4: Presales Consultant.

The participants are asked to rate on a scale from 1 to 5 the usefulness of each metric for a specific stakeholder. The complete assessment results can be found in Appendix .1.

Out of forty metrics, thirty-two unique metrics are part of the top 10 metrics for the stakeholders, shown in Table 4.2. Thirteen metrics are identified as being relevant for at least two of the stakeholders, most of them addressing the technical complexity.

KPI	**Occurrence**		**KPI**	**Occurrence**
Number of supported business processes	4		Functional scope	1
Lifecycle state	4		Number of supported business data objects	1
Strategic importance indicator	3		Deviation from standard	1
IT investment indicator	3		Future value	1
Functional overlap/ redundancy	2		Estimated savings	1
Number of infrastructure elements	2		Business standard indicator	1
Number of information flows / interfaces	2		Expected retirement date	1
Capability coverage	2		Investment risk	1
Technology diversity	2		Net present value	1
Functional readiness	2		Documentation quality	1
Application Lifecycle Duration	2		Number of incidents	1
Operating costs	2		Number of users	1
Investment value	2		Cost efficiency	1
Architectural standard compliance indicator	1		Return on Investment	1
Security status indicator	1		Revenue per User	1
Number of applications	1		Return on Asset	1

Table 4.2: Metrics Diversity in top 10 metrics for stakeholders

The Number of supported business processes and the Lifecycle state are both identified as the most common in the most important ten metrics, identified useful for four of the stakeholders. The first metric is relevant for the CIO, Project Manager, Business Analyst and Enterprise Architect, while the former for CIO, IT Manager, Application Portfolio Manager and the Enterprise Architect. The two metrics indicate the importance of an application for the business and the current state of the application.

Other common metrics are the Strategic importance indicator and the IT investment indicator, which are identified as relevant for three stakeholders. These are followed by metrics indicating the architectural and technical complexity of the supporting technologies.

Out of the metrics which occurred just once in the top ten, nine are investment related metrics, five are technical, two business metrics and two are architectural.

The most important ten metrics per stakeholder are shown in Figure 4.6 based on the average scores of their assessment.

	CIO	Project Manager	IT Manager	Application Portfolio Manager	Business Analyst	Financial Analyst	Enterprise Architect
Metric 1	Strategic importance indicator	IT project status	Application failure	Strategic importance indicator	Business Standard indicator	Investment value	Number of supported business processes
Metric 2	Security status indicator	Expected development date	Number of incidents	Functional readiness	Number of supported business processes	IT investment indicator	Strategic Importance
Metric 3	IT investment indicator	Cost efficiency	Incident processing time of an application	IT investment indicator	Number of supported business data objects	Estimated savings	Functional overlap
Metric 4	Investment value	Documentation quality	Lifecycle state	Investment value	Strategic importance indicator	Cost efficiency	Number of infrastructure elements
Metric 5	Return on Investment	IT investment indicator	Application Lifecycle Duration	Lifecycle State	Capability coverage	Revenue per User	Lifecycle state
Metric 6	Investment risk	Return on Investment	Utilization indicator	Expected retirement date	Functional readiness	Investment Risk	Number of information flows/inter-faces
Metric 7	IT project status indicator	Number of information flows/inter-faces	Number of users	Operating costs	Documentation quality	Net present value	Architectural standard compliance indicator
Metric 8	Future value	Number of supported data objects	Operating costs	Number of applications	Number of users	Return on Investment	Capability coverage
Metric 9	Lifecycle state	Technology diversity	Number of infrastructure elements	Application Lifecycle Duration	Functional Scope	Future value	Security status indicator
Metric 10	Number of supported business process	Application Size	Deviation from standard	Number of incidents	Functional overlap/ redundancy	Return on Asset	Technology diversity

Figure 4.6: Top 10 metrics assessment per stakeholder

The assessment of the metrics importance aligns with the responsibilities identified throughout the literature. The average score supports classifying the importance of the metrics per each stakeholder.

For the CIO, all the metrics identified are useful when assessing the strategic importance of an application and its financial value. The metrics identified for the Project Manager are related to the development planning, the alignment to the budget and the complexity of the application. Concerning the IT Manager, the identified metrics are addressing the technical complexity of an application and its usage.

The identified metrics for the Application Portfolio Manager are giving an overall impression of the application and its strategic importance. For each of the three remaining stakeholders, the metrics address their main responsibilities concerning an application, namely the business compliance for a Business Analyst, the financial value for the Financial Analyst and the architectural compliance for the Enterprise Architect.

For several metrics, the local experts have a strong agreement on the importance of the metrics per stakeholder. The metrics are related to strategic importance of applications and the architectural compliance.

The overall average scores show a difference in the perception of the local experts regarding the importance of the metrics for the stakeholders. The strongest agreement seems to be on the interests of an Enterprise Architect and the Application Portfolio Manager, while the least agreement falls under the interest of a Project Manager and a Business Analyst.

An interesting observation concerns the Strategic importance indicator. The local experts agree that the indicator is of high importance for the Application Portfolio Manager and the Enterprise Architect and for the CIO. Surprising is that for the first two stakeholders the indicator scores an average value of 5, while for the CIO, the average score has a lower value of 4.75.

All the 40 metrics are considered of importance for an Application Portfolio Manager. Moreover, more than 35 of them are considered useful for an Enterprise Architect, an IT Manager and a CIO.

The strongest agreement regarding the least important metrics is identified for the Financial Analyst, where 9 metrics score the minimum average value. The identified metrics are considered to have the lowest importance for a Business Analyst, were 38 of the identified metrics had an average score equal or less than 2, and for a Financial Analyst.

Local experts have similar opinions regarding the importance of the metrics for the involved stakeholder, however some disagreements are identified especially regarding the interests of a Project Manager. The assessment from two of the local experts, S3 and S4, are in strong opposition. The most relevant example is the assessment of the IT investment, one of the most important 5 metrics, where S4 indicated the minimum value, while S2 the maximum.

4.5 Defining metrics Valuation

This section presents the methods that can be used for metrics valuation, based on the findings from literature study and local experts interviews.

The set of metrics presented in the previous chapter is rather extensive and for the simplicity of the model the list of the metrics that will be implemented has to be revised. Therefore, for the case study, a selection is made based on their added value for the decision making process.

The architectural metrics are all implemented according with the literature study since the methods are straight-forward and easy to comprehend by stakeholders. Therefore, the "standard deviation" metric is normalized to 2 binary values indicating the alignment or misalignment with the architecture. For the "architectural standard compliance indicator" metric the compliance is defined using a Likert scale, where 1 shows compliance and 5 indicated lack of a decision. The other metrics are implemented as values.

With regards to the business metrics, different methods are used for valuation. The "functional scope" metric is implemented as a short text that can provide information over the purpose of the application. Two other metrics, namely "number of supported business processes" and "number of supported data objects", are valuated as numerical values. The "business standard indicator" is normalized to 5 values, each of them describing different levels of compliance with the business standards within the organization.

A new metric is considered necessary to add due to the value it would bring, namely the "Strategy term", which refers to the layers of systems and can help distinguish between different portfolios. The values for this metric are normalized to Systems of record, Systems of Differentiation and Systems of Innovation (Gartner, 2017a).

Regarding the technical metrics, in this step several metrics are excluded and two others are considered. The "IT project status indicator", "expected development date", "application lifecycle duration", "application age" can be useful for a stakeholder to estimate the stage of an application. In this case study, it is considered that "lifecycle state indicator" together with the "expected retirement date" can deliver the same information. The metrics can support the stakeholder to assess the actual stage of a software application and be alert on its life expectancy by using the retirement date, valuated using a date type value.

The "lifecycle state" metric is normalized to four values indicating the progress of an application, namely, planning, assembling, deployment, and end of life. For the metrics indicating the technical compliance, normalized values are used to indicate their level from low to high and an option to indicate a lack of a decision. Other metrics concerning the failures and the time required to resolve them are not included as it is considered that for this study case, the metrics included are still addressing the technical capability of an application software.

Two more metrics are added to identify the application profile and the delivery type. The metrics "application profile" an "delivery type" are normalized according to the types of applications that can be found within the company. An example of normalized values for " application profile" could be: website, mobile application or online platform. For "delivery type", the values need to indicate how the form of the application, such as browser, mobile, report or others.

When considering the investment metrics, for the practicality of the cost evaluation, several metrics are added to address specific costs, such as license, development, lifetime and maintenance costs. For this case study, they are all considered as values that stakeholders are expected to indicate at a specific stage in a decision-making process.

The "security status indicator" is valuated through 3 normalized values that indicate the progress, namely not started, in progress an earned. A scale from 1 to 10 is used for valuating the "strategic importance indicator" where 10 is the maximum value.

Moreover, it is considered that an additional metric is required for exactly indicating the service level of an application, therefore a new metric is created, namely "service level agreement". Its purpose is to clearly state the urgency of the service that an application provides. The normalized values used for this are: mission critical, business critical, business important and others (Gartner, 2017b).

Two additional aggregated metrics are created for indicating the operationality and functionality of an application, so that different stakeholders can indicate different values for them. The final value of each metric is an average of the initial values. This decision is taken so that different perspectives can be considered and integrated in a structured way. Their valuation is created through 3 normalized values, where 1 indicates that no changes are required and 3 indicates that measures need to be taken.

The normalized values used for the metrics valuation will further support creating straight forward displays of the outcome on the portfolio dashboards that can be easily comprehended by the stakeholders.

4.6 Creating the data-driven workflows

For this step, the defined process models serve as a foundation for the data driven workflows. The enterprise architecture model provided by the Client includes an application inventory, therefore only two workflows are implemented in this study case, namely the application assessment and the cost evaluation.

The start of the workflow consists in indicating the involved stakeholders, the application identifier and mapping them to the existing data model defined in Enterprise Studio. The users of the data-driven workflows are mapped with the stakeholders, modelled in Enterprise Studio.

For each task, a specific stakeholder is assigned and the relevant metrics for that task. When all the metrics have been assessed, the input data is saved as a data model with the configuration of the workflow.

For the assessment phase, an assumption is made that individual assessment are independent as they concern different aspects of the application. Hence, the tasks are sent in parallel to the IT Manager, Business Analyst and the Enterprise Architect. When all the assessments are completed, a new task is created for the Application Portfolio Manager for revision of the assessment. Once the task of the Application Portfolio Manager is completed, a new task for the

CIO is created. When the task is completed, all the information is sent back to the initiator of this workflow and a data model is created.

The workflow starts with an "Start event", followed by three user tasks, namely "Technical compliance", "Business compliance" and "Architectural compliance". The decision of sending these tasks in parallel and gathering them is done through inclusive gateways. Another exclusive gateway is used to control the data flow based on the answer regarding the revision of the assessment. The calculation of the values for two aggregated metrics are implemented as script tasks. The last task is the "Strategic compliance" and its completion marks the end of the execution. The workflow is shown in Figure 4.7.

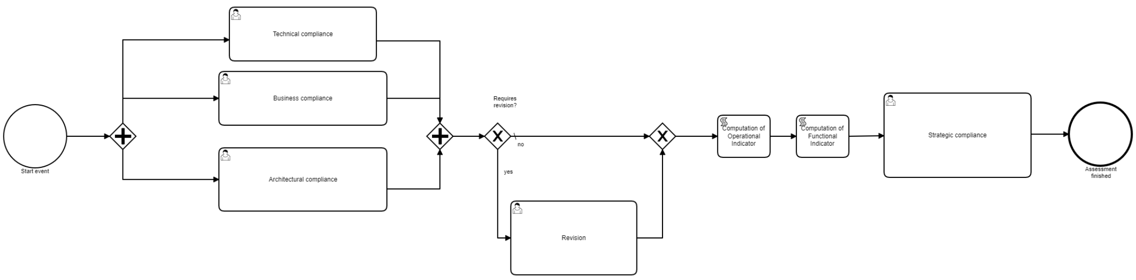

Figure 4.7: Application Assessment

For the cost evaluation phase, a task is sent to the Application Manager, where the costs related to development are expected to be assessed. After the task is completed, two new tasks are created and sent in parallel to the IT Manger and the Business Analyst. When both of the task are completed, a new task is sent to the Financial Analyst. Once the task is completed, the evaluation is sent to the initiator of the workflow, and the data is saved as a data model. As in this step, estimated values are expected, a measure is taken so that the repetition of the process is assured until all the indicated values are accurate.

