Master thesis in computer science

Ziv Baida
Vrije Universiteit
Amsterdam, The Netherlands
ziv@cs.vu.nl

February 2002
Preface

This Master thesis is the final product of six-months of research, comprising the last phase of my studies for an MSc degree in computer science at the Vrije Universiteit in Amsterdam, the Netherlands.

The research was carried out in cooperation by the Vrije Universiteit and Cap Gemini Ernst and Young Nederland B.V., where I was employed during the research.

Two people have supervised the research:

**Prof. dr. Daan Rijsenbrij**
Cap Gemini Ernst & Young
Daltonlaan 300
3500 GN Utrecht

daan.rijsenbrij@cgey.com

**Dr. ir. Hans de Bruin**
Vrije Universiteit, Amsterdam
Fac. der Exacte Wetenschappen, Div. W&I, Afd. IM&SE
De Boelelaan 1081
1081 HV Amsterdam

hansdb@cs.vu.nl

The document is targeted at architects. Architects of the physical world are of course most welcome to read it, but in first place I refer to architects in the IT-branch. This thesis can help them plan their communication with business managers of client organizations, and assist them in creating visualizations, which are a tool for supporting this communication process. Business managers can learn from this thesis what some of the issues are that architects are confronted with. By understanding this, they will help bridge the communication gap between them and architects.

Parts of the thesis can be of value for practically everyone. The outline of planning a communication process is such a topic, since we all are involved in important communication processes. Most people prepare some kinds of visualizations (e.g., PowerPoint presentations) in one stage or the other of their careers. They will find in this thesis useful guidelines for preparing their visualizations.

Acknowledgements

Carrying out this research project required a lot of help from many people.

First, I would like to thank both my supervisors, Hans de Bruin and Daan Rijsenbrij, for the guidance and tips they have provided me with.

The success of this research depended also on the cooperation of many other people. Frank Boterenbrood from Univé Verzekeringen is to be mentioned especially; Frank and I spent hours together, gathering information and analysing it. His feedback and support have been of great help.

Very special thanks are dedicated to my friends Gil Levy, multimedia producer, and Shiri Esh-Har, graphic designer. Gil and Shiri have made possible the implementation of a visualization, contributing their skills, creativity and support through many days and very late evenings. Shiri also produced the logo of this document.

Personal, warm thanks must go to Mark Evan Furman, founder of Cognitive Neurophysics. After having read Mark's book (see references), I felt I had discovered a new world, but many questions still bothered me. I managed to locate Mark's email address, and contacted him with a bunch of questions. This was the start of a fruitful correspondence. Mark also reviewed appendix A of this thesis.

I would like to thank the following people for their assistance in this project: Frits Alink (Cap Gemini Ernst & Young), Frank Baldinger (ING Group), Eric van 't Boveneind (Flower Auction Aalsmeer), Dave van Gelder (Cap Gemini Ernst & Young), Jaap Gordijn (Vrije Universiteit), Marleen Heldens (communication consultant), Eliezer Kinsbron (Oren Semiconductor Inc), Evert-Jan van de Kaa (Dutch Ministry of Transport, Public Works and Water Management),
Jan Kuper (Univé Verzekeringen), Wim Lucassen (Atos Origin), Nico Plat (West Consulting), Victor van Reijswoud (Devote), Fred Sanders (Flower Auction Aalsmeer), Jaap Schekkerman (Cap Gemini Ernst & Young), Jan Slager (Dutch Ministry of Transport, Public Works and Water Management), Marlies van Steenbergen (IQUIP), Steven F.N. van ’t Veld (Architectuur, Informatie & Management), Maarten Waage (Cap Gemini Ernst & Young) and Hetty Welschen (alderwoman, sub municipality De Baarsjes, Amsterdam).

I also thank the following people: Peter van Bentum (Ordina Sociale Zekerheid), Sjaak Brinkkemper (Baan), Gert Florijn (Software Engineering Research Centre), Johan van der Graaf (Cap Gemini Ernst & Young), Dieter Hammer (Eindhoven University of Technology), Ben Heideveld (ABN-AMRO bank), Henk Koning (Vrije Universiteit), Gerrit Muller (Philips Research Laboratories), Jack van ’t Wout, (Cap Gemini Ernst & Young) and all employees of Univé Verzekeringen who were involved in the project one way or the other.

Ziv Baida, Amsterdam, February 2002.
Management Summary

The goal of this research project is investigating how architectures can be visualized to support the decision-making process of business managers. The project focuses on three levels of architectures: enterprise architecture, domain architecture and system architecture.

This document presents the planning of a communication activity, in which an architect wants to communicate with a business manager. Visualization is presented as a tool in this process. It is preceded by, among others, a personality analysis of business managers and a contents analysis in which the contents of the message to be conveyed are defined. The contents analysis is guided by the principle that it's not necessary to visualize the whole architecture for a certain stakeholder; it's enough to visualize those aspects that this stakeholder considers important. The aspects we identified as most important for business managers are: costs and benefits, effectiveness, facilitating change, schedule, feasibility and risk analysis and integration. The latter proved to be interpreted differently by business managers and by IT-experts. Business managers consider this term to refer to the integration of organizations, whereas IT-experts refer to the integration of information systems.

We present a set of fourteen guidelines, with which visualizations should comply. A major conclusion of this research is that before the architect introduces some architecture to business managers, he must ensure that the business managers have a powerful enough mental model of architectures. The term ‘mental model of architectures’ refers to the internal representation that a person has of architectures. Research on the field of management theory yielded the conclusion that managers require powerful mental models of architectures in order to make decisions regarding architectures. From interviews with IT-experts we concluded that managers often lack this mental model. Creating a mental model of architectures is therefore required in order to ensure that a manager can make decisions about architectures. For this reason, we discuss visualizations for the creation of a mental model of architectures first; only then do we discuss architecture visualizations.

The following principles are defined as main criteria for good visualizations. These are important conclusions of our research.

- Visualizations should support verbal communication between architects and business managers.
- Visualizations must support switching between the architect’s profession and the business manager’s profession. The ability to switch back and forth between these professions is identified as a key factor in winning the managers’ trust, and must therefore be supported by the visualization.
- Visualizations should demonstrate that the architect speaks the business manager’s language, since we suggest visualization as a tool to bridge the gap between architects and business managers.
- Architecture visualizations must be dynamic. Dynamics are required to support main characteristics of architecture. It also helps keeping the attention of the audience focused on the screen.
- Architecture visualizations must be related to the mental model visualization. If business managers cannot relate both visualizations to each other, they cannot use their mental model to argue about architectures, and to make decisions. This would mean that their mental model of architectures is not powerful enough.

A complete list of the guidelines for visualization can be found on page 98.

We created two visualizations: the first one establishes a mental model of architectures, the second one is an example of how architectures can be visualized, complying with the guidelines we provide. These two visualizations are presented and discussed in this document.
# Table of Contents

**PREFACE** .................................................................................................................................. I

**ACKNOWLEDGEMENTS** ............................................................................................................... I

**MANAGEMENT SUMMARY** ..................................................................................................... III

**1 INTRODUCTION** .............................................................................................................. 1

1.1 PROBLEM STATEMENT ..................................................................................................... 1
1.2 ARCHITECTURE: DEFINITION ......................................................................................... 1
1.3 THE GOAL ......................................................................................................................... 2
1.4 RESEARCH STRUCTURE .................................................................................................... 2
1.5 RESEARCH METHODOLOGY ............................................................................................. 3
1.6 THINGS TO CONSIDER BEFORE READING THIS DOCUMENT ........................................... 4

**2 THE COMMUNICATION FRAMEWORK................................................................... 6**

2.1 CHAPTER SUMMARY ......................................................................................................... 6
2.2 INTRODUCTION TO COMMUNICATION ............................................................................. 6
2.3 WHY COMMUNICATE? ..................................................................................................... 6
2.4 ORGANIZING THE SENDER’S VERBAL COMMUNICATION ACTIVITIES ........................... 6
2.5 COMMUNICATING ARCHITECTURES BY MEANS OF VISUALIZATION........................... 10

**3 GOALS ANALYSIS......................................................................................................... 11**

3.1 CHAPTER SUMMARY....................................................................................................... 11
3.2 GOALS ............................................................................................................................. 11
3.3 GOALS OF VISUALIZATION ............................................................................................. 11

**4 ANALYSIS OF INFLUENCING FACTORS................................................................ 13**

4.1 CHAPTER SUMMARY....................................................................................................... 13
4.2 PERSONALITY ANALYSIS ................................................................................................ 13
4.3 SITUATION ANALYSIS ..................................................................................................... 18

**5 CONTENTS ANALYSIS – WHAT TO VISUALIZE? ................................................ 19**

5.1 CHAPTER SUMMARY....................................................................................................... 19
5.2 INTRODUCTION ............................................................................................................... 19
5.3 STAKEHOLDERS .............................................................................................................. 19
5.4 CONCERNS....................................................................................................................... 21
5.5 RESEARCH RESULTS ....................................................................................................... 23
5.6 SETS OF CONCERNS ....................................................................................................... 25
5.6.1 BUSINESS MANAGERS’ CONCERNS ................................................................................. 26
5.6.2 IT MANAGERS’ CONCERNS ........................................................................................... 28
5.6.3 USERS’ CONCERNS ........................................................................................................ 31
5.6.4 INTER-STAKEHOLDER ANALYSIS .................................................................................. 33
6 CONTENTS ANALYSIS – CONCEPTUALISATION

6.1 CHAPTER SUMMARY
6.2 INTRODUCTION
6.3 BUSINESS MANAGERS
   6.3.1 BUDGETING
   6.3.2 EFFECTIVENESS
   6.3.3 FACILITATE CHANGE
   6.3.4 SCHEDULE
   6.3.5 FEASIBILITY AND RISK ASSESSMENT
   6.3.6 INTEGRATION
6.4 IT MANAGERS
   6.4.1 GOVERNANCE
   6.4.2 FEASIBILITY AND RISK ASSESSMENT
   6.4.3 SECURITY
   6.4.4 COMPATIBILITY
   6.4.5 INTEGRATION
   6.4.6 SCHEDULE
6.5 USERS
   6.5.1 USABILITY
   6.5.2 PERFORMANCE
6.6 CONCLUSION

7 COMMUNICATION DESIGN – STRUCTURING & ENCODING MESSAGES

7.1 CHAPTER SUMMARY
7.2 THE STRUCTURE OF THE MESSAGE
7.3 THE ENCODING OF THE MESSAGE

8 COMMUNICATION DESIGN – HOW TO VISUALIZE?

8.1 CHAPTER SUMMARY
8.2 INTRODUCTION
8.3 THREE ASPECTS OF VISUALIZATION
8.4 GENERAL GUIDELINES
   8.4.1 CONTENTS
   8.4.2 MEDIUM
   8.4.3 DESIGN
8.5 THE FIRST STEP: CREATING A MENTAL MODEL
   8.5.1 THE MENTAL MODEL GUIDELINE
   8.5.2 PRACTICAL IMPLICATIONS
   8.5.3 IMPLEMENTATION ISSUES
8.6 THE SECOND STEP: VISUALIZING ARCHITECTURES
   8.6.1 CONTENTS
   8.6.2 MEDIUM
   8.6.3 DESIGN
8.7 CONCLUSION

Architecture Visualization
# Table of Contents

9  EXAMPLE VISUALIZATION ........................................................................................................... 67

9.1  CHAPTER SUMMARY .................................................................................................................. 67
9.2  INTRODUCTION .......................................................................................................................... 67
9.3  A MENTAL MODEL VISUALIZATION ......................................................................................... 67
  9.3.1  CONTENTS ............................................................................................................................... 67
  9.3.2  MEDIUM .................................................................................................................................. 68
  9.3.3  DESIGN ................................................................................................................................... 68
  9.3.4  DISCUSSION ............................................................................................................................ 68
9.4  ARCHITECTURE VISUALIZATION .............................................................................................. 75
  9.4.1  CONTENTS ............................................................................................................................... 75
  9.4.2  MEDIUM .................................................................................................................................. 75
  9.4.3  DESIGN ................................................................................................................................... 76
  9.4.4  IMPLEMENTATION ................................................................................................................... 77
  9.4.5  DISCUSSION ............................................................................................................................ 83
9.5  CONCLUSION ............................................................................................................................... 85

10  VALIDATION .................................................................................................................................... 87

10.1  CHAPTER SUMMARY .................................................................................................................. 87
10.2  THE VALIDATION PROCESS ...................................................................................................... 87

11  CONCLUSIONS .................................................................................................................................. 89

11.1  CHAPTER SUMMARY .................................................................................................................. 89
11.2  CONCLUSIONS ............................................................................................................................ 89
11.3  RESEARCH EVALUATION AND FUTURE WORK ....................................................................... 91
11.4  SHORTCOMINGS OF THIS RESEARCH ....................................................................................... 92

APPENDIX A – THE TWO HEMISPHERES OF HUMAN BRAIN ....................................................... 93

APPENDIX B – GLOSSARY .................................................................................................................. 95

LIST OF GUIDELINES ......................................................................................................................... 98

LIST OF FIGURES .................................................................................................................................. 99

LIST OF TABLES .................................................................................................................................... 100

REFERENCES ........................................................................................................................................ 101
1 Introduction

1.1 Problem Statement

An architecture can be compared to "physical" architectures, those of buildings and towns. Just like the "physical" architectures, those related to the IT world are written for various stakeholders. Many of them are not experts in IT. They can be businessmen, users or other kinds of stakeholders. Still, it is important that they understand the architectures, since the architectures are strategic assets that have major influence on the business and on the daily work of the stakeholders.

