Bringing Enterprise Architecture to the Boardroom

AGUNG ADI PRIYANTO

MASTER THESIS

UNIVERSITY OF TWENTE.

BiZZdesign

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It is better to sit alone than in company with the bad;
and it is better still to sit with the good than alone.

It is better to speak to a seeker of knowledge than to remain silent;
but silence is better than idle words.

-Muhammad ibn 'Abdullah ibn 'Abd al-Muttalib

Management Summary

Aligning business and Information Technology (IT) has become an important issue for any organization and Enterprise Architecture (EA) is very much related to this purpose. EA describes the overall structure and coherence of an organization. As such, it can provide valuable input for strategic decision making at the executive level. In recent years, EA has become an established discipline both in academia and industry.

This research is proposed to take the challenge in presenting EA to the top-level management for a decision making support activity. The research is conducted according to the design science research methodology. A theoretical framework supports the definition of EA, EA stakeholders and their concerns, and the types of EA analysis. Then, the identification of the current decision making process in the domain of EA is explored and then an approach to formalize the decision making activity is proposed. The focus is in the visual representation of the quantitative analysis for the decision making process. The findings of the research is expected to extend the research line in EA domain about the formalization of decision making activity for the top-level management.

The first result of this research is a formalized top-down method to support decision making activity that is called EA-based decision making method. Two out of eight steps from the method are explored intensively: defining the metric and preparing the presentation and visualization. This generic method is presented to address all relevant activities to support decision making based on information from EA and prepared in such way for an ease in practical use. The second result is a dashboard concept to facilitate the visualization of this method. The data structure and logic behind the dashboard is presented.

To demonstrate the proposed artifacts, the method is applied by means of a case study and then a dashboard concept is implemented in a dashboard prototype. Finally, an evaluation for both artifacts by means of interviews is conducted to know how well they support a solution to the problem. The result provides positive indications.

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In the Name of Allah, the Most Beneficent, the Most Merciful

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Agung Adi Priyanto
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Table of Contents

List of Figures

List of Tables

List of Abbreviations

BI	Business Intelligence
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIO	Chief Information Officer
COO	Chief Operational Officer
CTO	Chief Technology Officer
DIO	Division Information Officer
DoDAF	Department of Defense Architecture Framework
DSRM	Design Science Research Methodology
EA	Enterprise Architecture
e.g.	exempli gratia (*for example*)
ID	Identifier
i.e.	id est (*that is*)
IS	Information System
IT	Information Technology
KPI	Key Performance Indicator
TOGAF	The Open Group Architecture Framework
VB	Visual Basic

1 Introduction

In this chapter, section 1.1 describes the research proposition as the introduction of the research. Section 1.2 describes the goal, scope and objectives of the research. Next, the research questions are provided in section 1.3. Section 1.4 illustrates the research approach and overview to show the structure of the whole document and the brief purposes of each chapters. Finally, the research method is presented in section 1.5 to describe the selected academic research methodology.

1.1 Research proposition

Aligning business and Information Technology (IT) has become an important issue for any organization and Enterprise Architecture (EA) is very much related to this purpose. EA describes the overall structure and coherence of an organization. In recent years, EA has become an established discipline both in academia and industry. EA has been developed as a common practice for an organization to understand the complexity of the structure of an enterprise, to provide a knowledge base and support for decision making about the IT-related issues in a company and to aid the process of translating business vision and strategy into effective enterprise change (Lapkin, 2009; Lindström, Johnson, Johansson, Ekstedt, & Simonsson, 2006). In the time when the evolution of IT is emerging rapidly, having EA as an instrument to effectively face the enterprise change is an effective approach to adapt by the organization.

As a model-based approach, EA is realized and formalized by means of a framework. There are several notable frameworks for EA e.g. Zachman Framework (Zachman, 1996), Department of Defense Architecture Framework (DoDAF) (DoD USA, 2007) and The Open Group Architecture Framework (TOGAF) (The Open Group, 2011). These frameworks need a formal language to represent and communicate the model to their stakeholders. One example of an EA modelling language is ArchiMate (The Open Group, 2012) which is related to TOGAF and conforms to the open standard. An open standard means a standard that is freely available to public and not owned by a certain company.

Regarding the concerns of EA stakeholders, most stakeholders of EA systems have more concerns in the impact of the system itself rather than its architecture (M.-E. Iacob, Jonkers, Quartel, Franken, & van den Berg, 2012; Jonkers, Quartel, & Blom, 2012). Let us take ArchiMate modelling language as an example. In spite of the more common usage of ArchiMate as a standard EA model by many organizations lately, business-oriented people feel that the standard ArchiMate models are unsuitable for their purposes because they have too much of an IT flavor (Graves, 2011; Nelson, 2011). In other words, these models are perceived by them as having too much technical or IT-concept information. Regardless how valuable the EA process is, only few senior executives have taken this advantage for achieving benefits of EA in their organizations (Lapkin, 2009). The hindrance is pretty clear; the EA process and delivery are not well-communicated to these group of stakeholders. The challenge is then how to bring EA to the senior executives or top-level management in order to support them for decision-making activities.

Currently there are limited researches conducted in the area of the stakeholders of EA and even less at the top-level management area. Prior academic research about stakeholders of EA is proposed by Ekstedt which describes about EA as a means for IT management and sets focus at CIO as the stakeholder of EA (Ekstedt, 2004a, 2004b). Further, van der Raadt (2011) portrays the overall stakeholders satisfaction of EA function. From the industry or practical field, some companies have also conducted practical researches concerning the stakeholders of EA. A study by Broer and Roeleven (Roeleven, 2010) claims that top-level management may contribute to the failure of EA to meet expectation by not giving enough support in practice. Another study by Gartner proposes some recommendations for top-level management to meet their concerns using EA (Short & Newman, 2009).

1.2 Research goal, scope and objectives

This research is proposed to take the challenge in presenting EA to the top-level management for a decision making support activity. The identification of the current decision making process in the domain of EA will be studied and an approach to formalize the decision making activity will be explored.

The goal of the research is to define a set of interactive views based on EA modelling language that provide top-level management with information for strategic decision making. In this research, we use the concept of views and viewpoints defined in ArchiMate modelling language. In ArchiMate, typical examples of views for decision support are cross-reference tables, landscape maps, lists and reports (M.-E. Iacob et al., 2012). Figure 1-1 provides a classification of enterprise architecture viewpoints based on two dimensions namely purpose (designing, deciding, informing) and abstraction level (details, coherence, overview) (The Open Group, 2012). We want to propose a new set of views with purpose 'deciding' and abstraction level 'overview' (shown in the center-top black area in the figure 1-1).

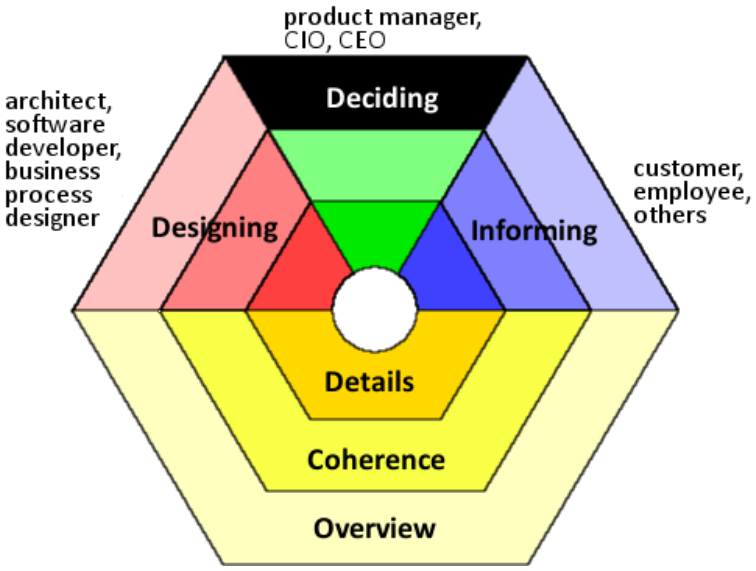

Figure 1-1: Viewpoint classification, adapted from Archimate 2.0 specification (The Open Group, 2012)

The scope of the research is in the exploration of visual representation of EA delivery for the decision making process based on the quantitative analysis practice and in how to represent that to the top-level management.

The first objective of this research is to propose a formalization of the decision making activity for EA practice in the management level in a company. A possible approach is presented as a step by step methodology in transferring the information from an EA result to these stakeholders. The approach is applied in a case study to demonstrate its practical use. The second objective is to create a conceptual dashboard to facilitate the resulting method from the first objective.

1.3 Research questions

In order to meet the research objective, first of all we need to understand the concept of EA, specifically EA at the business level. The top-level management as one group of EA stakeholders and their concerns regarding EA implementation needs to be identified. Then, the available types of analysis also need to be discussed to have the general overview of decision making in EA practice. In relevance with the research scope in visual representation for decision making, firstly we are going to explore about the relevant theory of visual language. Then, we are interested in exploring an established field about information processing for business purpose which has already a good practical support in delivering information in visual representation. Business Intelligence (BI) and its management dashboard are selected in order to know how EA could adapt the similar concept from them. Then, the next question is on *how* to support the decision making in EA by means of visual representation. For this objective, a structured method needs to be formulized. For an option of visual representations, a dashboard concept is selected for this research. The remaining question will be on how to build such dashboard including its relevant data structure. Based on this elaborated background, the following research questions are proposed:

RQ 1. What is the Enterprise Architecture at the Business Level?
- **1.1.** What is Enterprise Architecture?
- **1.2.** Who are the top-level management stakeholders for Enterprise Architecture?
- **1.3.** What are the concerns of the top-level management as the Enterprise Architecture stakeholders?
- **1.4.** What are the existing types of analysis for Enterprise Architecture?

RQ 2. What should Enterprise Architecture deliver for strategic decision making by means of visual representation?
- **2.1.** What is the relevant theory of visual language?
- **2.2.** What is Business Intelligence?
- **2.3.** What is Management Dashboard?

RQ 3. How can the decision making in Enterprise Architecture be supported by means of visual representation?

- **3.1.** How to facilitate a structured way for a decision making by means of visual representation?
- **3.2.** How to prepare the data elements for a dashboard?
- **3.3.** How to build a Management Dashboard to facilitate decision making in Enterprise Architecture?

1.4 Research approach and overview

This research document is divided into six chapters. The first chapter introduces the research proposition as the problem identification and motivation of the research. In the same chapter, the research questions as the base of the research, the research approach and research method as the academic methodology to conduct this research are described. The second chapter is the first part of the design and development phase and it contains the literature review as the theoretical framework. It describes the relevant literatures and references regarding the topic of the research to address research question 1 and 2. The third chapter is the second part of the design and development phase and it proposes the main artifact of this research which are the EA-based decision making method and the dashboard concept. It is prepared to answer research question 3. In chapter four, the demonstration of the method is illustrated and the implementation of a dashboard prototype is described. Finally, the last two chapters are prepared for the evaluation and conclusion of the research.

The following description briefly explain about the content of each chapter in this research:

Chapter 1 : Introduction and problem identification, research goal, scope and objectives, research question and research method
Chapter 2 : Literature review: to answer research question 1 and research question 2
Chapter 3 : Design artifact: to answer research question 3
Chapter 4 : Demonstration of the artifact
Chapter 5 : Evaluation of the artifact
Chapter 6 : Conclusion of the research

The research approach is illustrated in figure 1-2.

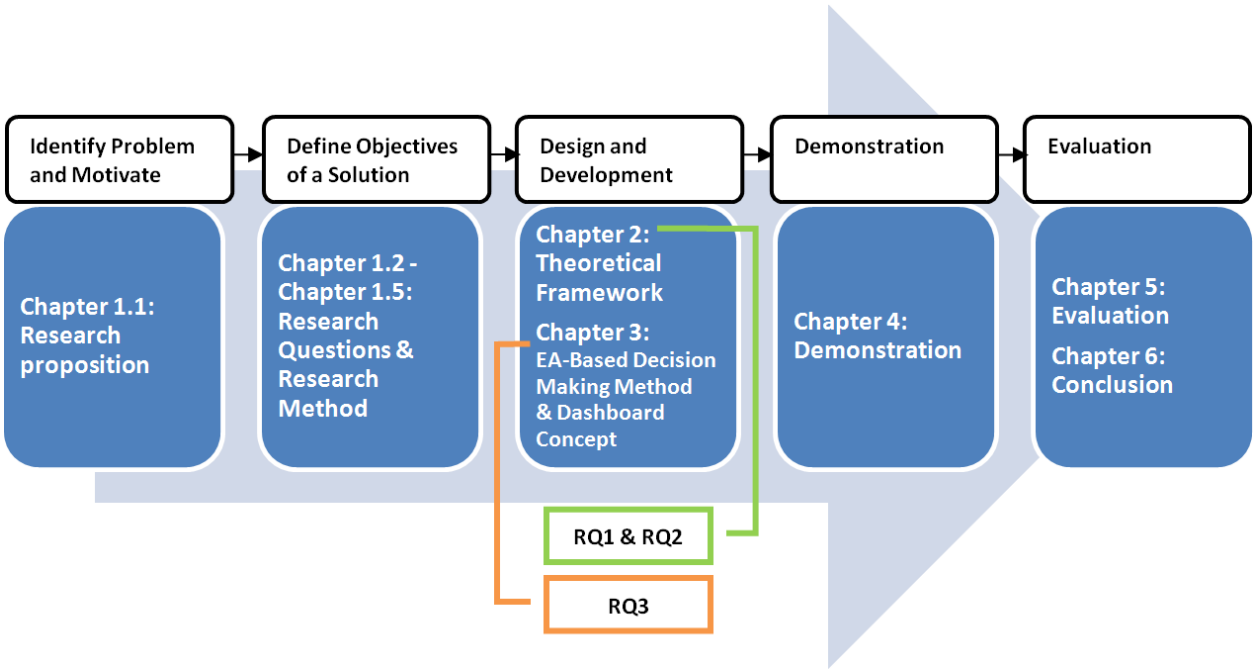

Figure 1-2: Research approach

1.5 Research method

Scientific research should contribute to a body of science and follow scientific method (Bhattacherjee, 2012). To conduct the research, the research process and research method approach from Bhattacherjee (2012) is used. This research will be conducted as a deductive research that will gather all related theories and insights from available literatures to be tested by means of an artifact. The type of the research will be performed as an explanatory research as the main direction is to know how to answer the problem addressed in the research questions.

The Design Science Research Methodology (DSRM) proposed by Peffers et al. (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007) will be used in this research. In line with the methodology proposed by the authors, the research will follow six steps. The first step is problem identification and motivation and this will be covered in the first chapter of the research document. The step of writing definition of the objectives for a solution will be explained further in chapter 2. The next one is the design and development step that will be addressed in chapter 3 and 4. Demonstration step will follow after that by means of a case study and then the evaluation step will be performed by means of a validation in interviews. Lastly, the communication step will be done by means of a presentation in a colloquium of the research project for the graduation and the publication of the final delivery of the research by the University of Twente. The steps are illustrated in the DSRM process model in figure 1-3.

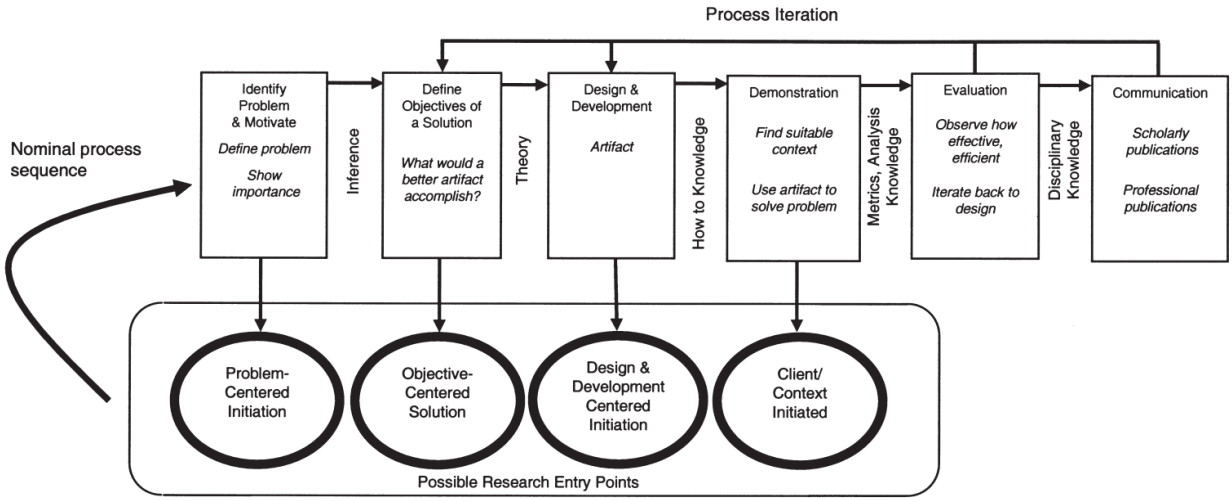

Figure 1-3: Design science research methodology (DSRM) process model (Peffers et al., 2007)

According to Peffers et al. (2007), there are four possible research entry points, including problem-centered initiation, objective-centered solution, design and development centered initiation and context initiated. As aforementioned in the problem identification chapter, the main objective of this research is to find a possible approach to bring Enterprise Architecture to the higher management. By having this purpose, the suitable entry point of this research would be categorized as an **objective-centered solution**.

2 Theoretical Framework

This chapter provides literature review to answer research question 1 and research question 2. Section 2.2 until section 2.4 address the first research question about EA at the business level. Particularly in section 2.3, the ArchiMate concept is described as the selected EA modelling language to illustrate modelling concepts and figures in this research. Section 2.5 until section 2.7 address the second research question about EA deliverable for strategic decision making by means of visual representation. Table 2.1 shows all sub research questions and their relevant section in this chapter.

Table 2-1: Research question 1 and 2 and their relevant sections

Research Question		*Section*	
1.1.	*What is EA?*	*2.1*	*Introduction*
1.2.	*Who are the top-level management stakeholders for EA?*	*2.2.1*	*The stakeholders of EA*
1.3.	*What are the concerns of the top-level management as the EA stakeholders?*	*2.2.2*	*The concerns of EA stakeholders*
1.4.	*What are the existing types of analysis for EA?*	*2.4*	*EA analysis*
2.1.	*What is the relevant theory of visual language?*	*2.5*	*Theory in visual language*
2.2.	*What is Business Intelligence?*	*2.6.1*	*Business intelligence*
2.3.	*What is Management Dashboard?*	*2.6.2 & 2.7*	*Management dashboard*

2.1 Introduction

Enterprise Architecture has an important role in the alignment of business and IT. As an organization-wide architecture, EA integrates business, information, application and technology aspects of an organization (Jonkers et al., 2012). EA captures the essentials of the business, IT and its evolution (Lankhorst, 2009). Business success is difficult to achieve without a good architecture. Regarding this concern, EA models can be utilized to translate the business strategy into business and system design, and to correlate the strategic level with the design level of an organization ((Jonkers et al., 2012). To have a better understanding, figure 2-1 illustrates this concept.

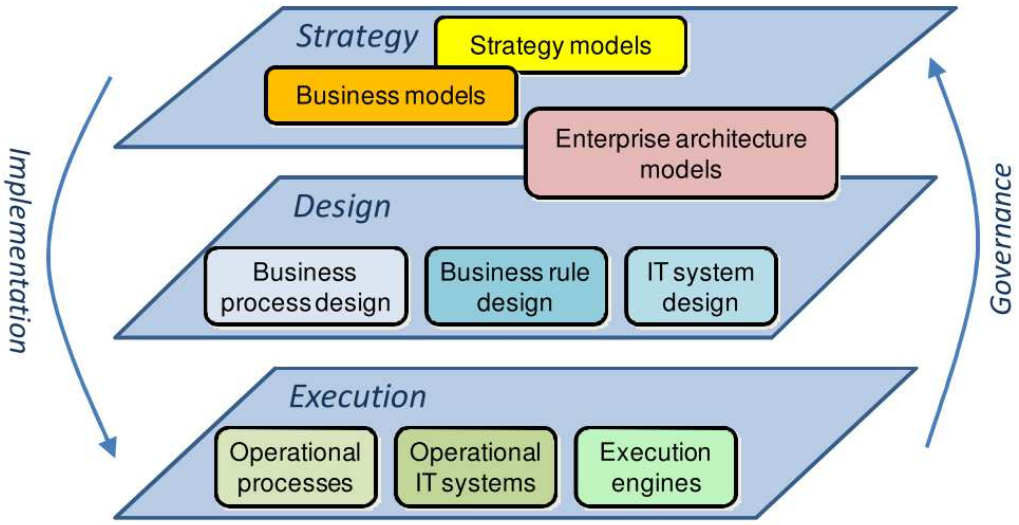

Figure 2-1: EA models at the strategy and design level of an organization (Jonkers et al., 2012)

Definition of Enterprise Architecture

Architecture is defined as "*the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution*" (Hilliard, 2000), and "*that set of descriptive representations (i.e. 'models') that are relevant for describing an Enterprise such that it can be produced to management's requirements (quality) and maintained over the period of its useful life (change)* " (Zachman, 1996). From the definition, an architecture may contain components, relationships between components, their environment and the representation of these components.

To continue from the previous definition, basically Enterprise Architecture (EA) is defined in the similar way specifically in the domain of Enterprise. Several EA definitions are given in table 2-2.

Table 2-2: Definition of Enterprise Architecture

	EA Definition from Literatures	Sources
1	"*A comprehensive description of all of the key elements and relationships that make up an organization"*	(Harmon, 2003)
2	"*A model based management and planning approach for the evolution of organization-wide information systems*"	(Johnson, Ekstedt, Silva, & Plazaola, 2004)
3	A model-based approach that "*provides a knowledge base and support for decisions about the overarching IT related issues within the company*"	(Lindström et al., 2006)
4	"*The process of translating business vision and strategy into effective enterprise change"*	(Lapkin, 2009)

From the definitions in the table, there are some key aspects from EA i.e. a model-based approach, evolution of organization (enterprise change), and decision support for IT related issues. Decision

support or decision-making support are related to the activities of management in the organization. As a management instrument, EA can help to translate the goal of an organization from the current state ('as is' situation) to the future state ('to be' situation) (Lankhorst, 2009, p. 8). EA has an important role as a communication instrument between different groups and interests in order to have a common base for discussion and decision making (Jonkers et al., 2006).

2.2 Enterprise Architecture at the Business Level

EA can deliver significant benefits to the organizations and it addresses many concerns from the senior executives (Lapkin, 2009). Regardless of its potential benefits to the organization, the realization of EA has not yet gained a maximum result in general. Some of the reasons why EA process failed to meet expectations are because it is not having enough understanding and support from the top-level management (e.g. CIO and CFO), it is not engaging the business people and not spending enough time on communication (Pettey & van der Meulen, 2009; Roeleven, 2010) and the real value of the EA process has not been articulated very well yet (Lapkin, 2009). These factors can be minimalized by providing an environment where stakeholders become active participants, are receptive to change, and are encouraged to foster collaboration and information-sharing among themselves (Mezzanotte, Dehlinger, & Chakraborty, 2010).

2.2.1 The Stakeholders of Enterprise Architecture

Knowing who are the stakeholders of Enterprise Architecture and what are their concerns is important to understand what kind of message to prepare and deliver for such a decision making activities. Therefore, this section explains briefly about these two concepts.

Definitions

A stakeholder is defined as an individual, a group of people or an organization which has a key role in the architecture (Minoli, 2008), has an interest in, or a concern about, the architecture (Hilliard, 2000; M.-E. Iacob et al., 2012), or is involved in creating or using the architecture (Smolander & Päivärinta, 2002).

Concern is the key interest for the stakeholders from a system which are critical or important to them and can be related to the system's operation, development or any other aspects (Hilliard, 2000) and determine the acceptability of the system (Minoli, 2008). According to the standard definition, concerns may relate to system's considerations such as performance, reliability, security, distribution, and evolvability (Hilliard, 2000). Furthermore, the minimum concerns of the stakeholders should include the purpose of the system, the appropriateness of the system, the feasibility of constructing the system, the risks of system development and operation, and maintainability, deployability and evolvability of the system (Hilliard, 2000). In the ArchiMate 2.0 motivational concept, a concern has similar meaning with a driver. Driver is defined as something that creates, motivates, and fuels the change in an organization (The Open Group, 2012).

Different stakeholders will have various roles in the system and different concerns (Minoli, 2008). In most cases stakeholders are not interested in the system's architecture, but only in the impact of the architecture according to their own concerns (M.-E. Iacob et al., 2012; Jonkers et al., 2006, 2012).

The EA stakeholders classification

The stakeholders of Enterprise Architecture can be categorized as two groups namely enterprise architects and non enterprise architects. Hilliard (2000) describes that there are two key roles among stakeholders i.e. the architect and the acquirer (or client) of the architecture. A buyer, customer, owner, user, or purchaser can be the role of the acquirer. A similar classification has also been proposed by Foorthuis, Steenbergen, Mushkudiani, Bruls, & Brinkkemper (2010) as the authors describe two classes of EA stakeholders i.e. EA creators and EA users. EA creators may consist of EA architects, manager and external EA consultant, and EA users may consist of project manager, project architect, business analyst, programmer, etc. In EA research, Van Der Raadt, Schouten, & Van Vliet (2008) argues that there is still not much research on EA stakeholders which has more focus on the role of the non architect. On the contrary, the research focus has been done more on the role of the architect. From this point forward, the term EA stakeholders will refer to the group of non enterprise architects.

Van Der Raadt et al. (2008) mention that one of the key success factors for EA is the effective collaboration between architects and the EA stakeholders. As the field of EA is maturing, studies about its practices and benefits are emerging (van Steenbergen et al., 2011). Foorthuis et al. (2010) argue that EA creators (e.g. enterprise architect) are significantly more positive than EA users (e.g. business analyst) in their evaluative perceptions regarding the benefits of EA. However, this finding might be subjective due to the involvement and commitment of EA creators toward EA.

A more elaborated attempt to make a classification of the Enterprise Architecture stakeholders has been proposed by van der Raadt et al. (Van Der Raadt, Bonnet, Schouten, & Van Vliet, 2010; Van Der Raadt et al., 2008) as shown in table 2-3. The columns represent the four EA aspect areas and the rows represent the four levels in the organization.

Table 2-3: Key EA Stakeholders, their aspect areas and organizational levels (Van Der Raadt et al., 2008)

	Business	Information	Information Systems (IS)	Technical Infrastructure (TI)
Enterprise	• CEO, CFO, COO	• CIO	• CIO	• CTO
Domain	• Head of BD/BU • Business change manager	• DIO • IT change manager	• DIO • IT change manager	• Platform manager • Platform subject matter expert
Project	• Business project manager • Business process designer	• Information analyst	• Software development project manager • Software designer/architect	• Infrastructure project manager • Infrastructure engineer
Operational	• Operational business manager • Business process engineer	• Data administrator	• Application management • Application administrator	• Data center management • Infrastructure administrator

Stakeholders at the enterprise level

The decision makers at the enterprise level, who are represented by individuals in the Board Room, are also the stakeholders of the EA. Table 2-4 explains more about the EA stakeholder classification at the enterprise level and some of their roles as a subset from the main classification from table 2-3.

Table 2-4: EA Stakeholder classification at the enterprise level; adapted from (Van Der Raadt et al., 2008)

EA aspect areas	Board members	Responsible for
Business	Chief Executive Officer (CEO), Chief Financial Officer (CFO), Chief Operational Officer (COO)	the enterprise business strategy
Information, Information System (IS)	Chief Information Officer (CIO)	business and IT alignment, i.e. that IT supply meets business information demand
Technical Infrastructure	Chief Technology Officer (CTO)	decision making regarding technology components and platforms

Scholars and also practitioners often use different terms when referring to the entity at the executive level of an organization. Some of them describe it as board of directors, board members, higher level management, top-level management, C-level management and upper level management. For a simplicity reason, hereafter the term top-level management will be used to refer to all of those similar terms.

2.2.2 The Concerns of Higher Management as EA Stakeholders

We now discuss the relevant concerns for the identified stakeholders.

Chief Information Officer - CIO

Due to CIO's responsibility for making decisions about overall IT related concerns of the company (Lindström et al., 2006), business and IT alignment (Van Der Raadt et al., 2008) and for the management, planning and evolution of the enterprise information system (Johnson et al., 2004), CIO can be considered as the primary stakeholder for EA (Lindström et al., 2006) from the top-level management. EA is suggested as a support for CIO's decision-making process and this process in essence can be seen as a problem of scenario selection (Johnson et al., 2004).

For a decision-making tool, EA is used by means of architectural models. Johnson et al. (2004) argues that it is often unclear why a certain model is chosen and what correlation the contents and structure of a model has, although the initial purpose of having the model is to be able to answer questions related to the modeled entity from the model. Thus, the authors propose Architectural Theory Diagrams, a means of presentation and comparison for architectural theories, to assess the analytical value of the architectural models.

According to Johnson et al. (2004), the steps the CIO will go through when making decisions consist of (1) formulating scenarios, (2) deciding upon evaluation criteria, (3) analyzing scenarios, and finally (4) selecting scenarios. In the decision-making process, CIO will face a situation of comparative analysis between various future states of EA (Johnson et al., 2004).

A survey on Swedish CIOs as the primary stakeholder of EA by (Lindström et al., 2006) shows the concerns of the CIO and their priority. As stated in the survey report, the two most important concerns for the CIOs are to decrease the business cost and to improve the alignment of business and IT. Nevertheless, these two concerns are given the least focus by EA frameworks (presented by the Department of Defense Architecture Framework (DoDAF) and the Zachman Framework for EA) (Lindström et al., 2006). At the end of the report, the authors propose to have an incorporation of cost information support and decision support for IT organization-related issues i.e. IT governance. The report summary is shown in table 2-5.