The design of the workflow starts with a "Start event" followed by a user task named "Development costs". Inclusive gateways are used to control the data flow and two new user task are created, "Business related costs" and "Maintenance Costs". Once the user tasks are completed, the information is gathered and a new user task is created, named "Financial Analysis". A trigger is implemented based one of the metrics, more specifically if "Estimation Check" is true, therefore indicating estimations instead of real values, a new execution of the workflow will be created in a specified amount of time. If the metric is false, the workflows ends its execution. The workflow for this step is shown in Figure 4.8.

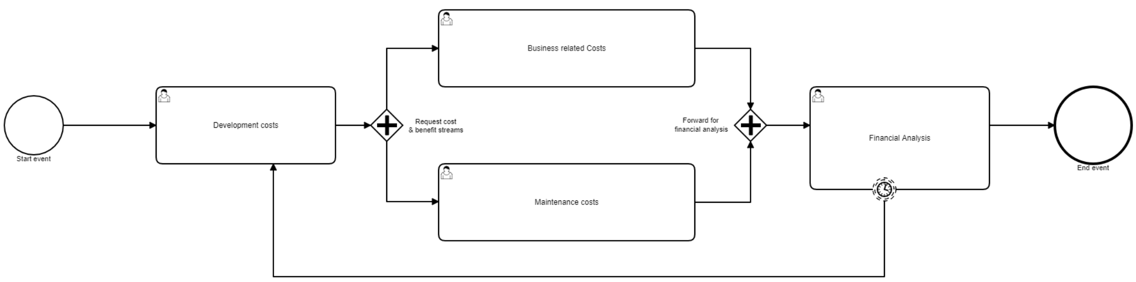

Figure 4.8: Cost Evaluation

In order to improve the efficiency of the workflows, as suggested by local experts, a decision is taken to merge them into a new one for the practicality of the approach. The final version of the workflow is presented in Figure 4.9.

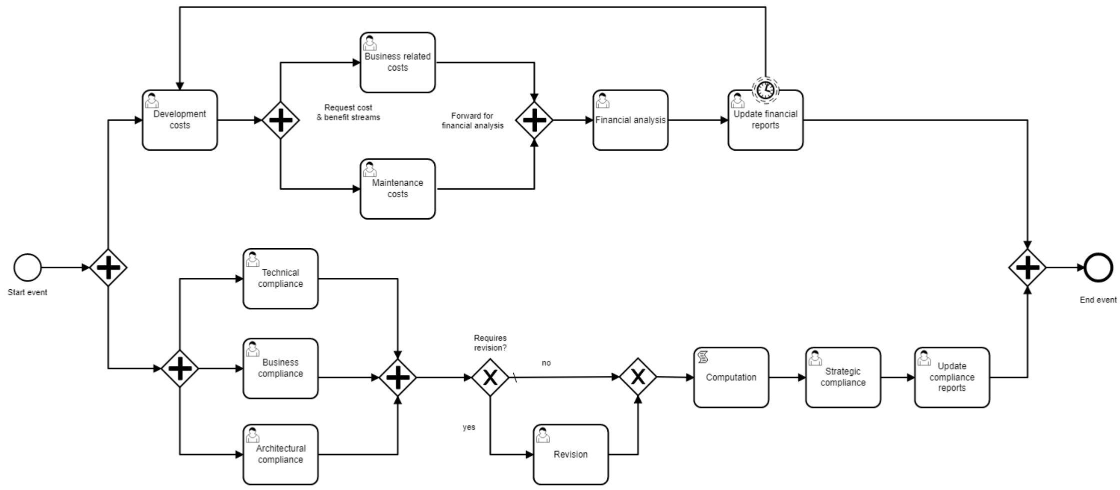

Figure 4.9: Complete model

The metrics described in the previous section are implemented and assigned according to the stakeholder needs and responsibilities. Moreover, the findings from the previous sections indicate that although some metrics are of high importance for the senior management, such as the CIO, other stakeholders are responsible with assessing their values. This aspect is considered when assigning the metrics to the stakeholders.

For this reason, for example, the Security Status Indicator is added under the architectural compliance, as it is considered that an Enterprise Architect is responsible with assessing it.

The inclusion of the metrics in each task serves different purposes. Some metrics require a value from the user. Some metrics, however, are being displayed as additional information without the need of introducing a new value, or changing an existent one. This is expected to support a stakeholder to take a better decision regarding the valuation of a metric that might require previous knowledge of values from other values.

The metric created for the repetition of the process, namely the Estimation Check, is normalized to two values, 1 for Real Value and 2 for Estimation. When an user indicates that the introduced values are estimations, the process will be started again in a defined period of time. This metric aligns with best practices indicated for financial analysis mentioned by Cantor (2011).

As an enterprise model is provided that already contained an application inventory, some of the values are mapped to the data model, while others are configured to be introduced by the stakeholders.

The existent inventory, was created as an enterprise model, where the data associated to the application objects are defined by the Client. The data includes an identification number and concerns the status of an application, its type, the lifecycle status and details about their alignment with the architecture.

Their solution is a local one, which cannot be accessed at same time by multiple users and which requires to be updated manually by stakeholders. Therefore, the model was outdated and not all of the metrics are valued.

The existent metrics are checked against the selection made in the previous section. Similar metrics are identified. They contain information about the applications' name, their delivery type, functional scope, security status and the processes they support. Therefore, the values of these metrics are mapped accordingly with the metrics selected.

The created data-driven workflow is used for assessing several applications and provides input for populating the data for the dashboard creation.

4.7 Creating the dashboards

In this section, the creation of the dashboard is presented.

The data-driven workflow represents the main data stream for the dashboard. Custom dashboards can be created for all the involved stakeholders. The customization is created based on the Figure 4.6 and the metrics assigned to each stakeholder in the data-driven workflows.

The data required for populating the dashboard couldn't be obtained in this case due to privacy regulations, therefore assumptions have been made for creating a set of dummy data that can serve as a proof of concept. The data set is based on the following assumptions:

- all applications are functional
- latest retirement date is 2030
- all applications have a wide accepted business standard indicator and are architectural compliant
- the strategic indicator ranges from 1 to 10

Classified as a Decision Maker, with high interest and a leading attitude in Section 4.2, the Application Portfolio Manager is also the only stakeholder involved in all the phases of the APM decision-making process presented in Section 4.3.

The assessment of the metrics considered useful for supporting the Application Portfolio Manager from Section 4.4 indicated a need for having a high-end view of the application landscape and the strategic importance. Therefore, the implication for the dashboard design consists in attributing this stakeholder the "Adult" BI level and it should provide an overview over the application portfolio that can easily be created with the metrics identified through the expert judgement.

Considering the responsibilities of this stakeholder in each phase of the APM decision-making process, additional features should be included for better assistance.

In order to analyze the data and create the dashboard, first it is required to connect Tableau to the data source. The software divides the data in two main categories: dimensions and measures. Dimensions are fields that cannot be aggregated, such as the lifecycle state or the delivery type of an application. Measures are fields that can be used for mathematical operations or indicating values to the sizes of markers, such as the costs or the investment value for an application.

Due to this automated step of the tool, it is necessary to check that this step has not affected other aspects of the data. In this case, the only required change is for the fields that included a date format, such as the field indicating the lifecycle value. Since the initial values are turned to dimensions, it is was required to specify the desired date format.

Before creating the visualizations in Tableau, the data set is grouped using the Hierarchy feature, that acts like a data model, connecting records from different fields through links. The use of the feature enhances future interactivity of the user with the design through the drill-down options, providing easy access to multiple information points.

For example, this feature is used for showing the operationality or the functionality of the application. Both metrics are defined as aggregated metrics, as an average of other three metrics. The stakeholders can identify the operationality of the applications through the aggregate metric Operationality, defined in Section 4.6 and prioritize those which require improvements or are not operational.

An Application Portfolio Manager can identify how many applications are not operational or require improvements using the vizualization presented in Figure 4.10. The colour filter is used for showing the type of Operationality in this case, however it can also be used for indicating a urgency. For example, if an internal threshold is set on how many applications should fall under a specific category, the colour filter can be applied on the number of records.

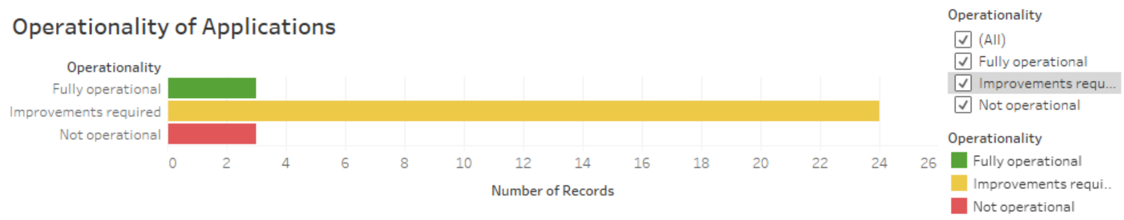

Figure 4.10: Visualization for investigating the number of applications that are operational

Considering that this information is based on assessment of different stakeholders, strong disagreements can exist, as presented in Section 4.4. Hence, this feature allows the user to investigate through the expansion of the data, as shown in Figure 4.11. A further expansion allows the user to easily identify the application names. Filtering and sorting of the visualization in this case can be done through any of the metrics used, such "Operationality", the underlying metrics, or the "Application Name". The same visualization is created for assessing the functionality of the applications.

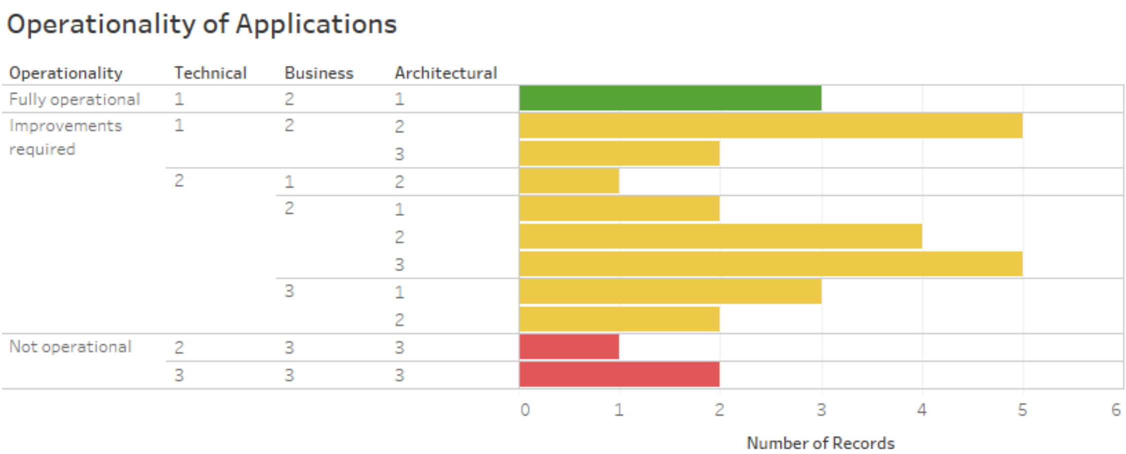

Figure 4.11: Visualization for investigating the operationality

A new metric "Readiness" is created as an average of "Operationality" and "Functionality" for supporting the Application Portfolio Manager in prioritizing applications. To facilitate the identification of strategic relevance of the applications, the hierarchy structure "Strategic Relevance" is constructed and its visualization can be depicted in Figure 4.12.

The first metric, namely the "Support tier", supports identifying the business relevance of the applications. The strategy term helps the user determine the nature of the supported processes and capabilities. The "Functional Scope" metric indicates in which department the application is being used. Additional metrics included for the strategic relevance are the "Security status", "Strategic id" and the "Investment value" and "Risk". The values of these metrics can be investigated by the user with a click on the headers, which will expand the visualization.