We therefore formulate the following problem:

Non IT-oriented stakeholders do not understand architectures well enough to make the right decisions based on the architectures; as a result the strategic value of these architectures is lost, at least partially.

But what do we mean by architectures?

1.2 ArchITecture: Definition

There is no consensus on what architecture means. The IEEE standard 1471-2000 defines architecture 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. But which "system" do we refer to? System is an abstract term that can be used for practically everything. It is therefore necessary to better define what we refer to.

The traditional use of the word architecture considers buildings as systems. In recent years, architecture has emerged as a hot topic in the IT world. The architectures referred to by the IT world are sometimes called "IT-architectures" or "architectures of information systems". These terms, however, narrow the scope of the architectures. They concentrate on the system, and ignore its environment: the business. This environment is a major issue in architectures. Moreover, if we use these terms, it is our fault that business managers don't show much interest in our architectures. After all, if it's an IT issue, it's the concern of their IT manager, and not their own concern. The result is that the gap between IT people and business managers increases.

As we have not come up with a better name than the rest of the architecture community, we'll use the name archITecture, which is inspired by the Dutch architect (in the traditional meaning, architect of buildings) Jan Brouwer. By using capital letters IT, we emphasize that IT is a major aspect in our architectures, but we do not imply that architectures are an IT issue.

In our research, an archITecture corresponds to one of the following (source: [22]):

1. Enterprise archITecture: defines the overall structure of the business, the information and technologies necessary to support the business, and the transitional processes necessary for implementing changes. These changes may be in providing services and in using new technologies, in response to changing business needs.
2. Domain archITecture: the archITecture of a specific part of an enterprise archITecture.
3. System archITecture: defines the system conception of one information system in its environment.
4. Infrastructure archITecture: defines the overall structure of the resources used by all levels above it. This includes not only the technical infrastructure, but also humans, basic business functionalities and more.

---

1 IT: Information Technology
These levels of architectures can be compared to the following “physical” architectures ([22]):

1. The architecture of a town
2. The architecture of a neighbourhood, within a town
3. The architecture of a house, within a neighbourhood
4. The architecture of all resources used by the levels above it: an electricity system, a public transport system, the city hall employees etc.

For the sake of this project, we regard these levels of architecture as a given fact; we do not confirm them first.

1.3 The Goal

The above-mentioned problem definition refers to non IT-oriented stakeholders, such as businessmen or users. Our research concentrates on one group of stakeholders: business managers. Other groups of stakeholders are also discussed in part of the document, but the visualizations we discuss are explicitly targeted at top-level business managers of the client organization. In some situations, the architect may work for the same firm as the managers, whereas in other situations the architect is an external expert.

The problem definition is the trigger of our research. Solving this problem requires knowledge of what information must be presented to business managers, and how to present this information. We suggest visualization as a means to tackle the “how” question.

The goal of this research project is investigating how architectures can be visualized to support the decision-making process of business managers. The project focuses on three levels of architectures: enterprise architecture, domain architecture and system architecture.

Investigating what information a visualization must consist of, easily requires years of research. However, the how question is the major subject of this research. As a result, we only did limited research into the first question, whereas more effort was put into the second question: how to create visualizations.

Definitions of various terms we use in this document can be found in appendix B.

1.4 Research Structure

Our research is divided into two major parts:
1. Investigating what to visualize (which aspects of architectures). Since every group of stakeholders has different concerns and fields of interests, the answer to this question is stakeholder-specific. We discuss several groups of stakeholders in this part of the research.
2. Investigating how to visualize these aspects of architecture. Visualization is a kind of language. As such, it is stakeholder-specific too; a certain type of visualization may be very successful with one group of stakeholders, but much less with another group of stakeholders. This part of our research discusses visualizations for business managers only.

Other subjects were studied parallel to the what and how trajectories. They will be discussed in this document as well.
The structure of our research is given in figure 1.

1.5 Research Methodology

Our research methodology combines theoretical and empirical work. We investigated multiple disciplines, to differing extents. The variation in the depth of research was very clear: all disciplines were subject to a – theoretical – literature research. Only some subjects were also tested empirically.
We started with a literature research about architectures: what this term refers to, and what types of architectures exist. We then translated the question “what to visualize?” to the research-field of stakeholders and concerns. We first conducted literature research into this field, after which we conducted a series of interviews. We analysed the information we had gathered during interviews, and formed a theory based on our analysis. We also conducted literature research into other disciplines: communication theory, management theory and brain functioning. The latter was enriched by the personal experience of an expert on that field.

All these disciplines generated input for the main issue of our research: investigating how to visualize architectures. We started with a literature research, which yielded very little information. Much more useful were a series of interviews with experts in the fields of communication and graphic design. We then combined the theory they provided us with, and the input we had from other disciplines, to formulate a series of guidelines for visualization. These guidelines combine the knowledge we gained from all disciplines involved in the research.

We implemented two visualizations that comply with these guidelines. A first version of one visualization was created in an early stage, and validated during interviews with business managers, whose reactions were very positive. A second visualization was created at a later stage and validated during interviews with business managers and during a workshop with architects.

1.6 Things to Consider Before Reading this Document

*It’s not necessary to visualize the whole architecture for a certain stakeholder; it’s enough to visualize those aspects that this stakeholder considers important.*

This statement has a central place in our research, and will be repeated several times in the document. The word *stakeholder*, by its definition, implies that architectures, just like anything else, mean different things to different (groups of) people. Those people may share a common understanding of what architectures stand for, but they have different needs for information regarding the architectures. Furthermore, they mostly aren’t interested in information that they do not consider important.

We use visualizations to provide stakeholders with information. As the above argumentation suggests, the information has to be stakeholder-specific: only those aspects that a stakeholder considers important ought to be visualized for him.

Also the way one visualizes architectures ought to be stakeholder-specific. In this document we consider visualizations for one group of stakeholders: business managers. Other stakeholders might require other types of visualizations.

Architectures is a difficult subject for research for some reasons. It is a young, immature field, with much less experience and “best practices” than other disciplines. Learning from the experience and mistakes of other people is therefore seldom an option. Also a common definition of the discipline is missing: it seems that any ten architects would have at least eleven different definitions of architecture. This fact was very well felt during interviews, conducted for this research. Ask ten random people what a car is. They will all give a similar description. This is not the case with architectures.

Since the item in question here – architectures – is not yet well defined, investigating its visualization was difficult. However we deliberately ignored the problem of defining this term, since we knew it could require years of research, leaving us lagging behind the world that is marching ahead.

The research identifies several disciplines, all of which can contribute to a better architecture process. We present this research as a multidisciplinary project: one that
1. Introduction

requires expert knowledge in multiple disciplines. We combine them all into one whole; we intertwine all these disciplines, and hope to contribute to them in return.

We present visualization as part of a communication process between architects and business managers. The need for visualizations stems from the existence of a communication problem between business managers and architects. The solution for the problem is therefore broader; visualization is part of it.

Chapter two introduces the communication theory, which forms the framework of the whole document. The following chapters discuss various phases of the communication process. Chapter three analyses the goals of this communication process. Chapter four analyses influencing factors, and focuses on a personality analysis of business managers. Chapter five answers the question what information the various stakeholders require, and chapter six conceptualises the findings of chapter five. Chapter seven presents two aspects of communication design, and chapter eight tackles the question how to visualize. In chapter nine we present and discuss visualization examples, which we implemented based on the theory we present. Chapter ten discusses the validation phase of the scientific research, which used the visualization examples to validate our theory. To conclude, chapter eleven presents our conclusions and concluding remarks.
2 The Communication Framework

2.1 Chapter summary

We present communication as the framework, that visualization is part of. This chapter presents this framework and how we will use it. It is based on [14].

2.2 Introduction to Communication

The Latin word communis means common. One of the meanings of the verb communicare is to make common. Messages become common for two groups (of one or more people each) in an inter-human communication process. Research has shown that 65% of inter-human communication is non-verbal. The communication process can be defined as committing perceptible encoding and decoding activities between one or more senders and one or more receivers. The three important parts of communication are the sender, the receiver, and the message, which is what the sender encodes and the receiver – hopefully – decodes. Most often the sender receives indirect – non-verbal – feedback, such as a look of appreciation or a bored posture. Sometimes the feedback is direct (verbal), and in other cases there's no feedback at all. The lack of feedback can also be a type of feedback. The big advantage of verbal communication is that feedback can mostly be perceived immediately, and the sender can “correct” his message, if he sees that he's being misinterpreted.

2.3 Why Communicate?

Communicating always has a goal. We recognise the following main goals of communication:
1. A cognitive or informative goal: When someone wants to inform somebody about something (productive-informative), or ask for information (receptive-informative). Examples are lectures, press conferences, interviews and surveys.
2. An affective goal: Sharing feelings, states of mind or values (possibly wishing that others share these feelings), or interpreting the feelings of others. Examples are speeches during parties or funerals.
3. A persuasive goal: Stimulating or influencing others, or convincing them to change their behaviour or ideas. Examples are speeches during strikes or election campaigns, sales talks, discussions and sometimes meetings.

Business communication is related to fulfilling one's function within an organization. Communicating archITectures to business managers is an example of business communication. It costs time, money and manpower, and therefore must be effective and efficient. We answer the question “why people communicate?” as follows: people communicate in order to reach one or more goals effectively and efficiently. Communication is successful for the sender if he has reached his goal.

2.4 Organizing the Sender's Verbal Communication Activities

Like with any other activity, also communication requires a plan in order to reach its goals. The sender ought to create a positive communication climate through preparations, and to
make sure he has a good starting point. He must further do whatever is necessary in order to reach his goals. This can be achieved through systematic work: through a logical analysis of the factors that influence the result, the goal and the communication process. The path one should follow is sketched in figure 2, followed by an explanation.

Figure 2 Phases in the communication process

**Step 1: Goals analysis**
The first thing to do is always determine the goals and the results we hope to achieve with the communication process. Not performing a goals-analysis means we will not be able to organize the communication process effectively and efficiently. Nor will it be possible to work according to a plan. One or more main goals have to be identified (cognitive/informative, affective, persuasive) and further refined with a specific goal(s), which must be defined and formulated. Based on the goal(s), a strategy has to be developed with which the goal(s) will be met by means of communication. The strategy consists of two dimensions:
- It can recognize a hierarchical structure of sub-goals
- It can recognize priorities in time (short-, middle- and long term goals)

**Step 2: Analysis of influencing factors**
The next thing to do is consider all those factors that might influence the results of the communication process positively or negatively. These factors will influence the strategy. The most important factors are:
- a. Personality structure: sender’s and receiver’s personality
- b. Communication situation
- c. Contents
2. The Communication Framework

**Step 2a: Personality analysis**
Sender and receiver can differ in many aspects: field of interest, place of origin, roles, needs, expectations, frame of reference and more. Both perceive the world through their own glasses. Their observations are always partial (they cannot observe everything) and selective; they observe what they want to observe, and ignore the rest.

This behaviour determines whether, how and under which conditions people are willing to accept messages, states of mind or feelings, and are open for influence.

Many communication problems originate from differences in personality structure. To tackle this problem, the sender has to consider the following questions:

- **Self analysis**: Who am I, and what is the receiver’s picture of me?
- **Receiver analysis**: Who is the receiver, and what is my picture of him?

Self analysis includes considering the receiver’s image of the sender, regarding all attributes necessary or desired for this communication activity, and to which degree the sender possesses these attributes. If he does not possess these attributes, he’d better let another sender do the communication process.

For the sake of the receiver analysis it is important that the sender knows his target group. The receiver analysis helps the sender overcome or even prevent resistance, and match his message to the receiver. Remember that the same information shall be presented in different ways for different audiences.

**Step 2b: Situation analysis**
Time, place and circumstances may have great influence on the results of the communication process, and must be analysed by the sender.

- **Time**: consider the time of day, the time required for the communication process, and the time available for the process.
- **Place**: hereby it is important to avoid external disturbances, such as noise, smoke, too high or too low temperature etc.
- **Circumstances**: good or bad economic situation, possible happy or sad events, stress, the presence of competitors, the presence of people from different cultures, with different values, etc.