Table 2-5: The concerns of the CIOs, their prioritization, and the harmony between foci of EA frameworks and CIO concerns; adapted from (Lindström et al., 2006)

Rank	CIO concerns	Example	Harmony with foci of EA framework
1	Decrease the cost related to the business organization	cost for personnel in the business organization	Lack of focus
2	Improve the quality of the interplay between the IT organization and the business organization	support, helpdesk, and end-user training	Lack of focus
3	Provide new computer aided support to the business organization	new functionality, new information, and communication means	Fine support
4	Improve the quality of the IT systems	security, performance, availability, reliability, quality of data, and correctness of functionality	Good support
5	Improve the quality of existing services or products that the business organization provides to the customers	-	Good support
6	Improve the quality of operation and maintenance, development, and acquisition of IT systems	-	Lack of focus
7	Develop new services or products that the business organization provides to the customers	-	Good support
8	Improve the maintainability and modifiability	by improving interfaces, introducing middleware, and standardize protocols and products	Good support
9	Decrease the costs related to hardware and software	-	Lack of focus
10	Decrease the costs related to the IT organization	wages and training for IT staff	Lack of focus
11	Provide new IT based solutions to the IT organization	administrative tools, b-logs, and back-up tools	Lack of focus

Chief Executive Officer - CEO

Gartner, an American information technology research firm, has conducted some researches regarding the concerns of the business leaders from time to time. During the challenging economic times in 2009, cost-cutting activities and innovation initiatives to support the recovery from the economic uncertainty were the two most demanding concerns for the leaders, mainly for the CEOs (Short & Newman, 2009).

In their research report, they mention top-five CEO issues in the domain of enterprise and propose some solution on how EA can help to manage the concerns. The summary is given in table 2-6.

Table 2-6: The concerns of CEOs in 2009 and how EA can help to solve the problem (Short & Newman, 2009)

No.	CEO concerns	EA role
1	Restructuring Operations	EA Optimizes Operations
2	Leveraging Information Strategically	EA Ensures Actionable Delivery of Relevant Information
3	Loss of Government and Business Trust	EA Has the Right Perspective
4	Complex and Unstable Globalization	The Business Needs EA Insights
5	Building Core IT Strength	EA Has the Right Business Focus

Chief Financial Officer - CFO

According to Lubbe (2011), there is a gap between CFO and EA which may leads the failure of EA process in meeting CFOs' expectation. The gap is described as how different in the way both stakeholders behave (here EA is represented by Enterprise Architects) as seen in table 2-7. This problem can be closed when the 'language barrier' between these two functions can be formalized based on universal standards (Lubbe, 2011).

Table 2-7: The problem between CFO and EA

No.	Aspect	CFO	Enterprise Architects	Problem
1	Interpreting external drivers and business strategies	Using own interpretation and judgement	Focused on capturing the process of decision making	Missing engagement in a conversation
2	Outcome direction	Working with probabilities and scenarios, in order to be able to work with missing information	Focused on 'Business Architecture'; design of processes; clearly defined	Lack of flexibility

2.3 ArchiMate

We are interested in the existing types of views and viewpoints which have been defined in the ArchiMate language standard. This section addresses this concern.

ArchiMate is an open standard modelling language from the Open Group for modelling Enterprise Architectures. What makes ArchiMate differ from any other modelling language such as UML is that it has a specific domain which is the Enterprise Architecture. As having an open standard characteristic, it has an industry-free tendency for its development. ArchiMate provides concepts to model the business and how it is supported by information technology. It provides a common language for "*describing the construction and operation of business elements to help stakeholder to design, assess, and communicate the consequences of decisions and changes within and between these business domains*" (The Open Group, 2012). ArchiMate 1.0 standard was published in 2009 and then in 2012 ArchiMate 2.0 was

released. In addition to the core component, the latter standard contains two extensions namely motivation extension and implementation and migration extension.

Layering is the next main concept in ArchiMate. Basically, ArchiMate model is divided into three main layers i.e. the business layer, the application layer and the technology layer (The Open Group, 2012). Each layer has its own specific stakeholders and function. As described in the specification (The Open Group, 2012), the business layer will realize the business processes performed by business actors. It will be supported by the application layer by receiving services from software applications. The technology layer as the final layer will support the application layer by providing infrastructure services which are needed to run these applications. Different layers will have different stakeholders with different concerns. In this research, the focus will be given more to the business layer of ArchiMate as it is more related to the top-level management and their concerns.

2.3.1 Views and Viewpoints

In ArchiMate, views and viewpoints are the two concepts that are highly related to the presentation of this language. They are the actual model representation of the architecture of the system to make the communication to the users (or stakeholders) possible. From the standard in IEEE-STD-1471-2000 (Hilliard, 2000), a view is defined as "*a representation of a whole system from the perspective of a related set of concerns*" and a viewpoint is defined as "*a specification of the conventions for constructing and using a view; a pattern or template from which to develop individual views by establishing the purposes and audience for a view and the techniques for its creation and analysis*". As a representation of the system, a view is used to demonstrate some particular concerns of a particular stakeholder or group so that these concerns are well-addressed in the design of the system architecture, while a viewpoint defines the way how to construct and use a view by means of a schema or template (Minoli, 2008). In a simple term, "*a view is what you see from the EA, and a viewpoint is where you are looking from"* (M.-E. Iacob et al., 2012).

From the document of ArchiMate 2.0 specification, there are 27 basic viewpoints which serve particular stakeholders with their different concerns. The full list of existing viewpoints and the definition of the purpose and the abstraction level of these viewpoints are described briefly in **Appendix A**. One of the purposes of this research is to propose a new kind of view which is intended for decision-making activities by the top-level management as the stakeholder of EA. Based on the introduction in the previous section, the suggested view should have two characteristics that are able to use as a decision making activities (i.e. "deciding" purpose) and have the general coverage of the system (i.e. the abstraction level of "overview"). The list in table 2-8 shows the relevant viewpoints which have both required characteristics.

Table 2-8: Viewpoints with 'deciding' purpose and 'overview' abstraction level

Group	No.	Viewpoint name
Standard (Core)	1	Introductory Viewpoint
	2	Layered Viewpoint
	3	Landscape Map Viewpoint
Motivation Ext.	4	Motivation Viewpoint
Implementation & Migration Ext.	5	Project Viewpoint
	6	Migration Viewpoint
	7	Implementation and Migration Viewpoint

As the goal of this research, a different kind of view will be proposed to represent the concerns of the stakeholders from this level.

2.4 Enterprise Architecture Analysis

To deliver value for stakeholders, it is important to allow some analysis on the architecture. In this section we discuss the different analysis techniques available on EA. Each analysis technique enables addressing one or more typical concerns stakeholders have.

2.4.1 Model-based Analysis Techniques

According to (Lankhorst, 2013), the value of Enterprise Architecture models will significantly increase if it can also help the decision making process. This decision making activity can be supported by applying model-based analysis techniques on top of these EA models. This architecture analysis can be done in several aspects like costs, quality and performance (Lankhorst, 2013).

(Lankhorst, 2009) describes two types of architecture analyses: functional analysis and quantitative analysis. *Functional analysis* is conducted to gain insight into the functional aspects of an architecture and *quantitative analysis* is conducted to answer quantitative questions. The consequence for the later is to have measurable indicators to be analyzed. Table 2-9 below illustrates typical analyses techniques in EA practice.

Table 2-9: Typical analysis in EA practice, partially adapted from (Lankhorst, 2009)

#	Analysis technique	Description	Functional analysis	Quantitative analysis
1	Functional analysis	To understand how a system in the architecture works, e.g. to see the structure of the architecture	supported	not supported
2	Validation analysis	To validate the correctness of an architecture	supported	not supported
3	Impact analysis	To see the impact of change in the architecture by adding or deleting components, e.g. in the 'what-if' analysis	supported	supported
4	Change (gap) analysis	To see the comparison from 'as is' situation to 'to be' situation, e.g. in the roadmap and portfolio analysis	supported	supported
5	Performance analysis	To measure the performance of indicators (metrics) in the system or properties (attributes) of a system or component in the architecture, e.g. quality times, importance, risk, usage, cost, etc.	not supported	supported

The two right-most columns in table 2-9 indicate whether the respective technique supports the functional/quantitative analysis or not. For example, the validation analysis is performed to see the functional validity of an architecture but it does not support a follow-up quantitative analysis. Gap analysis is capable to facilitate analysis in the difference between 'as is' situation and 'to be' situation both in the functional aspect (e.g. the structure) and quantitative aspect (e.g. the cost). Performance analysis is a collective term to cover all the quantitative analyses which are performed based on pre-defined indicators or metrics. For instance, risk and cost analyses fall under this category.

To date, there are still a few formal EA analysis techniques available, for example the performance analysis measurement in the workload, processing time, response time and utilization in the system (M. E. Iacob & Jonkers, 2006), the Bedell portfolio analysis (Quartel, Steen, & Lankhorst, 2010), the quality attribute analysis such as the availability, performance, interoperability, modifiability, and information security (Johnson, Johansson, Sommestad, & Ullberg, 2007) and the system quality analysis (Närman, Schönherr, Johnson, Ekstedt, & Chenine, 2008). In practice, the type of analysis is performed depending on the goal of the stakeholders and it will likely rely on the expertise of the architects or the aid from the consultancy service.

To set up a scope of the research, the **focus in this research is on the quantitative analysis,** such as performance analysis. The method description which will be described and discussed in chapter 3 is within this boundary.

2.5 Theory in Visual Presentation

To have a better understanding about the message to deliver by means of visual representation, we are interested in the theory of visual language and also to see how the existing theory could be applied in the context of EA deliverable.

2.5.1 Communication Theory

In practice, EA analyses are being done based on analysis of the *concrete* architecture models that represent a specific viewpoint of an architecture in the enterprise. These models are usually represented in the form of diagrams, for instance the ArchiMate models. To understand the message of the models, the underlying *semantic meaning* should be delivered properly. For those who are continuously working with the modelling language, for example the Enterprise Architects, or at least for those who have a basic knowledge of the language itself, understanding the message behind the models should be easier rather than for a novice group of people.

An effort to bring EA to the boardroom, specifically the ArchiMate models in this context of the research, has an important consequence: how to convey the message from the model in a way so that this particular stakeholder would receive the message properly. A simple approach could be by providing a brief annotation or legend for the symbols that are used in the model with a purpose that the users will read it carefully and then, hopefully, are able to grasp the message. This approach can also be conducted by simply explaining the semantic meaning behind every symbols verbally during a

presentation. However, there is a possibility that this approach is not that effective for instance when the users do not spend enough time to try to understand those new concepts or symbolic language. Even if these architecture models are effectively proven to facilitate communications for a certain group of stakeholders e.g. the Enterprise Architects, it might not be the same with the other stakeholders, e.g. the higher management. The message from the model should be communicated in the 'language' of this particular stakeholder.

A relevant communication theory is proposed by Moody which is an adaptation of a widely-accepted theory of communication from Shannon and Weaver (Moody, 2009), as seen in figure 2-2.

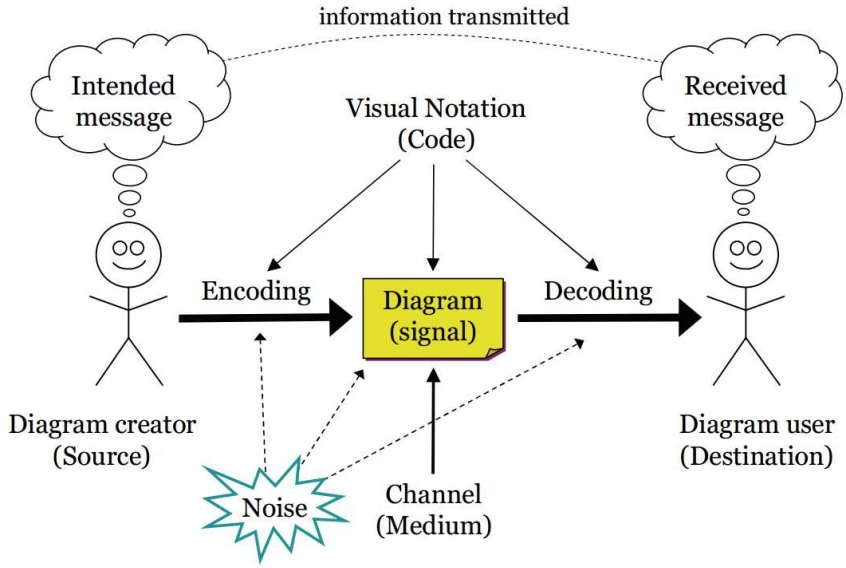

Figure 2-2: Theory of Diagrammatic Communication (Moody, 2009)

From the figure, a diagram creator sends (encodes) the message in the form of a diagram and the diagram user receives (decodes) the diagram. An effective communication is measured by the match between the intended message and the received message (Moody, 2009). The purpose of **visual notation** is to facilitate communication and problem solving. **Cognitive effectiveness** is defined as "*the speed, ease and accuracy with which a representation can be processed by the human mind*" and this is something that must be designed into visual representations (Moody, 2009). Research in diagrammatic reasoning shows that the visual representation (form) has an equal influence on cognitive effectiveness as their semantics (content) (Moody, 2009). To put it simply, visual representation is also an important aspect in the communication.

2.5.2 Visual Notation

People often use the terms *graph* and *chart* synonymously. Furthermore, these two terms are often grouped as *diagram*. According to Oxford dictionary, a **diagram** is defined as "*a simplified drawing showing the appearance, structure, or workings of something; a schematic representation*" (“Diagram,”

n.d.). A **graph** is defined as "*a diagram showing the relation between variable quantities, typically of two variables, each measured along one of a pair of axes at right angles*" (“Graph,” n.d.). A **chart** is defined as "*a sheet of information in the form of a table, graph, or diagram*" (“Chart,” n.d.). From the definition, diagrams can be exposed as the umbrella for both graphs and charts. Different definitions to distinguish these terms are also proposed by other researchers such as (Harris, 1999) and (Wilkinson, 2005).

From a recent research, Moody describes that "*a **visual notation** consist of a set of **graphical symbols**, a set of **compositional rules** and the definitions of the meaning of each symbol*" (Moody, 2009). The illustration is depicted in figure 2-3.

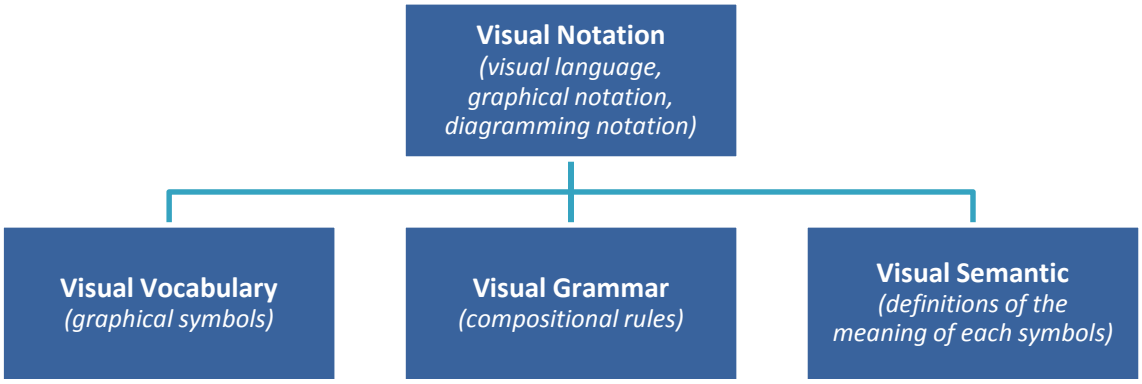

Figure 2-3: Elements of Visual Notation, adapted from (Moody, 2009)

A **visual sentence** or **diagram** is a valid expression in a visual notation and consist of symbol instances that are arranged based on the rules of the visual grammar. For instance, UML diagram and ArchiMate model clearly fall under this definition. Typical charts such as line chart, pie chart and bar chart and also comply to for this definition as they consist of shape symbols (e.g. line, circle and rectangle) and they have rules to be expressed (e.g. the rule to plot the symbol on the vertical and horizontal axes). In this research, the term **chart** is used to address a diagram which displays a relationship between two or more quantitative variables that express either discrete or a continuous range of values.

2.5.3 Principle of Cognitive Fit

The physics of notation is a theory for evaluating and designing the visual notations which is proposed by (Moody, 2009). The theory consists of 9 principles for designing cognitively effective visual notations. **The principle of cognitive fit** is one of the principles that is relevant in this research and it is basically derived from the well-known cognitive fit theory by Iris Vessey (Vessey, 1991). The principle describes that "*different representation of information are suitable for different tasks and different audiences*" (Moody, 2009). The theory is depicted in figure 2-4 and it shows that cognitive fit (or problem solving performance) is determined by the interaction between problem representation, task characteristics and problem solver skills.

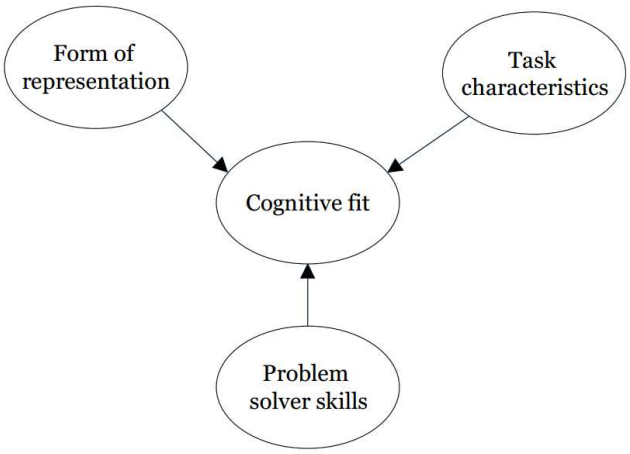

Figure 2-4: Cognitive fit and the interaction between constructs (Moody, 2009)

Form of representation reflects the visual representation of the notation. *Task characteristic* reflects the representational medium of the notation, e.g. paper-based medium or computer-based drawing tools. *Problem solver skills* represent the expert-novice differences between the notation users, e.g. business users and technical experts. The challenge in designing notation is that it needs to be understandable by both stakeholders. Practitioners sometimes develop their own notation for communicating with users in informal way, for example by creating a simplified version of the standard notation (Moody, 2009). This principle recommend to use different **visual dialects** for different tasks and audiences.

2.6 Business Intelligence and Management Dashboard

Compared to EA practice, Business Intelligence (BI) is a field that has been more established in delivering the business message in a visual representation such as in a management dashboard. This section discuss about the possibility on how to apply the concept used in BI to deliver the message in a visual representation on EA context.

2.6.1 Business Intelligence

Without any doubt, companies and organizations have data resources in any forms to maintain. As the company grows from time to time, the data volume will also grow larger and larger. The basic purpose to maintain this data is always the same; how to extract the valuable information out of it to help the planning and decision making activities. At this point, the concept of Business Intelligence (BI) emerges. According to Negash, "*BI systems combine data gathering, data storage, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision makers*" (Negash, 2004). Based on this definition, 'analytical tool' is one of the key points to facilitate this concern. Further in his paper, data visualization is mentioned as one of the essential components of BI. Visualization is the process to represent data with graphical images and it can be used to create advanced dashboard in which a rich information is presented on a single screen (Negash, 2004). From the industry perspective, Gartner as an IT research and advisory company mentions that reporting,

dashboard, analysis support and interactive visualization are some of the capabilities what a good BI platform should deliver (Schlegel, Sallam, Yuen, & Tapadinhas, 2013).

In relevance with the aforementioned BI concept, the same way of thinking is also applicable to Enterprise Architecture (EA). Implementing EA in organizations will provide them with a rich data about the architecture of the enterprise, for example by means of EA models. Then, this question will occur: How to present the effective information based on those models for analytical purpose? With a similar approach to the BI concept, having a data visualization for EA delivery is an intuitive way to present those information. This objective has been facilitated by the EA practice, for example in the classification of views and viewpoints in ArchiMate modelling language (M.-E. Iacob et al., 2012; The Open Group, 2012). In these viewpoints classification, the typical stakeholders for each view and viewpoint are provided. To narrow down the focus, we are interested to examine the viewpoints for top-level management as one of the group from the EA stakeholders. The common view types for these stakeholders are cross-reference table, landscape map, list and report (The Open Group, 2012). For a brief description about these viewpoints, please refer to Appendix A. Even though these pre-defined viewpoints are helpful to communicate the information about the EA models and their underlying concerns, there are still not enough options to facilitate the overall needs of representing the concerns of the top-level managements regarding EA.

There is one thing which is obvious: presenting the full EA model to the top-level managements which contains a lot of notations such as boxes and arrows will likely be overwhelming for them. These type of stakeholders usually have less time to understand the situation (e.g. to understand the whole EA model) yet they are expected to make some (important) decisions based on the provided information. In this case, common visualizations such as bar charts, line charts, heat maps and scatter plots will become more informative to use because they are clear and everybody knows how to read them (Tableau Software, 2011).

Figure 2-5: Business Intelligence Data Framework, adapted from (Negash, 2004)

Even though the process diagram in figure 2-5 is specifically prepared for BI process, the concept is still relevant with EA process. In EA, The 'data' is represented by the EA repository. EA repository is established to archive the documentation of EA components in the various areas of the EA framework (Bernard, 2012). To answer a certain goal or objective, the 'search' activity is conducted for example by creating or finding an appropriate EA model to describe the situation and then to facilitate the 'analysis' activity. Afterwards, the findings from the analysis activity are communicated to the stakeholders in the 'delivery' phase (e.g. to the top-level management) and these findings will be treated as a resource for the decision-making process (the 'action' activity). The whole process seems logic and intuitive. However, it is actually not as simple as it seems.

In EA process, the 'search' activity is actually a complex series of activities. First of all, one needs to determine in which part he wants to look at the enterprise. We need to understand the whole context of the problem in terms of architecture of the enterprise. If the architecture model is not available yet, then we need to create it from scratch which means that we need to get information from all the responsible parties for this specific problem domain. We also need to define the metrics or indicators to be measured. Afterwards, we will be able to analyze the current situation or the 'as is' situation and then deliver the findings to the respective stakeholders. The ways to communicate these findings are limitless. As described in (The Open Group, 2012), we can use the typical EA models or diagrams, tables, maps, lists, illustrations, animations, cartoons, flyers and so on. Based on the pre-defined metrics, we can also represent them in the common graphs or charts for an easier reading to reach a larger number of audiences.

2.6.2 Management Dashboard

Management dashboard is a common practice of Business Intelligence. Stephen Few describes a dashboard as "*a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance*" (Few, 2006). According to (Hardin, Hom, Perez, & Williams, 2012), by collecting some of the important analyses from different point of views in one place on a dashboard, we can deliver more clear message in order to make a better decisions. Figure 2-6 presents an illustration of management dashboards.

Figure 2-6: An illustration of management dashboards
taken from (http://en.wikipedia.org/wiki/File:3_Dashboards.JPG)

2.7 Management Dashboard as a View for EA Analysis

To increase the problem solving performance or the cognitive effectiveness from a visual notation, the principle of cognitive fit from the theory in section 3.6.3 gives suggestion to have different visual dialects for different tasks and/or audiences. According to the principle, a different form of representation may influence the cognitive fit of a notation.

For instance, to convey the message from an EA analysis activity to a specific group of stakeholders e.g. the higher-level management, the architects may want to present the result not in the form of an architecture model but in the normal general business chart e.g. bar chart or line chart. In this case, two aspects of the principle are addressed. The first difference is in the form of representation: from the architecture model to the business chart. The second difference is in the problem solver skills: the architects are skilled enough to read the architectural notation (EA model) but the managements are probably not. The later stakeholders will require a simplified version of the model and the choice of having business charts might be a solution because they are already used to interpret information in this kind of forms. To address the idea for presenting EA analysis result in the form of business charts as illustrated before, formal guides from literatures can be applied.

2.7.1 Business Charts

(Zelazny, 2001) describes that well visualized and designed charts will be able to help to communicate the message to the audience. In his book, he mentions five basic quantitative charts: pie chart, bar chart, column chart, line chart and dot chart, as depicted in figure 2-7.

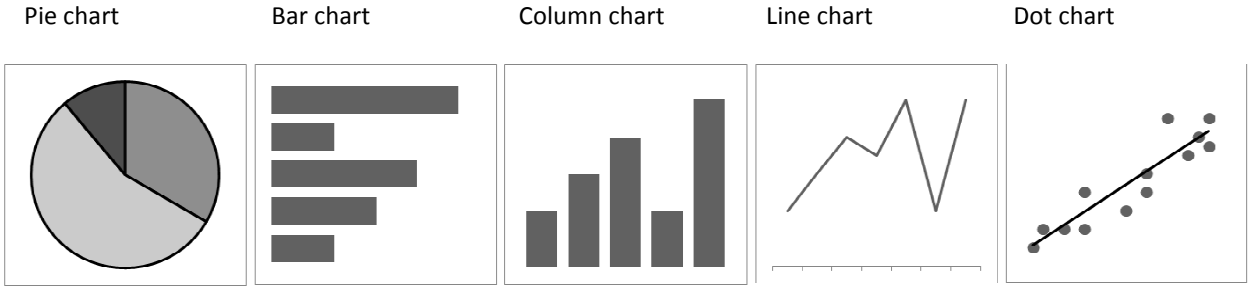

Figure 2-7: five basic quantitative charts, adapted from (Zelazny, 2001)

From these basic representations, several chart variants are identified to be able to facilitate different situation and messages. The summary is presented in table 2-10. For a full description and illustration for all variants, please refer to appendix B.

Table 2-10: Variants based on the basic charts, summarized from (Zelazny, 2001)

Basic Chart	Chart Variants
Pie chart	Doughnut, 100 percent bars, 100 percent columns
Bar chart	Deviation bar, sliding bar, range bar, paired bar, grouped bar, subdivided (stacked) bar
Column chart	Deviation column, range column, grouped column, subdivided (stacked) column, step-column (histogram), stock
Line chart	Grouped line (spaghetti), surface, histograph
Dot (scatter plot) chart	Grouped dot, bubble

2.7.2 Selecting and Designing Charts

The steps for selecting and designing charts are (Few, 2005; Zelazny, 2001):

1. Determine the message and identify the data
2. Determine if a table, chart, or combination of both is needed to communicate the message
3. Determine the best means to encode the values (the chart selection)
4. Determine where to display each variable
5. Determine the best design for the remaining objects (e.g. scale, legend, mark, text)
6. Determine if particular data should be featured, and if so, how (e.g. by color, border, background)

To perform a chart selection from step 3, we need to identify the characteristic of the message that we want to deliver. The relationship between variables needs to be determined. Table 2-11 illustrate possible categorization for this concern.

Table 2-11: Relationship between variables (Zelazny, 2001)

#	Category	Objective to Show	Relevant Terms	Basic Chart Form
1	Component	Percentage of a total	share, percentage of total, accounted for X percent	Pie
2	Item	Ranking of items	larger than, smaller than, equal	Bar
3	Time series	Change over time; trend	change, grow, rise, decline, increase, decrease, fluctuate	Column, line
4	Frequency distribution	Items (frequency) within ranges (distribution)	x to y range, concentration, frequency, distribution	Column (histogram), line (histograph)
5	Correlation	Relationship between variables	related to, increase with, decrease with, change with, vary with	Bar, dot

For a more comprehensive selection, Abela mentions four categories to classify the message: comparison, relationship, distribution, and composition (Abela, 2006). The full chart selection diagram is depicted in figure 2-8: Chart Suggestions Diagram.

Chart Suggestions—A Thought-Starter

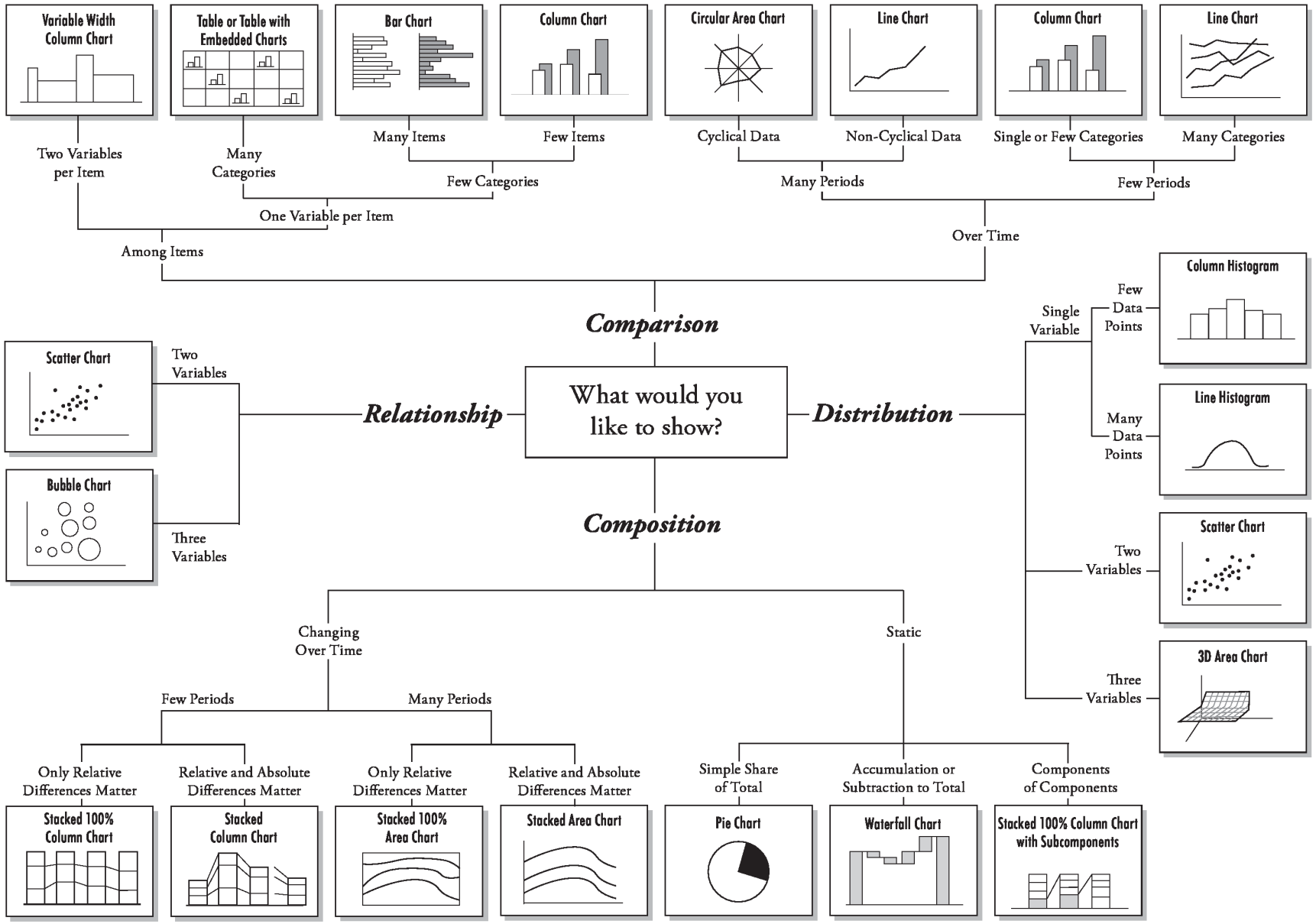

Figure 2-8: Chart Suggestions Diagram (Abela, 2006)

3 EA-Based Decision Making Method and Dashboard Concept

Chapter 3 is the main chapter of this document and it elaborates comprehensively the proposed artifacts for the research. In this chapter we introduce a stepwise approach to answer research question 3 on how the decision making in EA can be supported by means of visual representation. Section 3.1 describes the decision making in EA process and shows its relevant activity diagram. Section 3.2 introduces the first artifact of this research about EA-based decision making method and it answers research question 3.1 about structured method for a decision making support and research question 3.2 about preparing the data element for a dashboard. Section 3.3 describes the dashboard concept to answer research question 3.3 on how to build a management dashboard to facilitate decision making in EA.

