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Develop and Implement an Application Portfolio Management Framework: A case study at Atlas Copco

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Develop and Implement an Application Portfolio Management Framework: A case study at Atlas Copco

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Abstract

Application portfolio management (APM) is the ongoing process of managing and optimizing the IT application portfolio to maximize its value. It has become increasingly important since large organizations today rely on hundreds, if not thousands, of applications to operate their businesses which in turn causes problems such as unused, redundant, or inefficient applications. Thus, numerous APM research has been conducted in the past to efficiently manage the application portfolio, but there is a lack of recent studies. This case study, which is a collaboration with Atlas Copco aims to contribute to both research and industry by developing and implementing a simple yet flexible APM framework that yields insightful analysis and application assessments.

We propose a comprehensive APM framework consisting of the key phases: Objectives & scope definition, data type definition, data collection, process review and process adjustment. We identify the relevant information to be collected and the essential data analysis methods. To improve the flexibility of the proposed APM model, we also recommend adopting an iterative workflow by focusing on a small set of applications at a time. Our research approach consists in conducting interviews and workshops to gather input from key stakeholders and experts. Additionally, we perform a literature study to establish the theoretical foundation. In the considered case study, Power Apps and Power BI were used to collect and analyze the data. The outcomes were evaluated by the project managers and deemed successful in terms of fulfilling the main objectives. Furthermore, the evaluation reveals that the model is applicable not only within different departments of the company but potentially to other organizations as well.

Keywords

Application portfolio management, APM, Application portfolio rationalization, IT Management, Atlas Copco
Sammanfattning


Nyckelord
Organisering av applikationsportfölj, APM, rationalisering av applikationsportfölj, IT hantering, Atlas Copco
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iv | Acknowledgments
Contents

1 Introduction 1
   1.1 Background ................................. 2
   1.2 Problem .................................. 3
   1.3 Research Question ......................... 3
   1.4 Purpose .................................. 4
   1.5 Ethics & Sustainability .................... 4
   1.6 Research Methodology ..................... 5
   1.7 Structure of the thesis .................... 5

2 Background 7
   2.1 Definitions ............................... 7
      2.1.1 Application & Portfolio ................. 7
      2.1.2 Application portfolio management (APM) ... 8
      2.1.3 TOGAF & ITIL ........................ 8
   2.2 Application portfolio management motivation .... 9
   2.3 Application portfolio management process ........ 9
      2.3.1 Preparation ............................ 10
      2.3.2 Data collection ........................ 10
      2.3.3 Analysis ............................... 12
      2.3.4 Decision making ....................... 15
2.3.4.1 TIME model & Legacy matrix . . . . . . . 15
2.3.5 Optimization . . . . . . . . . . . . . . . . . . . . . . 18
2.4 Software Tools . . . . . . . . . . . . . . . . . . . . . . . 18
2.5 Power Apps . . . . . . . . . . . . . . . . . . . . . . . . 18
2.6 Power BI . . . . . . . . . . . . . . . . . . . . . . . . . . 19
2.7 Related work . . . . . . . . . . . . . . . . . . . . . . . . . 20
   2.7.1 APM through stakeholder involvement . . . . . . . 20
   2.7.2 APM capabilities . . . . . . . . . . . . . . . . . . . 21
   2.7.3 APM at Scania . . . . . . . . . . . . . . . . . . . . 22
   2.7.4 APM at Volvo . . . . . . . . . . . . . . . . . . . . . 24

3 Method 27
   3.1 Research Process . . . . . . . . . . . . . . . . . . . . . . 27
       3.1.1 Research question . . . . . . . . . . . . . . . . . 28
       3.1.2 Research design . . . . . . . . . . . . . . . . . . 28
       3.1.3 Data collection . . . . . . . . . . . . . . . . . . . 29
           3.1.3.1 Workshops . . . . . . . . . . . . . . . . . 29
           3.1.3.2 Interviews . . . . . . . . . . . . . . . . . 30
           3.1.3.3 Literature study . . . . . . . . . . . . . . 30
       3.1.4 Data analysis . . . . . . . . . . . . . . . . . . . . 31
   3.2 Research philosophy . . . . . . . . . . . . . . . . . . . 31
   3.3 Tool selection . . . . . . . . . . . . . . . . . . . . . . . 32

4 Results 34
   4.1 APM framework . . . . . . . . . . . . . . . . . . . . . . . 34
       4.1.1 Objectives & Scope . . . . . . . . . . . . . . . . . 34
       4.1.2 Data type . . . . . . . . . . . . . . . . . . . . . . . 35
## Contents

4.1.3 Set of applications ........................................... 37  
4.1.4 Data collection .............................................. 37  
4.1.5 Analysis ...................................................... 38  
4.1.6 Review & Adjust ............................................. 40  

5 Case study .................................................................. 41  
5.1 Objectives, scope & set of applications ....................... 41  
5.2 Data type .................................................................. 42  
5.3 Data collection ..................................................... 43  
5.4 Analysis ................................................................ 45  
5.5 Review & Analysis .................................................. 46  
5.6 Case study evaluation ............................................. 47  

6 Discussion and Conclusion ......................................... 48  
6.1 Discussion ............................................................. 48  
6.1.1 APM framework ................................................ 48  
6.1.2 Validity & reliability of the APM model .................. 49  
6.1.3 Case study ......................................................... 50  
6.2 Contribution ........................................................... 51  
6.3 Limitations ............................................................. 51  
6.4 Future work ............................................................ 52  
6.5 Ethics & sustainability ............................................. 53  
6.6 Conclusion .............................................................. 53
Chapter 1

Introduction

Enterprises, much like individuals, rely heavily on technology to achieve their business objectives. Software is arguably one of the most critical parts of an organization. They support key areas such as Human Resources, marketing, customer relationship management, accounting and finance [1]. Not to mention the everyday tasks including planning and communication. The question is not whether a business can survive without technology, but how long it can last before failing.

As large organizations become increasingly complex, the application portfolio can expand uncontrollably. Enterprises today face challenges caused by a growing inventory of applications that leads to increased complexity and costs which in the end comprises the performance and ability to fulfill the business capabilities. Simultaneously, companies face constant pressure to deliver faster and superior solutions to maintain competitiveness [2]. Consequently, there is a strong need for a method of managing and optimizing the organization’s application portfolio or also known as Application Portfolio Management (APM).

This research introduces a simple framework for companies to get started with application portfolio management which involves the collection of essential data for conducting an analysis of the applications across multiple dimensions and factors. The flexibility of the model enables modification based on individual needs. In addition, a case study will be presented at the end to demonstrate real-world implementation of the framework.
1.1 Background

The concept of APM revolves around the efficient management of an organization’s application portfolio. To quote the IT-service framework ITIL, “Application portfolio management (APM) is the process of managing and optimizing a company’s application assets to maximize business value” [3]. In short, the most important goal of APM is to align IT with the business objectives [4]. Practically, APM is a framework consisting of a set of processes aimed at assessing and optimizing the application portfolio [2].

APM offers numerous benefits. For instance, it enables the identification of unused and underutilized applications, as well as those with overlapping functionalities, resulting in cost savings for the company. More importantly, it provides both IT and business units with a comprehensive and transparent view to monitor and track the applications which allows for faster business capability realizations and integration of new software assets [2].

The first portfolio-based approach to IT systems surfaced in 1981 [5], but it was not until the beginning of the 21st century that APM gained its prominence [2]. The importance of this approach was highlighted in paper [6] in 2003 and subsequent research has been conducted in the field over time. An extensive research was published in 2007 which proposed a method for portfolio rationalization (a method to assess the portfolio) [7]. Due to its role in assisting businesses in maintaining and enhancing their competitiveness in the ever-changing technological environment of today [2], this field is of interest to both society and science. However, in recent years there have been relatively few studies on the topic.

The project is carried out at Atlas Copco which is a Swedish industrial corporation that operates in more than 180 countries and has a workforce of approximately 49,000 employees [8],[9]. The company is interested in implementing APM practices in its application portfolio. By offering this project they hope to gain valuable insights into the application portfolio. The Scope of this project is approximately 100 applications that are used by “Group Management and Corporate Functions” as shown in Figure 1.1. The specific group is responsible for operations that apply to the rest of the company, such as human resources, payroll, marketing, tax, etc.
1.2 Problem

Large organizations today rely on hundreds, if not thousands, of applications to support their business processes [11]. Managing them presents a significant challenge in terms of achieving desired efficiency and business value. Moreover, the number of applications may continue to increase as a result of factors such as resistance to new solutions, company acquisitions, or mergers. According to the journal [2], application inventory maintenance can consume up to 80% of the IT budget. Furthermore, this can also lead to a disconnect between IT and the business areas, as well as negatively impact decision-making [2]. This has led to difficulties for companies, including Atlas Copco, to keep track of their portfolio, resulting in unused, redundant, and inefficient applications, which are costly to maintain. Additionally, as the company acquires other businesses, it also inherits their software assets. Consequently, Atlas Copco faces the challenge of effectively managing the application portfolio. Poor data quality and a lack of a holistic view of the company’s IT architecture pose significant obstacles.