It is important that the sender tries to ensure correlation between time, place and circumstances and the communication activity. When this is not possible, the sender must anticipate “what do I do if…?” scenarios.

**Step 2c: Contents analysis**
A message is a set of elements, dependent on the goals of the communication activity and on the sender and receiver. Some elements can be communicated for the sake of a specific goal, but can better remain unsaid if the goal is different. While one sender can let his receiver know some details, a different sender is better off not doing this, also if their goals are identical. Some receiver might be influenced positively by some information, whereas others may be influenced negatively by the same piece of information.

In order to be understood and cause the required effect, the message must consist of:

- **required content elements** (information)
- possibly **motivating (encouraging) elements**, that will help create the right atmosphere
- **redundant information**: repeating information

Redundant information is required since in verbal communication the receiver is neither capable of rereading the whole message later, nor absorbing everything at once.

Not less important is considering which elements may **not** be included in the message (for example: in order not to confuse or irritate the receiver).

**Step 3: Communication design**
With the results of step 2, the sender is now capable of determining how to realise the communication activity in an efficient and effective way. Three aspects are of importance:
2. The Communication Framework

- The structure of the message
- The encoding of the message
- Using (audio) visual tools

**Step 3a: Structuring the message**
The earlier done contents analysis has yielded a list of elements that must be included in the message, and a list of elements that can be added as well. These elements must of course not be presented to the receiver in a random order, but in a well thought structured way.

Points to consider are:
- Which elements best fit into the introduction?
- How to build up our message? A logical, psychological-driven ordering of elements increases understandability, and probably also the receiver’s will to be open for ideas and for the sender’s goals. An illogical or not well-constructed message causes confusion and unexpected effects, and sometimes even anticlimax; it has a negative influence on achieving the sender’s goals.
- Which elements best fit at the end?

Multiple structures are discussed in [14], but will not be discussed here.

Specific methods exist for planning informative, affective and persuasive communication activities. Next to them, the sender must be inventive enough to structure the message while taking into consideration what his goals are, his own personality, the receiver’s personality, and the specific situation.

**Step 3b: Encoding the message**
Encoding means giving the contents elements an observable form that serves our goals.

It takes place on two levels:
- Primary communication tool (language): choosing the right words and sentence structure. Important issues are how familiar the receiver is with the language, and using or avoiding jargon. More techniques are mentioned in [14].
- Secondary and non-verbal communication tools: intonation, tempo, eye contact, posture etc.

**Step 3c: Using (audio) visual tools**
Verbal communication is typically auditory. But since most of the people prefer visual communication to verbal communication, it is very useful, especially in complex situations, to illustrate the message when possible, and thereby to make it more understandable and increase its effect.

Details, facts, numbers and their analysis in graphs can be presented via media as a flip-over, slides or a film. Sketches, photos, maps and even music can also be of good support for the verbal communication.

**Step 4: Choosing procedures, techniques and tactics**
Procedures are a set of related activities in a systematic order, to execute (part of) the communication process in a structured and clear way. They regard the course of things, the progress aspect of a communication task (both the preparations and the execution).

Procedures are a kind of ‘rituals’, with which efficiency and effectiveness are achieved. The whole 4-steps planning we present here is a procedure. Other procedures exist for gathering information, giving lectures, structuring a dialogue and more.

Techniques are tested ways to act in order to carry out some (sub) activities in a professional and target-oriented manner. They consider approaches to problems, being the execution aspect of (part of a) communication task. Techniques exist for making contact with listeners, for asking questions, for refutation and more.

Procedures and techniques are used to achieve common goals of those who communicate. If, however, they refer to personal goals, we call them tactics.

Procedures, techniques and tactics will not be discussed further in this document. More information can be found in [14].
2.5 Communicating Architectures by Means of Visualization

The goal of this research project is investigating how architectures can be visualized to support the decision-making process of business managers.

We suggest visualization as a tool for communication between architects and business managers. This document therefore sketches a communication process, where visualization is used as a tool. Since the main subject is visualizing architectures, the emphasis will not be put on the communication process, but on architectures (step 2c of the earlier presented planning) and visualizations (step 3c). The communication process serves as a framework.

Architects initiate the communication activity, for which visualization is to be used. Business managers are the audience. The architect is therefore the sender, and the business manager is the receiver in this communication process.
3 Goals Analysis

3.1 Chapter Summary

In this chapter we argue that the goal of our communication process is informative, rather than affective or persuasive.

3.2 Goals

The first thing to understand in communication activities is the reason for its existence. Why do we communicate? As mentioned before, we recognize three main goals for communication: a cognitive or informative goal, an affective goal and a persuasive goal. The goal statement of this research indicates that the ultimate goal of the visualizations is decision-making. Whether the architect works for the same company as the manager, or he is an external consultant, his task is to come up with the best feasible architecture that fits the business. The manager himself is not capable of setting up an architecture, since he does not have the required knowledge and expertise. The architect, on the other hand, is not authorised to make decisions about implementing the architecture he suggests, or about trade-offs. Only the manager can make these decisions. The goal of this communication activity is therefore to give the manager the necessary tools for making decisions regarding an architectural solution for a business problem. The manager does not have to design the solution by himself: the architect has designed a solution, possibly several solutions, and the manager has to:

- accept the architect’s solution, or
- reject the architect’s solution, or
- choose one of the solutions that the architect suggests.

3.3 Goals of Visualization

Let us now consider the three possible goals that visualizations might have in this communication activity.

- Suppose the architect’s goal is persuasive. In this case, he presents a solution, and he wants to convince the manager to accept this solution. He will therefore not present a completely correct picture of his solution, but will hide some of the weak points of his solution. If the communication process succeeds, the manager will accept the architect’s solution, but will not have a good understanding of the subject. He might think he does though.
- If the architect’s goal is informative (cognitive), he will provide the manager with details – enough details but not too many – about the characteristics of his solution. He will explain to the manager what his solution is about, so that the manager gains insight into the
subject, and can make the right decision. The right decision might be a different one than
the architect suggests, since the manager knows best what the course of his business is.

- If the architect’s goal is affective, he will try to make the manager identify with the
proposed solution. But even if the manager then accepts the architect’s solution, he will
not be able to “sell it”, or to explain why it’s the best one for his business. He will not have
enough insight into the subject.

The need for visualizations as a means for communication stems from the gap between
business people and IT people. This gap originates from the fact that business people and IT
people are two different groups, with different orientations, different fields of interest and
different ways of thinking. They have different frames of reference and they speak different
jargons, almost different languages. Some would say they both have a well-built ego, which
makes communication between them even more difficult.

A lot has been written about the need for architects who speak the business language. We
assume a good architect is capable of doing this already (although we know that this is often
not the case). But still the opposite is required as well: the manager must be familiar with the
IT frame of reference. This part of the communication gap is where we want to make use of
visualizations.

Understanding this, it becomes clear that the architect’s main goal in this communication
activity should be informative, and not persuasive or affective. Although he wants the
business manager to accept his architecture, if he chooses for a persuasive or affective
goal, the communication gap will remain. The informative goal is the only goal that serves
bridging the gap between architects and business managers. The affective goal can be
introduced as a secondary, much less important one. Once the manager has the information
to make a decision, we’d like him to feel identified with the solution, to feel something for it.

To sum up this discussion, the goal of this communication activity is informative, and to a
much lesser degree affective.

This goal has to guide the architect in the rest of the process; whatever he does, he must
bear in mind that his goal is informative.
4 Analysis of Influencing Factors

The goal of the communication process will guide us through the rest of the process. The next thing to do in preparing the communication process is to analyze the important factors that influence the process:
1. Sender's and receiver's personalities
2. The communication situation
3. The contents that ought to be communicated

4.1 Chapter Summary

We divide this step of the communication process into several sub steps, one per influencing factor. In this chapter, we discuss the personality analysis and shortly refer to the situation analysis. The personality analysis we present is based on the work of the organization theorist Henry Mintzberg, who analyzed the decision-making process of managers. We then formulate the implications that Mintzberg's theory has for architects who communicate with business managers. The personality analysis does not attempt to be complete. Since contents analysis is one of the two major issues in our research, we separate it from other influencing factors, and dedicate the next chapter for it.

4.2 Personality Analysis

Both sender's and receiver's personalities should be analyzed in order to ensure best communication. In our case, the sender is an architect, and the receiver is a business manager. We assume that the architect can analyze his own personality by himself; we list important characteristics of business managers' personality.

The personality analysis is our analysis of research done mostly by the organization theorist Henry Mintzberg. Mintzberg used in his study also the work of experts from various fields: management, decision-making, psychology and neurophysics. The analysis can be used by anyone who needs to communicate information to business managers who are not familiar with the subject of discussion. Since visualizing archITectures is the subject of this research, we explain which implications this analysis has when communicating archITectures. Understanding the personality characteristics can serve architects in bridging the communication gap between them and business managers.

As mentioned, the characteristics themselves are not based on own research. The own research done here has two aspects:
1. Literature research. Many sources were consulted, and the relevant information had to be found. The important thing was to spot those issues mentioned in some context, which could be relevant for our context as well.
2. Identifying and formulating the implications of the available information. Since the available research was not targeted at our topic, relevant conclusions had to be drawn based on the given theories.

This chapter presents several major pillars of managers' decision-making process. To gain a deeper understanding of this field, the reader can consult the work of Henry Mintzberg ([17], [18], [19]), Herbert Simon ([24]), William Taggart ([26], [27]) and Chester Barnard ([2]).
4. Analysis of Influencing Factors

**Personality Characteristic 1**
Managers require powerful mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes.

Managers synthesize soft information rather than analyse hard data. Mintzberg explains that this information helps the manager understand explicitly his organization and its environment, to “see the big picture”. He notes that this very expression, so often used in the management literature, implies a relational, holistic use of information. The information is being used to build mental models of the manager’s world. These models are implicit synthesized apprehensions of how their organizations and environment function. Then, whenever an action is contemplated, the manager can simulate the outcome using his implicit models.

Norman defines mental models ([20]) as “the internal representations that humans develop of themselves and the objects they interact with in the world”. He adds that these models provide predictive and explanatory power for understanding the interaction. Mental models are personal. For one driver, a car is a machine that can get him to his destination, and not more than that. For another driver, it is a wonderfully complex machine, and he masters the internal structure of it. Both drivers envision something different, when confronted with the term ‘car’; each has a different mental model of cars. Only the second driver is able to use his mental model of cars in order to decide whether some parts must be replaced or not. The first driver do not have a powerful enough mental model to make this decision.

This personality characteristic is also supported by research done by Rowe and Boulgarides (see [23]). Over 450 managers were asked how they would rank ten aspects of decision-making, among which leadership, perception, commitment and integrity. They found a significant level of consensus in the answers. The single most important factor was the manager’s ability to correctly perceive and understand the problems at hand. This ability does not exist without a reasonable mental model of the problem domain.

**Implications:**
This personality characteristic clearly indicates that managers need to “see the big picture”, in order to consider ways of action, and therefore in order to make decisions.
None of the experts interviewed for this research thought that managers understand the subject of architectures. Multiple experts also stated that managers do not recognize the importance of architectures. These two statements are certainly related. Not understanding what architectures are, stand for and imply, means that the manager does not have a mental model of architectures. This, following Mintzberg’s reasoning, means that managers cannot simulate outcomes whenever actions must be considered. In other words, it means that they cannot make a decision.

This reasoning leads to a crucial conclusion: architects engaged in an architectural study must ensure that the involved managers have a good mental model of architectures. This is necessary before it is possible to discuss a specific architecture.

We consider this characteristic to be a major issue in our research. We will refer to it further in chapter 8, when we discuss visualizations.

*Ensure the manager has a good enough mental model of architectures.*

**Personality Characteristic 2**
Managers desire relational, simultaneous methods of acquiring information, rather than the ordered and sequential ones.

Mintzberg states in [18]:

*Managers strongly favour the verbal media – namely, telephone calls and meetings. The evidence comes from every single study of managerial work.*
In [17], Mintzberg explains why managers prefer this type of communication:
- Verbal communication enables to “read” facial expressions, tones of voice and gestures.
- Verbal communication enables the manager to engage in the “real-time” exchange of information.

Verbal communication is opposed to the written forms, namely reading and writing, which are ordered and sequential.

Although this personality characteristic is concerned with how managers gather information, the type of information also plays an important role. Mintzberg makes a distinction between two types of input managers have: soft input and hard input. Soft input includes impressions and feelings about other people, hearsay, gossip, and so on. Hard input includes very analytical inputs – reports and documents. He states in [17] that the hard input seems to be of relatively little importance to many managers. Managers synthesize soft information rather than analyse hard data.

This does not mean however that analytical input is not required for the manager’s work, because as Mintzberg states, effective decision-making at the policy level requires also good analytical input.