3.1 Decision Making in EA Process

Decisions will always be made when an organization or company is running a business because the environment is constantly changing and the situations are continuously arising that will require a response (Parker, 2013). However, the decision making process is often ineffective and poorly formulated. Coming from this situation, the Enterprise Architecture (EA) which provides a complete repository of knowledge about the business may be able to provide a single access point for relevant information as a response to the arisen situation (Parker, 2013). The activity flow in figure 3.1 may describe the phases of a generic decision making activity.

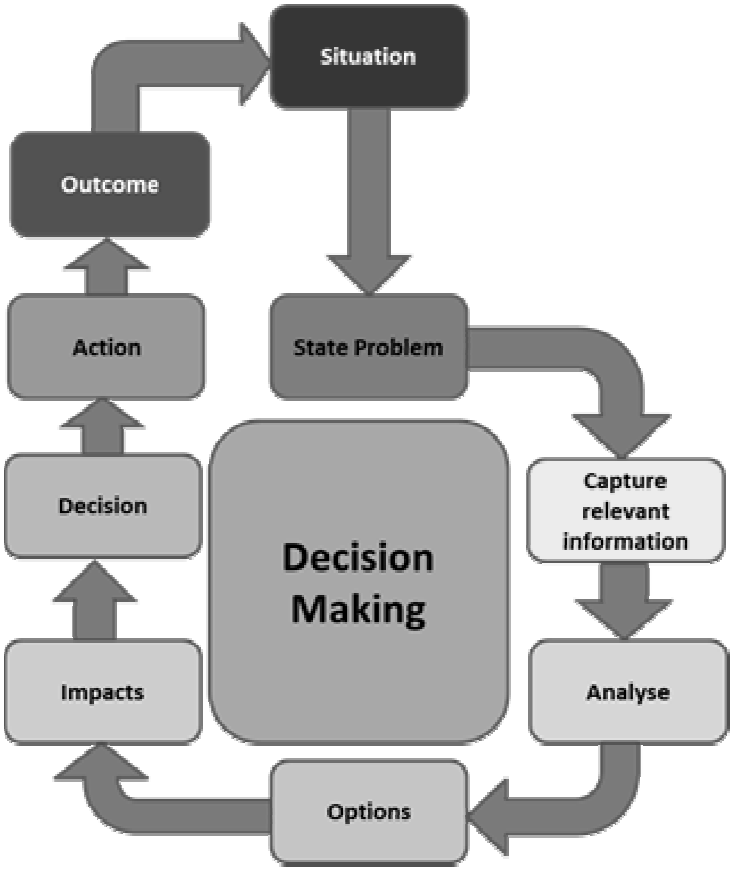

Figure 3-1: Decision Making Activity (Parker, 2013)

One of the purpose of having EA evaluation is to support the decision making activity by the stakeholders. This research tries to formalize the EA decision making activity to have a better understanding on a complete overview of this activity. The formalization can be in the form of a flowchart or a diagram. According to (Uml-diagrams.org, n.d.), an activity diagram is "UML behavior diagram which shows flow of control or object flow with emphasis on the sequence and conditions of the flow". The emphasized terms from the definition are 'the flow' and 'the sequence'. The activity diagram of the EA decision making activity in figure 3.2 is proposed to facilitate this intention.

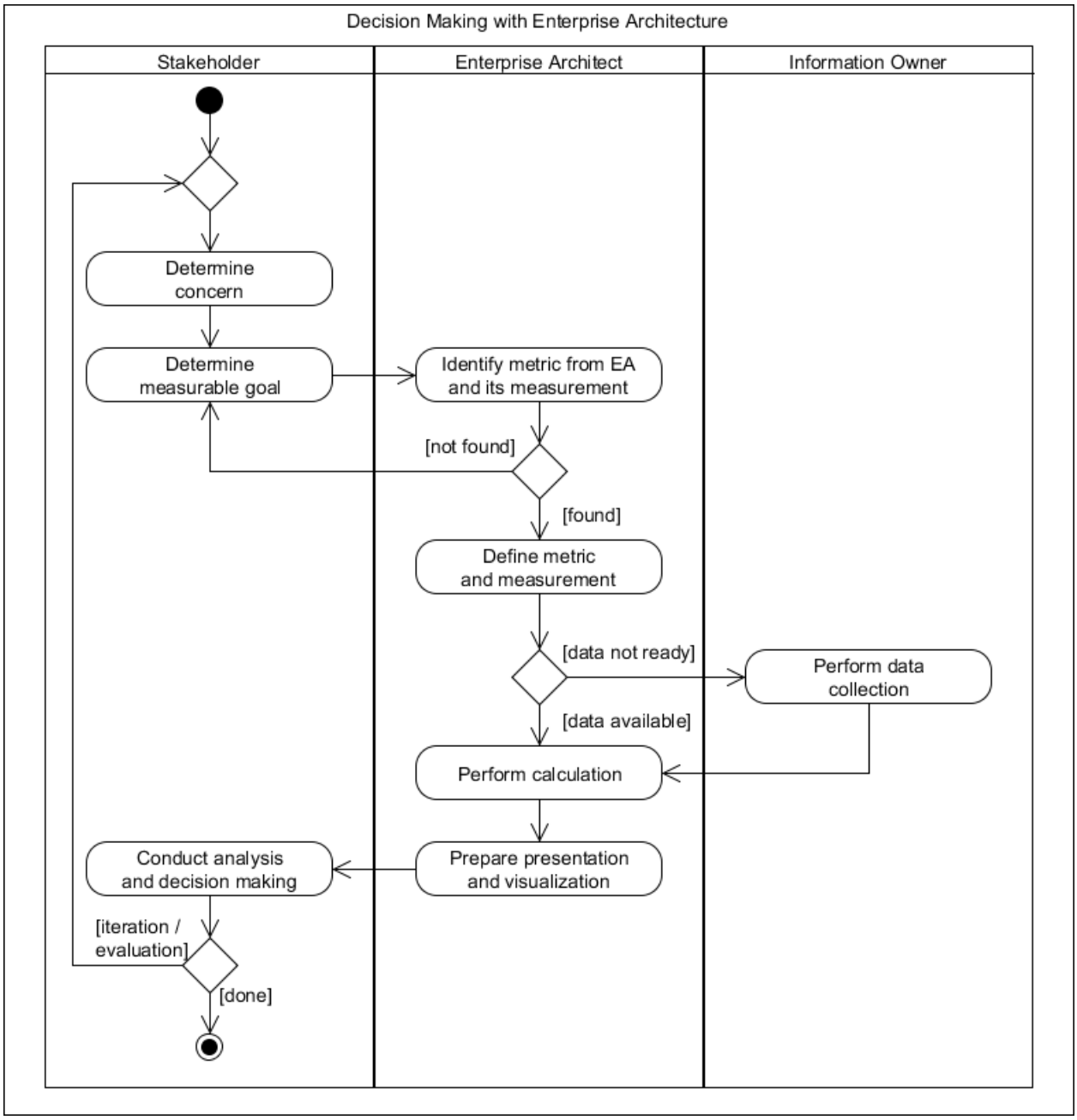

Figure 3-2: Activity Diagram of EA-based Decision Making

As seen in figure 3.2, the activity diagram contains several components: actions or processes (depicted as rounded rectangles) and controls (depicted as arrows). There are three partitions (swim lanes) in the diagram to show different business actors: stakeholder, enterprise architect and the information owner. More details on the processes are described in section 3.2.

3.2 EA-based Decision Making Method

The activity diagram in figure 3.2 contains eight activities to proceed. Based on this activity diagram, the method will consist of eight steps as follow:

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. Define the metric and measurement
5. Perform the data collection
6. Perform the calculation
7. Prepare the presentation and visualization
8. Conduct the analysis and decision making

Each of these steps will be described more in this section.

3.2.1 The Actors

The activity diagram in figure 3.2 contains three major actors: the stakeholder, the enterprise architect and the information owner. A brief description is given for each actor as follows.

Stakeholder

Quoting the definition from section 2.2.1, a stakeholder is an individual or a group of people who has an interest in, or a concern about, the architecture (Hilliard, 2000; M.-E. Iacob et al., 2012). The activity diagram is meant to address the top-level managements as the stakeholder. However, the same activity concept is still relevant for middle-managements who head specific business units or serve as project managers.

Enterprise architect

An enterprise architect is an individual or a group of people who is directly responsible for the enterprise architecture of the organization. Although it is not explicitly depicted in the diagram, the role to maintain the EA can also be extended to include (external) consultants so that the entire activities in the middle swim lane are also applicable for them.

Information owner

An information owner is an individual or a group of people who has the information (useful data) as the source of metric measurement in the architectural analysis activity, such as operational managers, system administrators, capacity planners, et cetera.

3.2.2 Step 1 - Determine the concern

The top-level management or any stakeholder of EA has a concern or driver that motivate a goal. As described in section 2.2.1, a concern or a driver will create, motivate and fuel the change in an organization (The Open Group, 2012). For instance, a CEO will be interested to steer the company to become agile enough to cope with the change in the environment and a CFO will put his most attention to the cost of a project or a system. An intensive literature study for the concerns of the top-level managements has been provided in section 2.2.2. In this step, the concern of the stakeholder will be determined and chosen. The illustration is depicted in figure 3.3 in an ArchiMate model.

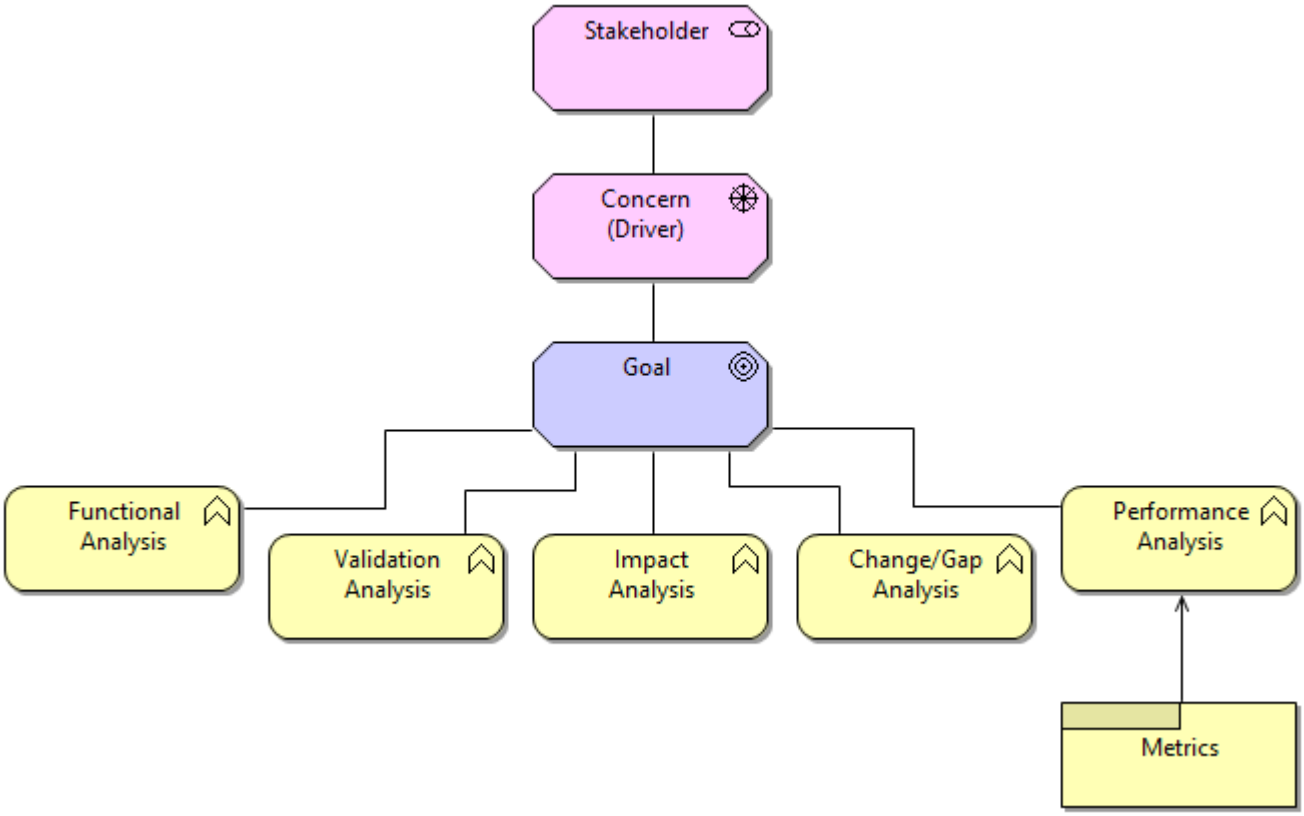

Figure 3-3: Typical analysis in EA practice

3.2.3 Step 2 - Determine the measurable goal

A goal is defined as "*an end state that a stakeholder intends to achieve*" (The Open Group, 2012) and it is derived from the concern of stakeholders. It is usually expressed using qualitative words (such as "improve", "increase", and "reduce") and can also be decomposed into a more specific goal (The Open Group, 2012). For instance, a CFO has a concern in the cost so he might want to have a goal such as to reduce the operational cost or to improve the effectiveness of cost allocation. The 'measurable' property of a goal is important. It means that the goal can be quantified.

The model in figure 3.3 also describes the possible type of analyses to assess the goal based on the information from the enterprise architecture. These analyses are described in table 2-9: typical analysis in EA practice. The focus of this approach is to address the performance analysis which is a quantitative analysis. A quantitative analysis will have a metric to measure.

3.2.4 Step 3 - Identify the metric from EA and its measurement

Based on the selected goal from the previous step, an identification of the metric is performed by the enterprise architect. A metric is something that can be measured, has a quantitative value and becomes valuable when it can be properly interpreted by the stakeholders and follow up actions can be performed (Kerzner, 2011). Assuming that an EA implementation has been established in the company, the architect needs to see the availability of the metric in the current architecture. The identification process can be performed with the stakeholders' involvement (e.g. in an executive meeting) or without their involvement (e.g. in an internal meeting of EA team). When a metric has been selected, the possible measurement for this metric also needs to be identified. For example, to accommodate the goal of the CFO to reduce the operational cost, the architect might be interested to see the effectiveness of the overall application utilization. A possible metric suggestion could be a 'resource utilization'. If the source of information for this metric can be extracted from the architecture, then the measurement, calculation method, or the quantitative analysis technique needs to be determined. For example, to measure the utilization of resources in the architecture model, the technique provided by (M. E. Iacob & Jonkers, 2006) can be performed

When the metric and measurement technique have been found and determined, the architect can proceed to the next step. If this information could not be determined from the architecture, then the previous step for selecting a measurable goal needs to be iterated. The template in table 3-1 is provided to help the activity in identification the concern, goals and metrics.

Table 3-1: Identification of the concern, goals, and metrics

Concern	
DESCRIPTION	
Concern name	What is the concern?
Stakeholder	Who is the stakeholder?
Goals	What are the measurable goals to achieve based on the concern?
Measurement frequency	How often is the assessment of the goal achievement performed?
GOAL <number>	
Name	What is the goal to assess?
Analysis type	What type of EA-based analysis is performed? (refer to table 2.9 in chapter 2)
Analysis metrics	What are the metrics to measure?
Information source	Where to find the source of information to measure the metrics? (e.g. from the enterprise architecture model or others)

3.2.5 Step 4 - Define the metric and measurement

The template in table 3-2 is provided to help the process to formalize a single metric. This activity is also intended as a documentation approach for the metric. This template is an adaptation from the KPI identification in (Kerzner, 2011, pp.354-357). If several metrics are identified, then this step will be done iteratively according to the number of the metrics.

Table 3-2: Formalization of the metric

Metric	
DESCRIPTION	
Name	What is the selected metric?
Information requirement	What is the motivation for selecting the metric?
Purpose	What is the purpose to measure the metric?
Measures	What will be measured? (output variables)
Inputs	What inputs are needed to calculate the measures? (input variables)
ARCHITECTURAL INFORMATION	
Analysis approach	Does the analysis use top-down or bottom-up approach?
Architecture layer	Which layer in the architecture is addressed by this metric? (business layer, application layer, or technology layer)
DEFINITIONS	
<Variable name 1>	Provide the definition of the input and output variables from the description section above
<Variable name 2>	...
<Variable name ...>	...
INPUTS	
Input name	Mention the first input variable
Unit of measure	What is the measurement unit? *(e.g. month, day, second, number, percentage, amount of money, count, et cetera)*
Frequency of collection	How often is the data collection performed?
Architectural representation	What is the representation of this variable in the architecture? *(e.g. business processes, application components, property of business functions, et cetera)*
Source of information	From whom is this input collected? *(e.g. system owner, system manager, or directly available in the architecture)*
Input name	Mention the second input variable, and so on..
Unit of measure	...
Frequency of collection	...
Architectural representation	...
Source of information	...
MEASUREMENT	
Indicator name	Mention the measured (output) variables
Algorithm	How the calculation will be performed to get this measures?

	(e.g. the cost of an application component is contributed by the total cost of the resources from the lower layer of the architecture that are directly connected to this node)
Target / baseline	What is the target or baseline?
Decision criteria	What is the meaning of the selected target or baseline for the output variable?
Reference or support	Mention the reference or source which is used to perform the calculation, if any *(e.g. journal, book, well known technique, et cetera)*

VISUALIZATION	
Visualization type	What is the relevant type of the visualization? *(comparison, relationship, distribution, or composition)*
Visualization option	What are the possible options for a visualization of analysis result by means of charts? Refer to chart suggestions in Figure 2-8: Chart Suggestions Diagram (Abela, 2006) *(e.g. line chart, bar chart, scatter-plot chart, etc.)*
Sample	Provide example(s) of the visualization (a real chart) and a brief information about the selected chart

ANALYSIS PROCESS	
Analysis Frequency	How often is the measurement analysis performed?
Interpretation	How should the chart visualization be interpreted and what kind of decision or insight can be acquired from the result?

3.2.6 Step 5 - Perform the data collection

The input variables defined in the previous step are collected in this step. If the data is already available in the architecture, then the architect can extract the information from the architecture and proceed forward to perform the calculation of the measures. If the data is not ready yet, then it needs to be collected from the owner of the information. For example, to have a daily data about application performance the architect will need to contact the operational manager and to have a monthly depreciation value of an application he will need to contact the finance manager.

3.2.7 Step 6 - Perform the calculation

Using the selected measurement technique, the calculation is performed. Tools might be useful to help an intensive calculation especially in a complex architecture model. Defining a case-specific meta-model in the architecture could also be helpful. The calculation process is not discussed here since it is out of the scope of this research.

3.2.8 Step 7 - Prepare the presentation and visualization

Based on the identified input variables and the measured variables, the visualization by means of charts will be prepared. The selection of the chart follows the information that has been provided in the metric table from step 4 ("define the metric and measurement")**.** A chart representation can be delivered in several different settings for example in a normal presentation slide or in a management dashboard.

As mentioned in section 2.7.2, there are some steps to follow in selecting and designing charts. In our approach, the following activities are proposed to be proceeded in step 7. This approach is an adaptation from (Few, 2005) and adjusted to facilitate (a conceptual approach of) a dashboard creation.

Table 3-3: Step 7 in Detail

Step 7 - Prepare the presentation and visualization
Step 7-1. Prepare the main data set Step 7-2. Determine the message, identify the analysis type and select the data subset Step 7-3. Determine the best means to encode the values with the chart selection Step 7-4. Determine the best design for the objects in the chart Step 7-5. Prepare the dashboard Step 7-6. Maintain the data for the future use

3.2.8.1 Step 7-1 - Prepare the main data set

To have a better understanding about the structural hierarchy of the data, the information structure in Figure 3-4: The information structure in a dashboard illustrates the conceptual approach. A **dashboard** may contain one or more **concerns**, and each concern has one or more **metrics** to be measured. Each metric consists of dimensions and measures. A **dimension** is the **input variable** in the metric and a **measure** is the **output or measured variable** as the result of the metric calculation. Figure 3-4 below depicts the structure of these elements.

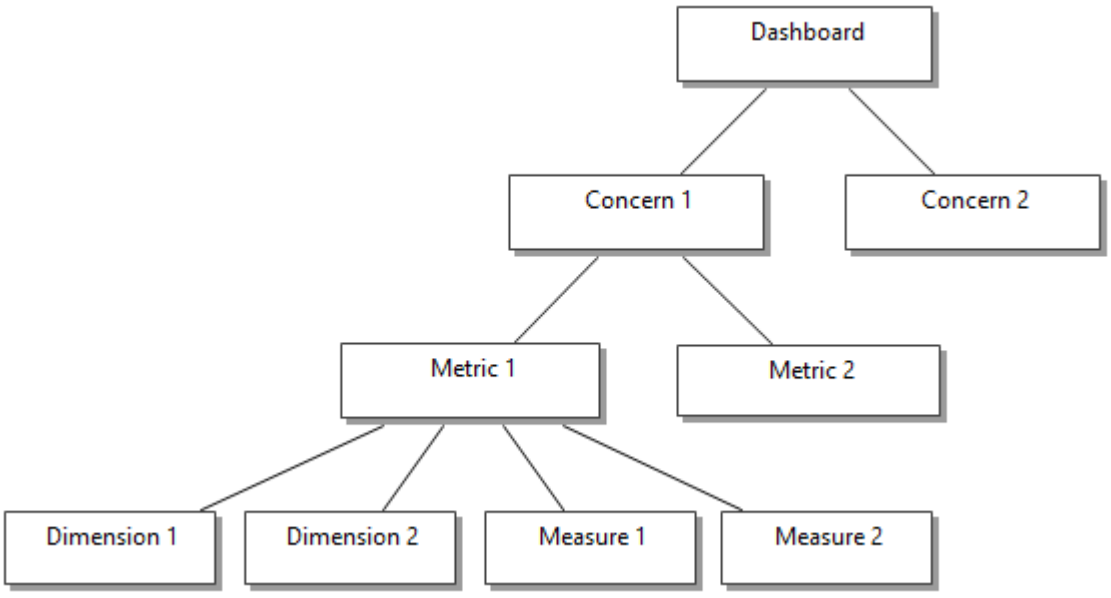

Figure 3-4: The information structure in a dashboard

For each information element, table 3-4 describes in which step from the method the information is identified, collected, calculated, visualized and finally presented.

Table 3-4: Milestone for all information elements in the method

Step #	Step name	Information elements			
		Concern	Metric	Dimension	Measure
1	Determine the concern	Identified			
2	Determine the measurable goal				
3	Identify the metric from EA and its measurement		Identified		
4	Define the metric and measurement		Described In detail	Identified	Identified
5	Perform the data collection			Collected	
6	Perform the calculation				Calculated
7	Prepare the presentation and visualization	Visualized	Visualized	Visualized	Visualized
8	Conduct the analysis and decision making	Presented	Presented	Presented	Presented

Quantitative information consists of numerical data and also the data which identifies what the numbers mean (Few, 2005). In charts, a dimension refers to the categorical data, the scale or the label whilst a measure refers to the numerical data. Both the dimension and the measure will typically be used along the axes in two-dimensional charts. A dimension or **categorical scale** may be presented in three fundamental types: nominal, ordinal, and interval (Few, 2005). **A nominal scale** consists of discrete items that belong to the same category, do not have a particular order and do not represent quantitative values. **An ordinal scale** has a particular order but still does not represent quantitative values. **An interval scale** has both an intrinsic order and quantitative values representation. Numerical interval range, date (year, month, day) and time (hour, minute, second) are categorized as interval scales. Examples of the scales are given in table 3-5.

Table 3-5: Example of dimension and measure

Element	Type	Example
Dimension (Categorical scale)	Nominal	➢ Business departments: finance, human resource, marketing, sales, IT ➢ Countries: Indonesia, Japan, Netherlands, France, Germany ➢ IT Resources: database server, database system, document server
	Ordinal	➢ Survey result: very satisfied, satisfied, neutral, dissatisfied, very dissatisfied ➢ rank position: 1st, 2nd, 3rd, 4th, 5th
	Interval	➢ Age group: 0-10, 11-20, 21-30, 31-40, 41-50, >50 ➢ Year: 2010, 2011, 2012, 2103, 2014 ➢ Business quarter: Q1-2013, Q2-2013, Q3-2013, Q4-2013
Measure	Numeric	Number of calls, processing time, utilization rate, cost value, usage percentage

For every identified metric, the dimension values which have been collected in step 5 and the measured values which have been calculated in step 6 will form the main data set. This data set needs to be presented in a structured form such as in a table. A template to use is given in table 3-6.

Table 3-6: Step 7.1 Template

Step 7-1 Template

Create the metric and dataset definition.

Metric ID	ID number of the metric
Metric name	The name of the metric
Data set ID	ID number of the data set
Concern	The name of related concern from which the metric is derived
Dimension	A set of input variables in the metric (dimensions)
Measure	A set of output (measured) variables in the metric (measures)

Create a table of data set to record all input and measured values.

Input variables			**Output (measured) variables**		
Dimension 1	**Dimension 2**	**Dimension *n***	**Measure 1**	**Measure 2**	**Measure *n***
Input value	*Input value*	*Input value*	*Measured value*	*Measured value*	*Measured value*
Input value	*Input value*	*Input value*	*Measured value*	*Measured value*	*Measured value*
Input value	*...*	*...*	*Measured value*	*...*	*...*

As a illustrative example of this template, the measurement information from the case study in (M. E. Iacob & Jonkers, 2006) can be written as depicted in table 3-7 below:

Table 3-7: Step 7-1 Example - Metric definition and its data set

Metric ID	1
Metric name	Resource utilization
Data set ID	1
Concern	Cost *(only as an example)*
Dimension	Resource, Service
Measure	workload (per second), processing time (second), response time (second), utilization

Resource	**Service**	**Workload**	**Processing time**	**Response time**	**Utilization**
Document server	Document access	0.0382	6	7.8	0.229
Database server	Data access	0.0278	0.2	0.2	0.006
Document mgt system	Retrieve document	0.0313	12.8	25	0.488
Document mgt system	Store document	0.0069	12.8	25	0.488
Database system	Database query	0.0278	0.7	0.7	0.019
Database system	Database entry	0.0069	0.7	0.7	0.019
Search component	Search report	0.0278	1.2	1.2	0.025
View component	View report	0.0313	27	174	0.843
Report scanning app.	Store report	0.0069	33.7	44	0.234

When the activity of data collection and measurement is being conducted periodically in a regular basis, an input variable that represents time is also recorded. By having this dimension, it is then possible to

have an analysis over time for example to see the trend of a data. The column 'period' in the following example illustrates the idea. The given numbers in the example are meant for an illustrative purpose only.

Table 3-8: Variant example of data set with time dimension

Resource	Service	Period	Workload	Processing time	Response time	Utilization
Document server	Document access	Jan-13	0.0382	6.0	7.8	0.229
Database server	Data access	Jan-13	0.0278	0.2	0.2	0.006
Document mgt sys.	Retrieve document	Jan-13	0.0313	12.8	25.0	0.488
Document server	Document access	Feb-13	0.0382	3.6	4.7	0.137
Database server	Data access	Feb-13	0.0278	0.1	0.1	0.004
Document mgt sys.	Retrieve document	Feb-13	0.0313	7.7	15.0	0.293
Document server	Document access	Mar-13	0.0382	6.6	8.6	0.252
Database server	Data access	Mar-13	0.0278	0.2	0.2	0.007
Document mgt sys.	Retrieve document	Mar-13	0.0313	14.1	27.5	0.537

3.2.8.2 Step 7-2 - Determine the message, identify the analysis type and select the data subset

When the main data set has been prepared, it is time to give meanings to the data. A **message** is an abstraction of the data with which the data becomes valuable to the users. A message covers a subset of the data. In this context, a message consists of four elements: visual analysis type, dimensions, measures and constraints.