1.3 Research Question

The research question of this study is:

• *How can modern enterprises implement application portfolio management practices and what are the most important steps involved in the process?*
Additionally, there are two objectives of this project:

- Develop a simple and automated method for effective Application Portfolio Management
- Set the foundation for application rationalization

1.4 Purpose

The purpose of this project is to develop an understanding of the most important steps involved in an APM process and how it can be implemented in modern enterprises. As previously mentioned, the complex application portfolio presents a challenge for both IT and business departments, hence the need for an asset management methodology. Although there have been numerous contributions to APM research in the past, only a few have been published in recent years and tested at companies. Thus, further research in this area is needed.

The objective of this work is a step-by-step process that outlines the APM framework from goal definition to analysis. The framework aims to assist the company in developing a holistic view of the application landscape and enable rationalization of the applications, resulting in improved IT and business alignment. Furthermore, the model is also implemented in a case study to demonstrate its applicability, this is of great importance for most businesses looking for an approach to manage their IT systems. The resulting framework should serve as an entry point to APM.

1.5 Ethics & Sustainability

The project raises a few ethical concerns that should be addressed. Firstly, the application portfolio can be confidential due to the fact that it contains company secrets. Secondly, because some personal data will be collected during the interviews/surveys, data management privacy issues will be raised. Finally, because of the involvement of various stakeholders, there may be some conflicts of interest. These issues can be addressed by implementing restricted access/permission to the information and encryption of the data. Furthermore, the company can propose an agreement that must be signed by all the stakeholders.
APM can also raise sustainability questions because it involves various aspects of optimization. As part of this project, the company must consider sustainability factors such as cost, resources, and those imposed by company-specific values. Both ethics and sustainability are discussed further at the end of this paper.

1.6 Research Methodology

The project begins with a literature review of relevant areas in APM to acquire not only basic knowledge of key concepts in the field but also to get an overview of the previous studies on the subject. Thereafter, an APM framework is developed with the assistance of managers and other experts at Atlas Copco, but mainly based on the literature study. Therefore, the primary focus is data collection through qualitative methods such as interviews and workshops as such approaches should provide an opportunity for a deeper understanding of the stakeholder’s thought process and allow both the participant and the interviewer to adapt the questions during the session. Qualitative methods also allow us to study the external factors that are not explicitly asked in the survey, such as participants’ own experiences and the cultural and historical context.

The chosen research philosophy for this project is predominantly interpretivism, which acknowledges the significance of human interests and contextual factors [12]. The project’s direction is determined by the company’s objectives and interest in managing its applications. Additionally, the data collection process also involves the engagement of various stakeholders and their interpretations and perspectives on the result. Furthermore, the findings must be contextualized in order to take into account the company’s priorities to produce insightful analysis. In summary, the research philosophy adopts interpretivism to ensure that the result of the work is aligned with the objectives of the project.

1.7 Structure of the thesis

Chapter 2 presents the theoretical background and related work about APM. Chapter 3 describes the methodology and research paradigm used to conduct the research. Chapter 4 presents the developed APM framework which is a
major part of the result. The rest of the result will be in Chapter 5 as a case study where the framework is applied at the company which also resulted in some technical artifacts. Finally, in Chapter 6 the results are discussed together followed by limitations, future work and ethics & sustainability.
Chapter 2

Background

2.1 Definitions

2.1.1 Application & Portfolio

The term “application” has been defined in different ways depending on the context and the author’s background. Previous research on APM has defined “application” as a type of software with functionalities to support business processes [5]. This definition is in line with TOGAF (a widely recognized enterprise architecture framework, more in section 2.1.3) that defines an application as an IT system that enables business functions, for instance, payroll [13]. A rather different can be found in Fabriken’s research which describes the application as a system that includes data input, processing and output [7].

Minimal changes have been made to the definition since similar, if not the same definitions are still used today. Some examples of applications are email, customer relationship management and enterprise resource planning [2]. Applications vary in terms of their scope and development techniques and can change to meet changing business challenges. Consequently, it is necessary to manage applications in portfolios [14].

The term “portfolio” generally refers to a collection of items managed as a group [5]. Specifically, a portfolio consists of selected investments that require careful management, as it is a dynamic entity that should be maintained and balanced to achieve business objectives [15]. The TOGAF framework defines
a portfolio as “A collection of programs, projects, and/or operations managed as a group to achieve strategic objectives” [16]. Furthermore, according to Fabriek [7], a portfolio is limited to a specific scope, such as a business area. Therefore, an application portfolio can be described as a set of applications operated under a particular entity to achieve business results.

### 2.1.2 Application portfolio management (APM)

Given the established definitions of “application” and “portfolio”, the concept of “application portfolio management (APM)” can be interpreted as the methodologies used in managing a group of applications. The notion of portfolio management has its roots in the financial sector, where it refers to the management of financial investments [2]. In essence, it aims to assess the financial portfolio by determining the value contributed by each investment, allowing investors to make informed decisions about whether to keep or sell the asset [4]. There have been various scientific descriptions of the concept of APM, however, the majority of them share a common framework or process. One widely used definition is:

“APM is the ongoing management process of categorization, assessment, and rationalization of the IT application portfolio” [4].

Another description of the concept is: “APM comprises all models, methods and guidelines applied by IT decision-makers for the assessment, management and optimization of an AP” [17].

In other studies, the APM is used interchangeably with application portfolio rationalization (APR), which similarly can be defined as a method to assess and restructure the portfolio [7].

### 2.1.3 TOGAF & ITIL

TOGAF is an Enterprise Architecture (EA) framework developed by the Open Group. It provides a set of best practices for alignment with the enterprise’s requirements. The framework is designed to address the requirements of stakeholders and considers both present and expected future business needs [18]. APM is closely linked with EA which can be seen as an EA process [5].
ITIL stands for Information Technology Infrastructure Library which provides a collection of best practices for effectively managing IT services and is a widely acknowledged model [19].

2.2 Application portfolio management motivation

As previously stated in the introduction section of this thesis, the increasing complexity of application portfolios drives the need for APM. The inclusion of new applications, the need to support legacy products, and the use of customized applications all add to the complexity [5]. There are several factors causing those outcomes, including users’ reluctance to new applications/versions, as well as the emergence of new applications as a result of mergers and acquisitions [2]. The resulting loss of control and transparency in the application landscape can have significant technical and economic consequences. Firstly, it raises a number of technical issues, such as poor maintainability, robustness, performance and expandability, as well as bloated source code [5]. These issues have a direct impact on the economy because a considerable amount of resources are spent on the maintenance and licensing of these applications. Furthermore, many of the applications become unused or underutilized as they fail to meet both business and technical requirements that change over time [2]. Lastly, the growing complexity results in challenges in the flexibility and agility of the portfolio, eventually impeding strategic alignment and causing time-to-market delays, ultimately reducing the organization’s competitiveness [5]. To mitigate these challenges, APM processes are required to obtain critical information about the portfolio in order to optimize and allow alignment of business objectives and IT strategies [2].

2.3 Application portfolio management process

Generally, APM contains a set of core activities that contribute to the overall framework. There have been a number of variations of the framework,
however, a common reference model (Figure 2.1) was developed by Simon et al. [5] which was based on previous research papers.

![Figure 2.1: APM model developed by Simon et al. [5]](image)

In this section, the fundamental steps of the model will be described, along with findings from the other papers. Additional relevant models will be presented in section 2.7.

### 2.3.1 Preparation

The model starts by identifying the driving factors of the APM initiative, this is already summarized in the previous section that outlines APM motivation. An additional aspect not mentioned in that section is the risk factors that may hinder the success, such as financial, governance, and policy-related issues. These are critical considerations for a company to take into account before implementing APM [5]. During the initial phase, it is also important to define the strategic goal and guidelines to guide the rest of the processes [4].