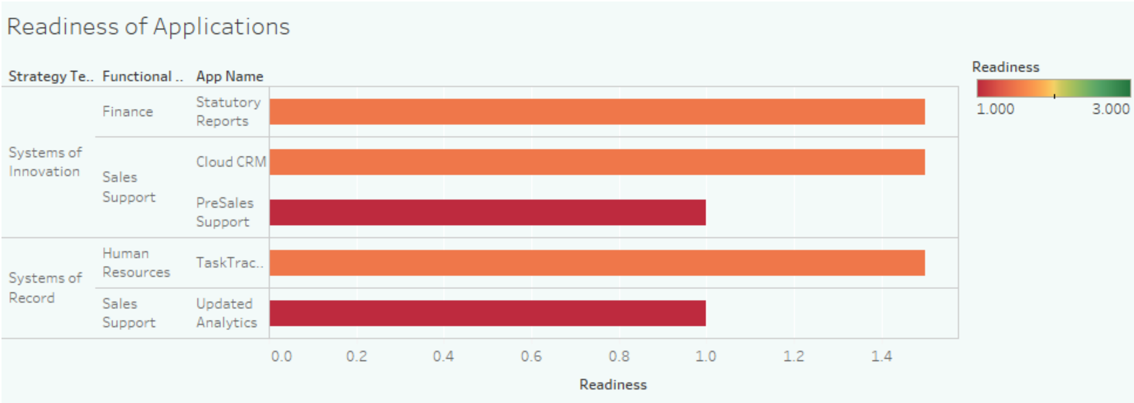

Figure 4.12: Visualization for investigating the strategic relevance

Different visualizations can be used to analyze the development costs against different criteria. Bar charts are used to present the development costs grouped by the supporting strategy term and the functional purpose of the applications in both Figure 4.13 and Figure 4.14. However, the usage of the colour makes a significant difference in the visualizations and has a different meaning. In Figure 4.13 an emphasis is put on the amount of money spent. While the absence of this feature would still support identifying how costs are spent across different departments, its usage is important when values are similar and the difference is not necessarily significant.

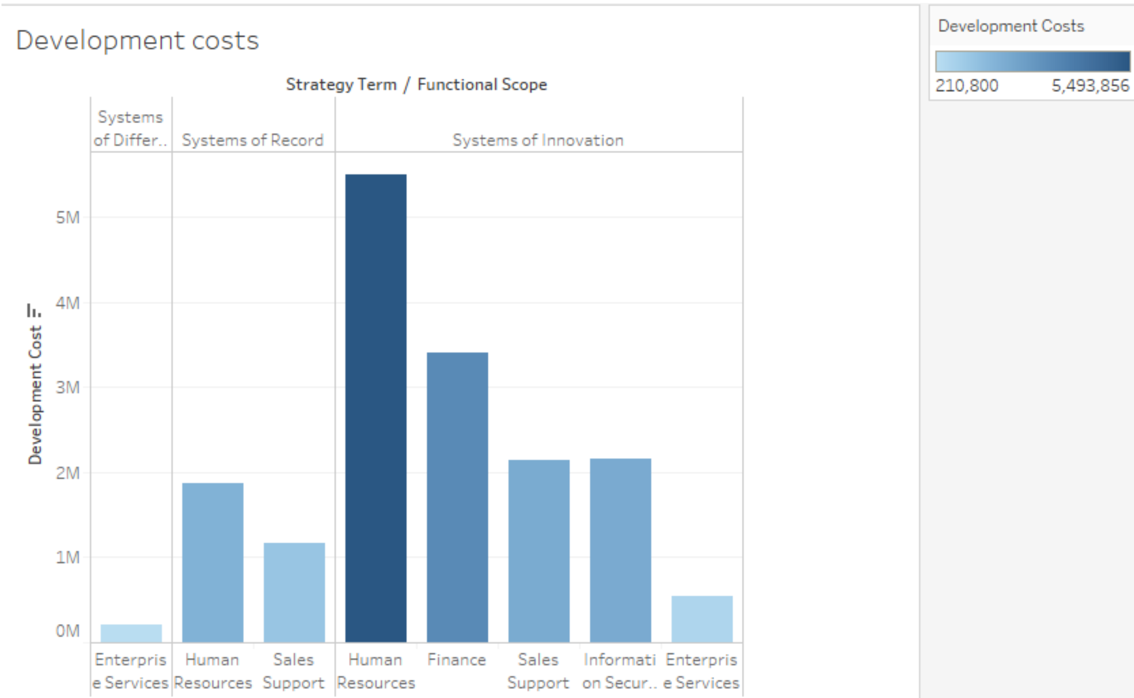

Figure 4.13: Visualization for investigating development Costs

In Figure 4.14 the colour feature helps creating a stacked bar chart with multiple measures. The new visualization indicates the diversity of the lifecycle state of consisting applications, where applications who are outdated will be at the top. The colours support an easier identification of bottlenecks. The tooltip feature also provides more information when the visualization is being investigated, such as the exact value of the development costs. For example, through this visualization an Application Portfolio Manager would easily identify that a significant amount of money is spent on outdated applications, therefore it would support him in taking decisions regarding the application landscape rationalization. In addition, the filter on the Investment risk metric allows investigating the costs associated with applications that have a high risk.

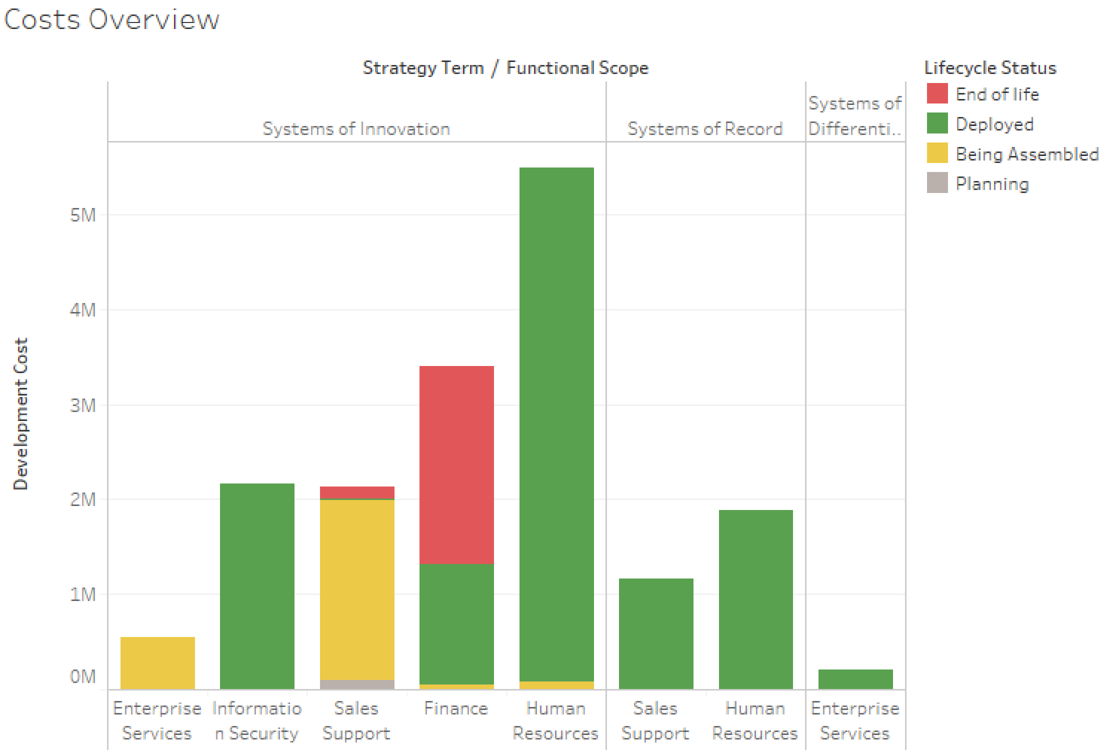

Figure 4.14: Visualization for comparing costs against strategy term

A dashboard has been constructed in order to demonstrate how different visualizations and their interaction can be used for supporting decisions and is presented in Figure 4.15.

The pie chart depicts the value of the "Return on Investment" for the application portfolio categorized by the support tier, illustrating the business relevance. When investigated, the visualization also provides information about the "Investment value" for each of the support tiers. Moreover, the visualization acts as a filter for the other visualizations included in the dashboard.

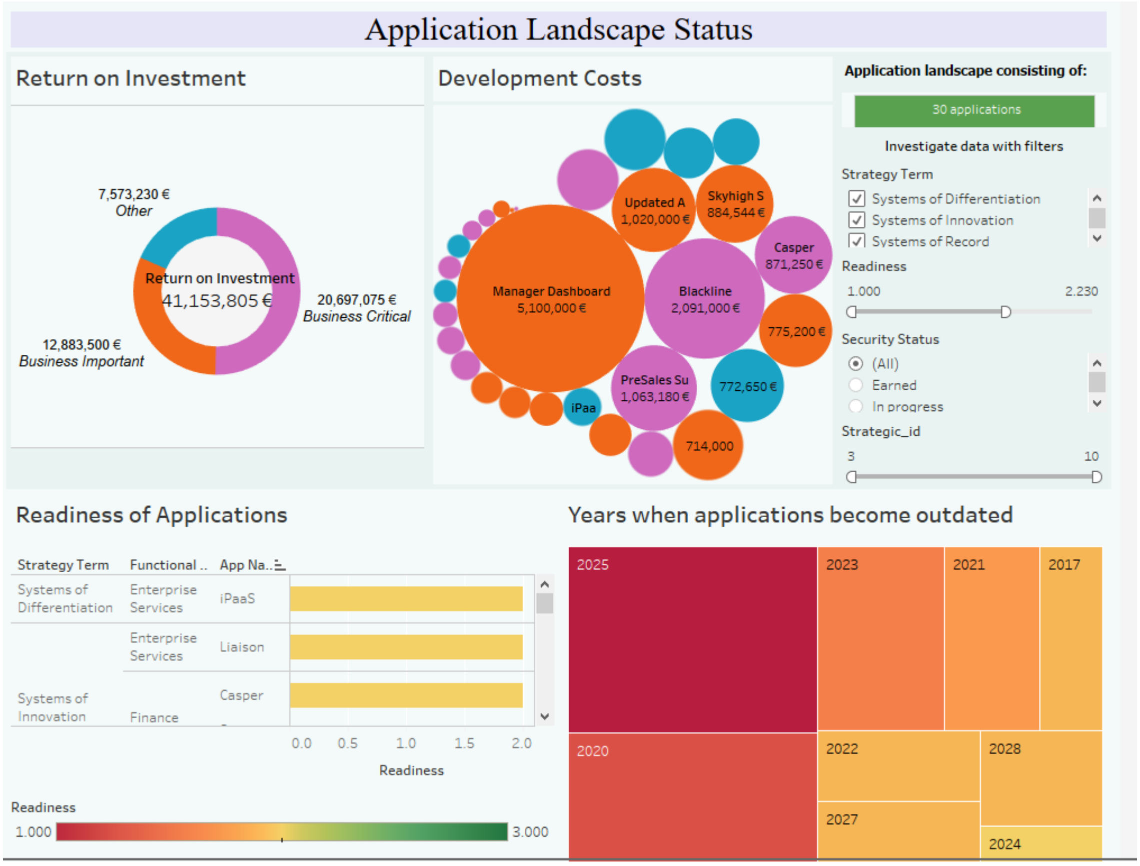

Figure 4.15: Dashboard Visualization

Once a specific tier is selected on the the pie chart, the information presented is changed. For example, Figure 4.16 presents information only for the applications that support Business Critical tier.

Furthermore, additional filters can be applied on the strategy terms and the readiness of the applications. Moreover, in this dashboard a different visualization is used for indicating the affiliated development costs. This decision is taken due to the flexibility offered by the interactivity based on strategy terms.