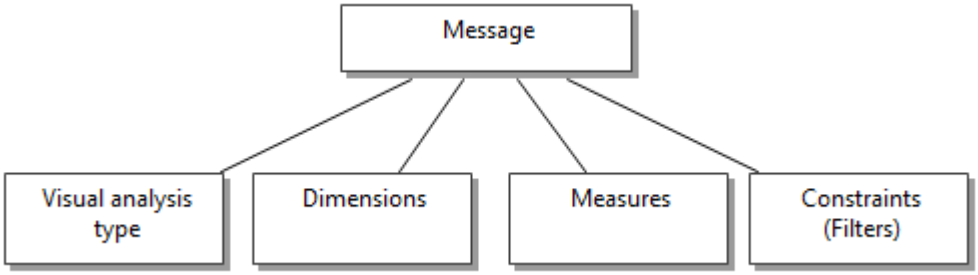

Figure 3-5: Elements of a Message

A **visual analysis type** is a type of analysis to see the relation among the data components namely the dimensions and the measures. As an adaptation from (Abela, 2006; Zelazny, 2001), the category consists of:

1. **Comparison** - to show comparison among variables
2. **Relationship** - to show the relationship between two or three variables
3. **Distribution** - to show the distribution of data or frequencies in the interval
4. **Composition** - to show composition or numerical proportion of data
5. **Change over time** - to show trend of data over a set of time interval

To have a better understanding about these visual analysis types, please refer to figure 2-8: Chart Suggestions Diagram.

As already described in the previous section, a dimension and a measure are the input and measured variables in the data set. A **constraint** is a filter to determine the rule on how to construct the data subset. It may contains a specific value from a dimension or a measure, or a specific function to aggregate the data subset. For example, to see the utilization of an individual service, we may set a filter value to that specific service. To see an aggregated utilization of a service in a yearly basis, we may want to calculate an average utilization for every service for the entire year. For those who are familiar with the data manipulation in a spreadsheet application, the concept of a message is similar to the technique on how we can slice and dice the data in a pivot table. A message can have multiple dimensions, multiple measures and/or multiple constraints.

Table 3-9: Step 7-2 Template

Step 7-2 Template

Determine the message and its elements.

Message ID	ID number of the message
Message description	Describe the message to convey
Dataset ID	ID number of the main dataset which is referred by the message
Sub dataset ID	ID number of the sub dataset for the message
Visual analysis type	Select the relevant type of analysis: comparison, relationship, distribution, composition, or change over time
Dimension	Select the appropriate dimension(s) from the main data set
Measure	Select the appropriate measure(s) from the main data set
Constraint	Determine the filter to construct the data subset

Generate the **data subset** *automatically* from the **main data set** based on the message definition. The data subset is generated by executing this database query:

```
CREATE TABLE new_sub_dataset_table
AS (
    SELECT
        dimension_1, dimension_2, ..., dimension_n,
        measure_1, measure_2, ..., measure_n
    FROM
        main_dataset_table
    WHERE
        {constraint_expression}
);
```

For an illustration, two examples are provided below.

Example 1:

Table 3-10: Step 7-2 Example (1) - Data information, data subset script and relevant data subset

Message ID	1.1
Message description	To show the trend of the utilization performance of specific services: document access, data access and retrieve document
Dataset ID	1
Sub dataset ID	1.1
Visual analysis type	Change over time
Dimension	Resource, Service, Period
Measure	Utilization
Constraint	Service = {Document access, Data access, Retrieve document}

```
CREATE TABLE sub_dataset_table_1_1
AS (
    SELECT
        Resource, Service, Period, Utilization
    FROM
        dataset_table_1
    WHERE
        Service in ('Document access', 'Data access',
                    'Retrieve document');
);
```

Resource	Service	Period	Utilization
Document server	Document access	Jan-2013	0.229
Database server	Data access	Jan-2013	0.006
Document mgt sys.	Retrieve document	Jan-2013	0.488
Document server	Document access	Feb-2013	0.137
Database server	Data access	Feb-2013	0.004
Document mgt sys.	Retrieve document	Feb-2013	0.293
Document server	Document access	Mar-2013	0.252
Database server	Data access	Mar-2013	0.007
Document mgt sys.	Retrieve document	Mar-2013	0.537

Example 2:

Table 3-11: Step 7-2 Example (2) - Data information, data subset script and relevant data subset

Message ID	1.2
Message description	To show the relationship between response time and utilization of services
Dataset ID	1
Data subset ID	1.2
Visual analysis type	Relationship
Dimension	Service, Period

Measure	Response time, Utilization
Constraint	Period = Jan-2013

```
CREATE TABLE sub_dataset_table_1_2
AS (
    SELECT
        Service, Period, 'Response time', Utilization
    FROM
        dataset_table_1
    WHERE
        Period = 'Jan-2013';
);
```

Service	Period	Response time	Utilization
Document access	Jan-2013	7.8	0.229
Data access	Jan-2013	0.2	0.006
Retrieve document	Jan-2013	25	0.488
Store document	Jan-2013	25	0.488
Database query	Jan-2013	0.7	0.019
Database entry	Jan-2013	0.7	0.019
Search report	Jan-2013	1.2	0.025
View report	Jan-2013	174	0.843
Store report	Jan-2013	44	0.234

To facilitate a more complex sub dataset generation, for example to have an aggregation of dimension or to create an average value from a measure, an advanced database query to create such table might be needed here.

3.2.8.3 Step 7-3 - Determine the best means to encode the values with charts selection

Based on the data subset for every message, a set of possible charts is identified. To start, five basic quantitative charts in figure 2-7 are accessed for possible options. Then, we can refer to the information of relationship between variables in table 2-11 and Chart Suggestions Diagram in figure 2-8. For a further guidance, please refer to charts evaluation in appendix B.

Table 3-12: Step 7-3 Template

Step 7-3 Template
For each message in step 7-2, determine a set of possible chart types This entry will be added as a new element to every message

Message ID	ID number
Chart type	Determine a set of possible chart types

To select a set of possible charts, the discussion in section 2.7.1, section 2.7.2 can be referred as a guide. As an addition, the charts evaluation in Appendix B might also be useful.

3.2.8.4 Step 7-4 - Determine the best design for the objects in the chart

This step is the additional step yet still important to do. We need to determine to best ways to represent these components in the chart: titles, scale, legend, mark, text, colors, highlighted data, and so on.

3.2.8.5 Step 7-5 - Prepare the dashboard

All information which has been prepared in step 7-1 until step 7-4 is actually the main ingredient for a dashboard. The metric, the analysis type, the dimensions, the measures and the chart selection information are collected to be represented in the dashboard. A comprehensive elaboration of a conceptual dashboard is provided separately in section 3.3.

3.2.8.6 Step 7-6 - Maintain the data for the future use

For a future use, the message structure (data subset structure) is kept. The data collection and measurement steps are re-conducted to get a periodic input and measurement.

3.2.9 Step 8 - Conduct the analysis and decision making

The final step is to bring the final delivery result to the stakeholder. In this step, the architect presents the result of the measured metric and how it can help to assess the goal achievement. One important point is a story-telling; the interpretation of the visual presentation which has been identified in the metric table is explained to the stakeholder to deliver the message behind it. A follow up action as the decision by the stakeholder is expected as the outcome of the analysis. When the decision has not been made, the whole activities might be iterated from the beginning.

3.3 The Dashboard Concept

In this section a conceptual dashboard is provided to facilitate the representation of the information and the message which have been collected in step 1-7. The dashboard layout is made as simple as possible to be intuitive enough to use.

3.3.1 The Dashboard Layout

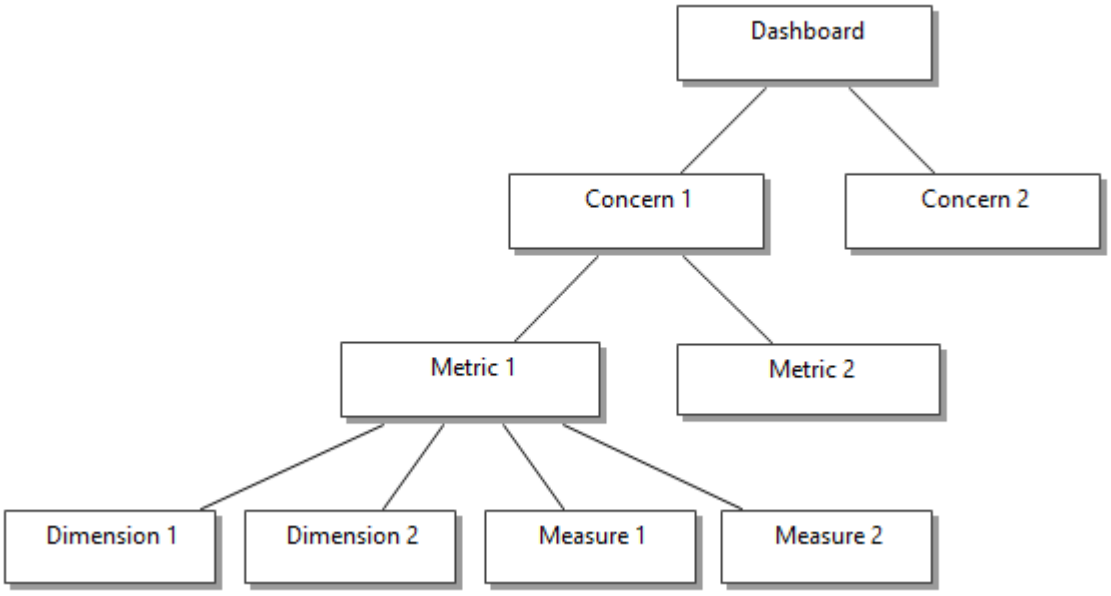

Figure 3-6: The information structure in a dashboard

Figure 3-6 is a copy of figure 3.4 from section 3.2.8.1. As we see in the figure, the dashboard may consist of concerns, every concern consists of its relevant metrics and every metric has its dimensions and measures. These elements will be represented in the dashboard as shown in table 3-13.

Table 3-13: The main dashboard elements

No.	Dashboard element	Information to present
1	Tabular pages	Concerns
2	Chart wizard grid	Selection of metric, analysis type, dimension, measure and chart type
3	Chart container	Container for generated charts
4	Log text box	Log and status information

The layout template for such dashboard is depicted in figure 3-7 below.

Figure 3-7: The Dashboard Main Page Layout

Every concern will reside in a single tabular page. In each page, there is a chart wizard to facilitate step-by-step selection of metric, analysis type, dimension, measure, and chart type. The chart container is the medium to put the generated chart based on the selections from the wizard. The log box shows the text of the current selection of the elements. The generated charts in the chart container may be deleted or saved for a future use. When there are already a lot of charts generated, a scroll bar might be introduced in the container to switch between charts. The 'Reset All' button below the log box is used to clear all selections in the wizard to create a new chart.

The idea of having a wizard is to facilitate sequential steps for the users to generate a chart. The metric option in wizard step 1 shows the relevant metrics for the concern of current page. The analysis type in wizard step 2 shows the possible visual analysis types of the selected metric from step 1 as discussed in section 3.2.8.2 (comparison, relationship, distribution, composition, and change over time). In wizard step 3 and step 4, the identified dimensions (input variables) and the measures (calculated variables) for the selected metric are shown as options for the users to choose. Finally, the chart type options in wizard step 5 will only consist of a set of possible charts based on the selected values from previous steps in the wizard.

When there is a requirement to generate a chart which contains two or more dimensions or measures, in wizard step 3 the user needs to click the "Advanced selection..." button to proceed. A pop-up window

will appear with an option to select multiple dimensions and/or measures. For each dimension and measure, there is also a text box to input a filter (constraint). The value of the filter is entered as a *value expression*, for example as shown in table 3.10 and 3.11:

- *Service = {Document access, Data access, Retrieve document}*
- *Period = Jan-2013*

Figure 3-8 illustrates this advanced selection window.

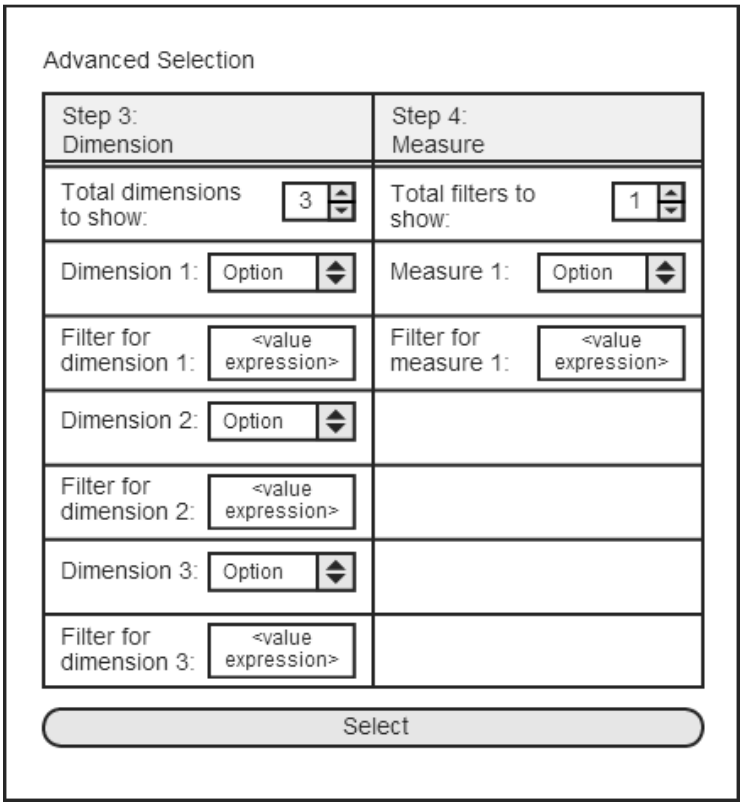

Figure 3-8: The Advanced Selection window to select multiple dimensions and measures

Apart from the main dashboard page, there will also be an introductory page which is called as *Homepage*. On this page, the user will be able to load a new data to the dashboard or to refresh the current data in the dashboard. The user will select the concern they want to see from a set of concerns in the lower left box on the page. If a concern is selected, the respective page for that concern will be displayed to the user.

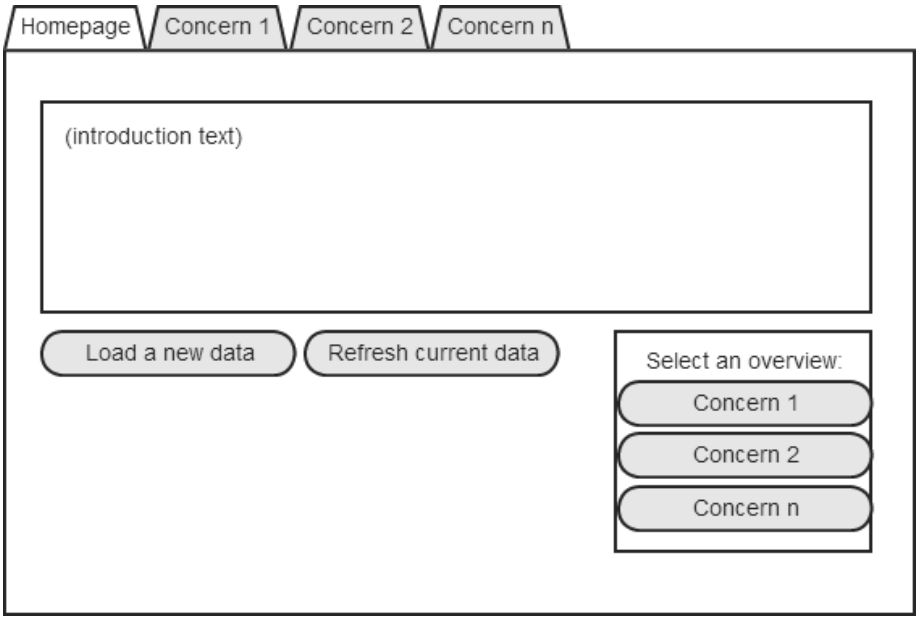

Figure 3-9: The Dashboard Home Page Layout

3.3.2 The Data Structure and Logic in the Dashboard

3.3.2.1 Building blocks of the data structure

An important aspect in the dashboard is the data source and the logic or algorithm to use the data. The data structure in the dashboard is constructed in a way to follow the information definition which has Figure 3-10 illustrates the full information structure in the dashboard.

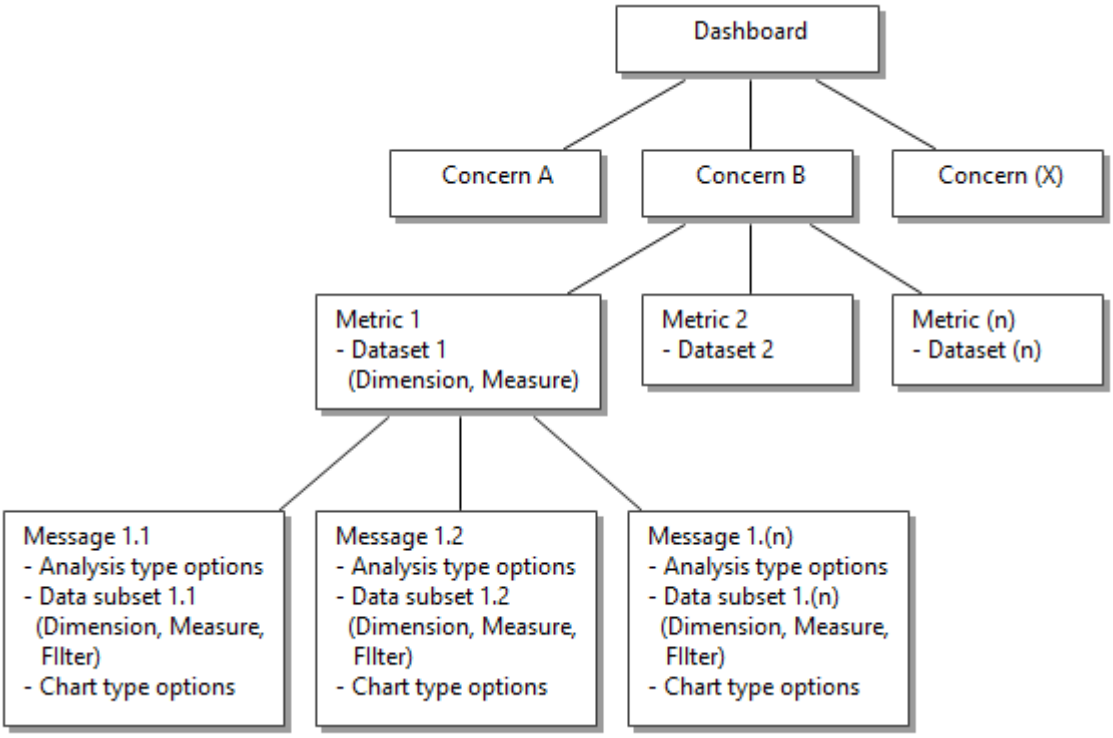

Figure 3-10: The full information structure in the dashboard

To satisfy the aforementioned information structure, the blocks of data structure in figure 3-11 is proposed.

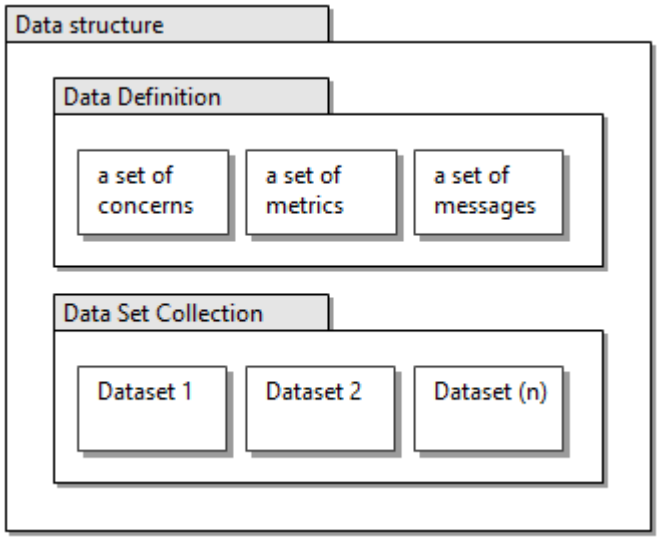

Figure 3-11: Data structure for the dashboard

The logic behind every page of *concern* in the dashboard is that the page will have a set of metrics to address that concern. For every metric, there will be a set of possible messages to be visualized by means of charts in the dashboard. In principal, the data source for the *chart wizard* is built based on this logic as shown in figure 3-12.

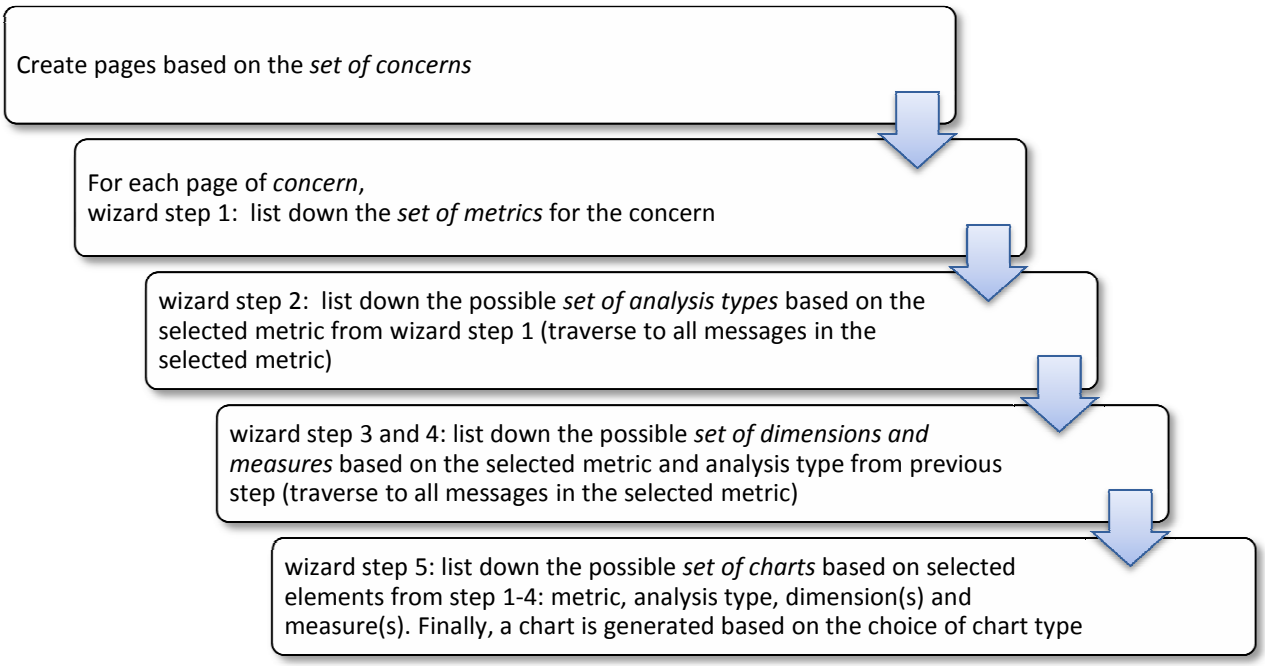

Figure 3-12: The logic for building the dashboard

3.3.2.2 Example of a data structure

Assuming that we currently have the following metric and the main dataset (only an excerpt) :

Table 3-14: Metric example

Metric ID	1
Metric name	Resource utilization
Data set ID	1
Concern	Cost
Dimension	Resource, Service
Measure	workload, processing time, response time, utilization

Table 3-15: Main dataset example

Resource	Service	Period	Workload	Processing time	Response time	Utilization
Document server	Document access	Jan-13	0.0382	6.0	7.8	0.229
Database server	Data access	Jan-13	0.0278	0.2	0.2	0.006
Document server	Document access	Feb-13	0.0382	3.6	4.7	0.137
Database server	Data access	Feb-13	0.0278	0.1	0.1	0.004
Document server	Document access	Mar-13	0.0382	6.6	8.6	0.252
Database server	Data access	Mar-13	0.0278	0.2	0.2	0.007

If we are going to deliver a message with the following definition in table 3-16:

Table 3-16: Message definition example

Message ID	1.1
Message description	To show the trend of the utilization performance of specific services: document access, data access and retrieve document
Dataset ID	1
Sub dataset ID	1.1
Visual analysis type	Change overtime, comparison
Dimension	Service, Period
Measure	Utilization
Constraint	Service = {Document access}
Chart type	Bar, Column, Line

then the relevant sub dataset according to the message definition will be the blue-highlighted cells from the main dataset. The result will be shown as in table 3-17.

Table 3-17: Sub dataset example

Service	Period	Utilization
Document access	Jan-2013	0.229
Document access	Feb-2013	0.137
Document access	Mar-2013	0.252

For an illustrative purpose, the following data representation in figure 3-13 for this example is prepared in XML style following the building block of data structure that has been discussed earlier.

```
<DATA-DEFINITION>

<set-of-concerns>
    <concern>Cost</concern>
    <concern>Customer Satisfaction</concern>
    <concern>Operational Performance</concern>
    <concern>... </concern>
</set-of-concerns>


<set-of-metrics>
    <metric>
        <concern>Cost</concern>
        <metric-id>1</metric-id>
        <metric-name>Resource Utilization</metric-name>
        <data-set-id>1</data-set-id>
        <dimensions>
                <dimension>resource</dimension>
                <dimension>service</dimension>
                <dimension>period</dimension>
        </dimensions>
        <measures>
```

Data Definition

A set of concerns

A set of metrics

Metric 1

```
                <measure>workload</measure>
                <measure>processing-time</measure>
                <measure>response-time</measure>
                <measure>utilization</measure>
        </measures>
    </metric>

    <metric>
        ...
    </metric>
</set-of-metrics>

</set-of-messages>

    <message>
        <message-id>1.1</message-id>
        <message-desc>To show the trend
                      of the utilization performance
        </message-desc>
        <data-set-id>1</data-set-id>
        <data-subset-id>1.1</data-subset-id>
        <analysis-type>
            <an-type-option>Change over time</an-type-option>
            <an-type-option>Comparison</an-type-option>
        </analysis-type>
        <dimensions>
            <dimension>
                <dim-name>Service</dim-name>
                <dim-filter>"=Document Access"</dim-filter>
            </dimension>
            <dimension>
                <dim-name>Period</dim-name>
            </dimension>
        <dimensions>
        <measures>
            <measure>
                <msr-name>Utilization</msr-name>
            </measure>
        </measures>
        <chart-type>
            <ch-type-option>Bar</ch-type-option>
            <ch-type-option>Column</ch-type-option>
            <ch-type-option>Line</ch-type-option>
        </chart-type>
    </message>

    <message>
        ...
    </message>

</set-of-messages>

</DATA-DEFINITION>
```

A set of messages

Message 1.1

(with definition to create data subset 1.1)

```
<DATA-SET-COLLECTION>

<data-set>
    <data-set-id>1</data-set-id>
    <name>Resource Utilization</name>
    <record>
        <Resource>Document server</Resource>
        <Service>Document access</Service>
        <Period>Jan-13</Period>
        <Workload>0.0382</Workload>
        <Processing-time>6</Processing-time>
        <Response-time>7.8</Response-time>
        <Utilization>0.229<Utilization>
    </record>
    <record>
        <Resource>Database server</Resource>
        <Service>Data access</Service>
        <Period>Jan-13</Period>
        <Workload>0.0278</Workload>
        <Processing-time>0.2</Processing-time>
        <Response-time>0.2</Response-time>
        <Utilization>0.006<Utilization>
    </record>
    <record>
        ...
    </record>
</data-set>

<data-set>
    <data-set-id>...</data-set-id>
    <name>....</name>
    <record>....</record>
</data-set>

</DATA-SET-COLLECTION>
```

Data Set Collection

Dataset 1

Dataset (n)

Figure 3-13: Example of data structure for the dashboard in XML

For more explanation and examples about XML representation of a relational database, please refer to (http://www.w3.org/XML/RDB.html). When using the dashboard, the whole data structure (data definition and data set collection) is at least loaded one time in the beginning to generate the layout of the dashboard. When the data definition has already been loaded, a new data set collection can be reloaded to refresh the current datasets while maintaining the basic layout of the dashboard (as defined in the data definition). This is a useful approach to utilize the dashboard in a continuous time (e.g. in periodic performance monitoring) without giving the same effort to create the data definition. If one wants to add a new concern or a new message, then the data definition needs to be updated and reloaded.

4 Demonstration

Demonstration is the fourth step of the DSRM process and it will be applied by means of a case study and a prototype implementation. Section 4.1 demonstrates mainly the metric identification in step 3 and 4 from the EA-based decision making method. Section 4.2 demonstrates the data visualization and representation in step 7 from the method. Finally, section 5.3 describes the implementation of a dashboard prototype that has been developed.

4.1 Demonstration of step 3 an 4: Metric Identification

This section shows the practical example for using the EA-based Decision Making Method which is described in section 4.2. The list of the steps is given as follows.

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. Define the metric and measurement
5. Perform the data collection
6. Perform the calculation
7. Prepare the presentation and visualization
8. Conduct the analysis and decision making

4.1.1 Case description

A CFO in a company wants to see all information related to cost from the EA that has been implemented recently. He wants to know whether his company is effectively managing its cost allocation or not.

4.1.2 Applying the method to the case

He, and probably with the help of his team, will need to determine the measurable goal(s) based on this concern. Afterward, the role of an enterprise architect is needed here to help to identify the possible metric from EA based on these goals and also to find out the possible measurement technique to measure this metric. These activities are reflected in step 1-3 of the method.

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. Define the metric and measurement
5. Perform the data collection
6. Perform the calculation
7. Prepare the presentation and visualization
8. Conduct the analysis and decision making

Table 4-1 is filled in with the result of step 1-3.

Table 4-1: Identified metric for case study

Concern - Cost	
DESCRIPTION	
Concern name	Cost
Stakeholder	CFO
Goals	1. Reduce operational cost 2. Reduce number of ineffective applications 2.1. Reduce the number of applications with low utilization 3. Improve operational performance
Measurement frequency	Quarterly
GOAL 1	
Name	Reduce operational cost
Analysis type	Performance analysis
Analysis metrics	Cost and budget performance
Information source	Enterprise Architecture, Finance department
GOAL 2	
Name	Reduce number of ineffective application
Analysis type	Performance analysis
Analysis metrics	*The goal is still unclear so the team decided to break down the goal into a measurable goal*
GOAL 2.1	
Name	Reduce the number of applications with low utilization
Analysis type	Performance analysis
Analysis metrics	Resource utilization
Information source	Enterprise Architecture
GOAL 3	
Name	Improve operational performance
Analysis type	Performance analysis
Analysis metrics	*The goal is still immeasurable so this one needs to be decomposed or redefined*

If at least one metric can be determined based on the goals, then the architect can proceed to the next step. Otherwise, he needs to go back to the stakeholder to redefine another measurable goal (step 2). The illustration of the relation between the stakeholder, concern and the goals is depicted in figure 4-1.