### 2.3.2 Data collection

The first stage of the APM process involves data collection, which includes the retrieval of the application information. The data should provide three levels of understanding of the portfolio of which the first is a list of applications possessed or planned to acquire. Secondly, data about the general characteristics of the applications e.g. name, owner, capabilities and so on. Lastly, the key attributes of the applications in terms of cost and performance [5].
The data collection is dependent on the defined objectives and criteria. However, a more detailed list can be found in the research by McKeen & Smith [4] that grouped the characteristics into 5 categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General information</td>
<td>Data that allows for identification of the application e.g. name, version and vendor.</td>
</tr>
<tr>
<td>Categorical information</td>
<td>Data that allows the application to be grouped based on factors such as life cycle, capability and type.</td>
</tr>
<tr>
<td>Technical condition</td>
<td>Data about the technical aspect of the application e.g. database and programming language.</td>
</tr>
<tr>
<td>Business value</td>
<td>Data about how the application adds value to the business e.g. efficiency, number of users and criticality</td>
</tr>
<tr>
<td>Support cost</td>
<td>Cost of using the application, excluding initial investment</td>
</tr>
</tbody>
</table>

Table 2.1: Data categories

Another way of identifying crucial data is by a number of key performance indicators (KPI) that affect the health application portfolio. These indicators should be impactful, frequently updated and also lead to clear actions [20]. A number of KPIs were created in the study [20] and were grouped into three categories: Complexity, Quality and Impact.

<table>
<thead>
<tr>
<th>Complexity</th>
<th>Quality</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of interfaces</td>
<td>Application failure</td>
<td>Operating costs</td>
</tr>
<tr>
<td>Capability coverage</td>
<td>Number of incidents</td>
<td>Number of users</td>
</tr>
<tr>
<td>Application age</td>
<td>Incident processing time</td>
<td>Business impact</td>
</tr>
<tr>
<td>Technology diversity</td>
<td>Empty</td>
<td>Strategic relevance</td>
</tr>
<tr>
<td>Deviation from standard</td>
<td>Empty</td>
<td>Empty</td>
</tr>
</tbody>
</table>

Table 2.2: KPI for portfolio health

Additional metrics will be presented in the next section about the analysis...
phase which can be used to base the data collection on.

In general, there are three types of data collection methods. The first approach is automatic data collection whereby the system automatically reads the source code of the applications which requires a more complex management system in place. The second method is a semi-automatic way to collect data, where the data is collected via the interfaces of the IT systems. The last method involves manual data collection by approaching the stakeholders through for instance surveys. In the end, the outcome of this phase should be a structured application inventory [5].

2.3.3 Analysis

Upon obtaining sufficient information, the next step is to conduct an analysis of the current state of the portfolio, commonly referred to as the “as-is” portfolio [5]. Also called the assessment phase in other studies [21]. In order to conduct a comprehensive analysis, it is recommended to consider the following dimensions according to Simon et al. [5]:
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Process Support</td>
<td>The range of business processes that the application supports</td>
</tr>
<tr>
<td>Strategic Fit</td>
<td>How it supports of business &amp; strategic objectives</td>
</tr>
<tr>
<td>Value/Benefits</td>
<td>The value and benefits it adds to business processes and users</td>
</tr>
<tr>
<td>Costs</td>
<td>Application-related costs. For instance, the cost of running the application, upgrading/replacing it, indirect costs and the total cost of owning the application.</td>
</tr>
<tr>
<td>Risks</td>
<td>Analyze the application failure probability and the impact of failure on other systems. Additional key attributes to consider are vendor viability, regulator compliance, privacy, maintainability, security and compatibility.</td>
</tr>
<tr>
<td>Lifecycle</td>
<td>Evaluate both the current and future state of the application including planned releases and life span.</td>
</tr>
<tr>
<td>Regulatory Compliance</td>
<td>Analyze compliance with internal and external policies.</td>
</tr>
<tr>
<td>Functional wealth</td>
<td>Evaluate usability features and functionalities that contribute to the user’s task to ensure high-quality support and reduce redundancy.</td>
</tr>
<tr>
<td>Technical health</td>
<td>Assess different technical aspects including code complexity, maintainability, compatibility, documentation quality and architecture fit.</td>
</tr>
<tr>
<td>Operational Performance</td>
<td>Evaluate factors such as number of issue tickets and failures, response time and availability.</td>
</tr>
<tr>
<td>Relations and Dependencies</td>
<td>How the application is dependent or affects other systems in the portfolio. Additionally, it is useful to conduct an investigation of vendor dependencies.</td>
</tr>
<tr>
<td>Vendor information</td>
<td>Analysis of the vendor including size, finance, support and other important services.</td>
</tr>
</tbody>
</table>

Table 2.3: Application assessment dimensions
Additional assessment methods can be found in the research by Fabriek [7], which states that this phase should focus on determining the value each application provides. This value is further divided into five components.

- **Value for the business unit**: Each application plays a significant role in achieving its tasks which in turn contributes to business goals. The IT department is responsible for maintaining these applications to ensure alignment with the business objectives. Therefore the value of the applications lies in their ability to contribute to that goal.

- **Investment value**: The value of an application is also influenced by the investment made in it, including upfront, operational and maintenance costs. In addition, indirect costs should also be assessed.

- **Technical value**: The technical value of an application is determined by assessing factors such as system reliability, portability, source code quality and data quality. Application with poor qualities requires additional maintenance, resulting in a lower value.

- **Value of use**: This is determined by assessing the usability of an application, which includes learnability, memorability, efficiency, user errors and user satisfaction. An additional aspect to consider is the frequency with which an application is used.

- **Management value**: The management value is determined by the application's capability to support various managerial functions such as staffing, coordinating, and planning. Managers and organizations benefit greatly from applications that both directly and indirectly assist these duties.

The second part of the assessment phase is to categorize the applications. One viable approach is to classify them based on the decisions. Common technical categories include databases, programming language and functionality. A feasible objective could be the removal of applications written in a specific programming language. However, in case there are no clear decisions, another method for evaluating the application value is to use a 2-dimensional grid where distinct dimensions are assigned to each axis. One example is to use the technical value on the x-axis and the management value on the y-axis [7].
2.3.4 Decision making

Based on the comprehensive application analysis, the following step is to plan the “to-be” portfolio which entails determining the allocation of investment i.e. which existing and/or new applications are worth investing in. The process involves careful examination of optimization alternatives, which are categorized into three types: create, modify and delete [5].

“Create” refers to either investing in new applications or replacing existing ones. The first choice is usually made when existing applications can no longer support business processes. Whereas replacement is appropriate when applications lack functional or technical quality or maintainability. Some methods to achieve the options are for example purchasing applications or developing customized solutions [5].

“Modify” includes the strategies such as “Functional Enhancement”, “Outsourcing”, “Service-oriented Architecture”, “Integration”, “Integration Optimization” and “Reengineering”. The suitable options must be chosen based on the specific aims. Outsourcing, for example, may be regarded as appropriate due to its financial and technological advantages. Service-Oriented Architecture has the potential to improve system flexibility and maintainability. Integration, in this case, refers to the introduction of new interfaces in order to adapt to changing environments. Lastly, reengineering may be implemented at different levels including application database and language [5].

The strategy “Delete” includes two actions: “Disposal” and “Consolidation”. When applications are no longer needed or financially feasible, “Disposal” is usually the suitable option. “Consolidation” refers to the practice of reducing redundant applications [5].

2.3.4.1 TIME model & Legacy matrix

A commonly adopted approach for mapping/categorizing applications into different strategies is through matrix-based decision-making. Two frequently referenced models found during the literature study were Gartner’s TIME model and Sommerville’s legacy matrix. These models share common dimensions, yet differences in their resulting strategies can be observed.

The TIME stands for tolerate, invest, eliminate and migrate. Applications
are assessed based on their business and technical dimensions, which leads to their placement in one of the four quadrants of a matrix \[22\], \[23\], see Figure 2.2.

Similarly, Sommerville assesses the application from business and technical perspectives with the matrix shown in Figure 2.3, the model was originally designed for legacy systems \[24\].

In both cases, the applications can be grouped into one of the four quadrants based on their business and technical/system quality \[24\], \[22\].
• **Low business value and low technical/system quality:** The applications should be scrapped/eliminated since they are not critical and has poor technical conditions [24]. Retaining them could lead to unnecessary costs. This option is referred to as “eliminate” in the TIME model [22].