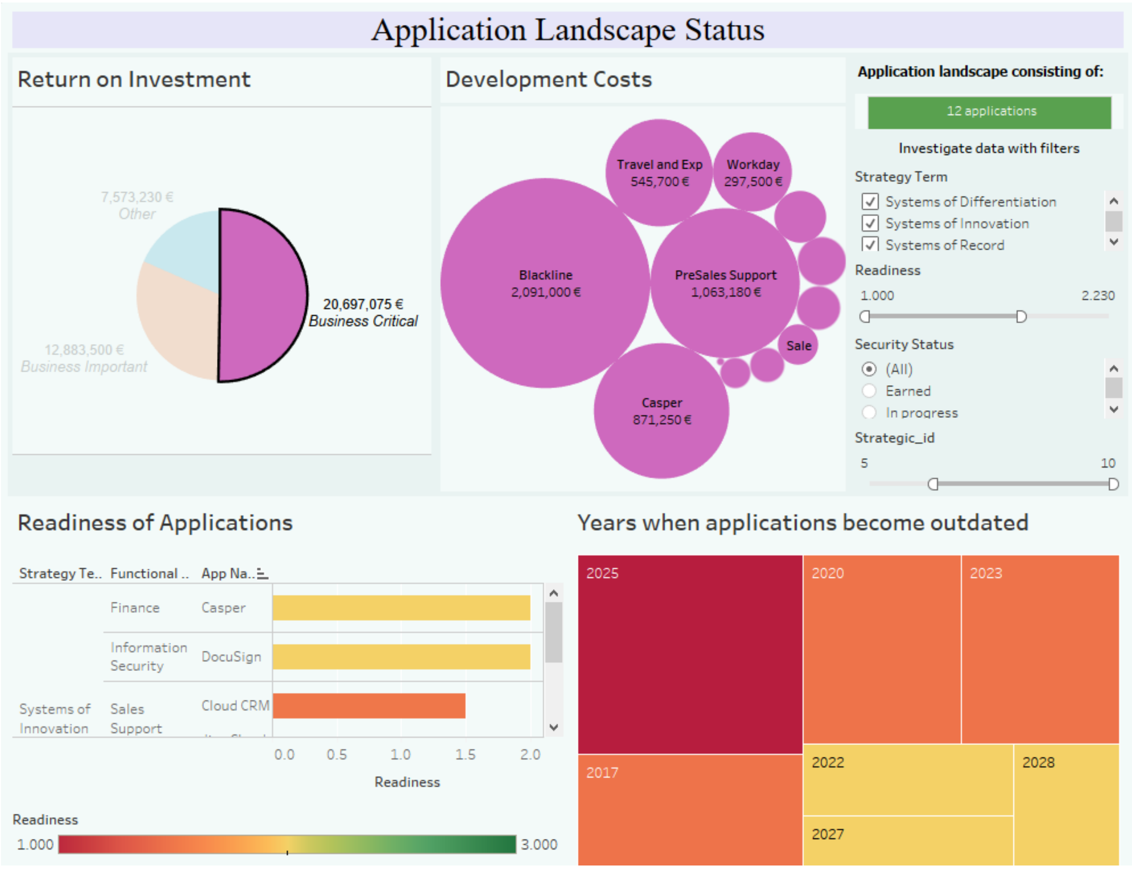

Figure 4.16: Dashboard Visualization based on interaction

The chosen features and visualizations are expected to support a Application Portfolio Manager in gaining an high-end perspective on the strategic importance of the applications and their assessment. Moreover, the decisions taken for the design align to the best practices suggested by Heikkinen and Kostakos (2012).

The designed method provides the guidelines for a framework that supports organizations in their APM ecision-making process. The first step provides the means to identify and assess the stakeholders involved in the APM decision-making process. When developing the dashboard only two of the criteria used in the assessment are being considered, namely the Power and the Interaction.

The process models are considered useful when assessing the current practice. The simplicity of the representation makes it easy to discuss possible changes with different stakeholders. They provide a starting point for the design of the data-driven workflows by providing a holistic perspective over the interactions required in the decision-making process. They indicate the stakeholders, the information flow, required resources and help identifying potential bottlenecks.

The metrics identified support the creation of an inventory and are regarded as being useful in the APM decision-making process. Their assessment by the local experts supports their classification per each stakeholder considered. Differences in the perceptions of stakeholders are interesting to analyze. A strong agreement is identified for the Application Portfolio Manager and Enterprise Architect. This could be explained by the fact that local experts work for a consultancy company specialized in EA, therefore they might have more knowledge about the related responsibilities due to their positions. Another explanation could be the fact that these two positions are the most emphasized in the academic literature.

The strong disagreement regarding the positions of a Project Manager and a Business Analyst could also be explained through different knowledge and few emphasis on these two positions in the academic literature. Moreover, since academic literature highlights the strong connection between project management and APM, it is surprising that only a few form the metrics identified address the needs of a Project Manager within the APM decision-making process.

Several methods of valuation have been identified and implemented to support the needs of stakeholders. The aggregated metrics are considered a good approach for considering different perspectives in a structured way. Not only they are relevant for the assessment of an application, but they can indicate strong disagreements between stakeholders which can be caused by a lack of knowledge. This provides an opportunity to identify when employees need to be trained for gaining experience with using new applications for example.

While most of the methods identified in the literature are easy to understand, their implementation can be quite challenging. The differences between the values introduced and the values that are desired to be displayed require different data formats. Moreover, when implementing the valuation methods, possible mistakes need to be considered and validation for the input provided by users has to be created. Therefore, the agile design is a good approach as changes can be implemented while testing.

The use of the data-driven workflow replaces the need of some different documents suggested throughout the stakeholder involvement theory. They provide the means to capture relevant data about processes, stakeholders, data, and changes in a single place. Moreover, the access to this information can be much easily controlled by senior management. Moreover, in the APM decision-making process, their use maintains the information updated in real-time in a single location and accessible to different stakeholders at the same time.

The dashboards present aggregated information in an interactive way which include metrics considered useful for a particular stakeholder. Different data can be displayed through various visualizations and features can be used for indicating an immediate action point.

5 Evaluation

This chapter presents the evaluation process regarding the implementation of the proposed method. The evaluation process is an essential step in the DSRM as it evaluates the outcome and the impact. This process is expected to measure the quality of the proposed designed method towards supporting a specific objective.

For this research, the evaluation process is conducted by organizing a workshop consisting of four experts in this field. During this workshop, the use of the designed method in the case study is presented by the author. At the end of the workshop, each of the participants is asked to fill in a survey as part of the evaluation of the method and as feedback for the author.

Section 5.1 offers further details about the construction of the survey, followed by the summary of the survey results in Section 5.2.

5.1 Survey

This section presents the construction of the survey and justifies the questions included. The survey is conducted with the aim of evaluating the method and to receive feedback regarding the proposed method. The survey is regarded as a qualitative analysis, as it aims to collect the subjective judgement from different experts, who, in this case, are practitioners from the related industry.

The successful implementation of any information technology depends on user acceptance. Venkatesh et al. (2003) integrates core elements from different models and theories for predicting and describing the adoption, acceptance and use of new technologies and proposes a unified model, referred as the Unified Theory of Acceptance and Use of Technology (UTAUT). This model provides a useful tool for managers and researchers to assess the user acceptance and elucidates the usage behaviour on similar technologies. The use of this model aims to provide insight on acceptance drivers so that solutions can be tailored for users who may be less likely to embrace and use new technologies. Because of its capability to explore the technology acceptance and usage, the UTAUT model is used to formulate the questions and the statement for the survey used in the evaluation.

Several constructs are regarded as being significant for impacting behavioral intention and usage behavior. The original model has been extended, as different constructs should be considered depending on the context (Venkatesh et al., 2003, 2012). More specifically, in an organizational context, four constructs play a significant role as direct determinants, namely the performance expectancy, effort expectancy, social influence, and facilitating conditions. Although indirect determinants, several other constructs, such as attitude toward using technology, self-efficacy and anxiety can be considered. In a consumer context, additional constructs, such as hedonic motivation, price value and habit (Venkatesh et al., 2012) are recommended to be considered. The extended version of the model includes more factors, which makes it more relevant when used for a product or service oriented research.

The method proposed in this study aims at improving the decision-making process within an organization to support relevant stakeholders. In organizations, new technologies are implemented to assure business growth (Khosroshahi et al., 2016; Sun et al., 2016). This happens because organizations need to stay ahead of the competition or to keep up with emerging technologies (Cognizant, 2014). Such decisions are taken by the senior management.

The constructs included in the extended UTAUT model address perceived enjoyment of an user, related costs, and willingness to change an existent habit. However, in an organizational context, users are not responsible for the costs affiliated with introducing new technology, as the costs are covered by the organization. Moreover, since decisions are taken by the senior management, employees have to adapt.

For this study, the framework for predicting technology acceptance in an organizational context is used (Venkatesh et al., 2003) as the senior management is expected to implement this method aims to improve the decision-making process. Thus, through this evaluation, further advice for the implementation of this method can be offered to senior management to improve its adoption.

However, if the method proposed would be incorporated in a single platform, it could be considered as a product that can sold to the clients. In such a context, the extended UTAUT model should be used for evaluation, which is more appropriate for a consumer use context.

According to the original UTAUT model, four factors influence the usage of the method: performance expectancy, effort expectancy, social influence, and facilitating conditions. Several other factors are regarded as moderators towards user acceptance, such as gender, age, experience and voluntariness of use. Since these constructs have an indirect determinant of intention and these characteristics are similar among the participants, they are not included in this thesis.

The author proposes eight main constructs with 31 items that should be considered (Venkatesh et al., 2003). The complete list of the items regarded as important in estimating UTAUT are explained in the Appendix .2. Table 5.1 presents the six items from this list that are used further to formulate the survey statements.

Table 5.1: List of constructs for estimating UTAUT (Venkatesh et al., 2003)

Construct	**Definition**	**Items**
Performance Expectancy	The degree to which an individual believes that using the system will help him/ her to attain gains in job performance	U6: I would like to use the proposed method as it is considered helpful. RA1: Using the proposed approach would improve my job performance. Using the proposed approach enables me to accomplish tasks more quickly. RA5: Using the proposed approach increases my productivity.
Effort Expectancy	The degree of ease associated with the use of system	EOU6: I would find the proposed method easy to use. EOU3: My interaction with the proposed method will be clear and understandable. EU4: Learning to use the proposed method is easy for me.
Attitude towards using technology	An individual's overall affective reaction to using a system	A1: Using the proposed method is a good idea. AF1: The proposed method makes my work more interesting. AF2: I look forward to those aspects of my job that require me to use the proposed method.
Facilitating Conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system	PBC2: I have the resources necessary to use the proposed method. PBC3: I have the knowledge necessary to use the proposed method. PBC5: The proposed method is compatible with other systems or tools I use for my work.
Self-efficacy	Judgment of one's ability to use a technology (e.g., computer) to accomplish a particular job or task	I would use the proposed method: SE4: If I could get help from someone if I got stuck SE7: If there is built-in guide for assistance
Behavioral Intention to Use	A person's perceived likelihood or subjective probability that he or she will engage in a given behavior.	BI1: I intend to use the proposed method in the future to help me completing my job. BI2: I predict I would use the proposed method in the future to help me completing my job. BI3: I plan to use the proposed method in the future for helping me when dealing with the clients.

5.2 Workshop Result

This section presents the results of the small workshop performed for evaluating the proposed method in this research. The workshop was organized at the BiZZdesign company. At the end of the workshop, participants were asked to fill in a survey.

In the evaluation, three questions are asked about participants' background and knowledge, namely their position in the company, the frequency of being involved in the APM decision-making process and the familiarity with the main concepts presented in this research. The constructs of UTAUT are furthermore considered and they address performance expectancy, effort expectancy, attitude towards using technology, facilitating condition, self-efficacy, and behavioral intention to use the system. The complete survey can be found in Appendix .3.

The findings of the survey provide valuable insights about the study. The survey responses can be found in Appendix .4. The findings of the survey will be discussed in detail as follows.

5.2.1 Background

Position in the company

The participants of the workshop consist of four experts from the BiZZdesign company. They have different positions in the company: two of them are Consultants, one being Presales Consultant and the other one Research Consultant, while the other two are researchers, namely one is Senior Researcher and Research Engineer. The research is performed under the Research and Development department of BiZZdesign, hence some of the participants have a background in research. Moreover, two of the participants are Consultants, therefore they support their customers in using the software tools provided by BiZZdesign. Thus, it becomes important to evaluate how the proposed method can add value to BiZZdesign's customers.

Involvement in APM decision-making

Two of the participants mentioned that they are never involved, while the other two answered that they are rarely involved. One of the Consultants mentioned that even he is not directly involved in the decision-making process, he does support their customers indirectly with advice regarding their internal processes.