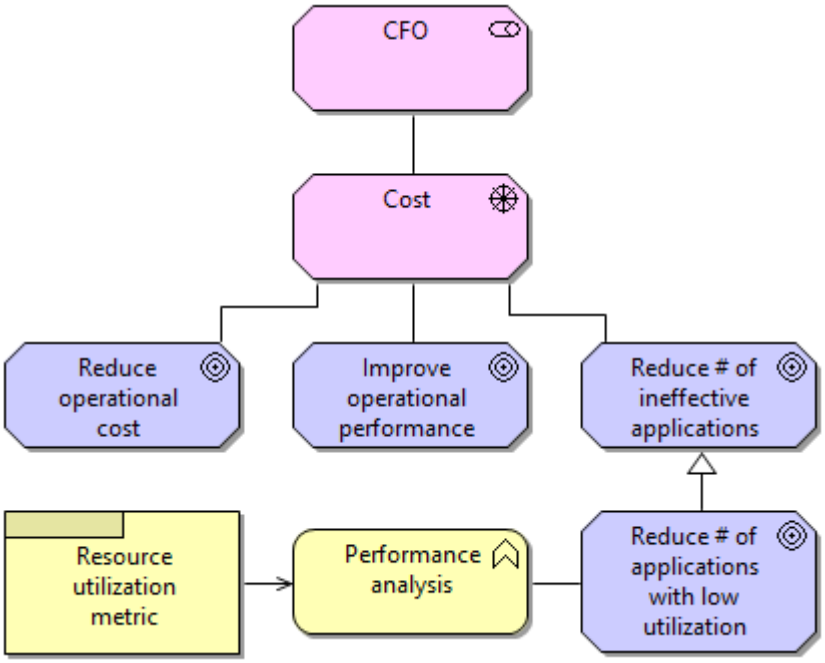

Figure 4-1: Concern - Cost

To serve as an example, the **resource utilization metric** is chosen to be discussed further.

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. Define the metric and measurement
5. Perform the data collection
6. Perform the calculation
7. Prepare the presentation and visualization
8. Conduct the analysis and decision making

The next step is to formulize the metric and the measurement option (step 4). Based on the selected metric, table 4-2 is filled in by the architect.

Table 4-2: Metric definition

Metric - Resources Utilization	
DESCRIPTION	
Name	Resource utilization
Information requirement	Is the utilization of a resource effective enough?
Purpose	To see the utilization performance of a resource / a group of resources
Measures	Utilization
Inputs	Processing time, workload rate

ARCHITECTURAL INFORMATION	
Analysis approach	Bottom-up analysis (M. E. Iacob & Jonkers, 2006)
Architecture layer	Application layer and technology layer

DEFINITIONS	
Resource	A resource is a source that can produce value in an amount of time. Architectural representation: a resource is represented as a structural element, e.g. an application component, a device, a node, or a system software.
Utilization	The percentage of the operational time that a resource is busy
Processing time	The amount of time that actual work is performed on a resource
Workload rate	The number of requests that are completed per time unit

INPUTS	
Input name	Processing time
Unit of measure	Second
Frequency of collection	Monthly
Architectural representation	Property of a node (resource)
Source of information	System owner, system manager

Input name	Workload rate
Unit of measure	Process per second
Frequency of collection	Daily
Architectural representation	Property of a node (resource)
Source of information	Operational manager

MEASUREMENT	
Indicator name	Utilization
Algorithm	Calculate: for every resource, monthly *Utilization* = daily average from (*Workload rate* * *Processing time*)
Target / baseline	80%
Decision criteria	Any number equal to or greater than baseline is required to justify the cost of the resource. Any number less than baseline will initiate an assessment.
Reference or support	Algorithm: (M. E. Iacob & Jonkers, 2006)

VISUALIZATION	
Visualization type	Comparison
Visualization option	Bar chart, column chart, line chart
Sample	

ANALYSIS PROCESS	
Analysis Frequency	Monthly
Interpretation	Increasing utilization is defined as a positive trend. A positive trend beyond the baseline is defined as an effective performance. Decreasing utilization is defined as a negative trend. A negative trend that goes below the baseline will initiate an assessment. A frequent occurrence of 100% utilization might indicate an overload and might initiate an assessment.

The next step is to perform the data collection (step 5). According to the metric table, the information about "processing time" of the resources will be acquired from the system owner or the system manager in a monthly basis. The information about "workload rate" of the resources will be collected from the operational manager in a daily basis. After the data has been collected, then the calculation based on the prepared algorithm in the metric table is performed (step 6). The result of this activity is the measured variables.

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. Define the metric and measurement
5. Perform the data collection
6. Perform the calculation
7. Prepare the presentation and visualization
8. Conduct the analysis and decision making

After this, the next step is to prepare the presentation and visualization based on the identified visualization option in the metric table (step 7). The type of visualization will be a comparison and the possible charts are line chart, bar chart and column chart.

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. Define the metric and measurement
5. Perform the data collection
6. Perform the calculation
7. Prepare the presentation and visualization
8. Conduct the analysis and decision making

The chart in figure 4-2 is produced for a comparison among resources at one time by means of a bar chart. The vertical red line is the baseline (80%).

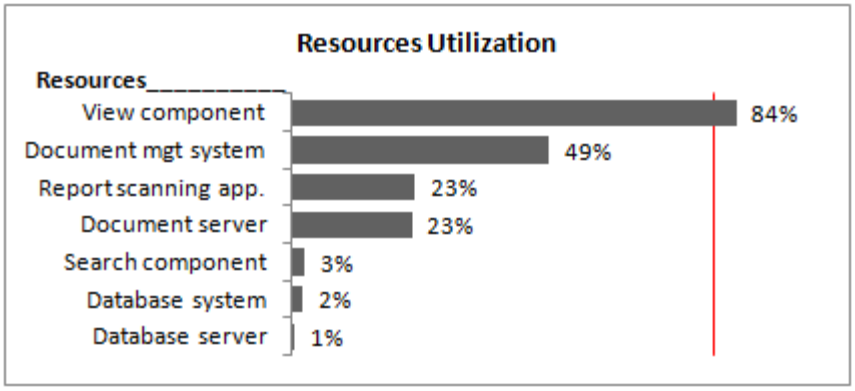

Figure 4-2: Chart example 1

To examine a monthly comparison (trend) for six months period, the line chart in figure 4-3 is prepared. Horizontal red line is the base line of the analysis. The interpretation guide for both of the charts are provided in the metric table.

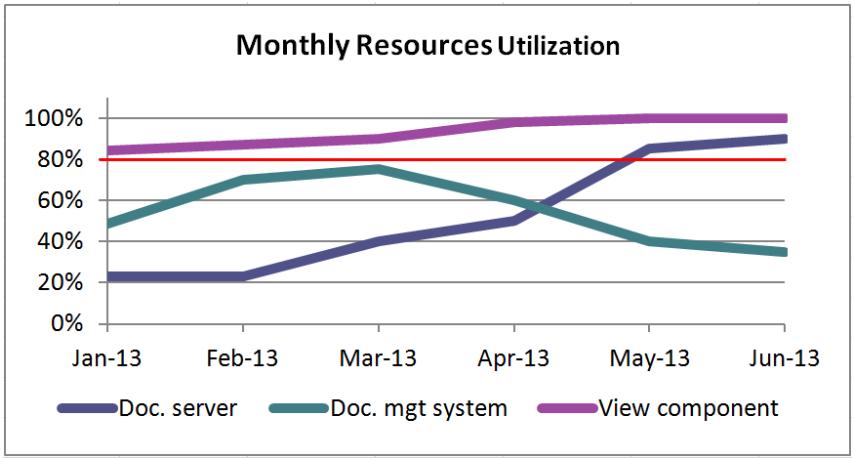

Figure 4-3: Chart example 2

The "document server" resource has a positive trend and starting from May 2013 it performs effectively. The "document management system" resource has a negative trend since March 2013 and it needs an assessment. The "view component" resource also has a positive trend. However, starting from May 2013 the utilization is reaching 100% until June 2013 and it may indicate an overload for that resource. This also lead to a further assessment.

The last step is to bring this result to the stakeholder (CFO) and conduct the analysis result with him (and the team). The result is expected to help the assessment activity regarding those resources based on their utilization performance.

4.2 Demonstration of step 7 in general: Case Study FromAtoZ

4.2.1 Case description

FromAtoZ (a masked company name) is a pension provider that is a merger of different smaller insurance companies. This merger is still visible in the internal organization that is divided in several, independent business units. Two business units carry out pension schemes, which are mainly an administrative functions. The original organizations were active in different sectors, and, therefore, there exists a natural distinction of clients between the two business units. Another business unit is responsible for managing the company's assets. FromAtoZ invests the pensions they manage to increase their value as much as possible. The last business unit offers income insurances that employers can select for their employees. The four different business units are supported by one IT department.

As a consequence of the different mergers, the IT landscape is large and diverse. The overall intuition is that there are quite some superfluous applications but nobody really has a good overview of the landscape. Therefore, it is impossible to determine which applications are used by which business unit, what their business value is or which ones could be deprecated.

In recent years the company decided that the different business units should be profit and loss responsible. As a consequence of this, the IT department is faced with an increasing number of questions from the business units on why some of their products are so expensive. For historical reasons, the IT department does not bill the business units separately for basic infrastructure services, but simply divides these costs over the different products they offer to the business units. For example, in the costs of a workplace provision (a product the IT department offers to the business units) also costs for certain generic applications are incorporated. Given the recent developments, this is not a favorable situation anymore since the IT department should be able to make clear which costs are related to which service, and business units should be billed accordingly.

To start creating an overview, and having more insights on what the current situation is, a small project is started. The goal is to show the CIO and controller of the company how the IT department is currently dividing IT costs over the business units, why this way of dividing costs is a problem, and how this problem could be solved. For this, two applications in the IT landscape are addressed in detail. First, all costs related to them are gathered, and the way these costs are divided over the business units is determined. Second, it is analyzed how intensively the business units use the applications. The intensity of use is compared to the costs that are paid by a business unit. These two examples are used to illustrate the problems and possible solution directions. The applications and their relations to the business units are modeled in the ArchiMate language. The resulting models are used to do the necessary analyses.

The consultant executing this project is confronted with the problem of translating the resulting ArchiMate models and analyses into a PowerPoint presentation for CIO and controller. He chooses simplified versions of the ArchiMate models to illustrate the model results, and bar charts for illustrating the analyses done on these models. In addition several text slides explain the charts and models.

4.2.2 The current EA model from the case

Based on the case description, the in-charge consultant of this project has made several ArchiMate models to show the architectural differences between cost and utilization (usage) structure of the resources in the company. For an example, the ArchiMate models in figure 4-4 and 4-5 illustrate how a resource named "JobScheduler" has a different structure in its cost and utilization scheme. The consultant has already performed a quantitative analysis to measure utilization and cost for every business unit which is relevant to this resource. The analysis measurement result can also be seen in figure 4-4 and 4-5 as the red text located above every business unit objects.

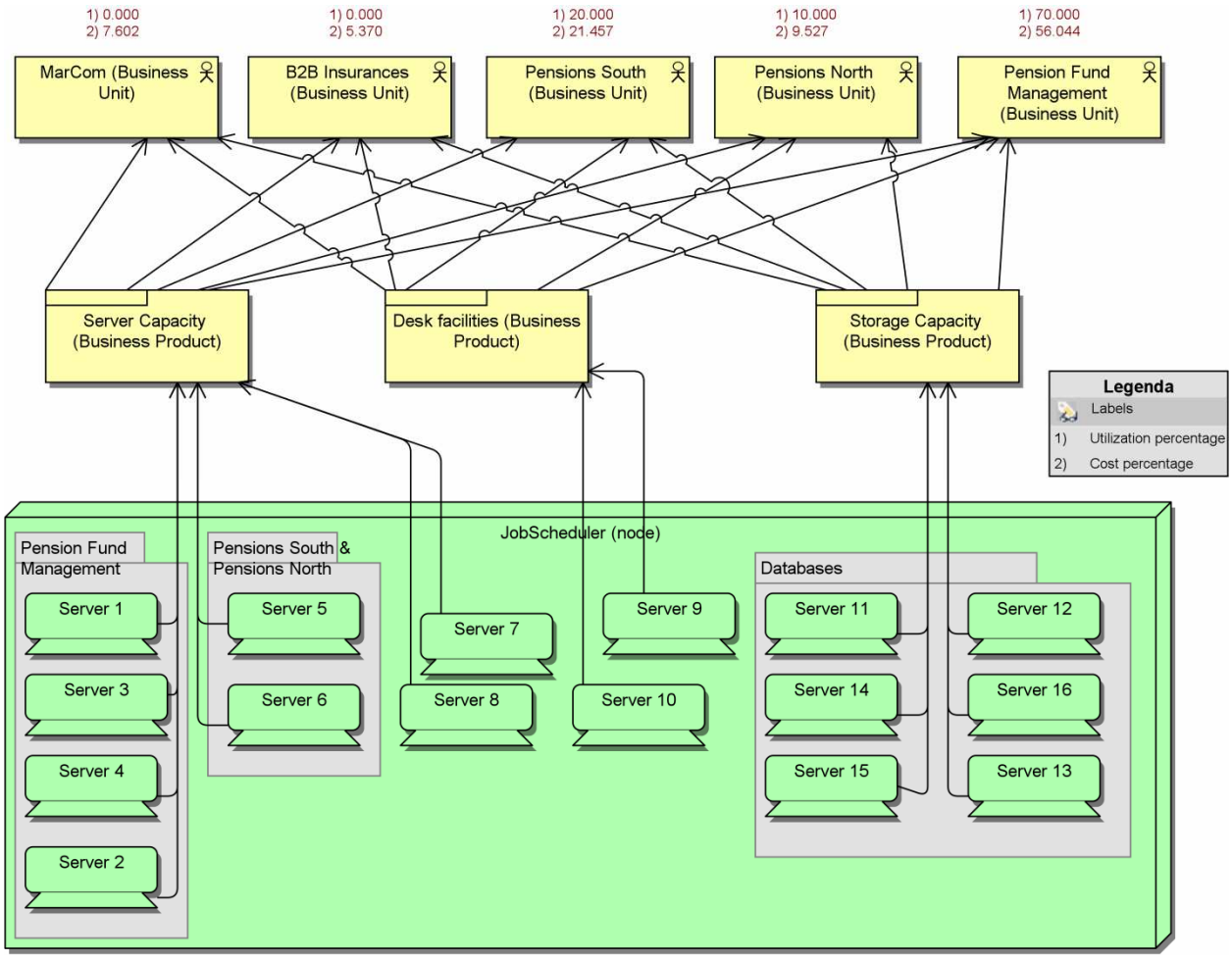

Figure 4-4: ArchiMate model for cost structure of "JobScheduler" resource

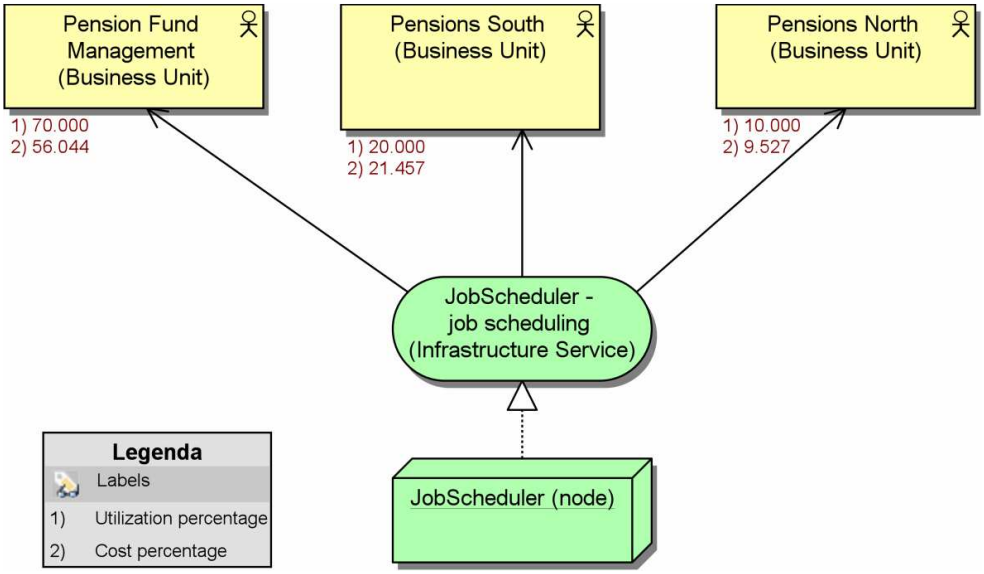

Figure 4-5: ArchiMate model for utilization (usage) structure of "JobScheduler" resource

A clear fact from figure 4-4 an figure 4-5 is that the JobScheduler resource is not used by business unit MarCom and B2BInsurances as indicated by no arrow coming from these two business units in figure 4-5. For now, it can be concluded that even though these business units do not use the JobScheduler resource, they still expend cost for this unused resource (as shown in figure 4-4: both business units have zero utilization percentage but positive cost percentage).

4.2.3 Dataset Identification

In the real case study, many resources were measured by the consultant in the similar way as shown in section 4.2.2. In this research, only two resources are selected to demonstrate step 7 of the EA-based decision making method: JobScheduler and PerformMonitor. As an additional analysis, a what-if analysis measures has also been provided for resource PerformMonitor. Based on the measurement result from quantitative analysis for these resources, a full quantitative data is prepared as the main dataset for a further analysis, as depicted in table 4-3.

Table 4-3: Case study 2 - main dataset

Resource	Business Unit	Usage	Cost	Usage Percentage	Cost Percentage	Status
JobScheduler	Pension Fund Management	4,900.0	145,238.0	70.0	56.0	As-is
JobScheduler	Pensions North	700.0	24,689.8	10.0	9.5	As-is
JobScheduler	Marketing, Communications and Branding	-	19,700.1	-	7.6	As-is
JobScheduler	Pensions South	1,400.0	55,605.3	20.0	21.5	As-is
JobScheduler	B2B Insurances	-	13,917.2	-	5.4	As-is
PerformMonitor	Pension Fund Management	26.3	267,228.3	34.1	50.5	As-is
PerformMonitor	Pensions North	4.6	59,988.5	6.0	11.3	As-is
PerformMonitor	Marketing, Communications and Branding	32.3	55,244.8	41.9	10.4	As-is
PerformMonitor	Pensions South	7.1	108,534.3	9.2	20.5	As-is
PerformMonitor	B2B Insurances	6.8	38,250.2	8.8	7.2	As-is
PerformMonitor	Pension Fund Management	26.0	234,924.0	28.3	41.0	What-if
PerformMonitor	Pensions North	19.4	82,079.5	21.0	14.3	What-if
PerformMonitor	Marketing, Communications and Branding	31.9	66,539.4	34.6	11.6	What-if
PerformMonitor	Pensions South	8.1	138,213.2	8.8	24.1	What-if
PerformMonitor	B2B Insurances	6.7	51,611.6	7.3	9.0	What-if

4.2.4 Identification of a Set of Possible Messages

In this section, four possible messages are prepared to demonstrate the detailed approach in step 7 and a set of possible alternative of visual representations that can be presented by the consultant executing FromAtoZ case. For the sake of simplicity, only the final sub data subsets and charts result are presented here. For a comprehensive description about step 7 in action, please refer to section 3.2.8 for some running examples of the sub-method.

Message 1: Composition: Usage percentage per Resource per BU

The purpose of message 1 is to show the usage percentage from every business unit for every resource. Since it is a composition type of analysis, then a simple pie chart is suitable to visualize this message.

Table 4-4: Case study 2 - Sub dataset 1

Resource	Business Unit	Usage Percentage
JobScheduler	Pension Fund Management	70.0
JobScheduler	Pensions North	10.0
JobScheduler	MarCom	-
JobScheduler	Pensions South	20.0
JobScheduler	B2B Insurances	-
PerformMonitor	Pension Fund Management	34.1
PerformMonitor	Pensions North	6.0
PerformMonitor	MarCom	41.9
PerformMonitor	Pensions South	9.2
PerformMonitor	B2B Insurances	8.8

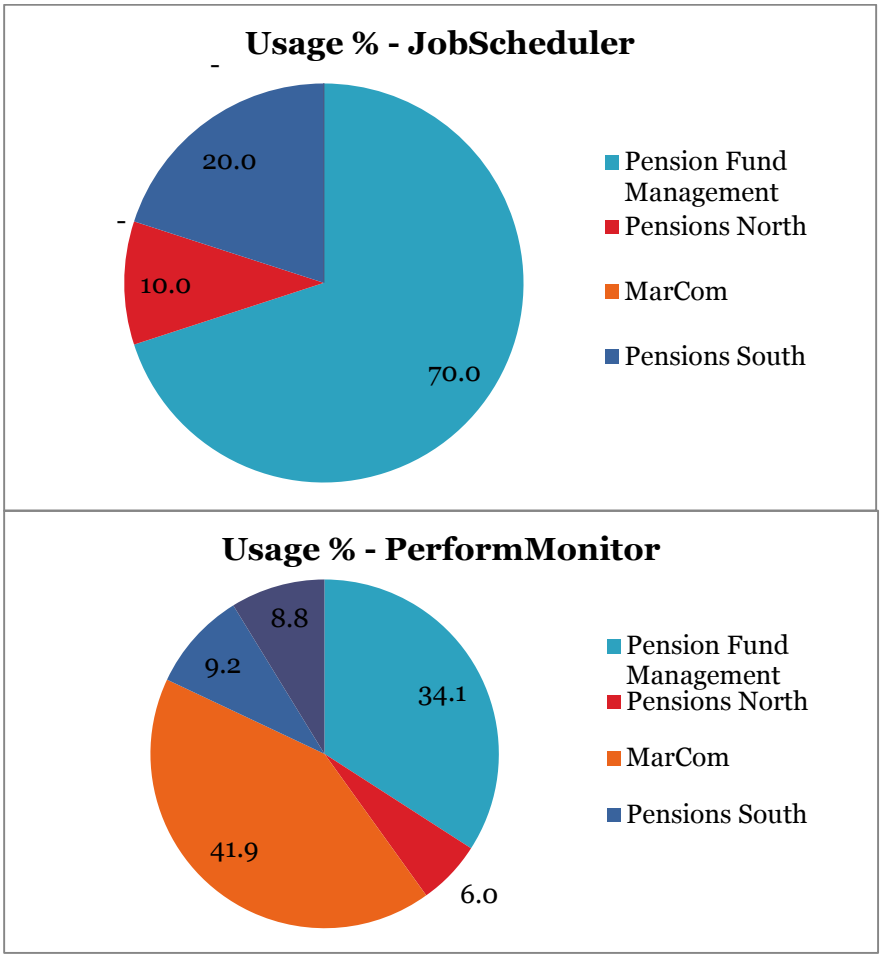

Figure 4-6: Charts for sub dataset 1

Message 2: Comparison: Usage vs. Cost per Resource per BU

Message 2 is more advanced compared to message 1 because now it has two measures to be visualized: usage percentage and cost percentage. An option to visualize this message is to have a group column chart so that the utilization (usage) and cost for every business unit can be compared side-by-side. Every resource will have its own chart. This type of visualization is the option which was originally chosen by the consultant to deliver the findings of the case to their client. Although the comparison can be visually seen, the meaning behind the comparison still needs to be verbally communicated.

Table 4-5: Case study 2 - Sub dataset 2

Resource	Business Unit	Usage Percentage	Cost Percentage
JobScheduler	Pension Fund Management	70.0	56.0
JobScheduler	Pensions North	10.0	9.5
JobScheduler	MarCom	-	7.6
JobScheduler	Pensions South	20.0	21.5
JobScheduler	B2B Insurances	-	5.4
PerformMonitor	Pension Fund Management	34.1	50.5
PerformMonitor	Pensions North	6.0	11.3
PerformMonitor	MarCom	41.9	10.4
PerformMonitor	Pensions South	9.2	20.5
PerformMonitor	B2B Insurances	8.8	7.2

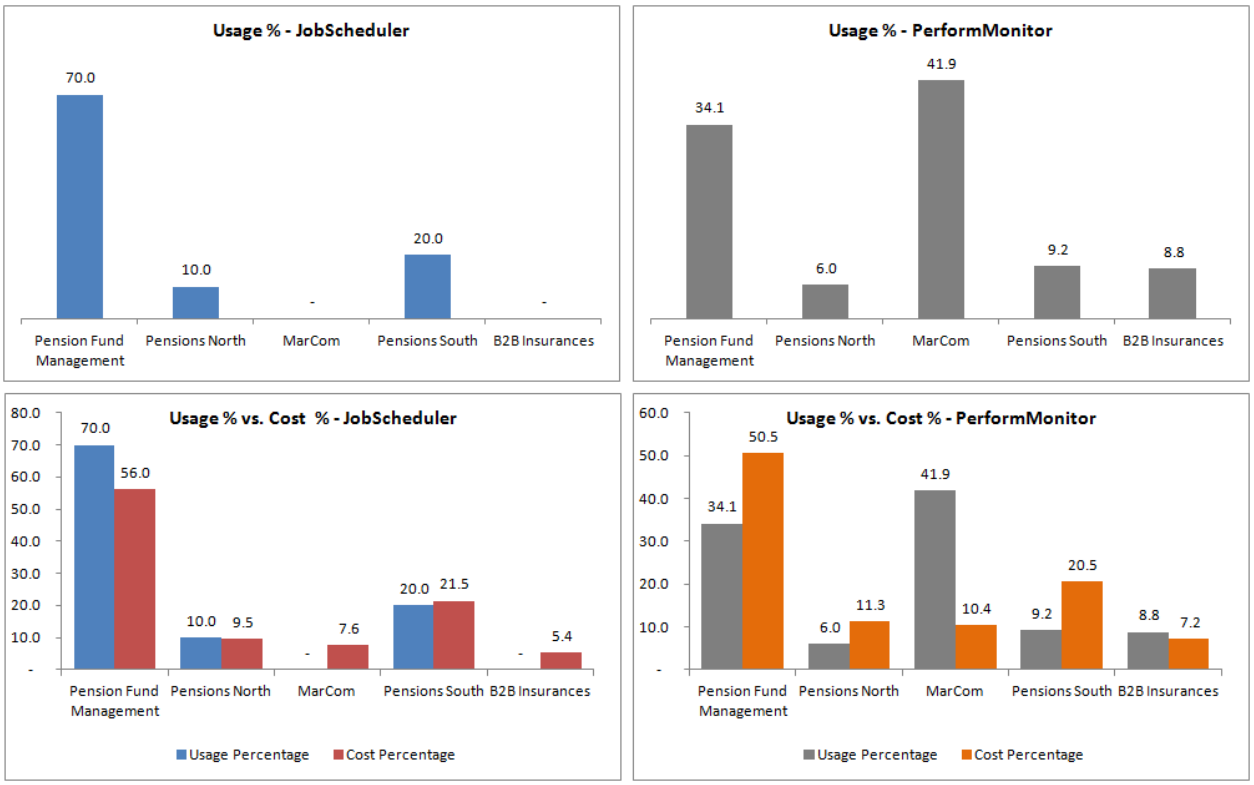

Figure 4-7: Charts for sub dataset 2

Message 3 : Relationship: Usage vs. Cost

With the same sub dataset as in message 2, message 3 is prepared to see the relationship between two measures. According to Chart Suggestion Diagram in figure 2.8, a relevant chart type for this purpose is the scatter chart. The scales for X and Y axis of the chart are equal (0-100) and a diagonal line is drawn to guide the analysis. The diagonal line can be seen as an ideal situation: the business unit spend the cost proportionally as much as they use the resource. With this setup, now it is easier to determine which business unit spend more or less cost than it should. For example on the right chart in figure 4-8, all business units beyond the diagonal line i.e. B2B-Insurances and MarCom have high utilization for the resource PerformMonitor but they pay only small percentage of cost and it is less than the proportional percentage.

Table 4-6: Case study 2 - Sub dataset 3

Resource	Business Unit	Usage Percentage	Cost Percentage
JobScheduler	Pension Fund Management	70.0	56.0
JobScheduler	Pensions North	10.0	9.5
JobScheduler	MarCom	-	7.6
JobScheduler	Pensions South	20.0	21.5
JobScheduler	B2B Insurances	-	5.4
PerformMonitor	Pension Fund Management	34.1	50.5
PerformMonitor	Pensions North	6.0	11.3
PerformMonitor	MarCom	41.9	10.4
PerformMonitor	Pensions South	9.2	20.5
PerformMonitor	B2B Insurances	8.8	7.2

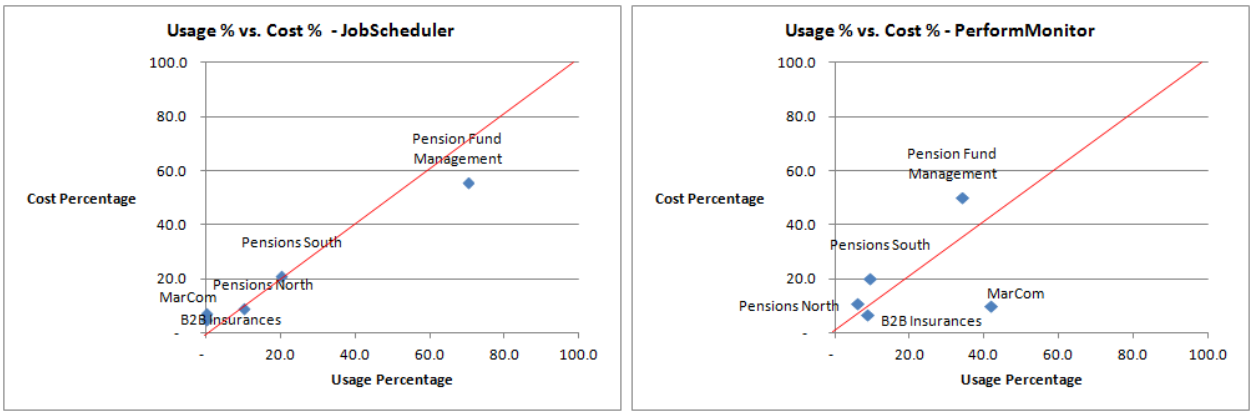

Figure 4-8: Charts for sub dataset 3

Message 4: Change over time: What-if

The last example to demonstrate is to visualize a what-if scenario from resource PerformMonitor. Two usage measures are provided in the sub dataset: as-is and what-if data. Since the visual analysis can also be treated as an analysis related to time, a simple line chart is selected to show the trend for applying this scenario. From the chart in figure 4-9, we can visually see immediately that the change scenario is only beneficial for business unit Pensions North as the only business unit that has a usage increase.