• **High business value and low technical/system quality:** The application is critical for the business process but with a low technical fit which leads to expensive maintenance costs [24]. Additional technical issues could be a lack of development skills and integration problems [23]. Consequently, the application should be re-engineered or replaced with a better alternative. The TIME model proposes application migration to another platform as a potential solution [22].

• **High business value and high technical/system quality:** the application fulfills their requirements and should be maintained [24]. The TIME model also suggests investing in exploring innovative means of reusing these applications [22].

• **Low business value and high technical/system quality:** Despite the application’s limited support of business operations, its technical condition may make maintenance desirable, because of the low cost to maintain and high risk to replace [24]. However, in case of high cost, removing may be required. Based on the TIME model, applications can be tolerated as long as they fulfill the necessary technical requirements [23].

In the end, a holistic view of the portfolio is required to make well-informed decisions. This entails taking into account all the dimensions and involving the significant stakeholders. Additionally, it is crucial to identify the root cause of the issues and examine the impact of the potential decision on different parts of the organization [5]. Different factors can contribute to the problem which can be identified by analyzing the so-called “underlying patterns”. such as IT/business strategy, enterprise architecture, culture and communication [7]. The decision-making process should result in a proposed action plan or roadmap to optimize the portfolio [5].

Effective planning should include not only the development of a business case [5], but also the identification of specific actions, allocation of necessary resources and creation of a time plan [7].
2.3.5 Optimization

During the last phase, the chosen course of action is carried out, beginning with the refinement of decisions into concrete actions. Throughout the project, effective management and alignment with the business case are crucial to ensure quality. Furthermore, it is essential to document specific project experiences for future efforts [5].

2.4 Software Tools

2.5 Power Apps

Figure 2.4: Power Apps interface

Microsoft’s Power Apps platform enables rapid application development by providing tools for building customized solutions for various business needs. It allows users to develop applications without the need for coding but also provides advanced programming features for developers. The resulting apps can be accessed on mobile and web browsers [25].

A canvas application can be created and designed using the interface provided by Power Apps Studio, see Figure 2.4.

Following is a description of frequently used components.

1. Command bar with controls like Insert, Settings and New Screen.
2. Menu that allows data sources selection and insert options for different media.

3. The canvas screen for designing the application structure.

4. Properties of the selected object in the canvas.

### 2.6 Power BI

![Figure 2.5: Power BI example](image)

Power BI, developed by Microsoft, is a package of tools designed to assist data visualization and insight development through dashboard and report creation. The program is accessible in three forms: a desktop edition, an online software-as-a-service platform and a mobile application [26]. Power BI supports a list of visualizations and metrics for data representation including different types of charts, maps, numbers, etc [27]. An example is shown in Figure 2.5.
2.7 Related work

2.7.1 APM through stakeholder involvement

In an extensive research on APM [14], Badea developed a model that emphasizes stakeholder involvement through a data-driven workflow. As shown in Figure 2.6, the framework consists of several steps divided into three main phases: identity, plan and management & control.

In the first step, both quantitative and qualitative methods are used to collect information regarding the stakeholders and their tasks. The aim of this stage is to identify individuals who should participate in the initiative, as well as to collect data for the next phase. Consequently, interviews are conducted to gather data about responsibilities, objectives and collaboration between stakeholders. This step and phase also conclude with a classification of individuals into five distinct groups according to an assessment of the attitudes: unaware, resistant, neutral, supportive and leading [14].

During the planning phase, the decision-making procedures are defined and examined. The processes are visualized using flowcharts that illustrate the activities and individuals that are required to reach a decision. After defining process models, the following two steps identify suitable metrics for each stakeholder as well as how these metrics should be represented. These steps are also used to assess the importance of the metrics through interviews and surveys. Consequently, it should result in a list of metrics and their valuation [14].

Figure 2.6: APM framework by Badea [14].
Finally, in the manage & control phase, a workflow combined with data models is developed. The output of the preceding steps is integrated to generate an executable workflow. The ability to monitor data flow is an important part of the process, as each activity must be mapped to the corresponding data objects necessary to facilitate the workflow. Next, the data should be modeled or visualized in a manner that is tailored to the specific needs of the various stakeholders. The goal is to enable more efficient decision-making, as the individuals will have access to a clear and intuitive representation of the required metrics [14].

The suggested framework was used in the study at a technical ICT company that required assistance with application integration following a recent acquisition. Because of data/access constraints, some assumptions were made. The results were evaluated by experts and were found to be beneficial. The author concluded that the data-driven approach facilitated collaboration among stakeholders and reduced the need for manual documentation, as data was collected and managed in a streamlined process. Furthermore, the study highlighted the value of obtaining input from stakeholders in designing customized dashboards that improved their workflow regardless of their backgrounds [14].

### 2.7.2 APM capabilities

McKeen and Smith [4] conducted a study on how APM is realized at companies. The study involved senior IT managers from various industries who participated in a recorded discussion in which they were asked to share their experiences including both benefits and challenges of APM. The discussion revealed three interconnected capabilities crucial for adding value: strategy & governance, inventory management and reporting & rationalization.

The first step in implementing APM is to define the application management strategy, objectives and principles. According to the study, the majority of APM projects are initiated solely by the IT department, with little or no support from the business side. This approach presents a challenge since aligning IT initiatives with business objectives is critical for maximizing benefits and securing funding. Hence, developing a business case based on the strategy is required. The strategy also determines the type of information needed to be collected and how it will be used in subsequent steps [4].
According to the study, the strategic goal should be guided by governance that includes principles and policies that can address three types of questions regarding decision-making: how decisions should be made, who is responsible for making the decisions and what decisions require to be made [4].

The focus group also concluded that APM governance should be integrated with existing organizational processes such as architectural reviews and strategic planning. Furthermore, responsibility for ownership at various levels was emphasized. Each application typically has an owner who is accountable for the access and the lifecycle of the application. Additionally, it is also beneficial to have a technically knowledgeable person responsible for application data management. Finally, at the portfolio level, a committee comprising owners, architects and strategists makes decisions on the outcome of the application [4].

The second step is to inventory the applications. The strategy is expected to result in a set of applications that will be included in the APM initiative. It is essential to collect various types of information during the inventory phase. The study compiled a list of potentially useful information that can be categorized into five different groups: General information, categorical information, technical condition, business value and support cost, which were described in the background section [4].

However, the challenge does not solely lie in determining the necessary information to gather. The focus group highlighted that the more demanding task is maintaining the effort of keeping the data up-to-date. As a result, the group suggested establishing clear guidelines for data governance and assigning responsibility to designated individuals [4].

In the final stage, the data must be analyzed and reported in accordance with the predetermined objectives. The report emphasized that the resulting value is dependent on the stakeholders, however, some of the areas that the focus group highlighted were portfolio health, cost savings and capability mapping [4].

### 2.7.3 APM at Scania

Nylén and Palomeque [21] conducted a study where an APM method was created and applied at a company in Sweden, namely Scania CV AB. The objective was to identify the most critical determinants of APM, both in
general context and for the particular company under consideration. The methodology used to achieve this goal starts with an initial stage consisting of a comprehensive literature review, as well as conducting interviews and workshops to gather essential data and knowledge that would help identify the problem and clarify the project requirements posed by Scania. Gaining knowledge of the APM was also a part of the objectives.

Using the acquired knowledge and requirements, the subsequent step was to develop an APM model. This was achieved through the use of a qualitative method which provided a more in-depth understanding of the context or phenomenon. The method involved various workshops and meetings with the department representatives, which resulted in an APM framework and survey questions that would be used later in the project [21].

In the third step, the surveys were employed to collect empirical data on the characteristics of the application, additionally, feedback on the survey questions was also obtained. The authors believed that this quantitative method was necessary to supplement the qualitative step. In the concept establishment stage, the collected data was analyzed to validate the APM framework according to the defined requirements [21]. This resulted in a final framework shown in Figure 2.7.

The initial step of the framework was the identification of applications to be included, which was followed by data collection of the application information with the assistance of IT experts within the organization. Next, in the quality assessment stage, these applications were evaluated on two different aspects, considering both their business value and technical quality. Each has its own criteria, listed in Figure 2.8 below. The assessment was conducted through a series of three questionnaires sent to the stakeholders including the user of the application, progressively exploring the technical questions. Each question had a defined value that would result in a final business or technical value [21].
In the recommendation stage, the collected answers were combined with the insights given by Scania experts to arrive at a conclusion. Beginning with an assessment of the application’s final business value and then the technical quality, each according to a set of predefined criteria. Next, three scenarios were examined [21]:

- Application lifecycle - to evaluate the stage of the application’s lifecycle, whether it is still adding value more than the required cost
- Substitutes - to identify possible redundancies
- Resources - to assess the possible actions with the available resources

The outcome of this final process was a proposed action, which could be one of replace, redevelop, remove or maintain. Ultimately, the APM method was applied in a case study involving three applications, yielding a favorable directional suggestion that could be useful for Scania’s decision-making [21].