Following results of several researches are given in [18]:
- In three studies, managers spent an average of 66%, 78% and 80% of their time in verbal (oral) communication.
- The CEOs in Mintzberg’s study treat mail processing (hard data) as a burden to be dispensed with.
- The same CEOs responded immediately to 2 of the 40 routine reports they received during five weeks, and to four items in the 104 periodicals. They skimmed most of these periodicals in seconds, almost ritualistically.

One of the CEOs in Mintzberg’s study processed 142 pieces of mail in just over three hours, to “get rid of the stuff”. This same manager looked at the first piece of “hard” mail he received all week, a standard cost report, and put it aside with the comment, “I never look at it”.

Mintzberg then draws the conclusion that managers’ concentration on the verbal media suggests that they desire relational, simultaneous methods of acquiring information, rather than the ordered and sequential ones.

**Implications:**
The architect must be aware of the manager’s preference for verbal communication (as a way to gather information) and soft data (the type of information).

The first implication for architects is to use as much verbal communication as possible. Instead of sending a report, a letter or an email to the manager, call him or meet him. Mintzberg’s study shows that a very short meeting with the manager can be much more effective than sending him a report, although much more information can be communicated using a report.

The second implication is that architects must recognize the importance of soft data. This does not imply that hard data is not required – since it definitely is. But remember managers consider it less important.

Two possible ways of action can be thought of to tackle the soft data problem:
- Provide the managers with soft data.
- Provide hard data to those who provide soft data to the manager.

The first way of action is problematic, since the architect is not a typical source of soft data for the manager. Soft data is often obtained from peers – managers of similar organizations – and through informal talks.

The second way of action is also anything but trivial. In actually means “convince those who later talk to the manager”. Note that these people do not have to be those he consults about the architecture, but those he talks to, even during social events. This way of action is rather difficult, because it requires not only identifying these people, but also getting to talk to them,
4. Analysis of Influencing Factors

and hopefully gaining their confidence. Own research has identified the following people as good “targets” for this way of action: CIO, CFO, CTO, head of users department, managers of business units and CEOs of other firms. Call these people “my soft network”.

*Use verbal communication (phone calls, meetings) to communicate with managers.*
*Insist on getting to know people in your soft network, and win their trust; it will pay.*

**Personality Characteristic 3**
Managers use judgement, and not explicit analysis, to make decisions.

Mintzberg identifies in [17] three fundamental modes of selection that managers can use when they must make serious choices:
- Analysis: a systematic evaluation of processes.
- Judgement: a process in the mind of a single decision maker.
- Bargaining: involves negotiations between different decision makers.

He indicates that according to his research, only few managers report using explicit analysis. The selection mode most commonly used was judgement. Typically, various options and all kinds of data associated with them are absorbed by the manager’s mind, and a choice comes out.

**Implications:**
When the moment comes for a manager to make a decision about an architecture, the architect must realize that it will do no good to provide the manager with a pile of reports, even if they present a good and valuable analysis of the business or of the architecture. Also interviews conducted for this research support Mintzberg’s statement that the decision-making process does not rely on a systematic analysis, but on intuition, as it is often called. Mintzberg uses the terms “hunch” and “judgement”.

Architects must therefore recognize, and try to understand the way managers make decisions, and not impose their own – often very systematic – decision-making method on managers.

*Recognize the non-systematic way managers make decisions, and don’t impose your own – often very systematic – decision-making method.*

**Personality Characteristic 4**
Managers have an unrelenting working pace.

Mintzberg states unconditionally in [18]:
*Study after study has shown that managers work at an unrelenting pace, that their activities are characterized by brevity, variety and discontinuity, and that they are strongly oriented to action and dislike reflective activities.*

Mintzberg cites the following observations from multiple studies:
- Mintzberg found that half the activities engaged in by CEOs lasted less than nine minutes, and only 10% exceeded one hour.
- A diary study of 160 British middle and top managers found that they worked for 30 minutes or more without interruption only about once every two days.
- 93% of the verbal contacts of the CEOs in Mintzberg’s study were arranged on an ad-hoc basis.
- No study has found important patterns in the way managers schedule their time.

Mintzberg therefore says, that the manager is a real-time responder to stimuli.
Two more aspects have to be considered, next to the time issue: workload and work complexity.

The CEOs Mintzberg studied supervised as many as 50 development projects at the same time. Some projects entailed new products or services; other involved public relations campaigns, improvement of the cash position, reorganization of a weak department, integration of computer operations and so on, all at the chief executive level. Mintzberg states that these projects do not involve single decisions or even unified clusters of decisions. Rather, they emerge as a series of small decisions and actions sequenced over time. Apparently, the CEO prolongs each project so that he can gradually come to comprehend the issue, if it is a complex one.

**Implications:**
Managers have a tremendous workload. They supervise a large number of projects at the same time, each of which is very complex. One could assume that activities would require a long time due to this complexity, but the contrary is true: half of the activities take no longer than nine minutes.

A question that obviously rises is whether or not the manager can – in such a short time – understand the information that the architect tells him, and whether the manager can understand the consequences of this information. This question is very relevant, since the main goal of this research is supporting the decision-making process.

We believe the implications of the observations mentioned here must be further studied. We can however suggest the following to architects:

- Architects should make sure they can convey their message fast. It’s wise to spend a lot of time figuring out how to make a story short, shorter and shortest, and bring it down to the minimum necessary. Only then should the architect talk to the manager.
- Architects should not try to explain the whole picture to managers, but limit themselves to a few strategic issues.
- Once again, limit time and contents.

_Hide complexity, be fast and short!_

**Personality Characteristic 5**
**How managers make decisions: picking the man instead of the proposal.**

In [18], Mintzberg addresses the question how managers authorize other people’s decisions, presented to them as proposals. He noticed that CEOs faced incredibly complex choices. They had to consider the impact of each decision on other decisions and on the organization’s strategy. They had to ensure that the decision would be acceptable to those who influence the organization, and that resources would not be overextended. They had to understand the various costs and benefits as well as the feasibility of the proposal. They also had to consider questions of timing. All this was necessary for the simple approval of someone else's proposal. At the same time, however, delay could lose time, while quick approval could be ill considered and quick rejection might discourage the subordinate who had spent months developing a pet project.

Undoubtedly, making a decision in such cases is not a piece of cake. Mintzberg observed one common solution for approving projects: pick the man instead of the proposal. That is, the manager authorizes those projects presented to him by people whose judgment he trusts. Of course, this trick cannot be used always. It is however a common solution, as Mintzberg states.

**Implications:**
Also this personality characteristic is very relevant for our research, since the main point of this research is supporting the decision-making process.

This personality characteristic is therefore very annoying, but it cannot be ignored.
It can best be understood, when combined with a personality characteristic on managers’ unrelenting working pace: the workload and complexity of managers’ work. When the manager has so many projects to supervise, and each of them is very complex, it is almost natural that he cannot make all decisions by himself, since he isn’t able to fully comprehend all required information. In such a case, he effectively – but not officially - delegates taking the decision. Hints in this direction were also given during interviews, conducted for this research. “I ask … for his opinion” is effectively letting someone else consider the pros and cons, and thus make the decision, hopefully the right one.

The implication for architects is therefore to find someone the manager trusts, and make sure he convinces the manager. Easy said, but not so simple to implement.

In some of the interviews conducted for this research, the names of the Gartner Group and META Group came up as organizations that managers trust. By calling in an analyst from one of these organizations, and letting him say what the architect would say otherwise, the story sounds more reliable and trustworthy to the managers.

Identify those the manager trusts, and let them convince him.

4.3 Situation Analysis
The subject ‘situation analysis’ was presented in chapter 2 and will not be discussed further in this report. To continue the discussion, we assume that time, place and circumstances do not pose any special limitations.
5 Contents Analysis – What to Visualize?

Contents analysis is a step in the communication process, in which the sender decides what the contents of his message will be.

5.1 Chapter Summary

This chapter concentrates on the question: “what must be visualized?”
The starting point for the theory presented here is that it’s not necessary to visualize the whole architecture for a certain stakeholder; it’s enough to visualize those aspects that this stakeholder considers important. We therefore define sets of concerns that specific stakeholders have in specific architecture types. The results of this chapter will serve as input in the process of creating visualizations.

5.2 Introduction

Our research started with a very broad scope, which was narrowed later on, based on the available information and on our research priorities.
At first, we defined a list of concerns in architecture processes. We then identified stakeholders in the architecture process, and mapped the concerns to the stakeholders.
After a while, we decided to concentrate on three stakeholders only.
We considered three types of architectures: Enterprise Architectures, Domain Architectures and System Architectures.
We then defined sets of important concerns per stakeholder, per architectural level. These will serve as input for later chapters.

5.3 Stakeholders

Our research considered seven groups of stakeholders, involved in the architecture process: business management of the client organization, IT management of the client organization, architect(s), users of information systems, developers of information systems and maintainers of information systems.
We later decided to concentrate on three stakeholders only: business management of the client organization, IT management of the client organization and the users of information systems.
We asked eighteen IT-experts to evaluate per group of stakeholders, whether this group of stakeholders requires architecture visualizations. The term visualization is defined in chapter 8. For the meanwhile, it is enough to say that when we use this term, we refer to a different type of visualization then what we call regular architecture drawings. The latter refers to diagrams that concentrate on information systems and often use the Unified Modelling Language (UML).

Business managers:
The experts agreed that business managers do not understand the regular architecture drawings. Many experts therefore draw the conclusion, that a different type of visualization is required for this group.
Some experts claimed that the business managers still like having the regular architecture drawings hang in their rooms in order to be able to present them to guests (a sort of “show off”). However, in order to present it to others, they must be able to somehow explain the drawings.

One expert claimed that business managers are not interested at all in architecture, but in the final product. Architecture is a tool for them, and therefore they are not interested in visualizations of the architecture.

The business managers themselves claimed they are interested in architectures, since it influences their business.

**IT managers:**
The experts had different opinions about IT managers:
Some experts claimed that IT managers understand the regular architecture drawings. Some of the experts claimed that IT managers understand part of the regular architecture drawings. Some claimed that IT managers need other visualizations, since they do not understand the regular architecture drawings.

**Users:**
When asked, the experts claimed that the users need visualizations.

The next question is for which types of architectures the various stakeholders need visualizations. Multiple experts were presented this question. For every combination of stakeholder and architecture type, they were asked whether the stakeholder is interested in that architecture type. The answer could be either positive or negative. In some cases however, the expert thought any of these two answers would be wrong, and introduced a third answer: the stakeholder is interested in the architecture to a very limited extent. This is an “almost negative” answer.

The average results of the answers, given by the experts, are given in table 1. The abbreviations EA, DA and SA denote the level of architecture (enterprise, domain, system).

<table>
<thead>
<tr>
<th>Stakeholder Type</th>
<th>Architecture Type</th>
<th>Stakeholder Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enterprise (EA)</td>
<td>Business manager</td>
</tr>
<tr>
<td>Interested</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Very limited interest</td>
<td>9%</td>
<td>IT manager (DA)</td>
</tr>
<tr>
<td></td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>Not interested</td>
<td>23%</td>
<td>User (SA)</td>
</tr>
<tr>
<td></td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1 Stakeholders’ level of interest in architectures**

**Conclusions:**
The following conclusions are very general, but serve as a starting point.
Business managers do not understand regular architecture drawings, but nevertheless require information about architectures. The question how much information they require about system architectures has to be further investigated.
IT managers understand the information-systems-centred architecture drawings. Some architectural aspects might require a different type of visualization.
Users require information about system architectures, and they do not understand the regular architecture drawings. The information must therefore be presented in a different way. The question how much information they require about enterprise architectures and domain architectures has to be investigated further.
5. Contents Analysis: What to Visualize?

5.4 Concerns

As stated in the personality analysis presented in the previous chapter, the message that the architect will communicate has to be short; complexity has to be hidden, and irrelevant information has to be discarded. For that reason we argue that not the whole architecture has to be visualized for a specific stakeholder. Only those aspects that are of interest for a specific stakeholder should be visualized. We call these aspects **concerns**.

We created a list of concerns, which apply for multiple stakeholders during the architecture process, for the three earlier mentioned levels of architecture. This list was dynamic; it changed during the course of our research, based on input given during interviews. The primary list was based on a literature research.

The concerns, including their definitions (as used by us), are listed below.

**Budgeting**: All financial matters with respect to setting up a suggestion for an architecture and implementing it.

**Compatibility**: (1) The ability of two or more systems or components to perform their required functions while sharing the same hardware or software environment. (2) The ability of two or more systems or components to exchange information. (IEEE standard 610.12-1990).

When considering architecture compatibility, we refer to the compatibility of the eventual information systems.

In the context of enterprise architectures, the enterprise-wide information systems of an enterprise must be compatible with each other and with those of other enterprises.

In the context of domain architectures, the domain-wide information systems of an enterprise must be compatible with each other and with those of other enterprises or other domains within the same enterprise.