Table 4-7: Case study 2 - Sub dataset 4

Business Unit	Usage % As-is	Usage % What-if
Pension Fund Management	34.1	28.3
Pensions North	6.0	21.0
MarCom	41.9	34.6
Pensions South	9.2	8.8
B2B Insurances	8.8	7.3

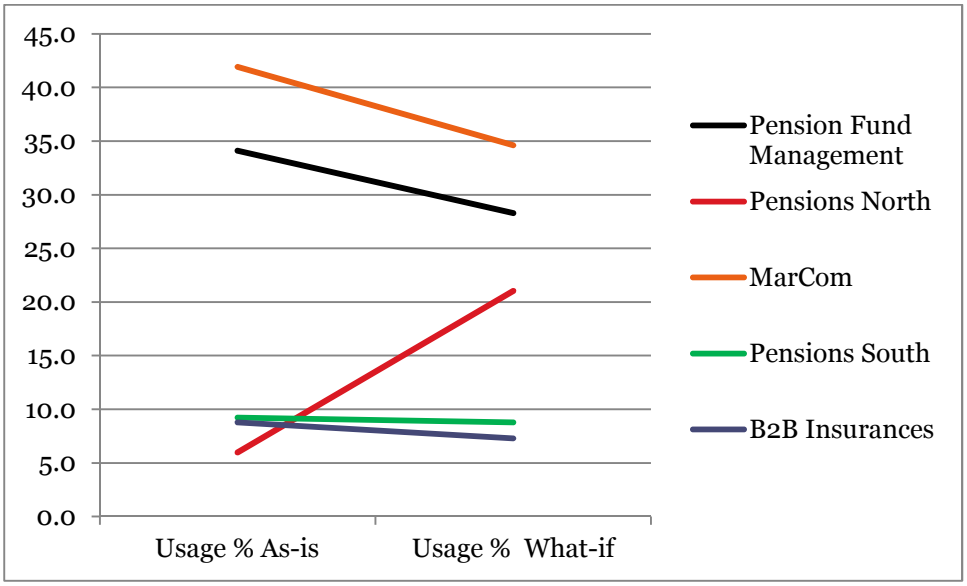

Figure 4-9: Charts for sub dataset 4

4.3 Dashboard Implementation

An activity to explore BI tools in the market has been conducted as part of the research. To facilitate a dashboard prototype creation, two data visualization tools are explored: QlikView (Personal Edition) from QlikTech (http://www.qlikview.com/) and Tableau Public from Tableau Software (http://www.tableausoftware.com/). Both of them are the free and public version with a limited functionalities compared to their commercial version. In this research, a prototype of the dashboard has been already implemented in QlikView Personal Edition. In this section, several screenshots from the main functionalities of the dashboard are provided. The prototype is developed by applying the dashboard concept which has been discussed in section 3.3.

In the dashboard, the homepage and concerns are prepared as individual pages as seen in figure 4-10.

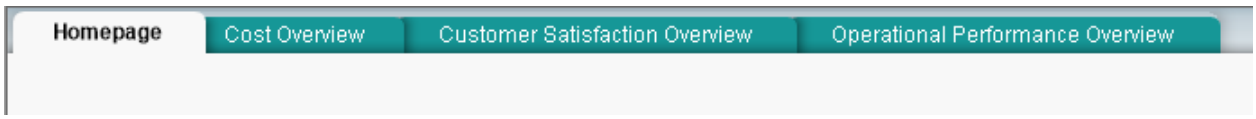

Figure 4-10: The tab pages screenshot

In the *Homepage*, there are buttons to load a new data (load a new data structure), refresh current data (load an updated dataset collection), and choose a concern overview.

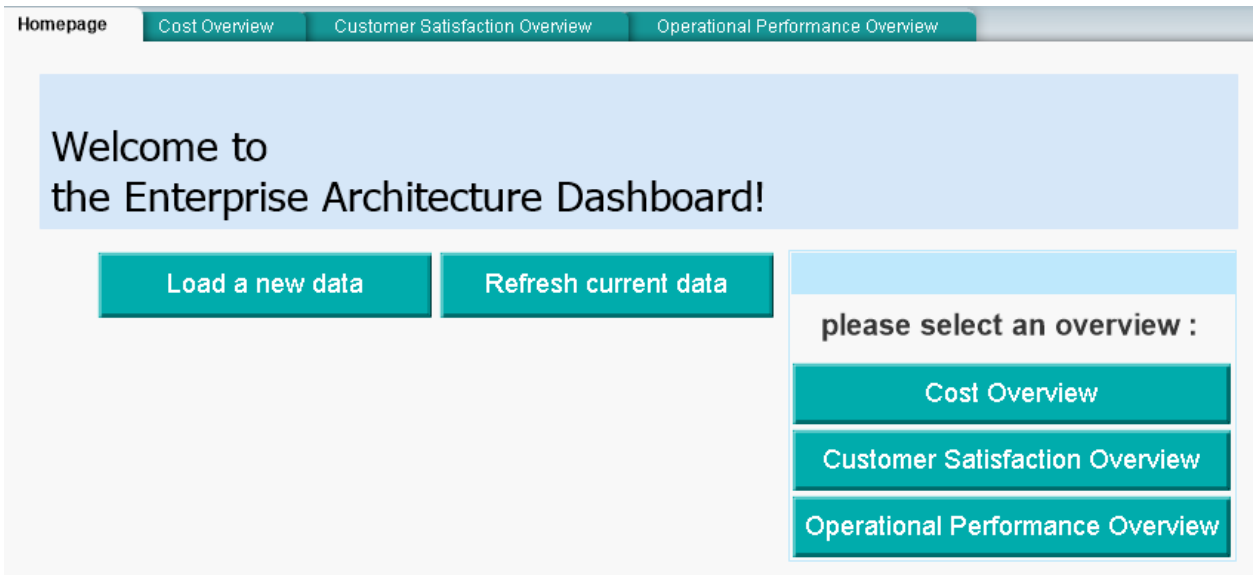

Figure 4-11: The homepage screenshot

For example, if we click on *Cost Overview* button at the homepage, the page of *(concern = Cost)* is displayed. Figure 4-12 shows the main layout of *Cost overview* page in the dashboard. The other concern pages will have a similar layout. In this page, the upper part serves as the navigation of the dashboard,

i.e. the *Chart Wizard*. The lower part serves as the main dashboard information, e.g. the generated charts in the *Chart Container.*

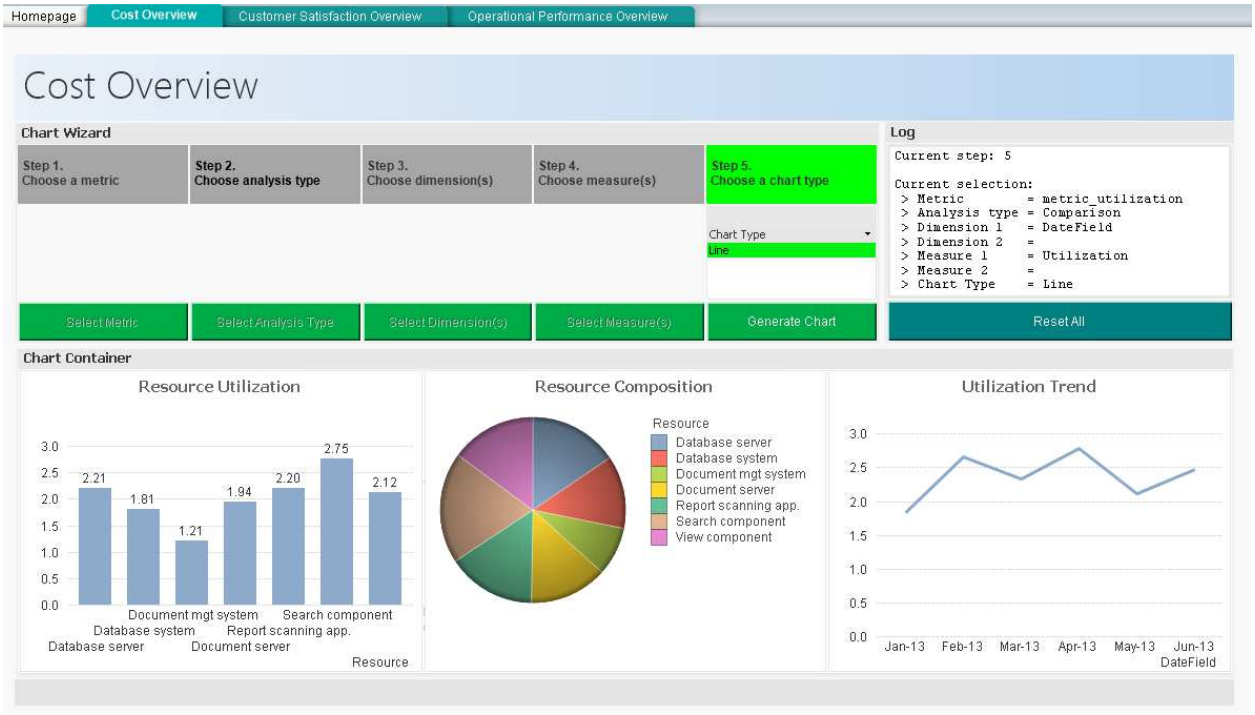

Figure 4-12: The concern page of "Cost Overview" screenshot

The chart wizard is prepared so that the user will always start the wizard from step 1. The current active step in the wizard is displayed in a light green box. Whenever the user has already selected an option in that step by clicking the lower dark green button, the next step will be activated in a similar manner.

Figure 4-13: The "Chart Wizard" screenshot

Figure 4-14 below is an example of pre-defined metrics for step 1 in the wizard.

Figure 4-14: Wizard step-1 screenshot

Figure 4-15 below is an example of the set of possible analysis types for step 2 in the wizard.

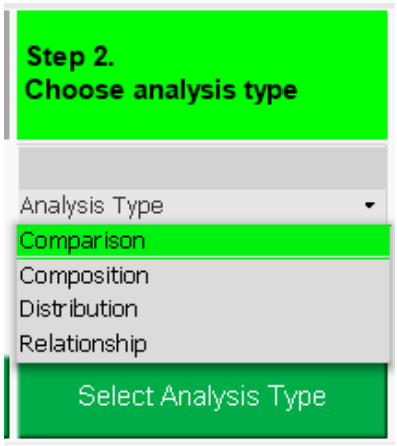

Figure 4-15: Wizard step-2 screenshot

The following steps in figure 4-16 shows an example of the set of possible dimensions for step 3 in the wizard. In a similar way, the set of possible measures will be shown for step 4 afterwards.

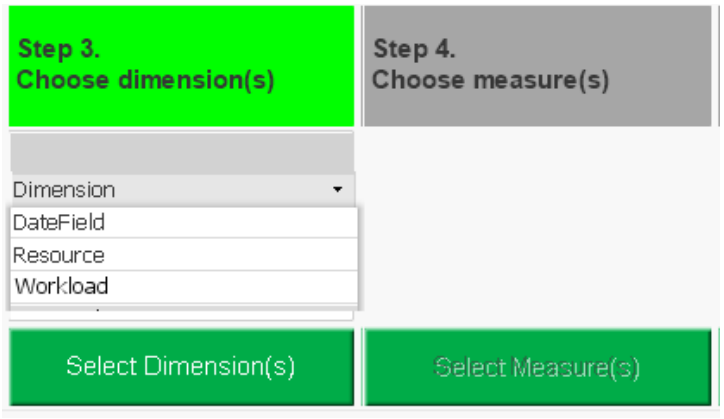

Figure 4-16: Wizard step-3 and step-4 screenshot

Finally, the set of possible chart types are shown for step 5.

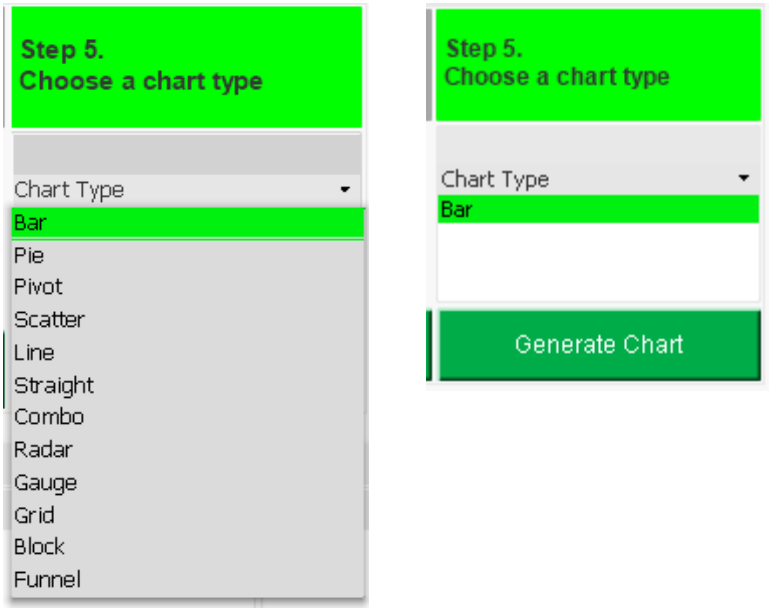

Figure 4-17: Wizard step-5 screenshot

When the user clicks on *Generate Chart* button, the relevant chart according to the selected definition is generated and put automatically in the *Chart Container* as seen in figure 4-18.

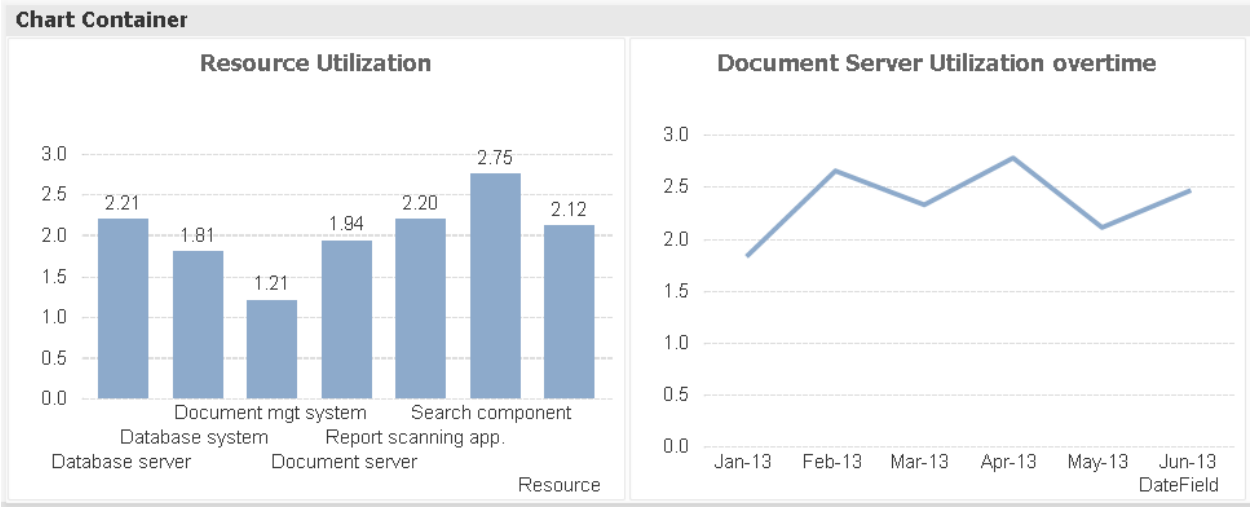

Figure 4-18: Chart Container screenshot

The current activity is logged in the log box. To restart the chart creation in the wizard, the user needs to click *Reset All* button, as seen in figure 4-19.

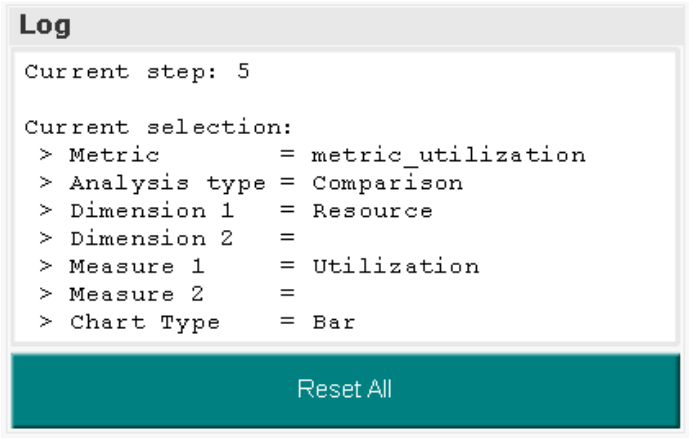

Figure 4-19: The Log Box screenshot

The logic from the dashboard concept is developed in this prototype by using the internal functions from the QlikView tool. When a specific function is not provided, a macro function or procedure is written as an additional module for the dashboard. In QlikView, the macro or scripting module is written either in Visual Basic (VB) Script language or JavaScript language. An example of a macro script to generate a custom pie chart in QlikView is provided in figure 4-20.

```
SUB GeneratePieChart
'// generate pie chart

    Dim vDimension, vExpression
    ' Get these values from PRE-DEFINED variables
    vDimension = getVariable("v_Dimension1") 'dimension: v_Dimension1
    vExpression = getVariable("v_Measure1")  'measure: v_Measure1
    vExpression = strSum(vExpression)        'create SUM aggregation

    ' Generate the chart
    Dim myChart
    Set myChart = ActiveDocument.ActiveSheet().CreatePieChart()
    myChart.AddDimension vDimension
    myChart.AddExpression vExpression

END SUB
```

Figure 4-20: A VB script example to generate a pie chart

5 Evaluation

Evaluation is the fifth part in the design science research methodology. The artifact is observed and measured to be able to know how well it supports a solution to the problem (Peffers et al., 2007). This chapter presents a qualitative analysis in the form of interview to evaluate artifacts of this research, the EA-based decision making method and the dashboard concept.

5.1 Interview

Qualitative analysis is a type of analysis of qualitative data, for example the text data from interview transcripts, and the emphasis in this type of analysis is sense making or understanding a phenomenon (Bhattacherjee, 2012). There are three formats for interview design which are summarized by (Gall, Gall, and Borg, 2003, as cited in Turner, 2010): (1) informal conversational interview, (2) general interview guide approach, and (3) standardized open-ended interview. The informal conversational interview relies on the spontaneous questions in a natural interaction with the participants. The general interview guide approach is more structured in the way that the questions are worded but they are depend upon the interviewers so it is still lack of consistency. The standardized open-ended interview is very structured in terms of the wording of the questions and these identical questions are always asked to the participants (Turner, 2010). In this research, the latter format of interview is selected.

5.2 Evaluation dimensions

The deliverable artifact in this research consists of two aspects: the EA-based decision making method and the dashboard concept. These two aspects will be evaluated by means of interview based on several dimensions. (DeLone & McLean, 2003) provides six dimensions and measures of Information Systems (IS) success. These dimensions are a refined work from their previous model in (DeLone & McLean, 1992) and consist of:

1. **System quality** - measures of the information processing system itself
2. **Information quality** - measures of information system output
3. **Service quality** - measures of the overall success of the information system department
4. **Use or intention to use** - recipient consumption of the output on an information system
5. **User satisfaction** - recipient response to the use of the output of an information system
6. **Net benefits** - measures the impact to the use of the information system

Three out of six dimensions are used as metrics to evaluate the artifact: system quality, information quality and net benefits. According to (DeLone & McLean, 2003), information quality or system quality may be the most important quality component to measure the success of *a single system*. In that sense, service quality dimension may be not relevant in this context. Use and user satisfaction dimensions are not relevant either because the artifact has not been used and tested independently by the users or the

potential stakeholders. Although the interview session will have a demonstration section of the artifact to the participants, this is only intended as a one-direction demonstration by the interviewer so the participant will not have a real user experience of the artifact. Net benefit dimension is addressed to see the use impact or benefit of the artifact in practice. Several criteria are derived based on these selected dimensions and they are realized as interview questions. The detailed criteria and questions are provided in the interview question script section.

5.3 Aspects from artifact to evaluate

There are two aspects in the artifact as described in chapter 4: (1) EA-based decision making method, and (2) the dashboard concept. The interview questions will explicitly address these two concepts.

The first aspect to evaluate is the overall steps in EA-based decision making method, especially for step 4 - *define the metric and measurement* and step 7 - *prepare the presentation and visualization*. The summary of the method is provided in figure 5-1 below.

1. Determine the concern
2. Determine the measurable goal
3. Identify the metric from EA and its measurement
4. **Define the metric and measurement**
5. Perform the data collection
6. Perform the calculation
7. **Prepare the presentation and visualization**
   - 7.1. Prepare the main data set
   - 7.2. Determine the message, identify the analysis type and select the data subset
   - 7.3. Determine the best means to encode the values with the chart selection
   - 7.4. Determine the best design for the objects in the chart
   - 7.5. Prepare the dashboard
   - 7.6. Maintain the data for the future use
8. Conduct the analysis and decision making

Figure 5-1: Summary of the method

The second aspect to evaluate is the dashboard concept and its representation. The evaluation will be based on the prototype implementation of the dashboard concept. The conceptual model (mockup) and the screenshot of the prototype are depicted in figure 5-2 and 5-3.

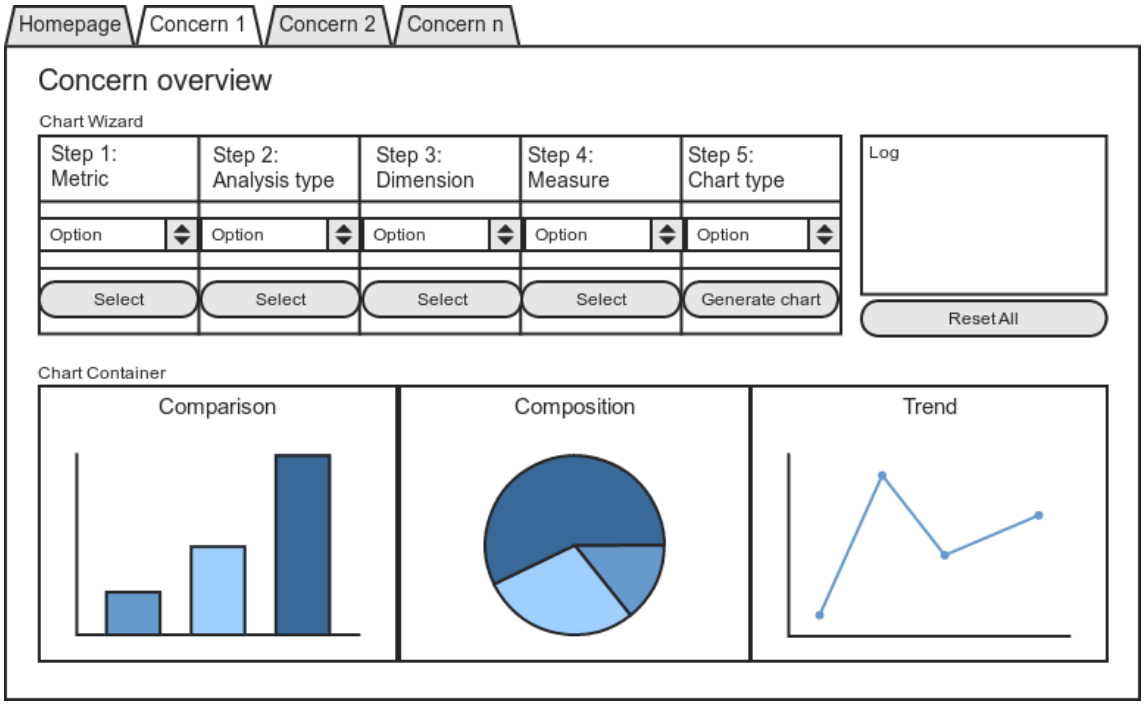

Figure 5-2: Dashboard template

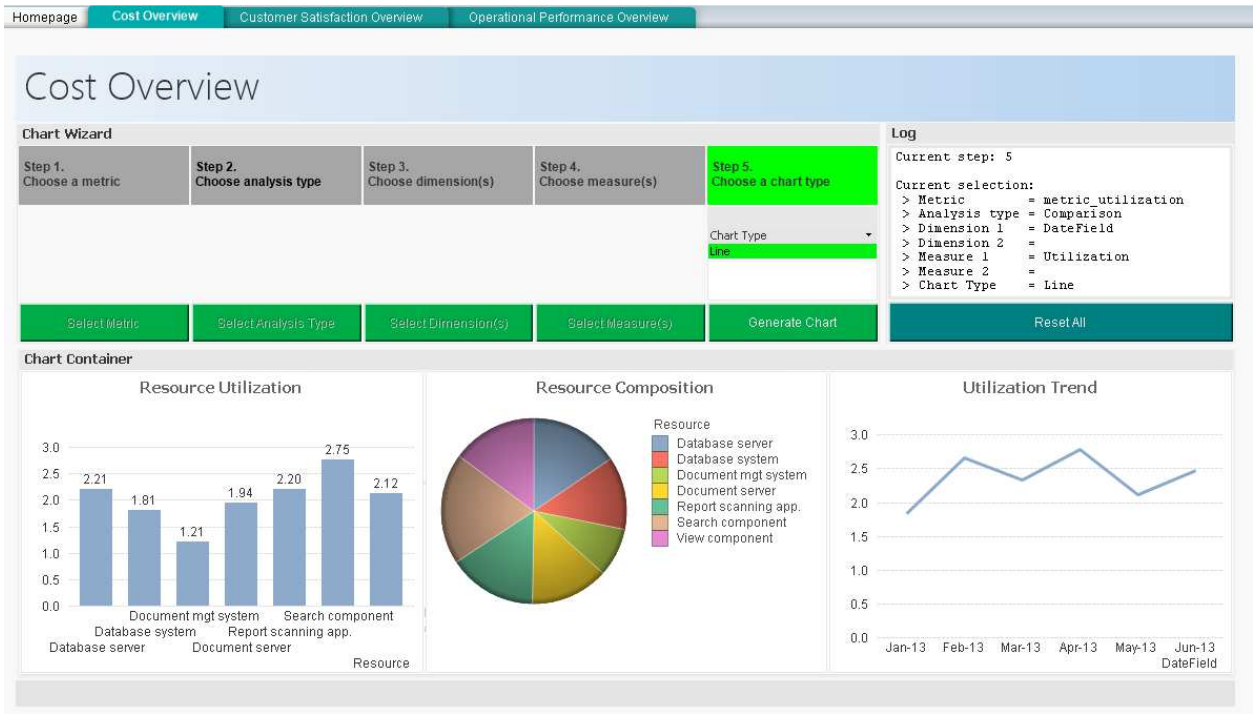

Figure 5-3: Dashboard prototype screenshot

5.4 Interview setting and respondents

Every interview session is conducted in maximum 75 minutes and follows the schedule in table 5-1:

Table 5-1: Interview setting

20-30 minutes	✓ Introduction to the research ✓ Presentation of the method ✓ Demonstration of the method by means of a case study ✓ Demonstration of the dashboard prototype
30 minutes	"Questions and Answers" session based on the interview question script
10-15 minutes	Open discussion for comment, feedback, and suggestion for improvement

The interview session is recorded by a recording device and the interview transcript will be attached anonymously in appendix C.

The respondents for the interviews are selected from the practitioner community based on their role in accordance to this research. Three representatives are selected as follow:

1. a representative of the consultant (in-charge consultant from the case study *FromAtoZ*)
2. a representative from the enterprise architect (practical expert)
3. a representative of the top-level management stakeholder as the possible user of the dashboard

5.5 Interview Question Script

The questions in table 5-2 and 5-3 are constructed to address the dimensions under evaluated and divided into two aspects. In question 3 and 4 a follow-up question is provided to extract more information based on the answer from the main question.

Table 5-2: Aspect 1 - Evaluation for the method: EA-based decision making

#	Dimensions	Criteria	Question
Q1	Systems quality	Completeness	Based on your experience, does the method include all the required activities in practice?
Q2	Systems quality	Adaptability	Do you see a need in this method to be able to customize?
Q3	Systems quality	Usability	Do you think this method is useful in practice? If (yes/no), why?
Q4	Information quality	Ease of understanding	Which steps in the method are already clear and which are not? Are there too many/few steps?
Q5	Net benefits	Time savings, repeatability	Do you see efficiency benefits in applying this method? (if unclear, provide an example: repeatability, time savings)

Table 5-3: Aspect 2 - Evaluation for the dashboard concept

#	Dimensions	Criteria	Question
Q6	Information quality	Ease of understanding	What do you think about the ease of understanding of the dashboard?
Q7	Information quality	Personalization	Does the dashboard give a flexibility to the user to analyze their concerns of the EA?

5.6 Analysis and result

The analysis from the interview result is described in this section. The product of the interview is the interview transcript text which are provided in appendix C.