**2.7.4 APM at Volvo**

Another study conducted in the field of APM at a Swedish company has been documented by Kellerman and Lögren [15]. The research was carried out in 2008 at Volvo with the objective of improving portfolio control to enable business alignment and future application integration. As in the Scania study, the authors developed a set of APM principles as a result of the project.

Similarly, interviews and workshops were used to collect data. Qualitative methods were deemed more flexible and provided deeper insights.
However, this study differed from the Scania project in that they interviewed two distinct groups. The first group comprised company employees, while the second group consisted of people outside the company who had prior experience in the APM field. This was done in order to obtain a different viewpoint on the topic [15].

The research expanded the general matrix (redevelop, replace, remove, maintain) method with four principles crucial to the application destination. These concepts included [15]:

- Business value: What business objectives the application contributes to.
- Functional value: Considers both application usability and the processes it supports.
- System quality: The technical aspects such as reliability, performance, infrastructure, etc.
- Cost: Both operational and maintenance expenses.

Ultimately, the study resulted in a framework that consists of 3 steps (Figure 2.9), each having a number of yes/no questions that should be answered [15].

The proposed framework consists of three steps. The first step is to decide whether an application should be removed based on the responses to business value-related questions. If all questions yield negative answers, then the
application should be removed. Conversely, if one or more questions receive a YES, the application advances to the next step for further investigation. In the second stage, the evaluation focuses on determining whether the application should be changed or left in its current state. A number of questions linked to the principles of functional value and system quality are used to make the evaluation. Lastly, the final step of the framework involves answering a set of questions to determine whether the application should be redeveloped or replaced. The questions at this point emphasize cost [15].

It is important to note that while the framework is useful for decision-making, the authors did not intend for it to serve as the sole source of decisions. Instead, the framework was meant to assist Volvo in its assessment. However, it was applied on 2 applications that resulted in a satisfactory evaluation which the company deemed useful [15].
Chapter 3

Method

3.1 Research Process

![Diagram](image)

Figure 3.1: Research process.

The applied research process is a model presented by Göttfert [28]. Figure 3.1 shows how the process is applied with key activities linked to each step of the
model.

### 3.1.1 Research question

The first phase is concerned with the definition of the research question that the study will investigate. It is necessary to be detailed in this regard in order to better design the research for instance what data to collect and the time span [28]. The research question for this work was developed with the project managers since the study was conducted as a part of an initiative at the company. An initial literature study was carried out to acquire some understanding of prior research and to inspire the development of research objectives. However, the key was to align the question with the intended aims of the project and to make sure that the research would meet the requirements from KTH.

### 3.1.2 Research design

During the research design phase, a framework should be developed to outline the steps involved in carrying out the research. Additionally, during the design phase, a research strategy should be formulated that includes all the procedures required to meet the goal, such as data sources, sample size and the method. [28]. The key activities of the research design will be presented and described below:

- **Pre-study & Preparation** - The primary objective of pre-study was to obtain a profound understanding of the background, problem area and the goal and/or expected product. To accomplish this purpose, several initial meetings were scheduled with the project managers to introduce the project, discuss its challenges and goals as well as set up a preliminary timeline. In addition, an exploratory literature study was carried out to acquire knowledge in the field of APM. This process involved reviewing relevant academic papers, journals, books and resources provided by the company. The acquired knowledge should cover APM principles and frameworks, as well as examine previous case studies of APM implementation at other companies.

- **Preliminary Data collection plan** - In the next step, the acquired knowledge and information were applied to propose and develop a
plan for data collection to accomplish the development of the APM framework. The primary focus is to acquire accurate and relevant data that are necessary to produce reliable results [28]. Moreover, this research also adopted an iterative approach which meant that data collection would occur multiple times to either confirm or acquire additional information. As the project also included a technical artifact that should automate the APM implementation, a requirement collection should be conducted with the relevant stakeholders who will be using the product.

- **Data analysis method** - The chosen data analysis method consisted of multiple coding stages and is described in section 3.1.4.

- **Case study** - a case study was selected as a part of the research strategy. There exist different definitions of the concept and a widely used is by [29] which defines case study as “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.” [29]. The method was chosen due to two primary factors. Firstly, the study was conducted as a part of a company initiative aimed to realize APM. Secondly, it is crucial to analyze the applicability and validity of any novel model in order to reinforce the underlying theoretical background. Furthermore, case study provides a holistic view of the phenomenon and allows for generalizations [30].

### 3.1.3 Data collection

#### 3.1.3.1 Workshops

Several workshops were held to engage key stakeholders and the APM project managers in order to present the initiative and gather feedback. The presentations addressed the challenges, aims, scope and expected outcomes. The stakeholders involved were directly or indirectly affected by the project, such as IT/business managers, application owners and controllers. Each session lasted approximately one hour and was designed to first inform participants about the initiative and future plans. More importantly, the workshops allowed stakeholders to provide feedback and any support they could offer. Workshops, as a qualitative method, encourage participant engagement and collaboration by providing an opportunity for sharing
experiences and constructive criticism. Additionally, they are also an effective technique to elicit information from those involved [31].

3.1.3.2 Interviews

A number of semi-structured interviews were arranged with experts from diverse fields for the creation of the planned APM framework. During these interviews, participants were asked a set of predetermined questions related to their backgrounds, experiences and specific questions about the project, as well as their input on improvements or features they deemed essential. Semi-structured interviews were chosen for their flexibility, as follow-up questions could be added during the interview or any modification to existing questions could be made if needed. The predetermined questions served as a so-called checklist which is recommended to ensure that the conversation stayed within the intended topic [31].

Given the limited availability of stakeholders, each interview was scheduled to last between 30-60 minutes, which is sufficient to thoroughly explore the investigated topic [32]. Multiple interviews with the same individual could be conducted in case additional clarifications/questions were needed.

Qualitative interviews were chosen as the research approach because they allow interviewees to effectively and openly communicate their own experiences, allowing for a more in-depth understanding of their perceptions and the investigated phenomena [32].

IT architect, IT specialist, data manager, application managers and cloud manager were among those interviewed for the project. These individuals were selected because of their ability to support/contribute to the project and their professional backgrounds. Some of them were suggested by the other stakeholders. Each interview concluded in documentation with important notes that were later analyzed.

3.1.3.3 Literature study

A thorough preparation for the project was carried out through a literature study about APM. The aim of the study was to gain a comprehensive understanding of APM, including its definition, state-of-the-art, various concepts, the process, benefits and the elements that can influence APM
implementation. Moreover, previous case studies that implemented APM at companies were examined in order to understand the practical aspects. The literature review was conducted with the help of the Google Scholar search engine, using relevant keywords such as APM, application portfolio management, application management, software asset management, IT portfolio management, IT system management, application portfolio rationalization and APM framework. Furthermore, the company also provided project-related materials which showcased the potential process and outcomes.

3.1.4 Data analysis

Data analysis and interpretation is the stage at which insights and knowledge are gained. The analytical approach is heavily dependent on the chosen methodology and research paradigm [28]. The collected data from workshops, interviews and literature were analyzed using the qualitative analysis methods inspired by [33]:

1. Initial coding: Coding refers to the process of analyzing data [33]. During the initial coding, the collected data were studied to identify similarities and differences. Additional data were acquired to fill any eventual gaps in understanding the information.

2. Intermediate coding: Data deemed relevant and of interest were categorized and compared to form an initial concept.

3. Advanced coding: The relationship between data was identified to build the model.

4. Result: The resulting product was presented.

3.2 Research philosophy

As mentioned in the introduction, an interpretive perspective was adopted given the significance of individual interpretations in shaping the study outcomes. Furthermore, interpretivism is reasonable in the context of a case study conducted within a single company, as generalizing results may not be accurate.