In the context of system architectures, an information system must be compatible with other information systems of the same enterprise and possibly also with those of other enterprises.

**Completeness**: The degree to which a full implementation of the required functionality is assured by the architecture ([16]).

**Consistency**: The degree of uniformity, standardization and freedom from contradiction among the documents or parts of the system or component. (IEEE standard 610.12-1990).

**Context definition**: Setting a "border" to the architecture. It includes two aspects:

- Stating what is not required of the architecture (for example: it is not requires that the architecture enables implementing a new channel for sales activities in the future)
- Stating which interactions the eventual information systems must have with other information systems (interfaces).

**Detail for design**: The degree to which the architecture includes the details required for implementation.

**Effectiveness**: The capacity to enable users to achieve specified goals with accuracy and completeness in a specified context of use. (Based on the ISO/IEC standard 9126-1:2000).

In the context of enterprise architectures, the goals are the business goals of the enterprise.

In the context of domain architectures, the goals are the business goals of at least part of the enterprise.

In the context of system architectures, the goals are those business goals of (possibly part of) the enterprise, which play a role in the definition and usage of the information system.

**Evolution guidance**: An analysis of how the architecture can evolve in the future.
Facilitate change: The degree to which the architecture and the related information systems enable future business changes, and a description of such foreseeable changes and how they are facilitated.

Feasibility and Risk assessment:
- **Feasibility**: The degree to which the requirements, design or plans for an architecture can be implemented under existing constraints. (Based on the IEEE standard 610.12-1990).
- **Risk**: A measure that combines both the likelihood that a hazard will cause an accident and the severity of that accident. (Based on the IEEE standard 1228-1994). We consider “an accident” to be anything that jeopardises either the process of setting up a suggestion for an architecture or the process of implementing this suggestion.

Governance: Organizational and procedural measures related to IT. This includes issues as responsibilities, auditing, making sure the systems operate according to the guidelines and checking whether the business goals related to the information systems are met. In the context of architecture governance, we refer to the governance of the eventual information systems.

Integration: The process of combining components into an overall system. (Based on the IEEE standard 610.12-1990). In the context of enterprise architectures, we consider integration of business processes of multiple enterprises and their information systems. In the context of domain architectures, we consider integration of business processes of multiple enterprises and/or various parts of one enterprise and their information systems. In the context of system architectures, we consider integration of one specific system and its environment with other systems (possibly systems of multiple enterprises) and their environments.

Modifiability/Flexibility: (1) The ease with which an architecture, and the related systems or components can be modified for use in environments other than those for which they were specifically designed. (Based on the IEEE standard 610.12-1990). (2) The ease of changing existing functionalities or adding new ones.

Performance: The degree to which an architecture assures that the related information systems accomplish their designated functions within given constraints, such as speed, accuracy or memory usage. (Based on the IEEE standard 610.12-1990). In the context of architecture performance, we refer to the performance of the eventual information systems.

Requirements traceability:
- **Traceability**: The degree to which a relationship can be established between two or more products of the development process, especially products having a predecessor-successor or master-subordinate relationship to one another; for example, the degree to which the requirements and design match. (Based on the IEEE standard 610.12-1990). In the context of requirement traceability, we consider any set of two or more products, one of which is the set of requirements relevant for the other products.

Schedule: All matters that concern time regarding the setting up of a suggestion for an architecture and implementing it.

Security: The capability to protect information and data so that unauthorised persons or systems cannot read or modify them, and authorised persons or systems are not denied access to them. (Based on the ISO/IEC standard 12207:1995).
In the context of architecture security, we refer to the security of the eventual information systems.

**Trade-off analysis**: An analysis of conflicting requirements (possibly set by various stakeholders) and a reasoning, which of them received a higher/lower priority and why.

**Usability**: The capability to be understood, learned, used and attractive to the user, when used under specified conditions. (Based on the ISO/IEC standard 9126-1:2000).

In the context of architecture usability, we refer to the usability of the eventual information systems. This includes several issues: How easy is it for the user to learn to use the system? Does the system make the user’s job easy? Does the system respond fast enough? Does the system anticipate and avoid user errors? Does the system help the user recover the errors?

We set up a matrix of the three stakeholders on the one hand, and the list of concerns on the other hand. We had three such matrices, one for each of the earlier mentioned architectural levels. We combined these three matrices into one table. Per combination of (stakeholder, concern, architectural level) we asked eighteen IT-experts and five business managers to answer the question “How important is this concern for this specific stakeholder, regarding this architectural level?” An example is the following question: “How important is schedule for business managers, regarding enterprise architecture?” The criterion for being important is that this stakeholder wants to receive information about this concern. If the stakeholder considers this concern important, but says that it’s enough if another stakeholder deals with it, we refer to this concern as not important for this stakeholder.

The following scores were used:

- 0 – this concern is **not** important or **little important** for this stakeholder
- 1 – this concern is **important** for this stakeholder
- 2 – this concern is **very important** for this stakeholder

The business managers rated their own concerns, but not those of other stakeholders.

### 5.5 Research Results

The scores given by the various experts were summed up, and we calculated an average score, using the same scale: from zero to two. Table 2 presents the average scores of the various concerns. Different averages apply for the various architectural levels, which are denoted as EA (enterprise architecture), DA (domain architecture) and SA (system architecture).

Note that the scores presented in this chapter have been rounded off, with a precision of 0.1. For example: a score 1.44 is presented as 1.4, and a score 1.45 is presented as 1.5. When calculating averages, we use the original scores (i.e. 1.44 and 1.45, instead of 1.4 and 1.5). This way it may happen, for example, that the average of 0.3, 0.3 and 0.4 is 0.4, which may seem wrong, but is right, since (0.33+0.33+0.44)/3=0.36, which is rounded off to 0.4.

Table 2 shows the results of the evaluations made by experts who evaluated full columns in the table (a column stands for a combination of a certain stakeholder and a type of architecture). Some experts however gave partial answers, evaluating just some of the concerns in a column. These answers could not be used to calculate the average scores, but they can be used as extra information to point out important issues. Where this **partial information** might be relevant, it will be discussed in this chapter.
Table 2 Results of the stakeholders-and-concerns matrix

<table>
<thead>
<tr>
<th>Concern</th>
<th>Business manager</th>
<th>IT manager</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EA</td>
<td>DA</td>
<td>SA</td>
</tr>
<tr>
<td>Budgeting</td>
<td>1.8</td>
<td>1.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Compatibility</td>
<td>0.3</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Completeness</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Consistency</td>
<td>0.3</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Context definition</td>
<td>0.5</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>Detail for design</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>1.8</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>Evolution guidance</td>
<td>0.8</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Facilitate change</td>
<td>1.3</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Feasibility/risk assessment</td>
<td>1.1</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Governance</td>
<td>0.8</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Integration</td>
<td>1.1</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Modifiability/flexibility</td>
<td>0.8</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Performance</td>
<td>0.3</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Requirements traceability</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Schedule</td>
<td>1.2</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Security</td>
<td>0.5</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Trade-off analysis</td>
<td>0.9</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Usability</td>
<td>0.5</td>
<td>0.9</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 3 Number of important concerns per stakeholder and architectural level

Based on the matrix results, the following statistics can be derived:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Business managers</th>
<th>IT managers</th>
<th>Users</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EA</td>
<td>DA</td>
<td>SA</td>
</tr>
<tr>
<td>Number of concerns that scored 1.5 or higher</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Number of concerns that scored between 1 and 1.5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Average scores of the top three concerns for enterprise architectures:
- Business managers: 1.6
- IT managers: 1
- Users: 0.4

Average scores of the top three concerns for domain architectures:
- Business managers: 1.6
- IT managers: 1.3
- Users: 0.8

Average scores of the top three concerns for system architectures:
- Business managers: 1.1
- IT managers: 1.6
- Users: 1.8
Average scores of the top three concerns of business managers:
- Enterprise architectures: 1.6
- Domain architectures: 1.6
- System architectures: 1.1

Average scores of the top three concerns of IT managers:
- Enterprise architectures: 1.0
- Domain architectures: 1.3
- System architectures: 1.6

Average scores of the top three concerns of users:
- Enterprise architectures: 0.4
- Domain architectures: 0.8
- System architectures: 1.6

5.6 Sets of Concerns

Based on the scores given by the experts to the various concerns, we defined sets of concerns. Using such a set of concerns, one can examine the architecture through certain aspects only.

Those concerns that score highest, form a stakeholder’s set of concerns, since these are the concerns that are of importance for a specific stakeholder.

Two sets of concerns are identified per stakeholder and architecture type: a basic one and a supplementary one. The basic one includes only those concerns most important for the stakeholder of a specific type of architecture, and the supplementary one includes those concerns that are also important, but do not belong to the group of most important concerns.

Before getting into the details of the sets of concerns, two remarks must be made.

1. In defining sets of concerns we are trying to present a very general picture, for as far as this is possible. The sets of concerns are based on the experience of experts from various sectors. Those concerns that are very important in at least several sectors received a high score. But specific sectors consider some concerns more important than others.

   The same can be said about architectures that serve different goals.

   We therefore suggest that the hereunder-defined sets of concerns be expanded or shrunk, based on specific characteristics of certain sectors, and based on the goal of the architectural study. Examples of such differences are:
   - Budgeting is almost a holy issue for business managers in the financial sector. In the governmental sector it is also of great importance, but sometimes compromises can be made.
   - Security is of higher importance in architectures for military use than in those for the private sector.
   - Facilitating change sometimes is less important in the governmental sector than in the industrial world, since the tasks of governmental organizations are sometimes more stable.

2. There appears to be a difference between what a stakeholder considers important and what he is "supposed" to consider important. Security, for instance, is sometimes considered less important than it "should" be. The matrix presents an answer for what the stakeholders really consider important, and not what they are “supposed” to consider important. Since this is a matter of internal politics, we leave it to the architect to decide whether he wants to add such concerns to his set of relevant concerns.
5.6.1 Business Managers’ Concerns

**Enterprise Architectures**

The highest scoring concerns for business managers are listed in table 4. Two scores are presented: the average of all scores, and the average of the scores given only by those experts who claimed that this architecture type is indeed important for this stakeholder (further referred to as “partial average”). Those two scores will be presented in all tables in this section and the following ones.

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budgeting</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Facilitate Change</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Schedule</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Feasibility/Risk Assessment</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Integration</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 4 Business managers’ important concerns in enterprise architectures

**Domain Architectures**

The highest scoring concerns for business managers are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Budgeting</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Facilitate Change</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Feasibility/Risk Assessment</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Schedule</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5 Business managers’ important concerns in domain architectures

**System Architectures**

The highest scoring concerns for business managers are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budgeting</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Schedule</td>
<td>0.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Facilitate Change</td>
<td>0.9</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 6 Business managers’ important concerns in system architectures

**Business Managers’ Set of Concerns Analysis**

As shown, the business managers’ set of concerns is very similar for all three types of architectures. Four concerns appear on all three lists. The following observations can be made, based on these results:
Observation 1:  
*Budgeting* and *effectiveness* are the main concerns of business managers. This is true for all three types of architecture.

Observation 2:  
The highest score on the system architectures level is much lower than the highest scores on the enterprise architectures and domain architectures levels. Possible explanations for this observation are:
- Some of the experts stated that business managers are not interested in system architectures at all. This of course lowers the average score.
- The business management involvement in system architectures is limited. As a result, IT experts (as those we interviewed) have less contact with business managers on the system level, compared to the domain or enterprise levels. This might imply that IT experts are less aware of what business managers consider interesting on that level, and therefore their opinions differ.
- System architectures are targeted at technical implementation, and less at business issues. They therefore fit less into business terms.

The first explanation is supported by another observation: the partial averages of the system architectures level (disregarding the experts who stated that business managers are not interested in system architectures at all) are very similar to those of the enterprise and the domain levels.

Observation 3:  
Almost all of the experts agreed that *budgeting* and *effectiveness* are very important for business managers in enterprise architectures and domain architectures.

Observation 4:  
*Schedules, feasibility and risk assessment* and *facilitate change* score, on the enterprise and domain levels, much lower than *budgeting* and *effectiveness*.

Observation 5:  
*Feasibility and risk assessment* scores very low on the system architectures level (0.6), but much higher on the enterprise and domain levels (1.1, 1.2). A possible explanation for this observation is: business managers sometimes (often?) consider system architectures as a pure technological issue, and therefore leave it for their IT managers, who in their turn are supposed to take care of the risks.

Observation 6:  
*Integration* scores much higher on the enterprise level than on the domain or system level. A possible explanation for this observation is: integration on the enterprise level refers to integration of various organizations that together form a value chain. On the system and domain levels, integration may be an internal matter of one organization only. It is obvious that integration on the enterprise level is a strategic business issue, whereas on the domain and system levels it can be considered an internal, sometimes technological issue, and is therefore of less importance for business managers. They leave it for their IT managers. This explanation also matches the scores for *integration* among IT managers. On the enterprise level they score very low (but business managers score higher), but on the domain and system levels they score higher (and business managers score low).