System quality

- *Completeness* - All respondents agreed that the method is already complete within the limited scope that has been defined in this research, i.e. only looking into the type of decision that is supported by quantitative analysis.
- *Adaptability* - All respondents had the same opinion that since the method is very generic then it is already enough to be applicable in most situations and that there are not many steps we can leave out. The method might be configured in the sense that it might have to be made more precise for specific organizations. One respondent mentioned that adding steps could also means to go into details for steps other than step 4 and 7 for example. These unfolded steps can be explored in the same way as what has been done for step 7.
- *Usability* - All respondents agreed that the method will be helpful in practice, especially to make the activities more explicit and structured. One respondent stated that a structured way may improve the quality of the visualization. Another respondent made a note that a lot of decision making is not always based on the exact analysis but more on intuition.

Information quality

- *Ease of understanding (for the method)* - All respondents agreed that the steps in the method are already clear and understandable. Except from the steps in focus (step 4 and 7), the other steps still need to be elaborated, however this is out of the scope of the research.
- *Ease of understanding (for the dashboard)* - Two of three respondents agreed that the steps in the wizard are understandable but not for the other respondent. A confusion might arise if the given options in every steps is not that intuitive enough. A workaround for this might be by having an additional information (e.g. tool tips or help menu) for every functions and options in the dashboard.
- *Personalization (for the dashboard)* - All respondents agreed that the dashboard provides flexibility in the sense that users can configure the type of visualization they want.

Net benefits

- *Repeatability and time savings* - Two of three respondents agreed that by applying the method one can save time in the way of a repetitive similar activities. However, most of them mentioned that it would be a time consuming activity to apply the method for the first time.

Feedback and suggestion for improvement

- To make an explicit step before step 1 to determine who the stakeholders are. To put an attention to the aspects of the stakeholders as well, for example their way of deciding and their way of taking information is relevant for the way to visualize the information.
- To include the data explicitly in the model.
- The proposed method is a top-down approach; it is started from an identification of the concern down through the visualizations options. In practice, there might be cases which are not this ideal where we go from the data to search for the concern and the visualization, or even where we go all the way around from the visualization selection to determine the concern and the data to collect. This bottom-up approach is being suggested for improvement.
- In the dashboard, a new layer on top of those charts where a simpler visualization like a smiley or traffic light indicators might be needed to summarize the overall message in the chart. In the board room, one needs to be aware that stakeholders might demand something that is more abstract or simpler, in which he based the information upon all those generated charts, for example.
- For a future research, to put both the method and the dashboard in a bigger context to address the untouched processes.
- To realize the connectivity between the architecture and the dashboard.
- To make an algorithm on transforming the data in step 7. This suggestion has been addressed in section 4.2.8.2 on how to create a data subset from a dataset.

Summary

In general , the overall evaluation shows positive values in every aspect in the method so that it might *indicate* that applying the method and the dashboard concept *might* lead to a positive contribution in practice. However, due to the nature of a limited set of interviews because of the time constraint in this research and also because of the different focus in the research, a generic conclusion about the dimensions quality in the method (e.g. system quality, information quality) cannot be derived from this evaluation. A further comprehensive evaluation and validation might be fruitful to be done in the future for the validation to state the validated benefits of the method.

6 Conclusion

In this final chapter, the conclusion of the research is presented. The introduction provides a brief summary of the research and section 6.1 describes its theoretical and practical contributions. Section 6.2 discusses the limitation found in the research and finally section 6.3 provides possible direction for the future research.

This document has been prepared to address the main objective of the research on how to bring EA to the boardroom. Research question 1 about EA at the business level and research question 2 about EA deliverable for decision making by visual representation have been addressed respectively in the theoretical framework in chapter 2. Research question 3 about decision making support for EA by means of visual representation has been comprehensively addressed in chapter 3. The EA-based decision making method and the dashboard concept are presented as the artifacts of the research. The demonstration and the evaluation have been conducted in chapter 4 and chapter 5 and the result indicates a positive result for the method and the dashboard to be applied in practice. A practical summary of the EA-based decision making method is provided in Appendix D in order to be used in practice. The comprehensive description about the method is provided in chapter 3 with some running examples and the demonstration of the method is discussed in chapter 4.

6.1 Contribution

6.1.1 Theoretical contributions

1) EA-based decision making method as a generic method in supporting visual representation of EA can be treated as a generic framework for a top down approach to facilitate such objective.
2) The building blocks of data structure, the detailed step 7, the template of step 7-1 and 7-2 as seen in appendix D are presented to facilitate the presentation and visualization of EA analysis in a dashboard. To date, there is still a limited research in EA domain which addresses the visual technique in a comprehensive method especially in relation to a management dashboard. This research is expected to fill the gap in this research line.

6.1.2 Practical contributions

1) The first artifact, EA-based decision making method, provides a structured method to be applied in practice, for example by EA consultant. The steps in the method, especially step 4 and 7, have been prepared in detail so that the method is applicable to use directly in practice. The generic yet formalized method is useful when the user uses it repetitively e.g. to inure the user to follow such a formal method for an effectiveness concern.
2) The second artifact, the conceptual dashboard, provides a guide to facilitate the deliverable of EA by means of visual representation. It can also be a possible option for a tooling implementation or a feature addition in the existing EA tools.

3) The prototype of dashboard concept is prepared to demonstrate the real use of the method and the concept of the dashboard. The design, script and code in the prototype can be referred to learn the actual implementation of a dashboard.
4) Some of the concept described in this thesis, e.g. the building blocks of data structure of a dashboard in chapter 3.3.2, can be adapted and implemented in the current EA tool e.g. BiZZdesign Architect in order to facilitate the charts and dashboard creation.
5) An application of the method for the first time might require more effort and time. However, it will be an efficient and fruitful method when a similar activity is performed for the second time and so on, for example in a periodic performance analysis, because the user has already defined and set up the metric definition, data collection, measurement method and the possible visualization options.

6.2 Limitation

There are several limitations from this research that have been identified, including:

1) Measurement techniques are assumed to be available so they are not discussed in this research.
2) The restriction of the research is only to explore performance analysis and it does not explore the other possible ways on decision making analysis, such as functional analysis.
3) Due to time limitation, the qualitative evaluation in chapter 5 was conducted only from the point of view of practitioners and not including the point of view of academic representatives.
4) In step 7-2: *determine the message and select the data subset*, the possible set of messages is fully determined based on the experience of the user, e.g. the architect. If he has already gained a good insight, then he can thinks of many possible messages, i.e. the possible set of data subsets. However, it could be quite challenging for a typical user who does not have such experience yet. To address this concern, the pivot table feature in spreadsheet tool (e.g. Microsoft Excel) might be helpful to seek for this possible set of messages.

6.3 Future research

There are several interesting research direction which can be conducted based on this research, including:

1) *In-depth research for every steps in the EA-based decision making method excluding step 4 and step 7***.** This research only addresses step 4 and step 7 in a comprehensive way. A similar approach can be explored for other steps in order to have complete practical steps for the entire method, e.g. how to choose an appropriate metric and measurement (step 3) and how to perform the data calculation (step 6).
2) *Connectivity from Enterprise Architecture (EA) tools to Business Intelligence (BI) tools*. As part of this research, we have also explored the possibility to connect BiZZdesign Architect, an EA modelling tool based on ArchiMate modelling language, to QlikTech QlikView, a leading BI tool.

The approach can be made by using COM object and the API from QlikView. A script file in Architect has been prepared to demonstrate the basic connectivity between these two tools. The script performs a quantitative analysis for EA model, stores the measurement result in a file, and then triggers an automatic chart creation based on this data in QlikView. The current approach is mediated by having a simple csv-text file as the data resource. It would be interesting for a future research to explore the creation of a full and dynamic management dashboard with its interactivity that is triggered from an EA tools, e.g. Architect. It might also be interesting to explore the use of a real database system as the data source intermediary between these two tools.

3) *Exploration on the bottom-up approach or from-middle-to-outer approach for the EA based decision making method*. The proposed method in this research is restricted to top-down approach; the user needs to follow the activity in the method sequentially from determining the concern in step 1 to visualize the result in step 7. However, the situations in practice are not always like this. As suggested during one of the interview session, there will be cases probably when we already have the data and we want to explore what nice thing we can do with it visually and then find out whether there is a concern that covers it. In another rare yet possible case, there might be a demand where the visualization type (e.g. the dashboard model) has already been requested so then the underlying data and concerns need to be identified based on that. So it is a bottom-up approach. The current method might need to be customized to adapt to these different approach.
4) *Adding another layer to encapsulate the current visualization method to make it simpler*. As another suggestion from the evaluation phase, the people in the boardroom might want to see something simple as *OK* or *not OK*, or *green for good* and *red for bad*, or *smile emoticon as a positive end-result* and *sad emoticon as a negative end-result*. Providing charts like bar chart, line chart, pie chart and any other basic chart might need extra interpretation and storytelling to understand the underlying message of those charts. To facilitate this concern, a future research in defining such aggregation layer is also interesting.
5) *Exploration in another type of EA-based analysis*. This research is restricted to quantitative analysis. However, as some analyses identified in Table 2-9: *Typical analysis in EA practice*, partially adapted from (Lankhorst, 2009)another types of analysis exist, e.g. functional analysis and traceability analysis. Exploring the possibility to configure the method and dashboard concept from this research to adapt another analysis types might be a possible direction for future research.

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Appendices

Appendix A: ArchiMate 2.0 Viewpoint Classification

In the ArchiMate 2.0 specification document (The Open Group, 2012), 27 viewpoints are grouped into three categories i.e. standard (core) viewpoints, motivation extension viewpoints and implementation and migration extension viewpoints. Each viewpoint has its own purpose and abstraction level (content) and will be used by different stakeholders with different concerns. Table A.1 provides all available viewpoints from the document including their purposes and abstraction levels detail. Some viewpoints that are relevant to this project are written in bold text for their occurrences in the table, namely all viewpoints which have "deciding" purpose and abstraction level of "overview". To have a better understanding for the meaning of these two classification dimensions, the description of purposes and abstraction levels are given in table A.2 and A.3.

Table A-1: Viewpoint Classification, adapted from (The Open Group, 2012)

No.	Group	Viewpoint Name	Purpose			Abstraction Level		
			Designing	Deciding	Informing	Coherence	Overview	Details
1	**Standard (Core)**	**Introductory Viewpoint**	V	V	V	V	V	V
2	Standard (Core)	Organization Viewpoint	V	V	V	V	x	x
3	Standard (Core)	Actor Co-operation Viewpoint	V	V	V	x	x	V
4	Standard (Core)	Business Function Viewpoint	V	x	x	V	x	x
5	Standard (Core)	Business Process Viewpoint	V	x	x	x	x	V
6	Standard (Core)	Business Process Co-operation Vpt.	V	V	x	V	x	x
7	Standard (Core)	Product Viewpoint	V	V	x	V	x	x
8	Standard (Core)	Application Behavior Viewpoint	V	x	x	V	x	V
9	Standard (Core)	Application Co-operation Vpt.	V	x	x	V	x	V
10	Standard (Core)	Application Structure Viewpoint	V	x	x	x	x	V
11	Standard (Core)	Application Usage Viewpoint	V	V	x	V	x	x
12	Standard (Core)	Infrastructure Viewpoint	V	x	x	x	x	V
13	Standard (Core)	Infrastructure Usage Viewpoint	V	x	x	V	x	x
14	Standard (Core)	Implementation & Deployment Vpt.	V	x	x	V	x	x
15	Standard (Core)	Information Structure Viewpoint	V	x	x	x	x	V
16	Standard (Core)	Service Realization Viewpoint	V	V	x	V	x	x
17	**Standard (Core)**	**Layered Viewpoint**	V	V	V	x	V	x
18	**Standard (Core)**	**Landscape Map Viewpoint**	x	V	x	x	V	x
19	Motivation Ext.	Stakeholder Viewpoint	V	V	V	V	x	V
20	Motivation Ext.	Goal Realization Viewpoint	V	V	x	V	x	V
21	Motivation Ext.	Goal Contribution Viewpoint	V	V	x	V	x	V
22	Motivation Ext.	Principles Viewpoint	V	V	V	V	x	V
23	Motivation Ext.	Requirements Realization Vpt.	V	V	V	V	x	V
24	**Motivation Ext.**	**Motivation Viewpoint**	V	V	V	V	V	V

25	**Implemnt. & Migration Ext.**	**Project Viewpoint**	x	V	V	x	V	x
26	**Implemnt. & Migration Ext.**	**Migration Viewpoint**	V	V	V	x	V	x
27	**Implemnt. & Migration Ext.**	**Implementation & Migration Vpt.**	x	V	V	x	V	x

V = exist; x = not exist

Table A-2: Viewpoint Purpose (The Open Group, 2012)

	Typical Stakeholders	Purpose	Examples
Designing	architect, software developer, business process designer	navigate, design, support design decisions, compare alternatives	UML diagram, BPMN diagram, flowchart, ER diagram
Deciding	manager, CIO, CEO	decision-making	cross-reference table, landscape map, list, report
Informing	employee, customer, others	explain, convince, obtain commitment	animation, cartoon, process illustration, chart

Table A-3: Viewpoint Abstraction Levels (The Open Group, 2012)

	Typical Stakeholders	Purpose	Examples
Details	software engineer, process owner	design, manage	UML class diagram, BPMN process diagram
Coherence	operational managers	analyze dependencies, impact of-change	views expressing relationships like “use”, “realize”, and “assign”
Overview	enterprise architect, CIO, CEO	change management	landscape map

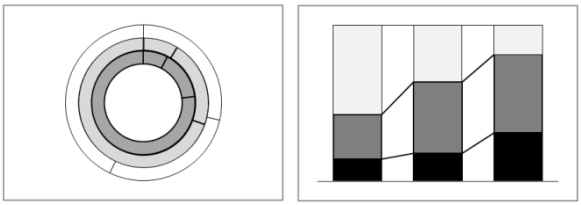
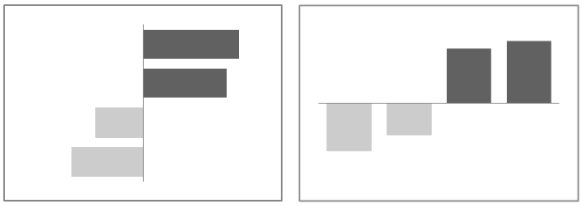
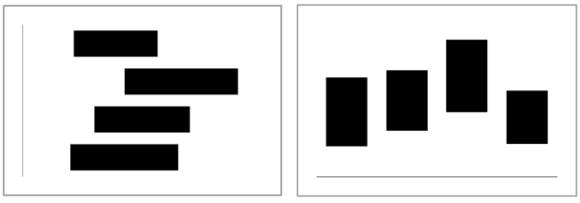
Appendix B: Charts Evaluation

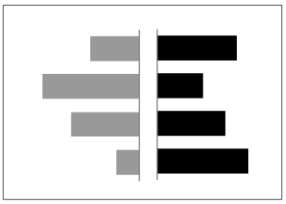
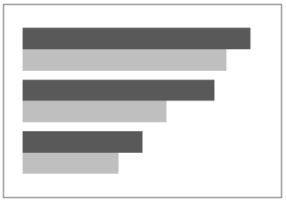
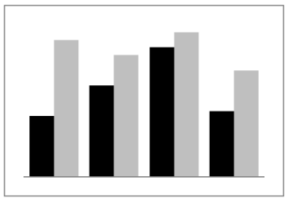
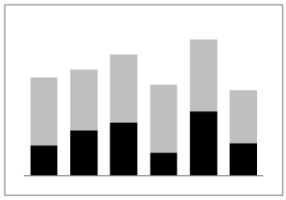
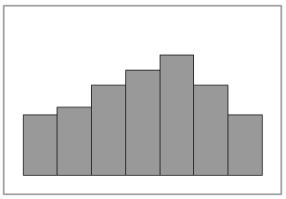
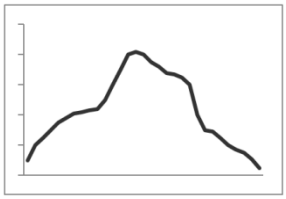
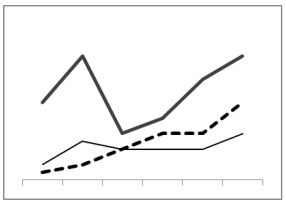
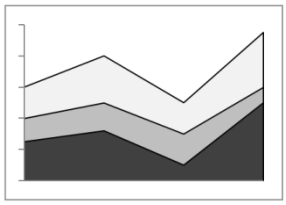
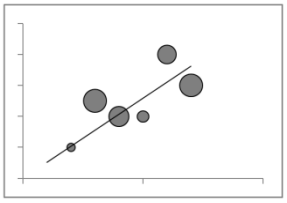
Choosing inappropriate display media is one of the common mistakes in quantitative data representation and when designing a dashboard in particular (Few, 2006). For example, to display a statistic of people based on age in a certain community who have lung cancer can be done by either a bar chart or a pie chart. However, when the data set gets bigger, it might be more efficient and more readable to display it as a bar chart rather than a pie chart. Choosing the proper chart representation will convey more effective message to the audiences.

B.1. Chart Variants

The following table illustrates the possible variants from the five basic chart forms: pie chart, bar chart, column chart, line chart and dot chart.

Table B-1: Description of the chart variants (Zelazny, 2001)

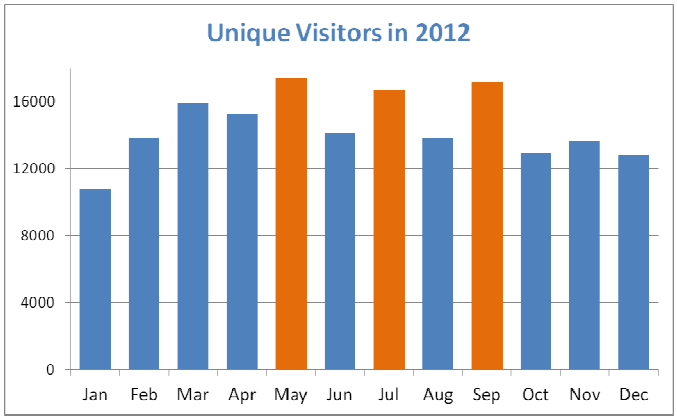
1 Doughnut chart and 100 percent bar chart To show the percentage of total for several items and see the relationship among each other; The relationship is presented better by a 100 percent bar chart rather than a doughnut chart	
2 Deviation bar/column chart To distinguish two groups based on a specific goal, e.g. the profit winners from the losers	
3 Sliding bar/column chart To show the different mix of two components	
4 Range bar/column chart To show the spread between low and high amounts, e.g. the possible discount-range of products; Another variant of range column chart is called *stock chart* that illustrates fluctuations in data, e.g. stock prices	

5	**Paired bar chart** To show the correlation between two items	
6	**Grouped bar/column chart** To compare various aspects of the same item or to see the relationships between items with the same category over various aspects e.g. time; The bars/columns can be placed either side by side or overlapped;	 
7	**Subdivided bar/column chart** To show how components contributing to the total value	 
8	**Histogram chart and histograph chart** To summarize vast amount of data to demonstrate some meaningful relationship; Histogram (column) charts are better for a few used ranges and histograph (line) charts are better for many ranges	 
9	**Grouped line (spaghetti) chart and surface chart** To compare the performance of two or more items	 
10	**Bubble chart** To facilitate a third dimension of the chart which is represented by the size of the bubble, e.g. the price of the products and the size of the assets	

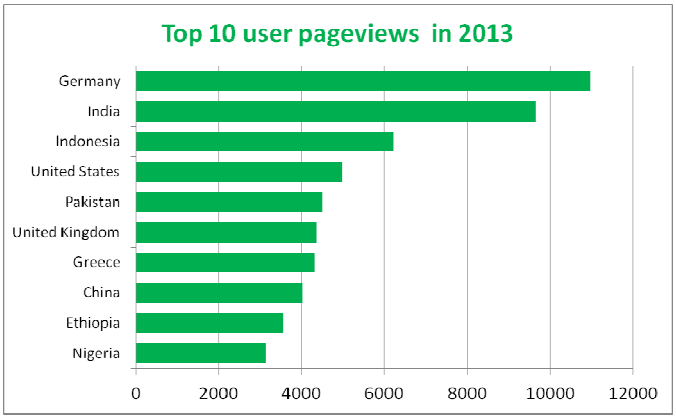
B.2. Charts Visualization Examples

In the following section, the most common charts are illustrated with examples. Additional charts are also added, e.g. heatmap chart, map chart. Some figures are adapted from (Hardin et al., 2012; Microsoft Office, 2013).

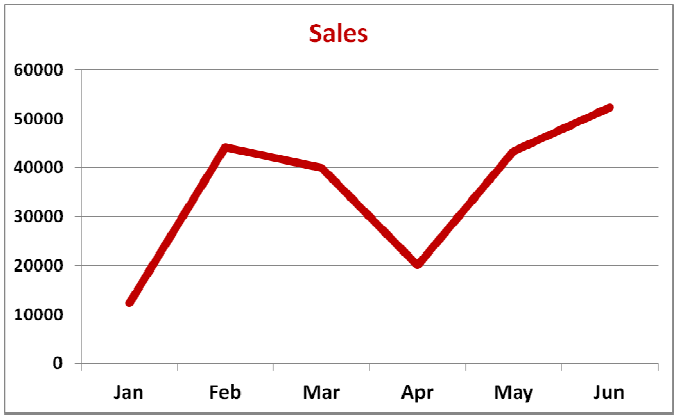
Column Chart



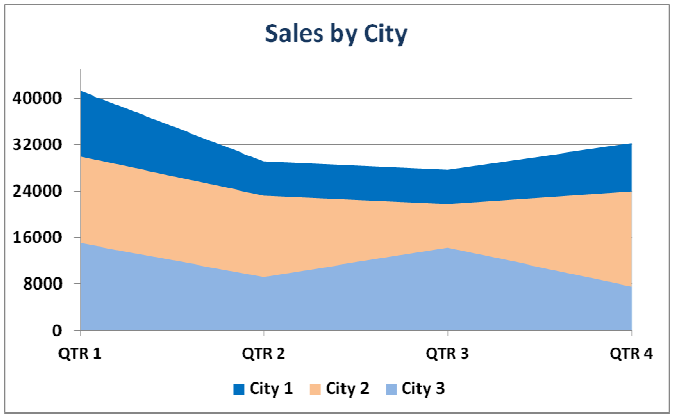
Bar Chart



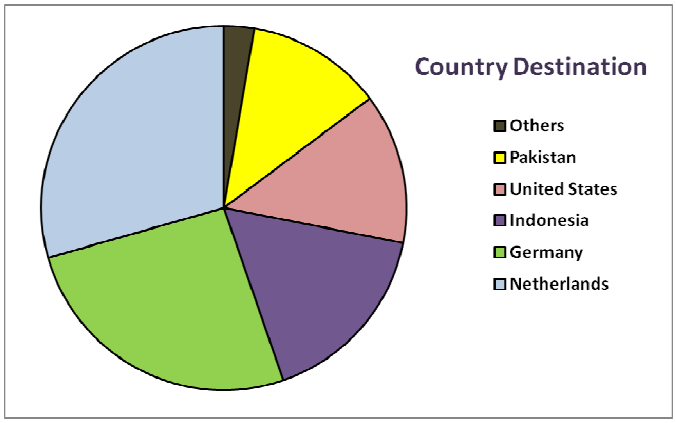
Line Chart



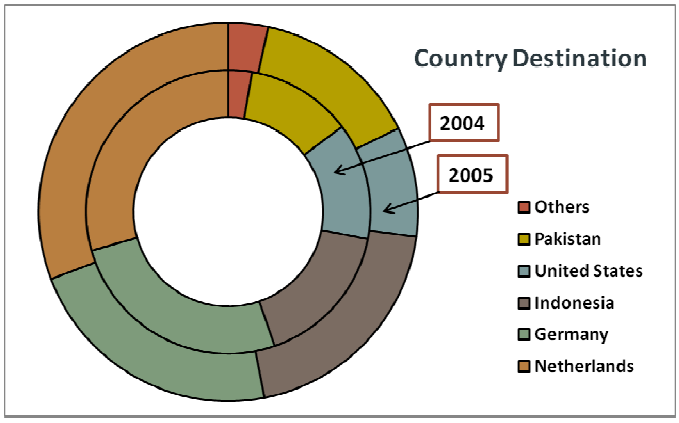
Area Chart



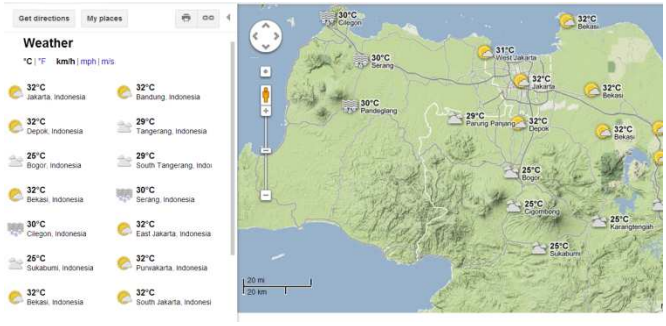
Pie Chart



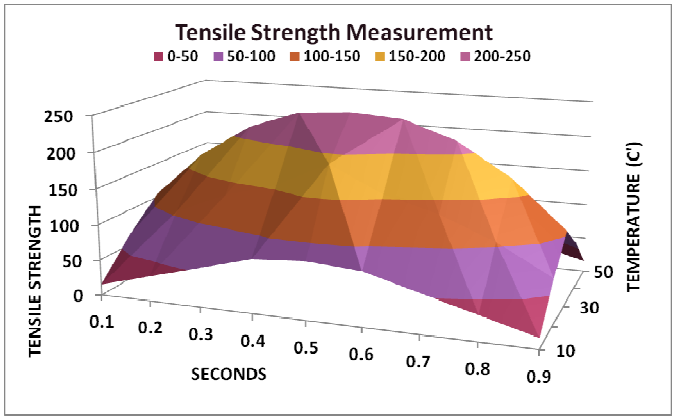
Doughnut Chart



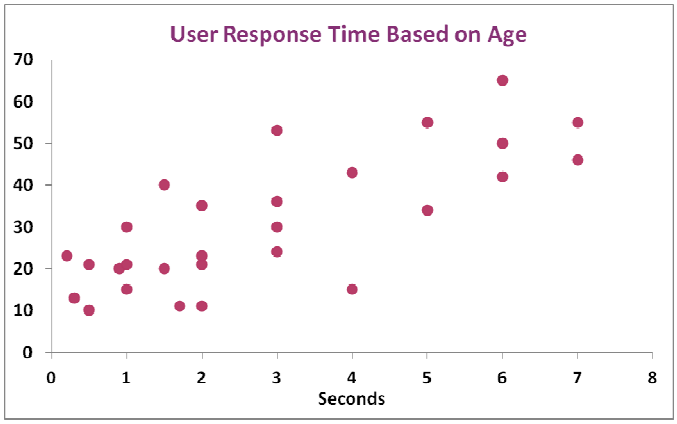
Map Chart



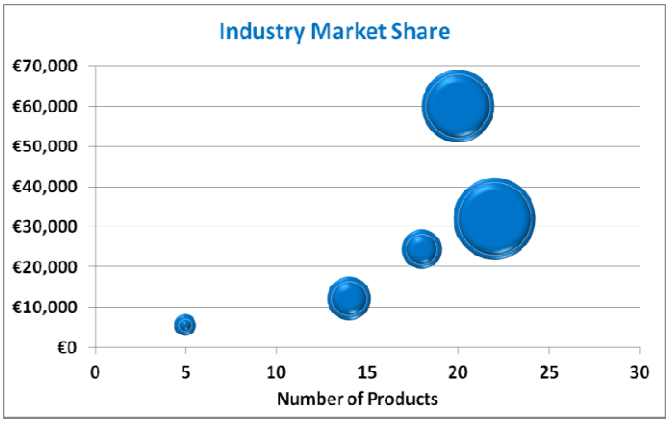
Surface Chart



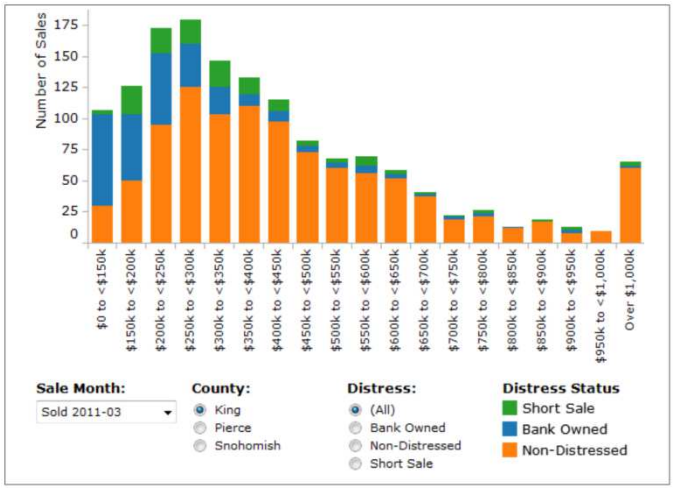
Scatter/Plot Chart



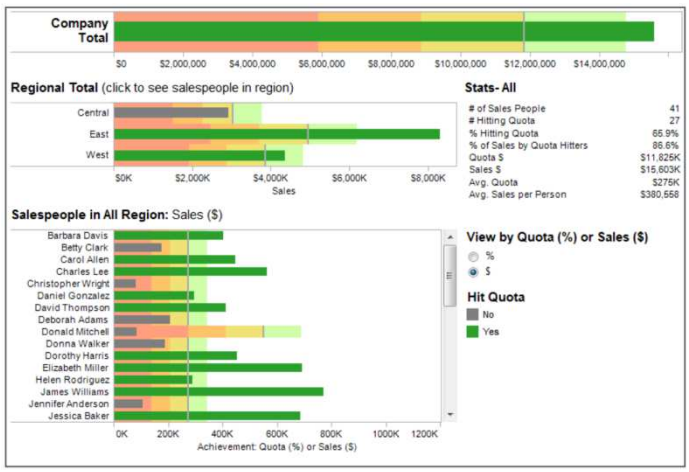
Bubble Chart



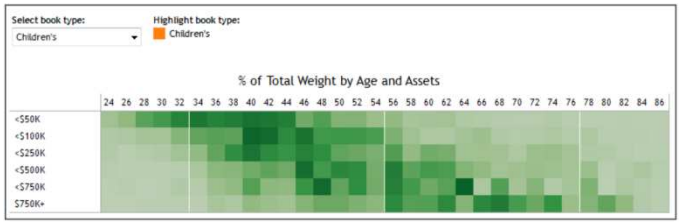
Histogram Chart



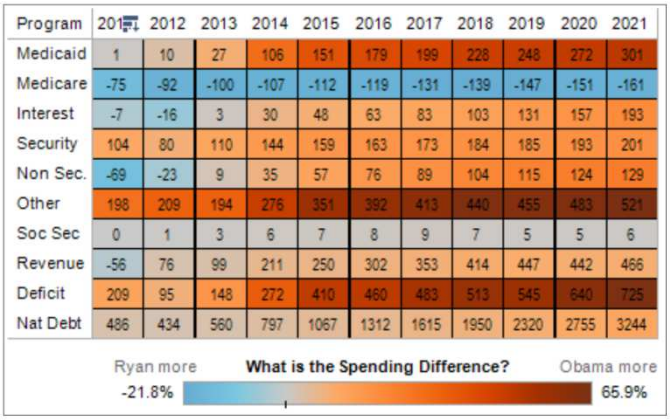
Bullet Chart



Heatmap Chart

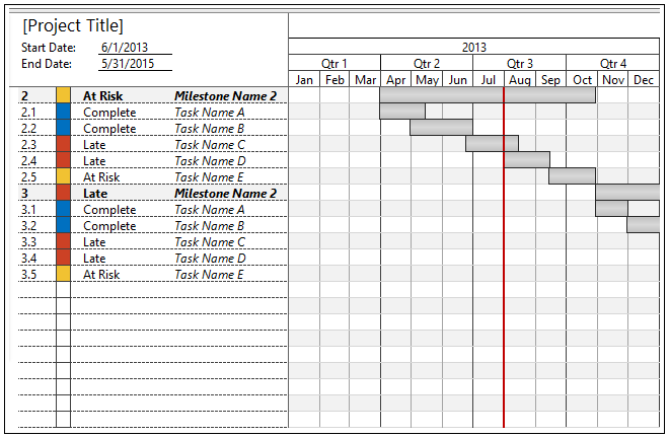


Highlight Table Chart

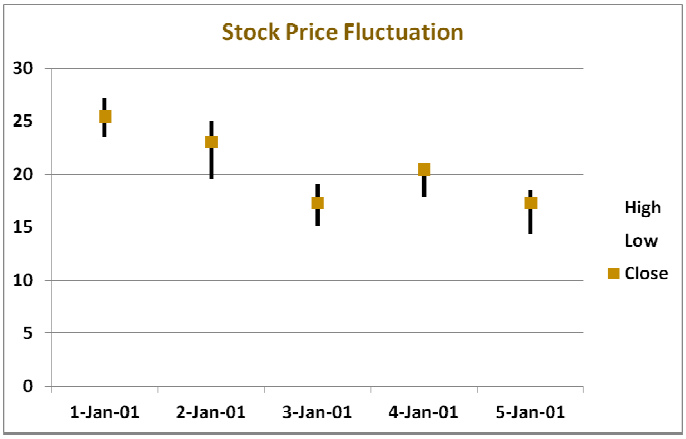


Program	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Medicaid	1	10	27	106	151	179	199	228	248	272	301
Medicare	-75	-92	-100	-107	-112	-119	-131	-139	-147	-151	-161
Interest	-7	-16	3	30	48	63	83	103	131	157	193
Security	104	80	110	144	159	163	173	184	185	193	201
Non Sec.	-69	-23	9	35	57	76	89	104	115	124	129
Other	198	209	194	276	351	392	413	440	455	483	521
Soc Sec	0	1	3	6	7	8	9	7	5	5	6
Revenue	-56	76	99	211	250	302	353	414	447	442	466
Deficit	209	95	148	272	410	460	483	513	545	640	725
Nat Debt	486	434	560	797	1067	1312	1615	1950	2320	2755	3244