In contrast to positivism, the interpretivism paradigm is distinguished by its
contextual nature, which takes into account various variables and factors [34]. Interpretivism is based on the assumption that humans differ from physical phenomena, as their subjective experiences add depth to the subject matter. Specifically, a single phenomenon can be interpreted in multiple ways and cannot be determined solely through measurements [35]. This case study acknowledges that numerous factors might influence project outcomes. For instance, the stakeholders involved in the project, each with their own interests and requirements are likely to have a considerable impact on the result. However, involving multiple perspectives in the research process can yield several benefits. One such benefit is the diversity in the interpretation of phenomena, which can help prevent bias. Furthermore, another advantage of interpretivism is to make abstract things such as feelings and values observable [35]. These observations serve as valuable inputs for the research.

### 3.3 Tool selection

The software tools used to implement the APM process were chosen based on the following aspects:

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality</td>
<td>The software must be able to fulfill all the necessary functionalities/needs</td>
</tr>
<tr>
<td>Availability</td>
<td>The software is ready to use by the individuals in the project</td>
</tr>
<tr>
<td>Compatibility</td>
<td>The software should be compatible with other products from the company to effectively automate the entire APM process</td>
</tr>
<tr>
<td>Cost</td>
<td>The cost should fall within the budget, preferably already included in the existing licenses or accessible as a free trial</td>
</tr>
<tr>
<td>Usability</td>
<td>The software should be easy to learn and use</td>
</tr>
</tbody>
</table>

Table 3.1: Tool evaluation based on company needs

Two tools were identified that satisfied the criteria above, namely Power
Apps and Power BI. Both of these products were included in the current Microsoft Office subscription, which is accessible to all employees within the organization. Moreover, a dedicated Microsoft Product support team was available for these tools, and a number of learning resources were offered by Microsoft. Lastly, according to Statista [36], Microsoft Office Enterprise is used by around 1 million companies worldwide which makes this research more applicable to a broader audience.

Power Apps, as mentioned in the background section, is a web-based platform for creating applications. It supports data connection to other Microsoft applications, such as Excel, where some of the application data can be stored. The platform was chosen to create customized surveys with enhanced functionalities to meet the needs. It has an intuitive user interface and requires minimal coding experience, making it an excellent tool for beginners to learn and use. For this project, a survey application was built in Power Apps.

Power BI offers a wide range of data modeling and visualization. More importantly, it supports the desired data visualization in the developed APM framework. Similarly, it has the capability to connect to other Microsoft products used at the organization, allowing for the usage of accessible data.
Chapter 4

Results

4.1 APM framework

Figure 4.1 shows the resulting APM framework/model.

4.1.1 Objectives & Scope

The initial phase should focus on understanding the problem and gathering most of the requirements. It is important to take a practical approach to obtain a complete list of applications within the scope [4] and to further refine the goals into well-defined and actionable objectives. It is crucial to involve all necessary stakeholders in this process. Moreover, another output of this phase
Results | 35

is an overview of a timeline where each milestone is set out, which provides a clear view of the project and also serves as a project proposal. However, since the model is meant to be iterative, the data collection should start as soon as possible.

4.1.2 Data type

![APM information overview diagram](image)

Data collection is critical for accurate analysis since the quality and availability of data strongly influence the results. It involves identifying the specific information to be collected based on the defined objectives. Moreover, the suggested list of items is intended to serve as a recommendation. Therefore, appropriate changes should be made accordingly based on the available data at the company and the project objectives.

The type of information is based on the suggestions by McKeen & Smith [4]. The goal is to only capture the necessary and the most important information to get started. Additionally, this model assumes that the data will be collected from the application owners. The recommended data types or application information to collect are the following (also presented in Figure 4.2):
Basic information consists of three different types of data, general application information, application categorization information and cost information.

- General information - the information that identifies the application including name, description, owners, etc [4].
- Categorization - the data that can map applications into different groups such as departments, functionalities, life-cycle status, location, and capability [4].
- Cost - various types of costs that are associated with the operation of the application, including license, infrastructure, vendor support, etc [4].

Business fit refers to the extent to which an application contributes to the accomplishment of the business objectives [21]. The components that determine business fit are based on the APM research conducted in this paper [37], which was described in section 2.7.3. However, the model includes an additional component called usability which focuses on user-friendliness. The decision was made as a result of reviewing input from IT experts at the company who emphasized usability as a direct factor for enabling users to achieve business objectives and that this specific aspect is more concerned with user experience than the underlying technical features. As a measurement, the different aspects are supposed to be rated [37]. Therefore, in this model, they should be evaluated by the application owner in which each aspect is graded on a scale ranging from 1 to 5, where 1 indicates poor quality and 5 indicates exceptional quality.

- Strategic importance - refers to the competitiveness and priority of the functions the application supports [37].
- Functional value - To which degree an application fulfills the intended business tasks and the demand from the users [37].
- Usability - describes how easy it is to interact and learn the application [21].
- Criticality - describes how critical the application and the business process it supports are [37].

Technical fit describes the technical quality of the application [21]. In this particular model, the evaluation is based on ISO 25010 standard [38] that is commonly used for assessing software quality and has been applied in various studies [39], [22]. The evaluation framework will be slightly modified to
better fit the purpose. As a result, the aspects "compatibility" and "portability" are excluded from the APM model due to the level of complexity deemed inappropriate for the application owners. The remaining factors to consider according to ISO 25010 standard are the following [38]:

- Functionality - the degree to which the application correctly performs the intended tasks.
- Performance - the experienced speed and responsiveness of the application.
- Availability - the degree to which the application is available when needed.
- Security - the degree to which the application protects the data from unauthorized access.
- Maintainability - the degree of modifiability in the event of any issues.

### 4.1.3 Set of applications

When dealing with a large number of applications, the evaluation process might become overwhelming, especially if the company is unfamiliar with APM. To overcome this issue, a small set of applications can be selected as the primary candidates for the evaluation. The selection can be based on different factors depending on the objectives and application owners. For instance, either focusing on the legacy applications or the application owners that are easily reachable. This approach ensures a feasible and easily testable process which is useful to test whether the outcomes satisfy the intended requirements. The strategy is iterative in nature and similar to the agile methodology that allows for change adaption and improved efficiency [40]. However, it is not necessary to have the same number of applications for each set, the number could gradually increase as the processes mature over time. Additionally, the same applications can be used multiple times in order to collect new data.

### 4.1.4 Data collection

Following the decision of the project scope and the necessary application information to collect, the data collection mechanism must be determined.
Most application data are not centrally maintained, therefore needing a dedicated approach for gathering data [5]. A common method is to use surveys which are applied in other APM projects as well [21] [22]. Given that this APM model is aimed to be iterative, meaning it should allow small changes to each cycle or set of applications, consequently, it is important to select a tool that is flexible and can be integrated with other company products to facilitate the APM automation since the process is required to run regularly in order to collect up-to-date application information. Once the tool has been determined, the cycle of data collection, analysis, review and adjustment should begin.

4.1.5 Analysis

The analytical methods are mostly dependent on the objectives and the data acquired. Certain immediate benefits can be the identification of high-cost, unused applications or applications with duplicated capabilities/functionalities. These aspects can be depicted through data visualizations such as pie charts, bar charts, matrices, etc.

As recommended by Mckeen & Smith [4], when looking for quick wins, a viable approach involves investigating the possibility of retiring applications that yields immediate wins. As part of this framework, TIME assessment matrix (described in section 2.3.4.1) will be adopted and adjusted as the primary tool for application analysis. To put this concept into action, two essential metrics must be obtained: business and technical fit value based on the received scoring from the survey.

Business fit value is calculated with the rating for the four aspects and these factors can be weighted equally to determine an average score as proven in the paper [21]. Thus, the proposed formula for assessing business fit is:

$$\text{Business Fit} = \frac{1}{4} \times \text{Strategic Importance} + \frac{1}{4} \times \text{Functional Value}$$
$$+ \frac{1}{4} \times \text{Criticality} + \frac{1}{4} \times \text{Usability} \quad (4.1)$$

Likewise, for the technical fit, the average score can be computed using the following formula:
Technical Fit = \( \frac{1}{5} \times \text{Functional Suitability} + \frac{1}{5} \times \text{Performance} \)
\[+ \frac{1}{5} \times \text{Availability} + \frac{1}{5} \times \text{Security} + \frac{1}{5} \times \text{Maintainability} \] (4.2)

However, the assigned weights of both business and technical fit are based on the assumption that each factor is of equal importance. Hence, depending on the specific context, these weights could be adjusted.

The resulting recommendation is derived by plotting the values on the TIME matrix, exemplified in Figure 4.3. For convenience, the axis can be scaled using the same five-point scale as the questionnaire.