Familiarity with the main concepts of the method

The concepts included in the survey are APM, Stakeholder Analysis, EA, Data-Driven Workflows and the Dashboards. Based on the answers presented in Figure 5.1, it can be concluded that all participants are familiar with the EA, while only three of them are also familiar with the other concepts apart from the Stakeholder Analysis.

The answers are not surprising. Firstly, since BiZZdesign is a consultancy company specialized in EA and the positions held by the participants are directly involved with either research or providing consultancy, the employees have the necessary knowledge in this field. Moreover, as shown by literature in Section 2.4, EA is strongly interrelated with APM. Secondly, the software tools offered by the company also provide the means for supporting APM, therefore they require the knowledge for addressing their customers' needs. The software tools also include some of the capabilities involved in the design method, such as workflows and dashboards. Building on the previous question, although the participants of this survey are not directly involved in the decision making process regarding APM, they are knowledgeable in the field.

Only two participants mentioned that they are familiar with Stakeholder Analysis, more precisely the ones who have the role of a Consultant. In their role, they require to understand their customers to create the results based on their needs. Therefore, they are more familiar with the stakeholder analysis if compared to other participants with different roles.

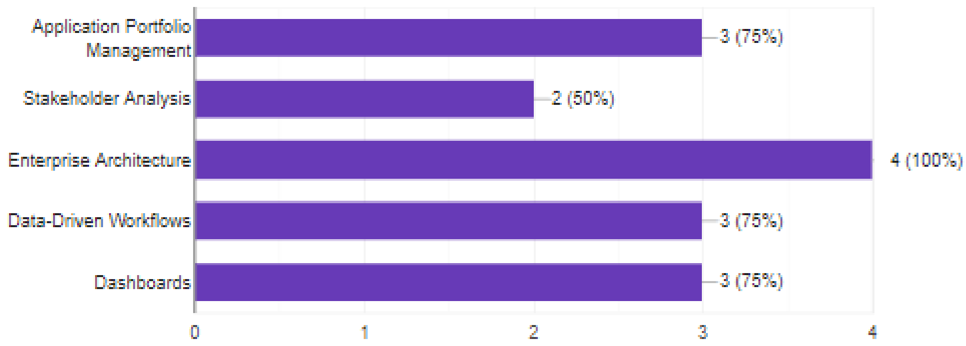

Figure 5.1: Participants Familiarity with the main concepts presented

5.2.2 UTAUT constructs

The results of the survey regarding the six aspects of the UTAUT model will be discussed in detail. The questions for this part are related to the user acceptance of the proposed method.

Descriptive statistics of the survey are presented in Table 5.2 to describe the main aspects of the data and to summarize the findings of this survey. The measures considered in this table refer to the minimum and maximum value and the total value of all the values filled by the participants. Moreover, the mean is calculated per question and also per construct together with the standard deviation. The standard deviation is used to measure the dispersion of the values around the central tendency.

Table 5.2: Descriptive Statistics

Question	Number of participants	Minimal Value	Maximum Value	Sum	Mean	Standard Deviation
PE-1	4	4	4	16	**4.00**	**0.00**
PE-2	4	2	3	11	**2.75**	**0.50**
PE-3	4	3	3	12	**3.00**	**0.00**
PE-4	4	3	4	13	**3.25**	**0.50**
EE-1	4	2	5	13	**3.25**	**1.50**
EE-2	4	3	4	13	**3.25**	**0.50**
EE-3	4	3	4	14	**3.50**	**0.58**
ATT-1	4	4	4	16	**4.00**	**0.00**
ATT-2	4	2	4	12	**3.00**	**0.82**
ATT-3	4	2	4	12	**3.00**	**0.82**
FC-1	4	1	4	10	**2.50**	**1.29**
FC-2	4	3	5	16	**4.00**	**0.82**
FC-3	4	4	5	17	**4.25**	**0.50**
SE-1	4	1	4	11	**2.75**	**1.26**
SE-2	4	1	4	11	**2.75**	**1.26**
BIU-1	4	1	4	10	**2.50**	**1.29**
BIU-2	4	1	4	11	**2.75**	**1.26**
BIU-3	4	3	4	15	**3.75**	**0.50**
Average PE	-	**3**	**3.5**	**13**	**3.25**	**0.25**
Average EE	-	**2.67**	**4.33**	**13.33**	**3.33**	**0.86**
Average ATT	-	**2.67**	**4.00**	**13.33**	**3.33**	**0.54**
Average FC	-	**2.67**	**4.67**	**14.33**	**3.58**	**0.87**
Average SE	-	**1.00**	**4.00**	**11.00**	**2.75**	**1.26**
Average BIU	-	**1.67**	**4.00**	**12.00**	**3.00**	**1.02**

In this survey, a five-level Likert scale was used, therefore possible answers include Strongly disagree, disagree, neutral, agree and strongly agree. Each of these answers is converted to numerical values from one to five based on the scale. Therefore, values ranging between one and two indicate negative feedback, three means neutral and upper values indicate positive feedback. Thus, the higher the value means the feedback is more positive.

The mean, as it indicates the overall trend, and the standard deviation, which shows the difference in the perception of the participants, are the main focus for this analysis. Their values are depicted in Figure 5.2.

The mean value for each question ranges from 2.50 to 4.25. The mean value for 16 of the questions is equal or above 3, with 9 of the values above 3.25 showing a positive acceptance towards the proposed method and 7 being neutral. The most positive feedback is recorded for FC-3 with a value of 4.25, and the lowest value of 2.50 by SE-1 and BIU-1. The most positive feedback is indicated regarding the compatibility of the method with the systems used in the company. This could be explained through the fact that the tools used throughout the method are products of the company, such as the Enterprise Studio, or the capabilities created can be easily integrated with their tools, such as the executable workflows or the dashboards. The lowest values are indicated regarding the integration of the method with the daily jobs of the participants. The results don't necessarily indicate a resistance regarding the usage and acceptance of the method. Since the participants indicated that they are not directly involved with the APM decision-making process, it is assumed that they might not intend to use the method because it is not required for their positions.

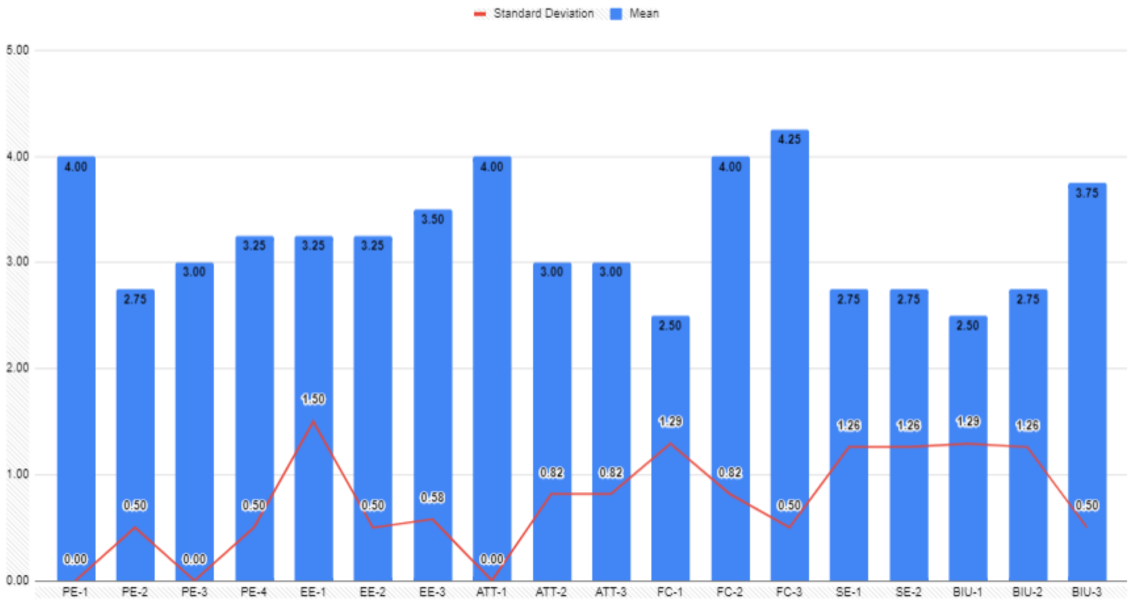

Figure 5.2: Mean and Standard Deviation Summary

Considering the standard deviation, a value equal with zero shows a strong agreement between the participants, meaning that a higher value than 1 means a lot of variation. Looking at the values, for some questions, there is some amount of variation in the answers. However, there is a strong agreement for three of the questions, namely PE-1, PE-3, ATT-1. A strong agreement is identified regarding the performance expectancy and attitude towards technology. Regarding the performance expectancy, the participants have a strong agreement regarding the helpfulness of the method. Moreover, the participants show positive feedback and a strong agreement indicating that the method is a good idea. This could be explained by the fact that the method provides the necessary steps for addressing the stakeholders' needs in the APM decision-making process.

For six of the questions, the answers are quite different. The highest value for the standard deviation is 1.50 for EE-1. The strongest disagreement is identified regarding how easy is to use the method. The participants have different positions, some of them might not be familiar with the presented concepts. This could be one of the reasons for their disagreement.

A detailed analysis is discussed for each of the constructs in the next subsections.

Performance Expectancy

Based on the answers regarding the performance expectancy of the method, it can be seen that all the participants agree that the designed method is considered helpful.

When asked about improving the productivity of their job performance, three of the answers were neutral, while one was negative. The answers also indicated a neutral response for the other two questions related to the performance expectancy. This can be due to the fact that none of the participants are directly involved in the APM decision-making process therefore the designed method would not necessarily improve their work, however they strongly agree that it is helpful. Moreover, the mean value of this construct is 3.25 indicates a positive attitude, while the standard deviation shows a common agreement.

In summary, the designed method is considered to be helpful, however the participants are neutral regarding its impact due to their lack of involvement in the decision making process.

Effort Expectancy

The questions are meant to evaluate the easiness of the proposed method.

As can be seen, participants have different perceptions regarding how easy is to use the method, with the highest standard variation value. While two of the participants disagreed that the method is easy to use, two other participants indicated they agree. A possible reason that two of the participants disagree is that they are not familiar with some of the concepts, especially with the data-driven workflows or the dashboards as indicated when asked about their background.

When asked about their expected interaction with the method, the answers indicated a neutral response from three of the participants and a positive one from the fourth. The designed method is quite broad and it requires involvement from different stakeholders, therefore it can be a bit confusing at a first glance.

Positive feedback is shown for learning how to use the method. It is important to note that two participants have a neutral opinion regarding this, which might also be explained by the usage of different tools throughout the method. The mean value for this question was 3.50, the highest for this construct.

In conclusion, the result implies that for effort expectancy, even though it might not be easy to use the method, it will be easy to learn and get familiar with it.

Attitude towards Technology

In this subsection, the attitude towards using technology was assessed. All the participants agreed that using this method is a good idea. More, this supports the first statement where all the participants agree that the method is considered useful.

However, there is quite some variation in the answers regarding the other two statements regarding the attitude towards technology. Two of the participants indicated that they have a neutral opinion when asked if the method would make their work more interesting and their enthusiasm for being engaged with the method. An assumption is made that since they are not directly engaged with the decision-making process it might be difficult to estimate how the application of the method can impact their work. Moreover, the statement is subjective and participants can have different definitions when it comes to what makes their work "interesting".

Also, an interesting aspect is that even though some participants were neutral about how the method can make their work more interesting, one of them agreed that he is enthusiastic to work with the new method while another disagreed. Also, a participant agrees that the method would make his work more interesting, however, he was neutral when asked about looking forward to the aspects of his work that would require using it. This could be explained by the fact that different knowledge might be required in the process or other factors could interfere, such as uncertainty, and the participants might react differently when asked to perform something new.

In the end, based on the overall results, the attitude regarding the technology is neutral, however, all the participants considered that the method is a good idea.

Facilitating conditions

The results of the survey related to facilitating conditions when using the proposed method are discussed in this subsection. Out of all aspects, this construct has the most positive feedback from the participants.