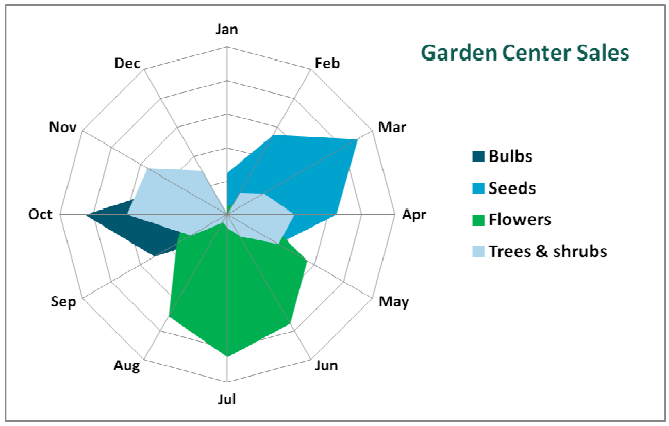
Gantt Chart



Stock Chart



Radar Chart



B.3. Charts Description and Suggestion

The following table describes best practice recommendations for chart types and their possibilities to be combined among each other.

Table B-2: Chart types and their purposes, summarized from (Hardin et al., 2012; Microsoft Office, 2013)

No.	Chart name	Purpose	Example	Suggestion	Possible combination
1	**Column**	✓ To present ranges of values ✓ To present specific scale arrangement ✓ To present names that are not in any specific order	✓ Item counts ✓ A likert scale with entries, e.g. strongly agree, agree, neutral, disagree, strongly disagree		
2	**Bar**	✓ To compare information, revealing highs and lows at a glance ✓ To compare data across categories ✓ To see trends within data	✓ Volume of shirts in different sizes ✓ Percent of spending by department	✓ Effective with numerical data that splits nicely into different categories ✓ Colored bars give more impact ✓ Stacked bars or side-by-side bars address multiple questions at once ✓ Use it when axis label are long ✓ Use it when the values that are shown are durations	✓ With map; e.g. map acts as filter for bar chart to display corresponding information ✓ With line chart
3	**Line**	✓ To visualize a sequence of values ✓ To display trends over a period of time at equal intervals, like months, quarters, or fiscal years	✓ Stock price change over a five-year period ✓ Revenue growth by quarter	✓ Add trend line to see the pattern of the data ✓ Line charts are the most effective way to show change overtime	With bar chart
4	**Area**	✓ To enhance information to line chart about the relative contribution that line contributes to the whole ✓ To draw attention to the total value across a trend	Sales by region per quarter	Effective on two or more data source	
5	**Pie**	To show relative proportions or percentages of information	✓ Percentage of budget spent on different departments ✓ Response categories from a survey	✓ To compare data, it is better to use bars or columns ✓ Limit pie wedges to six for easy interpretation ✓ Use it when there is only one data series and without negative or zero values	With map; e.g. to highlight geographical trends in the data

6	**Doughnut**	Similar to pie chart; to show relative proportions or percentages of information but it can contain more than one data series	Sales data for two years	Doughnut charts are not easy to read. Stacked column or stacked bar charts are easier to read	
7	**Map**	To show geocoded data, e.g. postal codes, country names	✓ Insurance claims by state ✓ Weather by cities ✓ Car accidents by zip code	Use maps as a filter for other types of charts	✓ With bubble chart; e.g. to interpret the geographical impact of different data points quickly ✓ With pie chart; e.g. to highlight geographical trends in the data ✓ With bar chart; e.g. as filter to display relevant information
8	**Surface**	To find optimum combinations between two sets of data	Tensile strength measurements (strength, time and temperatures)	✓ Colors and patterns indicate areas that are in the same range of values ✓ Both categories and data series are numeric values	
9	**Scatter (XY) plot**	✓ To show and compare numeric values, like scientific, statistical, and engineering data ✓ To investigate the relationship between different variables ✓ To see trends, concentrations and outliers of the data for further investigation	✓ Male versus female likelihood of having lung cancer at different ages ✓ Shipping costs of different product categories to different regions	✓ Add trend line / line of best fit to see the correlation among data ✓ Incorporate filters to identify patterns faster ✓ Use information mark types (symbols) to add more meaning ✓ Use it when there is a need to change the scale of the horizontal axis or to make that axis a logarithmic scale ✓ Use it when values for horizontal axis are not evenly spaced or there are many data points on the horizontal axis	
10	**Bubble**	✓ To accentuate data on scatter plots, to show the concentration of data along two axes ✓ To add the 3rd dimension of the data, i.e. the size of the bubbles	✓ Sales concentration by product and geography ✓ Class attendance by department and time of the day	Add colors to the bubbles to add the 4th dimension when necessary	With map; e.g. to interpret the geographical impact of different data points quickly

11	**Histogram**	To see how the data are distributed across groups	✓ Number of customers by company size ✓ Student performance on an exam	✓ Test different groupings of data to determine the most useful sets of data ✓ Add a filter to explore a lot of data views quickly	
12	**Bullet**	To evaluate performance of a metric against a goal	✓ Sales quota assessment ✓ Actual spending vs. budget	✓ It is designed to replace dashboard gauges, meters and thermometers because of their insufficient ✓ Use color to illustrate achievement thresholds ✓ Add bullets to dashboards for summary insights	
13	**Heat map**	To show the relationship between two factors	✓ Segmentation analysis of target market ✓ Product adoption across region	✓ Vary the size of squares to add a third element ✓ Use something other than squares may also help to convey data in a more impactful way	
14	**Highlight table**	To provide detailed information on heat maps	✓ The percent of a a market for a different segments ✓ Sales numbers by a reps in a particular region		With line chart, e.g. to understand overall trends as well as quickly drill down into a specific cross section of data
15	**Gantt**	✓ To display a project schedule; project management ✓ To show other things in use over time	✓ Illustrating key deliverables, owners and deadlines ✓ Duration of a machine's use	Add color to the bars to quickly inform viewers about key aspect of the variable	
16	**Stock**	To illustration fluctuations in stock prices or other data	Fluctuations in daily rainfall or annual temperatures	Ensure the data source has been arranged in the correct order	
17	**Radar**	To compare the aggregate values of several data series	Garden central sales		

Appendix C: Interview Transcripts

The three transcripts written in this section are the text products from the interviews. The transcripts are needed for the evaluation phase and analyzed in section 5.6.

Interview 1	
Interviewee's function	Enterprise Architecture Consultant
Interview date	Friday, November 1, 2013

Aspect 1: The overall steps in *EA-based decision making* method

Question 1:

Based on your experience, does the method include all the required activities in practice?

I think the method itself is good. You have pretty much all steps in there. There are few assumptions you made, that you have to identify who the stakeholders are, because your first step is to determine the concerns, so that means you have already an overview about the stakeholders that you have to do this process for every stakeholder involved. That is an assumption you made; you could consider make it as an explicit step to combine with the first step. But for the rest I think it is a pretty complete method to go.

Question 2:

Do you see a need in this method to be able to customize?

Well, I think your method is quite generic in the sense that you don't go really into the details. I think the method might be configured in the sense that it might have to be made more precise for specific organizations, well that means that determining the concerns, for that specific organizations, might be a different process for every organization. but I think the method itself is so generic, I don't think there are many steps you can leave out, that you always have to consider what the concerns are, you always have to consider what you're going to have as measurable goals, you always have to consider which measurement you need there, so I don't think there are many steps you can leave out.

And adding steps, I think, it means more that you are unfolding one activity like identify the metric from EA and its measurement, I think you can say in some organizations much more about that because there might be a bit gap between step 2 (determine measurable goal) and identifying the metric with what you can measure, e.g. if you have a goal to improve customer satisfaction and there is a big gap towards how to measure that in your architecture. So there are that, may be, steps added in how to actually identify that metric. I think that's more like extending step 3 into several sub steps like you've also done that for step 7. I do think for every organization you have to configure it. May be because you have here is what do I do, and not how do I do it. Well, you do have that in step 7 of course, and I think also for step 4, how to do it, but for the other steps it might be configured in similar way like step 4 and step 7.

Question 3:

Do you think this method is useful in practice? If (yes/no), why?

Yes, I am very happy to have the method, and I think it is very helpful to have in practice because typically when, as a consultant, you go to a company who needs some analysis of the architecture and once that analysis that you did for them presented to some managers because this then the technical situation you get into, then this is always an

adhoc manner of building data that you really focus on the architecture and the message in there and how to transform that to practical representation. You always do the work over and over again but there are also a lot of steps that you here explicitly this that you typically don't take that well into your mind like for example determining the concern is usually implicit thing to be done by the consultant, somewhere I think about what the concerns is of that managers but it's not an explicit first step that I conducted. And I also have to come up every time with for myself again on a method on how to do that then and this really helps in making that structured repeatable method, so I think it is very helpful to have in practice, also because of the big gap between architecture and the board room.

Question 4:

Which steps in the method are already clear and which are not? Are there too many/few steps?

I understand what you mean for every steps. I think it's a good set of steps and I understand them, but I do think that there should be a future research on how to do certain steps. I think you identified eight very important steps here and you also said how you do step 4 and step 7 in details but I think there is quite something to say for example on how to identify the metric from the architecture and its measurement, how do you do that.

Question 5:

Do you see efficiency benefits in applying this method? (For example: repeatability, time savings)

I think the benefit is that you can save a lot of time at the beginning, because now you typically start.. a company comes to you with a question and says do this analysis on the architecture and then present the result to the board. They typically do not tell me why they want to have that. So in the way of the whole process I find out that actually what their concerns are, but it is usually something that I found out later. And then typically the concerns they actually have are not completely being addressed by the analysis they originally asked for. This is typically how it goes. So then it becomes an iterative process where in the end I only found out what their concerns were, and then I have to go back, and then I have to design again and think about what to actually measure now in the architecture. So that process is pretty long. I think that is definitely one benefit of having such process (method).

The second thing is that it becomes something that you can repeat as consultant, you can develop in the sense that you can be more effective in it, you start having a habit on how you go to the process so you can more effectively help your customers, but it also helps your customers to do it themselves afterwards. So now they always have to ask me to do the analysis and to do the whole process and I set up conceptual part behind it. If I can show them the stepwise approach and I can show it for them for one example within the company, to be repeated afterwards themselves also when following the steps again. So having structured method definitely has many benefits.

Aspect 2: The dashboard concept

Question 6:

What do you think about the ease of understanding of the dashboard?

I think it is pretty understandable. I think the first part 'choose a metric' is very clear. And then 'the analysis type' is also very clear. But sometimes step 3 and step 4 are something you have to think about again. So it is intuitive since I've seen how the dashboard works a few time so now I know what that means, but these are the two that are less intuitive for me at least. And step 5 for me is very intuitive again: choosing the chart type. For the rest of the layout I think is really nice especially also that you can have several different visualization for one concern.

Question 7:

Does the dashboard give a flexibility to the user to analyze their concerns of the EA?

Definitely, especially because you have different ways of visualizing things and since you explicitly stated that each concern the stakeholder has or the stakeholder has stated what he wants to know, and for every concern you provide a screen in which he can visualize the result from the data that makes it very helpful that he can choose different visualizations and also different types of analysis. So within the limited scope of that specific concern user gets a lot of flexibility on what type of analysis he wants to do, and it boxes it efficiently not to get overwhelmed.

Open discussion

Comment, feedback and suggestion for improvement

For a suggestion for improvement, I would also like to think about not only for this thesis but may also for a future research. It would be good to put both of the method and the dashboard in a bit bigger context. So now you really, well it is already an enormous problem to think about how to get that architecture in some forms to dashboard for stakeholders at management levels, but there're of course processes around it that we now not address yet. And I think now it is still quite difficult to.. somehow there should be an agreement on what you're going to measure in that architecture and does the CIO have to say something about that about what he wants to see measured or is that somebody in more technical person decide for him, or should he get some freedom in choosing this metric.. and this is quite difficult because you cannot expect CIO to have a knowledge or insight what does it mean about the architecture. On the other hand the CIO has no idea what is making up his dashboard so there is a chance that he does not trust it, so stakeholder also needs to feel involved in the creation of this dashboard because the idea is that he gets now a dashboard with charts on it that he can nicely switch between visualizations he finds comfortable (with), and the data gets refreshed on a regular basis, that means he also needs to have a bit feeling on the data model that is behind it, I would find it very interesting for future research for putting in that setting in a bit.

Also to actually realize that connection, for example, between architecture and the dashboard. How to extract the data, how to maintain that, how to gather the data into because not every data presents in the architecture but should be somehow connected to it, or do you really import it into the architecture and then extract from that again, how do you connect the architecture tool with the dashboard tool, and for every stakeholder they might have a different dashboard by a rule-based control may be, so not every stakeholder is allowed to see all data.. so putting everything you made in a broader context might be a bit challenge.

Another thing that you now show is, for example in this case study (FromAtoZ), how to export that into a table where you then analyze it again, there should be an algorithm behind it that calculates that result, but it will be also interesting on how to set that up in a more generic way. An algorithm for example to make that calculation in a more structured way. So that would be for me interesting.

Interview 2	
Interviewee's function	Enterprise Architect (Expert)
Interview date	Monday, November 4, 2013

Aspect 1: The overall steps in *EA-based decision making* method

Question 1:

Based on your experience, does the method include all the required activities in practice?

Yes, I think so, for the scope that you have chosen. It's clear about the scope what is included and what isn't. Your scope is something that can be measured for a specific type of questions that you can address. Of course there are many ways to represent EA to the boardroom and you focus on the quantitative analysis. Another option would be traceability (analysis) but this is not within the scope.

And I am not really sure about including the data in your model, if that should be an implicit step or not, I'm not sure, because you collect the data then you have to cover that in the model again, this way you can do the calculation. It should be stored somewhere or structured in some way.

Question 2:

Do you see a need in this method to be able to customize?

I think this is very general. I think in general some steps might not be needed in smaller cases. I think it is general enough to be applicable in most situations.

Question 3:

Do you think this method is useful in practice? If (yes/no), why?

Yes, I think so. Of course there are a lot of experiences not written applied in this kind of practice but I think it helps to make it explicit. I think consultants are already doing this things but they don't say explicitly about how they work on it. If there isn't any change from a time to another time, I think it will help to standardize it a bit. I think it will help to improve the quality of the visualization if you do it in a structured way and may be you need more guidance for it because I don't know yet since I haven't read the complete method in your thesis.

Question 4:

Which steps in the method are already clear and which are not? Are there too many/few steps?

I think the way you present it is already clear to me, and I'm still not sure about the details. It is clear what the goals of the steps are.

Question 5:

Do you see efficiency benefits in applying this method? (For example: repeatability, time savings)

I am not sure about the efficiency but it may improve the quality and repeatability of the process, if you do it in such a structured way an especially for people who are less experienced to do thing, it will help. I don't think it will make more efficient. It may be more works at the beginning because you have to do all the steps. I'm not sure about the time saving, may be you can automate some partly, but I think that's not the main goal to save time.

Aspect 2: The dashboard concept
Question 6:
What do you think about the ease of understanding of the dashboard?
Not all of these steps are completely clear to me, especially the options because the names are a bit unclear. I know the meaning of the steps, but not the options in them yet. (Because I don't know the meaning of the options,) I would not know what to choose. You need to know what to select in what situation. May be in this example (in the demonstration), I still don't understand, so will still need help (to use the dashboard).
Question 7:
Does the dashboard give a flexibility to the user to analyze their concerns of the EA?
Yes, I think so because you can configure it. So if the question is will it create the flexibility, I think it will.
Open discussion
Comment, feedback and suggestion for improvement
I think I have mentioned most of the things during the presentation and the questions.

Interview 3	
Interviewee's function	Director of an IT company
Interview date	Tuesday, November 5, 2013

Aspect 1: The overall steps in *EA-based decision making* method
Question 1:
Based on your experience, does the method include all the required activities in practice?
What I think (is that this method) is not yet emphasized enough. It is not always about the concerns but also about the stakeholders. It's not only the concerns that determine the visualization presentation but also the stakeholders because the way the stakeholders is determine partly also what kind of how and what information you need. So, that would be something you don't need to include it in the method but you should be aware of it and also mention it that the person of the stakeholder is also very important thing because his way of deciding and his way of taking information is relevant for the way you visualize the information. (what I meant by the stakeholder is not that) it's related to the role, e.g. a CFO always wants this kind of representation, but it's more like a personal thing. For instance, there are people who like to see a graphical information and others like to see tables, charts and stuff like that, and they have a different way of looking at information and taking information so that's something, I would say, in the first step, instead of saying 'determine the concern', it would be good to have something like the stakeholders. I think that would be a valuable addition for your method. For the rest I think it looks complete to me, and of course there is a restriction in the sense that you restrict yourself to decisions that are which you can say that there is a metric and a data. There is a lot of other decisions as well of course. But I assume that somewhere in your thesis there will be a clear demarcation of your scope

saying that we know that there is more in decision making but you restrict yourself.

Question 2:

Do you see a need in this method to be able to customize?

(This question has been partially answered in the first question). For the rest I think all these steps are necessary. You can't take out one of the steps without problem I would say.

One other thing I could imagine that you start with a concern in this method but there will be cases probably when you say this is the data, what can we do with it? So that is the other way around: we have the data and what nice things can we do with it and is there a concern that covers that (data)? So that's a different approach; It's not the ideal approach because in an ideal world you start with a concern then work towards the visualization, but I think in practice you might have the fact that there is a limited set of data where you want to do something with it. So I think the steps are the same more or less but in that case you start with performing data collection and then see what kind of metrics can be found for it.

I guess that also sometimes it might be the case that you know what kind of visualization you need to present and then you have to work your way back. For instance in a case that in an organization the stakeholder says, I've been visiting the other company, and they have this dashboard and I really like it. Can you create me this dashboard? And then you know that he wants this kind of visualization then you have to find out which metric and which concern can you cover with it. But I think the steps are the same but you go through them in a different order.

Question 3:

Do you think this method is useful in practice? If (yes/no), why?

Yes, it is certainly useful in practice, with the remark that a lot of decision making is not this formal in the sense that this is based on the exact analysis but more on gut feeling. But for certain types of decision making I think this is very valuable and certainly if you can have it done with the QlikView-like stuff where you can really go to your data and make different visualization. We have examples from customers that create this kind of landscape maps or color their application landscape with certain properties to do this kind of thing.

Question 4:

Which steps in the method are already clear and which are not? Are there too many/few steps?

I think the steps are logical and clear in the sense that I understand why you need them. Of course it is a different question on how to do them because (for example) how to determine a measurable goal gives a concern, i think it is a difficult question, you can't give a recipe for it. Perhaps you can give some realistic ways to do it for example, but in general it is a difficult question to answer. But of course that the quality of the architect perhaps that is necessary to do this. I guess in step 4 and 7 you give a lot of guidance in your thesis.

Question 5:

Do you see efficiency benefits in applying this method? (For example: repeatability, time savings)

Yes, sure. If you have the data and you can flexibly switch between various visualizations and presentations it could be very useful because then you can address many different stakeholders and many different situations so that could be very efficient. But of course doing this method is taking time, especially for the first time. This is not efficient if you compare it with (a method that) just writing down the result. But that is always the case if you want

to have a decision-making grounded in facts and metrics that it will take more time than saying out loud "ok, this is it". But if you already have this (method) implemented then it is very easy to add, e.g. another dimension to the metric measurement, then it becomes very efficient.

Aspect 2: The dashboard concept

Question 6:

What do you think about the ease of understanding of the dashboard?

I think that is very easy to understand so that is quite clear. Of course you need some information about for instance what a certain chart type is, and what an analysis type is, so I guess there would be an information put somewhere saying that if you have comparison then it means this, but that's more to the first time you apply it. So I think that's quite easy to use.

Another question is that there might be another visualization that might be less formal. I guess in the boardroom, this (kind of chart) is still seen as an underlying information and an architect might still have the need to say, "well, I have looked at the number of the data set" and the result is a smiley or a happy guy, for example. And then you can drill down if they ask and explain why you put a smiley there and say "well, these five pie charts and these scatter diagrams, I conclude from this and the overall end visualization should be a smiley." There might be a layer on top of this where you have even simpler visualizations where you can say "well, if this part of the pie chart is larger than 50% then we'll have the smiley". It is something you need to be aware of that in this level there might be something that is more abstract or simpler in which you based upon all these done.

Question 7:

Does the dashboard give a flexibility to the user to analyze their concerns of the EA?

Yes, I think so, still of course within the scope, so within the thing that can be measured and in terms of numbers. Within that, I think that's very flexible; you can define a measurement and metric to get the information out of the enterprise architecture to give the question that the stakeholder has. So I think this is very flexible because then you can visualize any metric and the type of charts.

Open discussion

Comment, feedback and suggestion for improvement

I think I have already mentioned a lot when answering the questions so it is fine.

Appendix D: The Practical Summary of the Method

EA-Based Decision Making Method
Step 1. Determine the concern
Step 2. Determine the measurable goal
Step 3. Identify the metric from EA and its measurement
Step 4. Define the metric and measurement
Step 5. Perform the data collection
Step 6. Perform the calculation
Step 7. Prepare the presentation and visualization
Step 8. Conduct the analysis and decision making

Step 3 Template

Concern	
DESCRIPTION	
Concern name	What is the concern?
Stakeholder	Who is the stakeholder?
Goals	What are the measurable goals to achieve based on the concern?
Measurement frequency	How often is the assessment of the goal achievement performed?
GOAL <number>	
Name	What is the goal to assess?
Analysis type	What type of EA-based analysis is performed?
Analysis metrics	What are the metrics to measure?
Information source	Where to find the source of information to measure the metrics? (e.g. from the enterprise architecture model or others)

Step 4 Template

Metric	
DESCRIPTION	
Name	What is the selected metric?
Information requirement	What is the motivation for selecting the metric?
Purpose	What is the purpose to measure the metric?
Measures	What will be measured? (output variables)
Inputs	What inputs are needed to calculate the measures? (input variables)
ARCHITECTURAL INFORMATION	
Analysis approach	Does the analysis use top-down or bottom-up approach?
Architecture layer	Which layer in the architecture is addressed by this metric? (business layer, application layer, or technology layer)
DEFINITIONS	
<Variable name 1>	Provide the definition of the input and output variables from the description section above

<Variable name 2>	...
<Variable name ...>	...

INPUTS	
Input name	Mention the first input variable
Unit of measure	What is the measurement unit? *(e.g. month, day, second, number, percentage, amount of money, count, et cetera)*
Frequency of collection	How often is the data collection performed?
Architectural representation	What is the representation of this variable in the architecture? *(e.g. business processes, application components, property of business functions, et cetera)*
Source of information	From whom is this input collected? *(e.g. system owner, system manager, or directly available in the architecture)*

Input name	Mention the second input variable, and so on..
Unit of measure	...
Frequency of collection	...
Architectural representation	...
Source of information	...

MEASUREMENT	
Indicator name	Mention the measured (output) variables
Algorithm	How the calculation will be performed to get this measures? *(e.g. the cost of an application component is contributed by the total cost of the resources from the lower layer of the architecture that are directly connected to this node)*
Target / baseline	What is the target or baseline?
Decision criteria	What is the meaning of the selected target or baseline for the output variable?
Reference or support	Mention the reference or source which is used to perform the calculation, if any *(e.g. journal, book, well known technique, et cetera)*

VISUALIZATION	
Visualization type	What is the relevant type of the visualization? *(comparison, relationship, distribution, or composition)*
Visualization option	What are the possible options for a visualization of analysis result by means of charts? Refer to chart suggestions guide *(e.g. line chart, bar chart, scatter-plot chart, etc.)*
Sample	Provide example(s) of the visualization (a real chart) and a brief information about the selected chart

ANALYSIS PROCESS	
Analysis Frequency	How often is the measurement analysis performed?
Interpretation	How should the chart visualization be interpreted and what kind of decision or insight can be acquired from the result?

Step 7 - Prepare the presentation and visualization

Step 7-1. Prepare the main data set
Step 7-2. Determine the message, identify the analysis type and select the data subset
Step 7-3. Determine the best means to encode the values with the chart selection
Step 7-4. Determine the best design for the objects in the chart
Step 7-5. Prepare the dashboard
Step 7-6. Maintain the data for the future use

Step 7-1 Template

Create the metric and dataset definition.

Metric ID	ID number of the metric
Metric name	The name of the metric
Data set ID	ID number of the data set
Concern	The name of related concern from which the metric is derived
Dimension	A set of input variables in the metric (dimensions)
Measure	A set of output (measured) variables in the metric (measures)

Create a table of data set to record all input and measured values.

Input variables			**Output (measured) variables**		
Dimension 1	**Dimension 2**	**Dimension *n***	**Measure 1**	**Measure 2**	**Measure *n***
Input value	*Input value*	*Input value*	*Measured value*	*Measured value*	*Measured value*
Input value	*Input value*	*Input value*	*Measured value*	*Measured value*	*Measured value*
Input value	...	...	*Measured value*	...	...

Step 7-2 Template

Determine the message and its elements.

Message ID	ID number of the message
Message description	Describe the message to convey
Dataset ID	ID number of the main dataset which is referred by the message
Sub dataset ID	ID number of the sub dataset for the message
Visual analysis type	Select the relevant type of analysis: comparison, relationship, distribution, composition, or change over time
Dimension	Select the appropriate dimension(s) from the main data set
Measure	Select the appropriate measure(s) from the main data set
Constraint	Determine the filter to construct the data subset

Generate the **data subset** *automatically* from the **main data set** based on the message definition. The data subset is generated by executing this database query:

```
CREATE TABLE new_sub_dataset_table
AS (
    SELECT
        dimension_1, dimension_2, ..., dimension_n,
        measure_1, measure_2, ..., measure_n
    FROM
        main_dataset_table
    WHERE
        {constraint_expression}
);
```

Step 7-3 Template

For each message in step 7-2, determine a set of possible chart types
This entry will be added as a new element to every message

Message ID	ID number
Chart type	Determine a set of possible chart types

Chart Wizard Logic in the Dashboard