Each option specifies the recommended action to take, the options are modified in order to provide additional details that were found useful during the study.

- **Eliminate** - it is recommended to remove/eliminate the application due to its unsatisfactory technical and business qualities. A comprehensive examination may be conducted first to find out the impact of such removal, followed by the identification of potential substitutes. When an application falls into this quadrant an immediate investigation should be conducted to find the underlying problems.
• **Tolerate** - Despite having a lower business fit, the application can be considered acceptable due to its exceptional technical quality, provided there is a demand for it and sufficient resources to maintain it. Additionally, changing or eliminating it may present difficulties. However, they are still candidates for removal or replacement as they don’t satisfy the business needs. It is suggested to reach out to the application owners for further details.

• **Invest** - the application has outstanding quality across both dimensions and should, therefore, be maintained. However, the basic information can still be investigated to obtain useful information such as cost.

• **Migrate** - the application is vital to the business but has poor technical quality. Consequently, it is advised to improve its technical aspects, either by redeveloping the software or by migrating to another platform. A replacement is also possible if there are available alternatives that fulfill the requirements. In this case, it would be beneficial to consult with both IT experts at the company and the application vendor to discuss a potential solution.

Lastly, similar to other APM frameworks described in section 2.7. The analysis output only serves as a recommendation intended to support the decision-making process since there are many other factors that may influence the destination of an application. Furthermore, users may encounter results where the applications are placed on the boundaries of the quadrants. However, it is important to evaluate applications case-by-case which implies examining the result of each business/technical aspect and acting accordingly.

### 4.1.6 Review & Adjust

During the review & adjust phase, it is important to carefully evaluate both data collection and analysis processes. This entails gathering feedback from survey respondents and examining if the collected data are sufficient and whether the concluded recommendation options are appropriate. In essence, the goal is to confirm if the outcomes are in line with the defined objectives and apply the necessary changes to the next cycle. Furthermore, the review process can involve additional stakeholders such as APM project managers, IT managers, and any other relevant expertise available.
Chapter 5

Case study

A case study of the designed APM framework was carried out at Atlas Copco in order to reach the defined goals and evaluate the applicability and plausibility of the model. This section further introduces the technical artifacts developed during the implementation process. However, all data will be anonymized for security reasons.

5.1 Objectives, scope & set of applications

Since the APM initiative took place within a global company, the project was influenced by various stakeholders. To begin with, workshops with the project managers were used to collect requirements and opinions about the APM initiative. These inputs were then discussed with project managers in order to break them down into smaller objectives and the time plan consisting of when each step of the APM should be completed. This phase also resulted in a detailed list of applications in scope which was fetched from the company application database. A small set of 20-30 applications were selected as the first pilot group.

Two primary objectives were identified, the first of which was to establish a foundation for application rationalization. This entailed evaluating each application on both technical and business dimensions, then visualizing the results in the diagram using a state-of-the-art model, which in this case was
the TIME model. The aim is to assess each application and take action accordingly.

The second objective was to create a clear overview of applications within the defined scope. This objective was driven by the need to obtain updated information, as it was mentioned by the company that a significant percentage of the existing data was somewhat outdated. Furthermore, there was not a sufficient amount of information required to build a meaningful depiction of the application landscape, for instance, a capability or cost-based categorization. The process of information collection was intended to be conducted on a regular basis in the future to ensure data correctness.

Finally, the initial timeline for the work was to dedicate one month to define objectives & scope, the types of data to collect and the first set of applications. Following that, another month will be devoted to the technical implementations, specifically the development of tools for data collection and visualization. Thereafter, the remaining time will be spent on the cycles for each set of applications.

### 5.2 Data type

Followed by the preliminary plan, a specification of data to collect was created with the help of the project managers, IT architect and IT manager. However, this step took longer than planned due to multiple revisions and the limited availability of the managers involved. The resulting list of data included: name, description, application status, owners, department, number of users, capability, retirement plan, the total cost of ownership, business fit value, technical fit value and any constructive feedback on the project. Given the company’s existing application database, which contained some information for the applications, certain pre-defined data required to be validated and additional information that was not present in the database had to be obtained. Moreover, the formula of business/technical fit value provided by the APM framework was adopted.
5.3 Data collection

To facilitate the efficient collection of the defined data, a choice was made to develop a survey application that connected to an existing database, enabling modification and addition of data through an intuitive user interface. The decision to use this quantitative method was based on the number of applications in the scope, as well as the amount of information required, including basic information about the application, costs, and business and technical value. Which won’t be feasible through interviews. Figure 5.1 describes how the technical artifacts are connected to the APM framework.

As stated before, Microsoft Power Apps was selected as the platform for developing this customized questionnaire application which required multiple iterations of testing and bug fixing. As a result, the initial timeline was delayed further.

The application was divided into three different parts. The initial part was an introductory page (Figure 5.2) that provided an explanation of the project and the application itself, combined with relevant images (the image was blurred to ensure data confidentiality).
Following the introduction, the user was presented with a list (Figure 5.3) of applications under their ownership, from which they selected to begin with the questionnaire.

Once the questionnaire was started, the respondent was supposed to first validate the pre-populated information and then fill out the other fields and questions. Following are examples of general information (Figure 5.4) and a technical fit question (Figure 5.5):
The survey should be submitted upon clicking the “save” button and the user was redirected back to the list of applications.

5.4 Analysis

During the analysis phase, Microsoft Power BI was used as the data visualization tool due to its integration capabilities with the current database. The goal was to generate a diagram similar to the TIME model and also present various desired statistics and mappings based on the collected data. In Power BI a scatter plot was selected to plot the applications into one of the four quadrants, see Figure 5.6. The application name was removed from the picture.

Examples of additional visualizations that were possible to create were the cost for each business capability, for instance, HR or finance. And similar statistics were grouped by departments, owners and application status.
A number of additional visualizations were possible to generate in order to study each categorical data. For instance, one of them depicted the cost associated with each business capability, see Figure 5.7. Similar visualizations were made with other data such as departments and owners which would offer insights into cost distribution.

Moreover, pie charts were also used to provide the view of different distributions similar to Figure 5.8.

5.5 Review & Analysis

To review the result of the surveys, the feedback from the respondent was analyzed and additional emails were sent out to the respondents to directly ask for their input. At the moment of writing, a small number of responses
were received and most of them suggested adding additional fields to the survey which later were integrated into the application. Furthermore, some respondents also expressed positive feedback on the user-friendliness of the application.

The visualizations were also assessed and deemed valuable aligning with the defined objective. However, it was discovered during the review phase that new data modeling techniques could offer useful metrics, for instance, cost per department. Consequently, they were immediately added to the collections of visualizations.

In terms of the next step, a new batch of applications will be added once the majority of the first set of applications have been completed. At the moment of writing, only 50% of the initial group have responded or about 15. Consequently, reminders will be sent out to the owners to encourage their participation.

5.6 Case study evaluation

The outcomes were evaluated by project managers and resulted in the following key feedback:

- The current solution is aligned with the current goals, which are collecting the APM information from the pilot entities and getting a first glimpse of the applications.

- In terms of generalizability and applicability, the framework is standard and can be reproduced in other departments or companies.

- Some limitations of the case study are that the application data have to be manually added to the database. In addition to that, it would be helpful to explore what other specialized enterprise tools could offer but this would require a much longer time.
Chapter 6

Discussion and Conclusion

6.1 Discussion

6.1.1 APM framework

As demonstrated in the result, the proposed model for APM shares most of the key steps seen in previous research, such as goal definition, data collection and data analysis. Based on the previous research mentioned in the background section and the newly introduced model, these steps can be considered the fundamentals of any APM process.

However, what distinguishes this model from literature study 2.7 is the way in which these steps are carried out. Specifically, the model adopts an iterative approach to application management, which proves advantageous in several aspects mentioned in the result. Namely, flexibility to refine or modify the processes and the ability to approach sometimes an overwhelming number of applications.

Two considerations were taken into account during the creation of the framework to improve its generalizability. Firstly, the framework is intended to be adopted by organizations of various sizes and operating in different fields, each with its own experiences and priorities. Therefore, it was designed to facilitate a quick start for APM initiatives that gradually mature, reaching different maturity levels proposed in the study [5]. As mentioned in the background section 2.3.2, there is a wide range of metrics that can be collected and analyzed to assess different aspects of an application. According to the
study [4]. APM initiatives face challenges in both funding and management, therefore, the proposed implementations of each step in the framework only include the essential information required for the defined analysis methods. It is expected that following the first execution of the APM processes, the company will gain a more comprehensive understanding of both the value it provides and the desired results. Consequently, major changes are anticipated after the first review phase which might lead to other artifacts not mentioned in the suggested implementation.