Observation 7:  
Business managers have more interests in enterprise architectures than in domain architectures (six main concerns in enterprise architectures, five main concerns in domain architectures). Their interest in domain architectures is broader than in system architectures (only two main concerns in system architectures).
Observation 8:
The partial averages of the system architectures level (disregarding the experts who stated that business managers are not interested in system architectures at all) are very similar to those of the enterprise and the domain levels.

Defining the Business Managers’ Set of Concerns

The top two concerns of business managers, for all types of architecture, are:
- Budgeting
- Effectiveness

The basic set of business managers’ concerns includes these two concerns. It is valid for all three types of architecture: enterprise architectures, domain architectures and system architectures.

The third highest scoring concern for enterprise architectures is facilitating change. The results of the concerns evaluation show a big difference between the second place (Effectiveness, 1.8) and the third place (Facilitate change, 1.3). If however, we also take into account partial evaluations, which are not represented in the table of scores, then the concern of facilitating change scores higher on the enterprise level. We therefore add this concern to the basic set of concerns for enterprise architectures.

The supplementary set of concerns for business managers introduces the difference in interest for the three types of architecture, and is level specific.

On the enterprise level, it includes:
- Schedule
- Feasibility and risk assessment
- Integration

On the domain level, it includes:
- Facilitate change
- Feasibility and risk assessment
- Schedule

On the system level it includes:
- Facilitate change
- Schedule

5.6.2 IT Managers’ Concerns

Enterprise Architectures

The highest scoring concerns for IT managers are listed below. Once again, two scores are presented: the average of all scores, and the partial average.

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility/Risk Assessment</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Security</td>
<td>0.9</td>
<td>1</td>
</tr>
<tr>
<td>Evolution Guidance</td>
<td>0.9</td>
<td>1</td>
</tr>
<tr>
<td>Schedule</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Modifiability/Flexibility</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Budgeting</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Governance</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Table 7 IT managers’ important concerns in enterprise architectures
5. Contents Analysis: What to Visualize?

Domain Architectures

The highest scoring concerns for IT managers are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Feasibility/Risk Assessment</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Compatibility</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Integration</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Security</td>
<td>1.1</td>
<td>1.2</td>
</tr>
<tr>
<td>Schedule</td>
<td>1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 8 IT managers’ important concerns in domain architectures

System Architectures

The highest scoring concerns for IT managers are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Compatibility</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Integration</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Security</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Budgeting</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Feasibility/Risk Assessment</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Schedule</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Performance</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Usability</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Modifiability/Flexibility</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 9 IT managers’ important concerns in system architectures

IT Managers’ Set of Concerns Analysis

Unlike business managers, IT managers introduce more variety among the levels of architecture. Different concerns are of importance on different levels of architectures.

The following observations can be made, based on the results:

Observation 1:
IT managers consider the enterprise architectures level as much less important for them than other levels. Only one concern scores 1 on this level, and none scores higher.

Observation 2:
No concerns were identified as "very important" for IT managers on the domain architectures level (score 1.5 or higher). Six concerns were identified as "important", with scores ranging from 1 to 1.3.
Observation 3:
The system architectures level is obviously of great importance for IT managers. Eleven of the nineteen concerns score 1 or higher, and four of them score 1.5 or higher. This is the highest number of high scoring concerns in the table.

Observation 4:
Observations one through three lead us to another observation: the level of involvement of IT managers in the architecture process increases, as the architecture's level of abstraction decreases.

Defining the IT Managers’ Set of Concerns

Analysing the results for IT managers revealed a fundamentally different involvement in the architecture process for the various types of architecture. The involvement differs in its intensity, as well as in the fields of interest. We consequently define different sets of concerns for the three types of architectures.

Enterprise Architectures
Only one concern scores 1 or higher on this level of architecture. The average score of the top three concerns is 1, which is very low. As a result, it is not possible to define any set of concerns on the enterprise level. More research is required in order to define such a set, and in order to define whether or not such a set is required at all. It is nevertheless likely that if such a set is found necessary, it will include on the enterprise level at least some of the concerns that scored relatively high. These are:

- Feasibility and risk assessment
- Security
- Evolution guidance
- Schedule
- Modifiability/ flexibility
- Budgeting
- Governance

Domain Architectures
Also on the domain level no concerns were identified as very important (scoring 1.5 or higher). However six concerns were identified as important, with scores ranging from 1 to 1.3. We define a basic set of concerns that includes these six concerns, since they apparently play an important role. We nevertheless believe that more research is required in order to test the validity of this set.

The basic set of concerns of IT managers on the domain level therefore includes:

- Governance
- Feasibility and risk assessment
- Compatibility
- Integration
- Schedule
- Security

System Architectures
On the system architecture level we can identify two major groups of concerns:

- Most important concerns: these are four concerns that score 1.5 or higher:
  - Governance
  - Compatibility
  - Integration
  - Security
5. Contents Analysis: What to Visualize?

- Important concerns: these are seven concerns that score between 1 and 1.2:
  - Budgeting
  - Feasibility and risk assessment
  - Schedule
  - Performance
  - Effectiveness
  - Usability
  - Modifiability/flexibility

Together, these two groups of concerns are more than half of the list of concerns that was presented to the experts. Other concerns also score not much less than 1. It is obvious that IT managers have many important concerns on the system level.

We define the basic set of concerns of IT managers on the system level as the group of four most important concerns: governance, compatibility, integration and security.

Although the seven important concerns are good candidates for a supplementary set of concerns, we refrain from defining such a set, since we believe more results are required in order to do so; there are too many "candidate concerns" that score a medium score. Further research will have to be done in order to prioritise them and define such a set.

5.6.3 Users’ Concerns

Enterprise Architectures

The highest scoring concerns for users are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>0.4</td>
<td>1</td>
</tr>
<tr>
<td>Performance</td>
<td>0.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Consistency</td>
<td>0.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table 10 Users’ important concerns in enterprise architectures

Domain Architectures

The highest scoring concerns for users are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Performance</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table 11 Users’ important concerns in domain architectures

System Architectures

The highest scoring concerns for users are:

<table>
<thead>
<tr>
<th>Concern</th>
<th>Total average</th>
<th>Partial average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Performance</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Modifiability/Flexibility</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Compatibility</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table 12 Users’ important concerns in system architectures
Users' Set of Concerns Analysis

The results for users are very much different from those of the business managers and IT managers. The following observations can be made, based on the results:

Observation 1:
The highest score on the enterprise level is 0.4, which is by far lower than highest scores of other stakeholders, for any type of architecture. The same is true also for the average of the top three concerns: 0.4.
Even if we consider partial averages, the highest score is 1, and there's only one concern that scores that high.
The conclusion of this observation is that the level of interest of users in enterprise architectures is very low.

Observation 2:
Only one concern is evaluated as important for users on the domain architectures level (usability, with a score of 1.3, or partial average 1.6). The second highest scoring concern (performance) scored only 0.6 (partial average 0.8).
We can conclude that usability is the most important concern for users on the domain level.
No other statements can be made about other important concerns, based on the results of this research.

Observation 3:
The only concern that was evaluated as “very important” (score 2) by all of the experts is usability, with regard to users and system architectures.

Observation 4:
Usability and performance are the only two concerns of users that score very high on the system architectures level. The difference between them and the third best scoring concern is enormous.

Defining the Users' Set of Concerns

Since there are important differences between the three types of architecture, we will not define a global set of concerns. Instead, we will consider each level of architecture for itself, like we did with IT managers.

Enterprise Architectures
We conclude that the level of interest of users in enterprise architectures is very low. As a result, we will not define sets of concerns for this level of architecture. Whether or not defining such sets is necessary should be subject to more research.

Domain Architectures
Based on observation 2, we define a basic set of concerns for users on the domain level. This set includes only one concern: usability.
Since no other concern scored medium or high, we will not define a supplementary concern.

System Architectures
As shown before, two concerns are of great importance for users on the system level. These are usability and performance.
We consequently define the basic users’ set of concerns as a set that includes these two concerns.
We do not define a supplementary set of concerns for users, since there are not enough results to do so.
5.6.4 Inter-Stakeholder Analysis

Comparing the results of the various stakeholders with each other also leads to some interesting observations:

Observation 1:
By comparing the most important concerns of business managers (the top two concerns on the enterprise architectures and domain architectures levels) with the most important concerns of IT managers (the top two concerns on the system architectures level), we can see that the concerns of business managers score higher.

Observation 2:
By comparing the issues important to business managers (important concerns on the enterprise architectures and domain architectures levels) with the issues important to IT managers (important concerns on the system architectures level), we can see that IT managers have more high-scoring concerns than business managers, implying that they are responsible for a broader range of aspects of architectures.

Observation 3:
Users have much less important concerns than business managers and IT managers. In fact, the involvement of users in architectures is mostly limited to the system level, and to two concerns: usability and performance. This can be explained by the fact that users have a very limited responsibility in architecture processes within their organizations. They will seldom be held responsible if the project fails, and they sometimes even do not care what is happening in the organization, as long as it doesn’t influence them and their work.

5.6.5 Summary: Sets of Relevant Concerns

The definitions of the various sets of concerns are summarized in tables 13, 14 and 15. Where no concerns are mentioned, no set is defined. These sets of concerns emerged as the most important aspects of architectures, for the specified stakeholders. Architects should therefore provide the stakeholders with information about these concerns. When using visualizations as a means to communicate with stakeholders, visualizations should provide information about these concerns.
### The Business Managers' Sets of Concerns

<table>
<thead>
<tr>
<th>Set</th>
<th>Enterprise Architectures</th>
<th>Domain Architectures</th>
<th>System Architectures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Set</strong></td>
<td>Costs and benefits; Effectiveness; Facilitate change</td>
<td>Costs and benefits; Effectiveness</td>
<td>Costs and benefits; Effectiveness</td>
</tr>
<tr>
<td><strong>Supplementary Set</strong></td>
<td>Schedule; Feasibility and risk assessment; Integration</td>
<td>Facilitate change; Schedule; Feasibility and risk assessment</td>
<td>Facilitate change; Schedule</td>
</tr>
</tbody>
</table>

Table 13 Business managers' sets of concerns

### The IT Managers' Sets of Concerns

<table>
<thead>
<tr>
<th>Set</th>
<th>Enterprise Architectures</th>
<th>Domain Architectures</th>
<th>System Architectures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Set</strong></td>
<td>Governance; Feasibility and risk assessment; Security; Compatibility; Integration; Schedule</td>
<td>Governance; Feasibility and risk assessment; Security; Compatibility; Integration; Schedule</td>
<td>Governance; Compatibility; Integration; Security</td>
</tr>
<tr>
<td><strong>Supplementary Set</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 14 IT managers' sets of concerns

### The Users' Sets of Concerns

<table>
<thead>
<tr>
<th>Set</th>
<th>Enterprise Architectures</th>
<th>Domain Architectures</th>
<th>System Architectures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Set</strong></td>
<td></td>
<td>Usability</td>
<td>Usability; Performance</td>
</tr>
<tr>
<td><strong>Supplementary Set</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 15 Users’ sets of concerns

2 We use the term ‘costs and benefits’ instead of the term ‘budgeting’. An explanation is given in the conclusion of section 6.3.1.
6. Contents Analysis – Conceptualisation

Conceptualisation is part of contents analysis, a step in the communication process, in which the sender decides what the contents of his message will be.

6.1 Chapter Summary

In chapter five we learned which concerns are important to which stakeholder. Knowing this is not yet enough in order to start visualizing. The concerns are no more than abstract terms, even though we defined what they mean. They remain abstract because various differently oriented people have different mental models of specific terms. In this chapter we conceptualise the earlier discussed concerns: we investigate what the various stakeholders refer to, when they use these terms.

6.2 Introduction

Although we defined the concerns discussed so far, various stakeholders may interpret them in different ways, since these terms may be “loaded”, have some meaning in a specific environment. Ask a computer scientist what he thinks of when confronted with the term security, and pose then the same question to a police officer. What are the chances you will get the same answer?

By saying that a specific concern is important to a stakeholder, we assume he wants to receive information about it. Sometimes the information is required for decision-making, and sometimes he simply wants to know it. In both cases, he expects certain information. Keeping the police officer example in mind, the architect has to understand what the stakeholders expect to hear about the concerns. Otherwise, he might provide his stakeholders with irrelevant information, although on the relevant subjects.

Defining what the various stakeholders understand when they think of the concerns discussed earlier is therefore our next step. We call it conceptualisation. We conceptualise the important concerns. By conceptualising the concerns that form a set of concerns, we conceptualise the set itself.