Based on the answers, it can be seen that the result is quite dispersed, however, it leans more on the negative side regarding the necessary resources for using the proposed method. This statement had the minimum value record for the mean, namely 2.50, also with the highest value for the standard deviation, 1.29. The usage of the method requires significant resources, from human resources to intellectual resources, thus a lot of planning is required in the process.

Therefore, it is understandable that the participants have different opinions, as their expected efforts are also different.

When asked about the necessary knowledge, the feedback was mainly positive. The participants agree that they have the necessary knowledge, and this aspect is considered important regarding the feasibility of the method. Moreover, all the participants agreed that the proposed method is compatible with the existent systems and tools they use for their work. This statement had the highest value recorded for the mean, more exactly 4.25. The main reason can be that the process models were modeled with Enterprise Studio, therefore, the created capabilities can be easily integrated into their tools.

In conclusion, the participants have the necessary knowledge for using the methods and it is considered that the method is compatible with the tools in the company. Although additional resources might be required, the overall result shows positive feedback regarding the facilitating conditions of the proposed method.

Self Efficacy

This subsection presents the self-efficacy aspect of the proposed method. Out of all the aspects, self-efficacy has the most negative feedback, but with the strongest disagreement between the participants.

It is assumed that opinions are so different because participants are not expected to directly interact with the method. Therefore, strong disagreements between the participants can be interpreted as the method is not necessarily expected to be used since their responsibilities don't require it. This is supported by the answers regarding their background.

Thus, for this aspect, it can be concluded that the participants don't expect to use the method as their positions do not require it.

Behavioral Intention of Use

The results regarding the intention of using the proposed method are presented in this subsection. It can be said that on average participants have a neutral opinion, however, opinions vary.

The assumption regarding the disagreement is that the participants are not directly involved in the APM decision-making process, therefore using the method is not expected from them. This is supported by the questions related to the self-efficacy construct and their background.

However, positive feedback was shown when participants were asked about using the method for dealing with their clients. The mean value for this question was 3.58, which is considered as high value. This means that the method is assumed to bring value to their customers.

In summary, the participants agreed that they would use the method for addressing the needs of their clients as is considered valuable.

To sum up the findings of this survey, in general, the participants gave positive feedback regarding for majority of the construct of the UTAUT model, namely performance expectancy, effort expectancy, attitude towards technology and facilitating conditions. The lowest score is recorded for the self-efficacy, based on the assumption that participants' roles are not directly related to the APM decision-making process. Moreover, the results show the most positive feedback for facilitating conditions, thus the participants are confident that they have the necessary knowledge to use the methods and the method is compatible with their organization.

Overall, the method is agreed to be helpful and expected to be used when addressing customer needs. This implies that the method is considered to be useful both for BiZZdesign, or other practitioners in the industry and also for their customers.

6 Conclusion

This research aims at improving the decision-making process in the APM through stakeholder involvement. This chapter presents various aspects regarding the research, which is presented in this thesis. In the beginning, the findings of conducting a systematic literature review, as well as a case study will be discussed in the first section. Then, the following section presents the contributions made as a result of this research. The last part of this chapter describes the limitations of the research, along with guidelines for possible improvements and recommendations for future research.

6.1 Discussion

The objective of this research is to articulate a method for an APM solution to help organizations improve their decision-making process. This objective is defined in the context of this research from the main research question ***" How can the APM decision-making process better support different stakeholder needs with the help of data-driven workflows?"***. To assist in answering it, the following five sub-research questions were formulated:

1. **RQ1:** What is the state of art in Application Portfolio Management (APM)?
2. **RQ2:** What kind of methods are available for the assessment of an organization's application portfolio?
3. **RQ3:** How can the practice of APM better address stakeholder needs?
4. **RQ4:** How to use data-driven workflows to make the process of APM executable?
5. **RQ5:** How can dashboards support different stakeholders in the APM decision-making process?

As a result of this research, the proposed method is expected to support organizations to improve their decisions regarding APM by addressing the needs of the stakeholders involved in the process. The proposed method consists of six sequential steps that need to be carried out. Besides, several key attributes are identified, classified and operationalized for contributing to a thorough application inventory and a reporting capability for each of the stakeholders involved through the use of the data-driven workflows and dashboards.

The systematic literature review presented in Chapter 2 contributes to the necessary knowledge for developing the method. The findings of the literature review answer the first two sub-research questions regarding the state of the art in APM and the existent methods that are available for its assessment. The literature review shows that APM is regarded as a necessary practice that organizations need to align their business with IT strategies to create value and to improve their business performance from their IT investments. More specifically, APM provides the means to perform a thorough assessment of the capabilities of an organization across all its functions and enabling senior management to plan accordingly. This supports improving the strategic alignment by reducing the complexity of the application portfolio, reducing costs and making better decisions that deal with uncertain information.

To answer RQ1, APM provides several transformation strategies that organizations can follow in order to optimize their application portfolio. These are presented under different names, however, all of them indicate similar decisions, namely a further investment, for creating new applications or modifying existing ones, outsourcing, or retirement. However, the information required for choosing a transformation strategy can result in a large amount of data. This happens mainly due to the emerging technologies, increasing accessible data sources and the integration between the application landscape with other business capabilities. The data complexity issue forces decision-makers to struggle when making decisions, due to incomplete or unreliable information.

With regards to RQ2, several methods and frameworks are developed to support organizations to clearly visualize the state of their application portfolio and define a transformation strategy. Two methods are identified from the literature as being complete and addressing the complexity of APM. To identify if best practices align with research studies and potential differences, two other approaches are selected from the gray literature. Along the time, the methods are building upon existing ones and follow the same steps in the decision-making process: creating an application inventory, conducting an assessment and making decisions for possible transformations. A striking difference between academic research and gray literature consists of the factors considered in the decision-making process, where the industry is considered. Their enhancement requires a holistic perspective, where the purpose of each application is known and is mapped to existing resources, processes and data.

The APM decision-making process can be enhanced by two important concepts, namely EA and DM. Recommended as a strong concept for coping with complexity, EA can enable change by determining the level of architectural awareness and the level of integration of the architecture with the organization. Providing a high-end view offers a common and integrated understanding and enforces compliance and transparency over the business processes. DM can, therefore, support by capturing this explicit knowledge about an organization's data and systems. This can provide a starting point for future decisions regarding the application landscape, together with the improvement of their business processes and data quality. With data being a vital aspect of all the three practices mentioned, this research focuses mainly on how the data complexity issue can be addressed by the means of the data-driven workflows and dashboards.

Furthermore, based on literature, the complexity and the dynamic nature of the APM approach requires structured and transparent decision-making that embraces a diversity of knowledge and perspectives. Active participation of the stakeholders, cross-functional teams and senior management support are regarded as critical success factors of APM, therefore the practice of stakeholder involvement is chosen to be integrated within the decision-making process.

The last three sub-research questions are answered together throughout the Chapters 3 and 4. For this reason, the answers for these questions are discussed together.

Chapter 3 provides an answer for RQ3 and presents the proposed method and a detailed description of its steps together with the expected output. The method consists of six steps that need to be performed in sequential order. Throughout the consisting steps of the method, stakeholders, their needs and expected collaboration throughout the decision-making process are identified.

To answer RQ4, data-driven workflows are used for improving the collaboration between stakeholders while addressing the data concerns that can appear. Moreover, the use of the data-driven workflow replaces the need of different documents suggested in the stakeholder involvement theory and brings automation to the APM decision-making process. The solution of gathering the data from different stakeholders by using workflows is much more powerful than updating them in different sources, as it becomes the system of record for application metrics transformation. The mapping with data objects supports alignment with architecture assets within a central repository and enables stakeholders to work from a single source of information and helps organizations to gain a business-wide visibility of the data.

A dashboard contain custom-made visualizations on a single page that support stakeholders to make informed decisions. Regardless of their technical or non-technical background, stakeholders can easily interact with the visualizations to explore large and complex data sets and inspecting specific elements through drill-down options. The assessment of involved stakeholders contributes to a better experience, as users benefit from the custom-made design which match their interests and needs. To answer RQ5, the user-centric design of the dashboard provides each stakeholder with the necessary knowledge for making sound decisions regarding the APM and represents a communication tool with other team members.

To demonstrate the usage of the method in a real situation, a case study is provided in Chapter 4. Subsequently, the case study is discussed in a workshop attended by four participants from a company as part of the evaluation. The findings of the evaluation indicated that the proposed method is agreed to be helpful and expected to be valuable when addressing customer needs. A detailed analysis of the results is presented in Chapter 5 of this research.

6.2 Contributions

This section presents a summary of the contributions of this research to theory and practice. Both aspects will be explained briefly subsequently in the following subsections.

6.2.1 Theory

This research has started by recognizing the idea that the interests of stakeholders need to be considered and addressed to support the improvement of the APM decision-making process. Findings of the literature study confirm that little emphasis exists on the stakeholders, their involvement, concerns and needs in the APM decision-making.

Stakeholder theory indicates the importance of an explicit classification model and, in addition to that, an identification method as the first step in stakeholder involvement. However, in academic literature, such a stakeholder approach seems to be lacking.

Therefore, in this research, potential stakeholders that should be involved in the APM decision-making process have been identified and their responsibilities and the information they require have been analyzed. The approach provides insights into how certain stakeholders should be involved and managed through the APM decision-making process. A framework is created for assessing importance and usefulness of relevant metrics by local experts, to provide customized information for different roles.

In this research, it is presented how data driven-workflows can be utilized to ensure consistency between an enterprise model and the actual information systems. This modeling approach supports addressing the data complexity issues and enhancing the collaboration between stakeholders in the APM-decision making process. The use of data-driven workflows brings automation to the APM decision-making process by linking data assets, business processes, applications, and the infrastructure.

A different way of visualizing information is introduced through the use of dashboards. The method supports creating custom-made visualizations for stakeholders in order to compare different business scenarios and to ensure that their decisions are based on real-time and accurate information.

The method proposes a new data modeling approach for the APM decision-making process, where stakeholders' needs are central, and ensures clear relationships between the organizational assets empowering stakeholders to improve their efficiency.

6.2.2 Practice

In practice, this research has several contributions and they are presented as follows.

The proposed method can be used by organizations as a guideline for improving their APM decision-making process. The steps mentioned in the method need to be researched and developed to best suit the organization's characteristics and needs, however, the method is easy to use and understand.

Organizations require a comprehensive portfolio understanding of the inherent relationships and dependencies between applications (Zelt et al., 2013b). This method supports senior management for implementing the necessary capabilities for gaining a holistic view and supporting their employees throughout their daily tasks with regards to APM. Moreover, guidelines are being given on how to implement custom-made visualizations addressing the need of aggregated information identified through the literature review (Simon et al., 2010; Schneider et al., 2015). The metrics list and their classification can be used as a checklist when building their application inventory.

The data modeling approach by the use of data-driven workflows and dashboards provides the means for creating a framework with customizable interface for every stakeholder. This way, stakeholders are engaged and informed about the decision-making process, and given the chance of expressing their concerns, offering a solution to the challenges identified by practitioners (Erwin, 2017). More than that, the capabilities used become a record system for daily changes in the business processes, supporting senior management to assess work performance and stakeholder involvement and implement correcting strategies when required.

The proposed method can be considered useful for consultancy organizations to better address their customer needs. The research provides knowledge about best practices and indicates how existing tools can be improved.

6.3 Limitations and Future Research

There are several limitations to the research which are necessary to be mentioned. Recommendations for future work are built on the existing limitations and presented as well.

For this research, interviews with stakeholders could not be conducted, therefore assumptions were made based on the literature study and expert interviews. As academic literature only identifies the high-end positions and practitioners use more specific terminologies, there is space for misunderstandings regarding the necessary knowledge assumed for a certain position. It is expected that in some organizations the roles and responsibilities might not be clearly defined, however concrete interviews with actual stakeholders are expected to be more insightful.

Moreover, several stakeholders which were regarded as relevant were not included in the case study. In this research, assumptions about stakeholders contributions are made based on literature, where responsibilities within the decision-making process are not always clear defined. The exclusion is made in such a way that responsibilities of considered stakeholders are clearly defined, different and that stakeholders are directly involved in the decision-making process.

The selected stakeholders are considered enough to provide a proof of concept on how stakeholders' needs can be better addressed. The results are considered relevant and significant, as the findings from the metrics assessment by local experts align with responsibilities identified in the literature.