The second consideration was the fact that application owners often possess a more in-depth understanding of the available application data than the APM project managers but are not as technical as the developers. The recommended data types are therefore based on general characteristics that are commonly shared by the majority of applications. However, and also as indicated by case study feedback, there is a high chance of missing some fields that the respondent deems important. As emphasized earlier in the result, it is beneficial to start the process as soon as possible to gather the necessary feedback and fix the issues.

### 6.1.2 Validity & reliability of the APM model

Using the definition of validity as the ability to accurately measure the intended objects [41], there are two reasons that the APM model should be valid. Even though the project was conducted for and in collaboration with the stakeholders at Atlas Copco, the resulting model was predominantly developed by adopting knowledge from previous APM research, including the phases and the questions used to conduct the assessment of applications. While a few changes were made to the procedure, these decisions were taken after consultation with both IT specialists and application managers, this type of validity is called content validity [41].

Moreover, to obtain a subjective evaluation of the model, also known as face validity [41], a case study was implemented and evaluated by the project managers. This further confirms the applicability of the model and that it indeed gives the intended outcome, the most important one being the application rationalization measure by business and technical values.

The repeatability and consistency of the results are referred to as reliability [41]. A significant part of the model revolves around data collection and analysis which could be implemented differently and the data might change
over time because of the application life cycle, thus, it could be unreasonable to expect the same result in every case. However, the implemented tools were carefully tested by both the developer and the end-users to verify their reliability. It should be noted that the survey section responsible for collecting business and technical ratings is subjective which can affect the analysis result. On the other hand, similar techniques have been successfully applied in prior research, thus, it is not expected to obtain results with significant deviations from the desired outcomes.

6.1.3 Case study

A few issues were encountered during the case study which caused major delays in certain phases, specifically in the definition of the type of data to collect and the development of the questionnaire application on Power Apps. The first issue arose as a result of the large number of changes that needed to be implemented after the workshops/interviews as well as conflicting schedules with the stakeholders. Consequently, it is important to know that any company process can often demand more time than expected. This may be another reason for a simple APM model that serves as a starting point.

The second delay was caused by the time spent learning the advanced features of Power Apps and testing. Certain features proved unexpectedly difficult to implement due to a lack of previous implementations, this required additional time and also expert assistance from the company. Moreover, the testing phase lasted longer due to the number of changes needed to finalize the questions. However, once all of the questions were established, the actual implementation should be much faster.

Another challenge encountered in this study was the slow response rate. One factor could be the time constraint since the data collection started not too long ago. Additionally, insufficient awareness of the APM initiative and its importance could result in a lack of prioritization among the owners. Hence, it is crucial to create organizational awareness and understanding of APM which is also supported by the study [4].

Ultimately, the predefined objectives were met, resulting in a database that could provide valuable insights into the portfolio. However, this was just the initial implementation of APM, further efforts are required to fully realize its benefits. Additionally, APM should be an ongoing process integrated into the company’s strategy.
6.2 Contribution

The project is scientifically relevant because it addresses software usage at the enterprise level. It contributes to the research by presenting a novel APM approach for managing the applications to maximize the portfolio value. Additionally, it demonstrates the potential of its generalizability. The proposed framework acknowledges the importance of adapting to changing requirements, as evidenced by a case study based on real-world company data. This practical application connects theoretical work to practice. Moreover, the study addresses some of the challenges associated with APM in order to enhance and build upon previous academic works.

Furthermore, this holds significant relevance for many businesses looking for a way to manage their applications. The automated process of collecting and analyzing data using modern services presents a modern and cost-effective way (in this case) of implementing each phase of the process. The study seeks to gain news-value by offering guidelines and raising awareness of the benefits of APM as well as potential challenges. Overall, the framework demonstrates its ability to support decision-makers with valuable information.

From a broader perspective, the work contributes to society by raising awareness of the APM concept, specifically regarding its significance and benefits. Additionally, the research promotes efficient resource allocation and the case study serves as a valuable experience for the public.

6.3 Limitations

One possible limitation is the oversimplification of application analysis which is a common issue for matrix-based assessments [5], [15]. To perform a thorough analysis, it would be necessary to include additional factors that were discussed in the background section. Additionally, it is important to remember that they might be other factors, which are not stated in this thesis, that influence the decision-making process for the application. However, such an approach would also require more time and resources, which is beyond the scope of this study and would not fit the purpose of the intended APM model. Nevertheless, given the rapid advancement of technologies, further investigation is recommended to enhance application portfolio management.
In terms of the case study, while the framework does not explicitly specify software tools used for data collection & analysis, the case study was carried out using technologies that were available at that time to demonstrate a practical implementation of the model. However, it is worth noting that Power Apps and Power BI may not be the most suitable and optimal tools in all cases. To the team’s knowledge, there exists a few software services that offer a wide range of features for APM, although they most likely cause an additional cost.

Lastly, due to time limitations, no actions were taken according to the TIME model recommendations. As a result, this model does not examine the impact of these options. Since the group was unable to test the execution, there could be additional strategies that would be more suitable for other companies.

### 6.4 Future work

In terms of future work, it could focus on addressing the limitations described before. Firstly, a more in-depth analysis method could be introduced for application assessment. In addition to the evaluation methods outlined in the background section, another is to explore the AI-driven solution. For instance, by applying machine learning to provide recommendations and classifying applications into different categories. Additionally, external data also be incorporated into the analysis, some examples are business strategies, new technologies and the economy. This could be useful as external factors are highly dynamic.

Furthermore, an extension to this research could be to execute the recommended options for a small number of applications followed by an analysis of the outcomes. It would provide valuable feedback regarding the applicability of the strategies. Additionally, measuring return on investment would display the direct value of APM.

Finally, in order to demonstrate the robustness of this framework, it should be applied in different organizations. A more innovative approach to leverage APM could be involving other departments, where additional data are collected to benefit for example sustainability or even human resources by tracking the capabilities needed for the IT systems.
6.5 Ethics & sustainability

The introduction highlighted two key ethical concerns, namely data management and conflicts of interest. Firstly, the database used to store application data was accessible to all employees at the company, thereby eliminating the need for implementing permission/access restrictions on the data collected. Additionally, all tasks and work were carried out on the company computer. In terms of conflicts of interest, the involvement of stakeholders did not raise any major conflicting circumstances because each participant contributed to different areas of the framework with the same aim in mind i.e. improving the application portfolio management, any additional feedback was discussed together during workshops.

Regarding the sustainability aspect of the developed framework, it did not require additional computing power or cost. Moreover, it should be noted that the framework itself does not directly measure the environmental impact of each application. However, it provides metrics that support actions aimed at addressing some of the sustainability concerns, such as managing unused, duplicated, or overpriced applications.

6.6 Conclusion

This study aimed to answer the research question “How can modern enterprises implement application portfolio management practices and what are the most important steps involved in the process?”. In conclusion, the APM framework developed encompasses the following six key phases:

- **Objectives & scope definition**: The starting phase should focus on defining clear goals and plan for the project in order to guide the following steps. It is important to specify the applications that will be included and divide them into groups of smaller groups in order to facilitate the process.

- **Data type definition**: In order to conduct the data collection, the company has to first define the type of data they need to collect. As a starting point, the model recommends three data categories necessary to gather consisting of basic information, business fit and technical fit.

- **Data collection**: The practical process of data collection should enable
a simple and automated process. This step is meant to be conducted regularly in order to collect up-to-date data.

- **Data analysis**: Once critical data are collected the data analysis can be performed to create insights into the portfolio such as unused or overpriced applications. There are many techniques available, however, the most common one is by plotting the business and technical value of each application in order to arrive at a recommendation.

- **Process review**: The entire process needs to be reviewed in order to find appropriate adjustments that can improve and better align the APM process with the company goals.

- **Process adjustment**: Adjustments should be implemented before the next wave of applications.

The proposed model is based on previous research that focuses on the examination of basic information, business quality and technical quality of each application. However, it emphasizes the use of an iterative approach to adapt to necessary adjustments throughout the project.

The conducted case study uses modern software tools such as Power Apps and Power BI to showcase an implementation of data collection and data visualization. Evaluation by the project managers confirmed the model’s ability to fulfill the predefined objectives and the generalizability of the model.
References