Note that the study of identifying relevant concerns per stakeholder and the conceptualisation of the concerns were intertwined. In most of the cases when an expert or a manager claimed that a certain concern is very important for some stakeholder, he was asked to conceptualise this concern.

Some of the concerns appear to be relevant for certain stakeholders on more than one type of archITecture. In such a case, if the conceptualisation appears to be different for the various types, this will be mentioned. Otherwise, the conceptualisation refers to all archITecture types discussed.

Since the conceptualisation is stakeholder specific, we will repeat it for each stakeholder.
6.3 Business Managers

6.3.1 Budgeting

*Budgeting* is the highest scoring concern of business managers. This means that receiving information about *budgeting* is more important to business managers than receiving information on other concerns.

Consulted experts unanimously stated that business managers require information on costs and benefits of architectures. This in fact is the conceptualisation of the concern *budgeting*: costs and benefits. Let us therefore look at these two terms in more detail.

**Costs**

What are the costs of setting up a suggestion for an architecture? Mostly, they are not very high. But an architecture never is the goal itself. An architecture is a means to achieve a goal. There is some kind of a business goal. It might be an expanding strategy, a reorganization of an enterprise or part of it, supporting some business process, political issues or many other matters.

The costs in which business managers are interested are not only the costs of setting up an architecture by a team of architects. Business managers are interested in the costs of achieving their goal. Setting up the architecture — as a first step towards achieving the goal — is only part of the costs.

Note that also the total costs of implementing what the architecture prescribes, does not yet cover the scope of the term *costs*. This term refers also to costs of exploitation and maintenance.

A term some of the experts used is *Total Cost of Ownership (TCO)*.

The TCO model, introduced by the Gartner Group in [11], uses two major categories of costs:

1. **Direct (budgeted) costs:**
   - Hardware and software – the capital expenditures and lease fees for servers, client computers (e.g., desktops and mobile computers), peripherals and network components
   - System management – the direct network, system and storage-management labour staffing, activity hours and activity costs, maintenance contracts and professional services or outsourcing fees
   - Support – the help-desk labour hours and costs, help-desk performance metrics, training labour and fees, procurement, travel, support contracts and overhead labour
   - Development – the application design, development, test and documentation labour and fee expenditures including new application development, customisation and maintenance
   - Communications fees – the inter-computer communication expenses for lease lines, server access remote access and allocated WAN expenses

2. **Indirect (unbudgeted) costs.** These costs often are hidden in most organizations and are not measured or tracked; they often go unaccounted for:
   - End-user IS$^3$ – the cost of end users supporting themselves (and each other) instead of relying on formal IS support channels (i.e., peer and self support), end-user formal training, casual learning (i.e., non-formal training), self-development/scripting of applications and local file maintenance
   - Downtime – the lost productivity due to planned (i.e., scheduled) and unplanned network, system and application unavailability, measured in terms of lost wages (i.e., lost time)

---

$^3$ IS: Information Systems(s)
We add one more aspect to this definition: the costs of the required organizational changes.

**Benefits**

Benefits are a more problematic issue. According to Gianotten ([12]), half of the organizations are trying to determine the value of IT for the organization, but only few succeed. Many organizations claim that benefits of IT can only be expressed in non-quantitative terms. Gianotten also states that the management mostly doesn't recognize the strategic benefits of IT well enough.

Bearing this in mind, it is no surprise that most of the experts claimed the architect is not capable of presenting sound calculations of financial benefits of architectures. Some exceptions were given, for situations when financial benefits can be calculated:

- When there are details from other organizations that have implemented the same solution in the past
- When the goal is replacing labour with machines
- When a ready-made solution is implemented (a “package”), for which the supplier provides the calculations

However when the architecture presents also strategic value, the architect is not capable of expressing the benefits in terms of money.

Some interviews with business managers revealed that the managers do not expect such calculations. They want to know what the benefits are in terms of strategy, organization, business activities, products, client satisfaction and cooperation with other organizations. Then they can evaluate by themselves how much money this is worth. Sometimes they don’t even do that, since an exact evaluation is not necessary; they have a good enough “feeling” of how much such benefits are worth.

The Gartner Group makes a distinction between *hard benefits* and *soft benefits* (see [5]).

**Hard benefits** are quantifiable and can be translated to money. Examples are reduced expenses and savings in manpower.

**Soft benefits** are sometimes measurable, but cannot be fully expressed in terms of money. Examples are customer satisfaction, employee satisfaction, improved decision-making and community goodwill.

Architecture benefits can be divided into four fields of benefit, according to the Gartner Group (see [6]). The following *architecture benefits checklist* is provided:

**Interoperability (ease of exchanging data)**

- Data access for decision-making
- Faster business process execution
- Rapid financial close and reporting
- Easier supplier contract initiation
- Responsive to customer requests
- Easier business process outsourcing
- Faster integration/spin-off of strategic business units
- Easier global operations
- Better leveraging of customer data
- Consistent performance measures
- Straight-through processing
- Sharing of intellectual capital

**Lower Support Costs**

- Lower purchasing outlays
- Less training
- Fewer spare parts
- Fewer diagnosticians
- Fewer upgrades
- Less vendor administration
6. Contents Analysis – Conceptualisation

- Less product evaluation
- Faster implementation
- Shared know-how
- Higher quality

**Improved System Management**
- Capacity planning
- Performance management
- Fault management
- Security management
- Configuration management
- Performance measurement

**Superior Operations**
- Software distribution
- Backup and recovery
- System software support
- Software asset management
- Test and validation
- Help desk
- Transfer of personnel

This list includes both hard and soft benefits, and can guide the architect in trying to identify and formulate the architecture benefits.

**Conclusion**
The conceptualisation of this concern includes:
- Total cost of ownership
- Benefits – express hard benefits in hard currency; identify and explain soft benefits

We identify four areas of architecture benefits:
- Interoperability
- Lower support costs
- Improved system management
- Superior operations

Note that although this concern was first defined as a strictly financial concern, the conceptualisation revealed that business managers consider it as a broader term. For them, the term *budgeting* refers to a cost and benefits analysis; it includes financial matters, as well as other benefits. When we refer to this concern of business managers in the rest of this document, we will use the term ‘*costs and benefits*’ instead of the term ‘budgeting’.

6.3.2 Effectiveness

The definition of *effective business* changes from business to business. This explains why various experts defined *effectiveness* in different ways. Nevertheless, most of the experts seemed to share some ideas about their definitions. We will use these common ideas to conceptualise this term.

- As trivial as it might sound, effectiveness is effectiveness. Repeat the definition of the term: it’s about reaching business goals. If the business manager is convinced that he reaches his business goals, he’s convinced in effectiveness.

Although this statement by itself is (part of) the conceptualisation of the term *effectiveness*, it is not practical enough, as it gives rise to the question “how do you convince a manager that he can reach his business goals?” Quite a few experts
answered by saying that business processes – which is something the manager understands – must be linked to information systems. By making this link we can bridge the gap between the terms the business manager is familiar with and the world of information systems, which he is unfamiliar with.

The Gartner Group discusses an equivalent issue under a different title: IT Value. In [7], the Gartner Group proposes to link the value of IT to the business strategy. Nowadays, IT is supposed to enable business. IT benefits are often fuzzy, and so is IT value. The Gartner Group proposes to look where the justification (i.e. value) has already been determined and accepted, and where it is a common subject for discussion among senior business managers. Business strategy is identified as such. For that reason, the Gartner Group suggests to move the “IT value issue” forward by linking the notion of IT value to the value of business strategies, instead of linking information systems to business goals, as suggested earlier.

- A second common aspect of effectiveness is money. Some experts named profit or ROI (Return On Investment) as management criteria for effectiveness. Others named winning a bigger market share, meeting the financial requirements of the organization or a favouring costs and benefits analysis as criteria. Almost all of these criteria have in common that they are financial criteria, looking at the future. Note that some of these financial criteria can also be covered by the first common aspect: meeting the business goals.

In its note [8], the Gartner Group presents financials as no more than one aspect of IT value, and suggests not to look for ROI, but for VOI – Value on Investment. VOI is the total measure of benefits derived from soft initiatives; ROI is a component of VOI. The softness of initiatives stems from the underlying assets (e.g., human knowledge, digitised information etc), which are intangibly connected to “hard” ROI. The Gartner Group claims that over time, VOI is increasingly the source of competitiveness, including increased value of brand, new and deeper core competencies, innovation, knowledge creation, increased depth and range of talent, and improved strength and diversity of human and technology networks. For the CEO, VOI may be increasing market value and sustained innovation. For individual business managers, it may be ROI, increasing capacity, efficient business processes and talent development.

Next to these two aspects, which were more or less a consensus, some other aspects of effectiveness were introduced. The architecture is effective if...

- it enables new solutions (new products or services) for existing business problems
- it enables us to be better than our competitor
- the quality of work of the employees improves

On the system level, another aspect for effectiveness is that the information systems generate managerial information. This information must be of high quality, and on time. It can be managerial reports, or generating some alarm when a situation occurs that requires human intervention.

All these aspects are part of what the Gartner Group defines as VOI.

It’s hard not to notice how this concern – effectiveness – is related to an earlier concern – costs and benefits – since hard benefits (gains) are a criterion for effective business.

Conclusion

The conceptualisation of this concern includes:

- Reaching the business goals, or fitting into the business strategy
- Financials

Since effectiveness is understood so differently by different organizations, it is necessary to further refine this definition in every architectural study, by understanding what is important for the business managers. The aspects mentioned above can serve as a guideline.
6.3.3 Facilitate Change

Research done by the Gartner Group (see [9]) shows that 90 percent of enterprises have undertaken a major change affecting at least half of their overall organization in the last two years. Yet, only 5 percent have been free from unexpected problems or time overruns. The Gartner Group predicts that through 2004, enterprises that fail to prepare and support their workforces for major and continuing organizational change will miss business objectives by at least 30 percent and will experience turnover rates of at least 20 percent annually for their key knowledge and leadership workers.

The frequency and scale of organizational change are increasing, and the ability to change is crucial for enterprises.

A change can refer either to **what** an organization does or to **how** the organization does it.

- What an organization does often doesn't change drastically. An insurance company will continue selling insurances; governmental organizations also have stable tasks. But other firms adapt more often to demands for new products, and for these organizations the **what** is very important. They must be able to introduce new products and services, and possibly to address a completely new market.
  
  To this end, the architecture facilitates change when the services are independent from the goals they serve. These are infrastructural facilitating services, which can flexibly be used to meet the goals. This however is not a business explanation, but an expert's definition.

- The second type of change is about **how** organizations carry out their activities. This aspect seems to be very unstable in recent years. Following changes are very common:
  
  - The trend in most markets is to work together with other organizations that are part of a value chain. Integrating your activities with those of other organizations is becoming more and more important, and this is mostly a major change for organizations.
  
  - More and more organizations start using new channels for offering traditional products. The most dominant new channel for many organizations is of course Internet. Such a change often results also in the creation of new departments.
  
  - Mergers and acquisitions create new enterprises. These often address new markets (also a change in **what** organizations do).
  
  - Many enterprises design customer-centric business processes instead of the traditional product-centric business processes.

**Conclusion**

The conceptualisation of this concern includes:

- Changing **what** you're doing: introducing new products and services.
- Changing **how** you do business: integration with business partners, using new channels and redesigning your business processes.

Often all these aspects are important to organizations, but sometimes a subgroup of them is enough. The architect must understand which of these issues are of strategic value for his client, and define which of above aspects must be addressed.

6.3.4 Schedule

When business managers make plans, they think about the future of their organization. Their planning is on a high level. Issues as introducing new products, mergers and winning market share are of great importance for them. Different criteria exist for governmental or other non-profit organizations, but also managers of such organizations will be dealing with the highest-level issues that concern the organization.
A crucial part of planning is stating when things ought to happen. The point in time in which something has to happen, is determined by the business. The architecture can play an enabling role. The other side of an enabling role is being a constraint: the architecture can support some business activity, but what if implementing the architecture takes longer than planned, and as a result a new product cannot be introduced, or it becomes impossible to take over another organization?

With this in mind, we can understand that the following issues are of importance to business managers:

- When will implementation be finished?
- Can I do … on …? (Fill in: business activity or change, date)

This is also the conclusion.

6.3.5 Feasibility and Risk Assessment

Laudon and Laudon ([15]) identify three areas of feasibility that must be addressed in IT projects:

- **Technical feasibility:** whether the proposed solution can be implemented with the available hardware, software, and technical resources.
- **Economic feasibility:** whether the benefits of the proposed solution outweigh the costs.
- **Operational feasibility:** whether the proposed solution is desirable within the existing managerial and organizational framework.

They further state that a project's degree of risk depends on the project size, project structure and experience with technology.

When asked to conceptualise this concern, several experts referred to time and money issues. Time can be understood as an operational matter, which leaves the technical feasibility neglected. An explanation for this might be that business managers leave this aspect to their IT managers.