Although the case demonstration is based on literature, the method provides the necessary guidelines for implementing it in a organization. Therefore, further research could focus on a real-life context with an expanded selection of stakeholders. Furthermore, more attributes from the stakeholder analysis can be used for the customization of the dashboard design. For example, a governance model can be built based on the collaboration diagram and used as a validate method for access to data.

When operationalizing metrics, the valuation methods identified in literature don't necessarily address the complexity expected in an organizational setting. The tools chosen for this research can support more complex calculations, therefore a future research can focus on implementing more complex metrics calculations. In addition to that, mapping actual data objects and business processes is recommended to enhance the use of the metrics that only indicate their number.

A recommendation received in the evaluation for constructing the dashboards was to focus on more specific decisions and choosing metrics that build the knowledge for addressing it. With regards to the chosen tool, an academic version was used, therefore several limitations were encountered regarding the features and the number of visualizations that can be included. Therefore, other tools can be considered.

Lastly, the evaluation was conducted with a limited number of participants that are not directly involved in the APM decision-making process. A future iteration should consider stakeholders involved in the APM decision-making process to gather more feedback on potential improvements.

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Appendix 1

.1 Assessment Framework

This section presents the complete assessment by the four local experts for all the selected stakeholders included in this case study. The selected metrics for each individual stakeholder are presented, classified based on their average score.

Table 1: Assessment for CIO

Metric	E1	E2	E3	E4	Mean	STD
Strategic importance	4	5	5	5	4.75	0.50
Security status	5	4	4	5	4.5	0.58
IT investment	4	5	4	5	4.5	0.58
Investment value	5	5	3	5	4.5	1.00
Return on Investment	5	4	4	5	4.5	0.58
Investment risk	4	4	4	5	4.25	0.50
IT project status	5	4	3	4	4	0.82
Future value	4	3	5	4	4	0.82
Lifecycle state	3	4	5	3	3.75	0.96
Number of supported business processes	3	5	3	4	3.75	0.96
Architectural standard compliance indicator	5	3	4	3	3.75	0.96
Business standard indicator	5	4	2	4	3.75	1.26
Capability coverage	3	3	4	5	3.75	0.96
Deviation from standard	5	3	4	2	3.5	1.29
Operational excellence indicator	3	4	3	4	3.5	0.58
Application failure	4	4	3	3	3.5	0.58
Net present value	4	3	4	3	3.5	0.58
Estimated savings	4	3	4	3	3.5	0.58
Cost efficiency	5	3	2	4	3.5	1.29
Functional readiness	5	3	4	1	3.25	1.71
Application Lifecycle Duration	3	3	5	2	3.25	1.26
Number of incidents	3	4	3	3	3.25	0.50
Functional overlap/ redundancy	4	4	2	3	3.25	0.96
Operating costs	4	4	2	3	3.25	0.96
Functional scope	4	3	4	1	3	1.41
Expected development date	5	3	2	2	3	1.41
Technology diversity	2	4	3	3	3	0.82
Number of users	3	4	2	3	3	0.82
Incident processing time of an application	5	2	2	3	3	1.41
Expected retirement date	5	3	3	1	3	1.63
Revenue per User	4	3	2	3	3	0.82
Number of infrastructure elements	4	3	2	3	3	0.82
Number of supported business data objects	2	3	2	4	2.75	0.96
Number of applications	2	3	3	3	2.75	0.50
Return on Asset	1	3	4	3	2.75	1.26

Metric	E1	E2	E3	E4	Mean	STD
Application Age	2	3	3	2	2.5	0.58
Number of information flows / interfaces	2	2	4	1	2.25	1.26
Application size	2	4	2	1	2.25	1.26
Utilization indicator	2	2	1	1	1.5	0.58
Documentation quality	2	2	1	1	1.5	0.58

Table 2: Assessment for Project Manager

Metric	E1	E2	E3	E4	Mean	STD
IT project status indicator	5	5	5	5	5	0.00
Expected development date	5	5	3	5	4.5	1.00
Cost efficiency	3	4	3	4	3.5	0.58
Documentation quality	2	5	2	4	3.25	1.50
IT investment indicator	4	5	3	1	3.25	1.71
Return on Investment	3	4	2	4	3.25	0.96
Number of information flows / interfaces	4	4	1	3	3	1.41
Number of supported business processes	4	5	2	1	3	1.83
Technology diversity	4	4	1	3	3	1.41
Application size	2	5	2	3	3	1.41
Number of users	3	3	3	3	3	0.00
Expected retirement date	4	4	3	1	3	1.41
Strategic importance indicator	4	4	1	3	3	1.41
Future value	3	3	2	4	3	0.82
Estimated savings	3	3	2	4	3	0.82
Application failure	3	3	4	1	2.75	1.26
Number of incidents	3	3	4	1	2.75	1.26
Architectural standard compliance indicator	3	4	1	3	2.75	1.26
Business standard indicator	3	4	1	3	2.75	1.26
Functional overlap/ redundancy	3	4	1	3	2.75	1.26
Investment risk	1	4	3	3	2.75	1.26
Lifecycle state	4	3	2	1	2.5	1.29
Application Lifecycle Duration	3	4	2	1	2.5	1.29
Functional readiness	2	3	2	2	2.25	0.50
Deviation from standard	2	4	1	2	2.25	1.26
Functional scope	2	4	2	1	2.25	1.26
Security status indicator	3	3	1	2	2.25	0.96
Capability coverage	3	3	2	1	2.25	0.96
Number of infrastructure elements	3	2	1	3	2.25	0.96
Operational excellence indicator	3	3	1	1	2	1.15
Number of supported business data objects	2	4	1	1	2	1.41
Investment value	1	3	2	2	2	0.82
Return on Asset	1	3	2	2	2	0.82
Application Age	2	2	1	1	1.5	0.58
Revenue per User	1	1	2	2	1.5	0.58
Utilization indicator	2	1	1	1	1.25	0.50
Operating costs	1	2	1	1	1.25	0.50
Number of applications	1	2	1	1	1.25	0.50
Net present value	1	2	1	1	1.25	0.50
Incident processing time of an application	1	1	1	1	1	0.00

Table 3: Assessment for IT Manager

Metric	**E1**	**E2**	**E3**	**E4**	**Mean**	**STD**
Application failure	5	5	5	5	5	0.00
Number of incidents	4	5	5	5	4.75	0.50
Incident processing time of an application	5	4	5	5	4.75	0.50
Lifecycle state	5	4	5	4	4.5	0.58
Application Lifecycle Duration	5	3	5	4	4.25	0.96
Utilization indicator	4	4	5	4	4.25	0.50
Number of users	5	5	3	4	4.25	0.96
Operating costs	3	5	5	4	4.25	0.96
Number of infrastructure elements	4	4	4	5	4.25	0.50
Deviation from standard	4	4	4	4	4	0.00
Security status indicator	4	5	4	3	4	0.82
Operational excellence indicator	4	4	5	3	4	0.82
Expected retirement date	4	4	4	4	4	0.00
Strategic importance indicator	4	4	3	5	4	0.82
Functional readiness	2	4	4	5	3.75	1.26
Technology diversity	3	5	3	4	3.75	0.96
Documentation quality	4	3	3	5	3.75	0.96
Functional scope	2	4	4	4	3.5	1.00
Business standard indicator	4	5	2	3	3.5	1.29
Number of information flows / interfaces	4	3	3	3	3.25	0.50
Number of supported business processes	4	5	2	2	3.25	1.50
Capability coverage	3	4	3	3	3.25	0.50
Number of applications	1	5	3	4	3.25	1.71
Investment value	1	5	2	5	3.25	2.06
Future value	4	4	2	3	3.25	0.96
Application Age	3	3	3	3	3	0.00
Architectural standard compliance indicator	3	3	2	4	3	0.82
IT investment indicator	2	4	3	3	3	0.82
Investment risk	1	4	3	4	3	1.41
Expected development date	1	4	3	3	2.75	1.26
Application size	1	4	3	3	2.75	1.26
Return on Investment	1	4	2	4	2.75	1.50
Number of supported business data objects	2	3	2	3	2.5	0.58
Revenue per User	1	3	2	4	2.5	1.29
Functional overlap/ redundancy	1	4	3	2	2.5	1.29
Estimated savings	2	3	3	2	2.5	0.58
Cost efficiency	1	4	2	3	2.5	1.29
IT project status indicator	2	3	2	2	2.25	0.50
Return on Asset	1	3	2	3	2.25	0.96
Net present value	1	3	1	2	1.75	0.96

Table 4: Assessment for Application Portfolio Manager

Metric	E1	E2	E3	E4	Mean	STD
Strategic importance indicator	5	5	5	5	5	0.00
Functional readiness	5	4	5	5	4.75	0.50
IT investment indicator	5	4	5	5	4.75	0.50
Investment value	5	5	3	5	4.5	1.00
Lifecycle state	4	4	5	4	4.25	0.50
Expected retirement date	4	4	5	4	4.25	0.50
Operating costs	5	5	3	4	4.25	0.96
Number of applications	3	5	5	4	4.25	0.96
Application Lifecycle Duration	4	3	5	4	4	0.82
Number of incidents	3	5	3	5	4	1.15
Revenue per User	5	3	4	4	4	0.82
Capability coverage	4	4	5	3	4	0.82
Investment risk	5	4	3	4	4	0.82
Future value	5	4	4	3	4	0.82
Expected development date	4	4	4	3	3.75	0.50
Security status indicator	3	5	4	3	3.75	0.96
Number of users	4	5	2	4	3.75	1.26
Number of infrastructure elements	3	3	4	5	3.75	0.96
Cost efficiency	5	4	3	3	3.75	0.96
Return on Investment	5	3	3	4	3.75	0.96
Deviation from standard	3	4	4	3	3.5	0.58
Functional scope	2	4	5	3	3.5	1.29
Operational excellence indicator	4	3	4	3	3.5	0.58
Application failure	1	5	3	5	3.5	1.91
Architectural standard compliance indicator	3	4	3	4	3.5	0.58
Business standard indicator	3	5	3	3	3.5	1.00
Functional overlap/redundancy	3	4	5	2	3.5	1.29
Estimated savings	4	3	5	2	3.5	1.29
Utilization indicator	1	4	4	4	3.25	1.50
Application Age	2	4	4	3	3.25	0.96
Number of information flows / interfaces	1	4	5	3	3.25	1.71
Number of supported business processes	3	5	3	2	3.25	1.26
Technology diversity	1	5	3	4	3.25	1.71
Incident processing time of an application	3	2	3	5	3.25	1.26
Net present value	5	3	3	2	3.25	1.26
IT project status indicator	4	3	3	2	3	0.82
Number of supported business data objects	1	4	4	3	3	1.41
Documentation quality	1	4	2	5	3	1.83
Application size	1	4	4	3	3	1.41
Return on Asset	1	3	3	3	2.5	1.00

Table 5: Assessment for Business Analyst

Metric	E1	E2	E3	E4	Mean	STD
Business standard indicator	5	4	5	5	4.75	0.50
Number of supported business processes	4	5	5	4	4.5	0.58
Number of supported business data objects	3	4	5	5	4.25	0.96
Strategic importance indicator	4	5	3	4	4	0.82
Capability coverage	5	4	4	3	4	0.82
Functional readiness	5	3	3	4	3.75	0.96
Documentation quality	3	4	4	4	3.75	0.50
Number of users	3	4	5	3	3.75	0.96
Functional scope	5	3	3	1	3	1.63
Functional overlap/ redundancy	4	3	3	2	3	0.82
Revenue per User	1	4	3	3	2.75	1.26
Investment risk	2	3	2	4	2.75	0.96
Operational excellence indicator	2	2	3	3	2.5	0.58
Application failure	1	3	4	2	2.5	1.29
Number of incidents	1	2	4	3	2.5	1.29
Number of applications	4	2	3	1	2.5	1.29
Deviation from standard	3	3	2	1	2.25	0.96
Expected development date	1	3	2	3	2.25	0.96
Security status indicator	1	2	2	4	2.25	1.26
Number of information flows / interfaces	3	2	3	1	2.25	0.96
Expected retirement date	3	3	2	1	2.25	0.96
Investment value	1	3	1	3	2	1.15
Future value	2	3	2	1	2	0.82
Lifecycle state	2	2	2	1	1.75	0.50
Application Lifecycle Duration	2	2	2	1	1.75	0.50
Utilization indicator	1	3	2	1	1.75	0.96
Application size	1	2	3	1	1.75	0.96
Incident processing time of an application	1	1	4	1	1.75	1.50
Architectural standard compliance indicator	2	2	2	1	1.75	0.50
IT investment indicator	2	2	2	1	1.75	0.50
Net present value	1	3	2	1	1.75	0.96
Estimated savings	1	3	2	1	1.75	0.96
Return on Investment	1	3	2	1	1.75	0.96
Operating costs	1	2	2	1	1.5	0.58
Cost efficiency	2	2	1	1	1.5	0.58
Return on Asset	1	2	2	1	1.5	0.58
Application Age	1	2	1	1	1.25	0.50
Technology diversity	1	1	2	1	1.25	0.50
Number of infrastructure elements	1	2	1	1	1.25	0.50
IT project status indicator	1	1	1	1	1	0.00

Table 6: Assessment for Financial Analyst

Metric	E1	E2	E3	E4	Mean	STD
Investment value	4	5	5	5	4.75	0.50
IT investment indicator	3	5	5	5	4.5	1.00
Estimated savings	4	5	4	5	4.5	0.58
Cost efficiency	4	5	4	5	4.5	0.58
Revenue per User	4	4	4	5	4.25	0.50
Investment risk	3	5	4	5	4.25	0.96
Net present value	4	4	4	5	4.25	0.50
Return on Investment	5	4	4	4	4.25	0.50
Future value	4	4	3	3	3.5	0.58
Return on Asset	1	4	4	5	3.5	1.73
Expected development date	1	4	3	3	2.75	1.26
Operating costs	3	1	5	2	2.75	1.71
Number of users	1	3	2	4	2.5	1.29
IT project status indicator	1	4	1	3	2.25	1.50
Number of applications	1	5	2	1	2.25	1.89
Security status indicator	1	3	1	3	2	1.15
Strategic importance indicator	2	4	1	1	2	1.41
Lifecycle state	1	3	1	2	1.75	0.96
Capability coverage	3	1	2	1	1.75	0.96
Operational excellence indicator	1	3	1	1	1.5	1.00
Application Lifecycle Duration	1	3	1	1	1.5	1.00
Utilization indicator	1	3	1	1	1.5	1.00
Application Age	1	3	1	1	1.5	1.00
Number of supported business processes	1	3	1	1	1.5	1.00
Technology diversity	1	2	1	2	1.5	0.58
Documentation quality	1	3	1	1	1.5	1.00
Application size	1	1	3	1	1.5	1.00
Deviation from standard	1	2	1	1	1.25	0.50
Functional scope	1	2	1	1	1.25	0.50
Expected retirement date	1	2	1	1	1.25	0.50
Functional overlap/ redundancy	1	1	2	1	1.25	0.50
Functional readiness	1	1	1	1	1	0.00
Number of information flows / interfaces	1	1	1	1	1	0.00
Number of supported business data objects	1	1	1	1	1	0.00
Application failure	1	1	1	1	1	0.00
Number of incidents	1	1	1	1	1	0.00
Incident processing time of an application	1	1	1	1	1	0.00
Architectural standard compliance indicator	1	1	1	1	1	0.00
Business standard indicator	1	1	1	1	1	0.00
Number of infrastructure elements	1	1	1	1	1	0.00

Table 7: Assessment for Enterprise Architect

Metric	E1	E2	E3	E4	Mean	STD
Number of supported business processes	5	5	5	5	5	0.00
Strategic importance indicator	5	5	5	5	5	0.00
Functional overlap/ redundancy	5	5	5	5	5	0.00
Number of infrastructure elements	5	5	5	5	5	0.00
Lifecycle state	4	5	5	5	4.75	0.50
Number of information flows / interfaces	4	5	5	5	4.75	0.50
Architectural standard \ compliance indicator	4	5	5	5	4.75	0.50
Capability coverage	5	4	5	5	4.75	0.50
Security status indicator	5	5	4	4	4.5	0.58
Technology diversity	4	5	5	4	4.5	0.58
Number of applications	5	5	4	4	4.5	0.58
Functional scope	4	4	4	5	4.25	0.50
Number of supported business data objects	3	5	4	5	4.25	0.96
Functional readiness	5	4	4	3	4	0.82
Deviation from standard	4	4	3	5	4	0.82
Application Lifecycle Duration	4	4	5	3	4	0.82
IT investment indicator	3	4	4	5	4	0.82
Future value	4	3	5	4	4	0.82
Estimated savings	4	3	5	4	4	0.82
Business standard indicator	4	4	4	3	3.75	0.50
Operational excellence indicator	4	3	4	3	3.5	0.58
Expected retirement date	3	3	5	3	3.5	1.00
IT project status indicator	4	3	3	3	3.25	0.50
Expected development date	4	4	2	3	3.25	0.96
Application Age	2	4	3	4	3.25	0.96
Operating costs	3	3	3	4	3.25	0.50
Utilization indicator	3	3	2	4	3	0.82
Investment value	3	3	3	3	3	0.00
Investment risk	4	3	2	3	3	0.82
Net present value	3	3	3	3	3	0.00
Documentation quality	2	4	2	3	2.75	0.96
Application failure	2	3	3	3	2.75	0.50
Application size	2	3	3	3	2.75	0.50
Number of incidents	2	3	3	3	2.75	0.50
Number of users	3	3	2	3	2.75	0.50
Cost efficiency	3	3	2	3	2.75	0.50
Return on Investment	2	3	3	3	2.75	0.50
Revenue per User	2	3	2	3	2.5	0.58
Incident processing time of an application	2	2	2	3	2.25	0.50
Return on Asset	1	2	3	3	2.25	0.96

Appendix 2

.2 UTAUT constructs (Venkatesh et al., 2003)

Table 8: List of constructs for estimating UTAUT (Venkatesh et al., 2003)

Construct	Definition	Items	Root Constructs
Performance Expectancy	The degree to which an individual believes that using the system will help him/ her to attain gains in job performance	U6: I would find the system useful in my job. RA1: Using the system enables me to accomplish tasks more quickly. RA5: Using the system increases my productivity. OE7: If I use the system, I will increase my chances of getting a raise.	Perceived usefulness (TAM/TAM2 and C-TAM-TPB), extrinsic motivation (MM), job-fit (MPCU), relative advantage (IDT), and outcome expectations (SCT)
Effort Expectancy	The degree of ease associated with the use of system	EOU3: My interaction with the system would be clear and understandable. EOU5: It would be easy for me to become skillful at using the system. EOU6: I would find the system easy to use. EU4:Learning to operate the system is easy for me.	Perceived ease of use (TAM/TAM2), complexity (MPCU), and ease of use (IDT).
Attitude towards using technology	An individual's overall affective reaction to using a system	A1: Using the system is a bad/good idea. AF1: The system makes work more interesting. AF2: Working with the system is fun.	Attitude toward behavior (TRA, TPB/DTPB, C-TAMTPB), Intrinsic motivation (MM), Affect toward use (MPCU), and Affect (SCT)
Facilitating Conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system	PBC2: I have the resources necessary to use the system. PBC3: I have the knowledge necessary to use the system. PBC5: The system is not compatible with other systems I use. FC3: A specific person (or group) is available for assistance with system difficulties.	Perceived behavioral control (TPB/DTPB, C-TAM-TPB), facilitating conditions (MPCU), and compatibility (IDT)
Self-efficacy	Judgment of one's ability to use a technology (e.g., computer) to accomplish a particular job or task	I could complete a job or task using the system: SE1: If there was no one around to tell me what to do as I go. SE4: If I could call someone for help if I got stuck. SE6: If I had a lot of time to complete the job for which the software was provided. SE7: If I had just the built-in help facility for assistance.	Self-efficacy (SCT)

Construct	Definition	Items	Root Constructs
Behavioral Intention to Use	A person's perceived likelihood or subjective probability that he or she will engage in a given behavior.	BI1: I intend to use the system in the next <n>months. BI2: I predict I would use the system in the next <n>months. BI3: I plan to use the system in the next <n>months.	Attitude Toward Behavior (TRA, TPB/DTPB, C-TAMTPB),Perceived behavioral control (TPB/ DTPB, CTAM- TPB), Intrinsic motivation (MM)

.3 Evaluation survey

This section presents the survey used during the workshop in order to evaluate the proposed method.

Survey

Thank you for participating in this survey. The goal of this survey is to validate the design method and to get a better understanding of the acceptance of the proposed approach.

The responses to this survey are anonymous, and the collection and usage of the responses are done while keeping your privacy in mind. The survey starts with some general questions regarding your background, followed by the questions regarding the proposed approach.

The completion of this survey is estimated to take approximately 10 minutes. The questions marked with * are required.

*Required

Background Information

1. **What's your position in the company? ***

 ____

2. **How often are you involved in the Application Portfolio Management (APM) decision-making process as part of your job? ***

 Mark only one oval.

 - ( ) Always
 - ( ) Very often
 - ( ) Sometimes
 - ( ) Rarely
 - ( ) Never

3. **How familiar are you with the following concepts? ***

 Tick all that apply.

 - [ ] Application Portfolio Management
 - [ ] Stakeholder Analysis
 - [ ] Enterprise Architecture
 - [ ] Data-Driven Workflows
 - [ ] Dashboards

Performance Expectancy

4. **I would like to use the proposed method as it is considered helpful ***

 Mark only one oval.

	1	2	3	4	5	
Strongly disagree	( )	( )	( )	( )	( )	Strongly agree

5. **Using the proposed approach would improve my job performance** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

6. **Using the proposed approach enables me to accomplish tasks more quickly** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

7. **Using the proposed approach increases my productivity** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Effort Expectancy

8. **I would find the proposed method easy to use** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

9. **My interaction with the proposed method will be clear and understandable** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

10. **Learning to use the proposed method is easy for me** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Attitude towards Technology

11. **Using the proposed method is a good idea** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

12. **The proposed method makes my work more interesting** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

13. **I look forward to those aspects of my job that require me to use the proposed method** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

Facilitating Conditions

14. **I have the resources necessary to use the proposed method** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

15. **I have the knowledge necessary to use the proposed method** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

16. **The proposed method is compatible with other systems or tools I use for my work** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

Self efficacy

17. **I would use the proposed method if I could get helpt from someone if I got stuck** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

18. **I would use the proposed method if there is built-in guide for assistance** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Behavioral Intention of Use

19. **I intend to use the proposed method in the future to help me completing my job** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

20. **I predict I would use the proposed method in the future to help me completing my job** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

21. **I plan to use the proposed method in the future for helping me when dealing with the clients** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Additional feedback

22. **Please state any additional feedback regarding the proposed approach**

.4 Evaluation survey results

This section presents the answers to the survey used in the evaluation.

Question	E1	E2	E3	E4
What's your position in the company?	Researcher	Consultant	Research Consultant	Research Engineer
How often are you involved in the Application Portfolio Management (APM) decision-making process as part of your job?	Never	Rarely	Never	Rarely
How familiar are you with the following concepts?	Application Portfolio Management, Enterprise Architecture	Application Portfolio Management, Stakeholder Analysis, Enterprise Architecture, Data-Driven Workflows, Dashboards	Application Portfolio Management, Stakeholder Analysis, Enterprise Architecture, Data-Driven Workflows, Dashboards	Enterprise Architecture, Data-Driven Workflows, Dashboards
PE-1	4	4	4	4
PE-2	3	3	2	3
PE-3	3	3	3	3
PE-4	3	3	3	4
EE-1	2	4	2	5
EE-2	3	3	3	4
EE-3	4	4	3	3
ATT-1	4	4	4	4
ATT-2	3	2	4	3
ATT-3	2	3	3	4
FC-1	1	4	3	2
FC-2	5	4	4	3
FC-3	5	4	4	4
SE-1	1	3	3	4
SE-2	1	3	3	4
BIU-1	1	2	4	3
BIU-2	1	3	4	3
BIU-3	4	4	4	3

Table 9: Survey results