Other issues that were mentioned by some of the experts are:

- Having enough human resources (enough people with the right knowledge and capabilities)
- It's important that someone the managers consider a reliable source will say he'd go for it, in spite of the risks.
- Showing the manager that the proposed solution is common in the market will make him more willing to accept it. If others take the same risks, and they succeed, why shouldn't we?
- It is important to provide the managers with a plan of how the architect intends to make his suggestion feasible (a realisation plan).

Conclusion

The aspects mentioned here are of two types: what are the threats, and how to convince the managers to take the risk.

The conceptualisation of this concern includes only the first group:

- Schedule risks (see section 6.4.4)
- Financial risks (see section 6.4.1)
- Having the right human resources

Technological risk seems not to play an important role for business managers, maybe because they leave this for their IT managers.
6.3.6 Integration

Integration is a good example for a term that is understood differently by IT experts and business managers. IT experts immediately think of systems integration, whereas business managers immediately think of business integration. This difference plays an important role on the enterprise level.

During an interview with a manager, this difference became very clear. When he was asked to evaluate how important this concern is for him, between 0 and 2, he said: "If you're talking about systems integration, it's 0; if you're talking about business integration, it's 2."

Business managers define integration as bringing together several organizations, and not several systems (as IT experts define it). In this context, an organization may be either an independent entity or a different department in the same entity.

Systems integration is just one aspect of business integration. Theoretically, business integration can take place without requiring systems integration. Depending on the organization, the business manager might also require that the integration is invisible for external parties, meaning that although several entities integrate, for the outsider it still looks like one organization.

In a research note from 1999 (see [10]), the Gartner Group identified Enterprise Integration as a new critical role for architecture.

The Gartner Group notices a rapidly growing need to reach beyond the enterprise to end customers, suppliers and business process outsourcers, where not only the architectures but also the basic infrastructures are divergent. Yet the level of data sharing and the need for timely information intimacy is essential to meet competitive demands. The conclusion is drawn that the only way to cope with this situation is to achieve this type of integration and interoperability through a comprehensive strategy for facile and consistent communication among different applications and even across the chasm of different infrastructures. This approach, which needs to be raised from the divisional or functional level to the enterprise level, is achieved through enterprise integration architecture.

Conclusion

The conceptualisation of this concern includes bringing together several organizations, possibly making this invisible for the outsider. This business integration requires EAI – Enterprise Application Integration.

6.4 IT Managers

Due to the fact that this research is a one man task, within a very limited timeframe, the amount of information gathered about how IT managers define the various terms is not enough to make scientifically sound statements. We therefore do not conceptualise the concerns of IT managers. Instead, the information gathered so far is given as a guideline.

6.4.1 Governance

Following aspects play a role when IT managers consider the term Governance on the system level:

- How the suggested system fits into the picture of all systems together.
- How reliable the suppliers of tools/components/etc are.
- Whether the technology is well supported in the market.
- Whether enough personnel is available that can use the suggested tools or systems.
- Whether the suggested system will also function ten years from now.
6.4.2 Feasibility and Risk Assessment

Following aspects play a role when IT managers consider the term *Feasibility and risk assessment* on the system level:

- Is it technically possible to implement the architecture?
- Having enough people with the right knowledge and capabilities for implementation and exploitation.
- Running out of money. This includes costs of development and exploitation of information systems.
- Running out of time.

6.4.3 Security

Since *Security* is a broadly used term among IT people, and there's quite a good understanding of what it means, this term received a low priority in the research, and too little information was gathered to make any statement.

6.4.4 Compatibility

Since *Compatibility* is a broadly used term among IT people, and there's quite a good understanding of what it means, this term received a low priority in the research, and too little information was gathered to make any statement.

6.4.5 Integration

Like *Security* and *Compatibility*, also *Integration* is a broadly used term among IT people. Also this term (when related to IT-managers) received a low priority in the research. It is nevertheless important to mention again a point we discussed earlier: the difference in the interpretation of this term between business managers and IT people. Whereas business managers immediately think of business integration, when confronted with this term, IT people consider the integration of information systems.

6.4.6 Schedule

The only information received on this aspect is very trivial: having it implemented on time.

6.5 Users

6.5.1 Usability

Unlike *security* and *compatibility*, *usability* is a much less broadly used term. This fact became apparent, when several of the experts asked what exactly is meant with *usability*. Neither of them asked the same question about *security* or *compatibility*. This could serve as an explanation for the variety of answers given by the experts, when asked to conceptualise this term.

Due to the variety of answers, we are unable to define a common conceptualisation. Instead, the answers can serve as a guideline here as well. The answers refer to the system level, and partly also to the domain level. The experts named the following aspects of usability:
6. Contents Analysis – Conceptualisation

- The technology must fit into the user's mental world
- The information systems should prevent the user from making mistakes
- The information systems should not enable the user to give incorrect input
- An ergonomically efficient work place

Several experts stated that the users are only interested in their own work and in what falls under their own responsibility.
Several experts also stated that the users actually do not care about the archITecture. One expert continued by saying that actually it doesn't matter what information we give to the users, as long as we give them the feeling that they are involved in the process. This feeling is, according to the expert, what they want.

6.5.2 Performance

*Performance*, as understood by the users, is also a broadly used term, since most of us are users of some information systems. Who hasn't complained about his Windows-supported computer being too slow?
One expert named it “fluent”. Another named it “fast”. The important thing is that once the user clicks on the “OK” button, he doesn't have to wait long until he receives a reaction. And no blue screens...
One expert gave a nice example to explain how users think of the term *performance*. If carrying out an activity requires going through ten screens, and each of them has a reaction time of one second, the user will consider it fast. But if the same activity requires just one screen, and this screen has a reaction time of three seconds, the user will consider it slow.

Conclusion

The conceptualisation of this concern is getting a quick reaction.

Chapters five and six presented a contents analysis, which is one of the steps of planning a communication process. Once the architect has identified the set of concerns he wants to discuss in his visualization, attention has to be paid to three issues regarding the message he is about to communicate:
1. Which contents elements are absolutely required?
2. Which motivating (encouraging) elements are to be used, to create the right atmosphere?
3. Which redundant information will be included in the message?

6.6 Conclusion

The conceptualisation of concerns is part of answering the question “what to visualize?” It is necessary, since multiple groups have a different mental model of the various terms we use. *Integration* is a good example.
This chapter has turned a set of abstract concerns into a set of tangible subject to discuss when architects communicate with business managers. Not enough information was collected to make the concerns of other stakeholders just as tangible.
Having analysed the influencing factors, including the question “what is the message we want to communicate?”, the next step in preparing the communication process is communication design. This step tackles the question “how to communicate our message?”. The answer to this question considers three main aspects of communication design:

- The structure of the message
- The encoding of the message
- Using (audio) visual tools

7.1 Chapter Summary

Discussing the question “how to visualize architectures?” is split into the three aspects of communication design, two of which are very shortly considered in this chapter. The emphasis of this research is put on the next chapter, where the third aspect of communication design is discussed. In this chapter we present guidelines that refer to structuring messages and encoding them. The guidelines provided in this chapter and in the following one form the most important outcome of this research.

7.2 The Structure of the Message

A message consists of a start, a main (middle) part and an end. All three of them have to be planned, based on all aspects of communication that we discussed so far, and in a way that serves the goal of the communication process. The structure of the message is also important for keeping the attention of the public, which tends to disappear fast. Multiple structures that support the various goals of the communication process are discussed in [14], but will not be discussed here. Instead, we present one guideline that applies for this step of the communication process.

**Guideline 1: Present hard benefits first, and then soft benefits.**

The conceptualisation of the term costs and benefits revealed that business managers consider it to refer also to other benefits than financial ones. Benefits can therefore be divided into hard benefits (measurable in money) and soft benefits (not measurable in money). According to research, done by the Gartner Group ([5]), presenting hard benefits first establishes good faith and allows the subjective soft benefits to enhance the hard benefits. Presenting soft benefits first, even if they are the most significant, is less effective, because there is no quantifiable base established on which the subjective, non-quantifiable, value can build.

We adopt this guideline, given by the Gartner Group.
7.3 The Encoding of the Message

Encoding means giving the contents elements an observable form that serves our goals. As we explained in chapter 2, it refers to the use of language, as well as to secondary communication tools, such as intonation, tempo and eye contact.

Also this step is discussed in [14], but will not be discussed here. Instead, we present one guideline that applies for this step of the communication process.

**Guideline 2: Refrain from using jargon.**
Visualizations should include no more than few terms that business managers are unfamiliar with, and as many as possible terms that managers are familiar with. This guideline serves to make the visualization accessible for managers, and to win their trust. If the architect uses jargon that the business managers are not familiar with, his message won’t be understood, and he will lose the attention of his public, which will lead to the failure of the communication process.

This guideline applies for the whole communication process, and ought to be applied in creating visualizations as well.
8 Communication Design – How to visualize?

Using (audio) visual tools is part of the communication design step of a communication process. Visual tools make it easier for the audience to understand the message. They therefore play an important role when the subject of the message is complex or when the audience is unfamiliar with the subject.

8.1 Chapter Summary

This chapter discusses the question “how to visualize architectures?”, which is the main question posed in this research. Earlier chapters presented various subjects that ought to be discussed in order to be able to reason about this question. The use of (audio) visual tools is an optional step in the communication process. We argued in chapter 5 that business managers require visualizations to understand architectures. In this chapter, we therefore consider various types of visualizations, and present guidelines for creating good visualizations. Where necessary, we identify the implications that these guidelines have for architects.

The most important guidelines are listed below. We termed them ViSuAL DreaM, using an acronym to ease memorizing them. We consider the first guideline to be the most important one; the rest are listed here in the sequence of their appearance in the acronym.

- Managers require powerful Mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes.
- Use Verbal communication to present an architecture, and not textual documents.
- Architecture visualizations must support Switching between the architect’s profession and the business manager’s profession.
- Visualizations should demonstrate that the architect speaks the business manager’s Language.
- Architecture visualization must be Dynamic.
- The visualization of an architecture must be Related to the mental model visualization.

We also analyse several ways of creating visualizations, list their pros and cons, reason and make recommendations about their use.

To fully understand the theory about how to visualize, chapter 9 has to be read as well.

8.2 Introduction

Visualization is a communication tool that supports the more-basic verbal communication, where a message is conveyed from a sender to a receiver. It illustrates the message, and thereby makes it more understandable and increases its effect.

When considering the term visualization, many people immediately think about pictures. Information systems experts often think about a subset of the term pictures: diagrams.
In our study, we adopt definitions given by The American College Dictionary ([1]):

**Visualize:** To make perceptible to the mind or imagination.

This calls for a definition of “perceptible” or “perceive” as well:

**Perceive:** To gain knowledge of, through one of the senses; discover by seeing, hearing etc.

The reader is encouraged to read these definitions once again, and to consider every word with the same importance.

One can understand from these definitions that visualizations may include much more than pictures; visualizations may include physical (3D) models made of wood, concrete, plastic or any other substances, music, films, smells, flyers and many other options.

Being aware of the fact that many types of visualizations exist, is the first step in utilizing this tool in a way that serves our goal. In the rest of this chapter we analyse the various factors that influence the choice of certain visualization methods, and present guidelines for creating visualizations for architectures. Whenever the guideline is rather theoretical, or the way to use it does not speak for itself, its practical implications are discussed as well. The guidelines are not ordered according to their importance; they are always related to the subject, which is discussed in a specific section.

The goal of this research project is investigating how architectures can be visualized to support the decision-making process of business managers. However, a main conclusion of the research is that before presenting a visualization of a specific architecture, the audience needs to have a suitable mental model of architectures. We therefore discuss two steps in visualizations:

1. A visualization for creating a mental model
2. A visualization of a specific, suggested architecture

It is important to notice that the question “how to visualize?” may be answered in a different way, when discussing a different stakeholder. Influencing factors as intellectual level, cultural background and environment of presentation determine whether it is better to use hints, or to be straight to the point, whether cartoons or photos should be used and more.

### 8.3 Three Aspects of Visualization

Following aspects play an important role in creating visualizations:

- **Contents:** what is our message?
- **Medium:** which visualization tool will we use to convey the message?
- **Design:** a policy for how it will look like

**Contents**

*Contents* refers to the question “what do we want to visualize?”. Before preparing any visualization, one has to define which message should be conveyed to the audience by the visualization: what is the story that the architect wants to tell by means of visualization?

**Medium**

With a *medium* we refer to a type of visualization, through which the desired effect is produced. The effect, in our case, is supporting decision-making by informative means. Examples of media are PowerPoint presentations, diagrams and physical models.
8. Communication Design – How to Visualize?

Design
Once the architect has defined **what** the contents of his visualization ought to be, and **how** he will convey the message (by what medium), a proper, supporting design line has to be decided upon. The design line has to be consistent through the whole visualization, thereby helping the human brains recognize ideas and patterns, and make links between the various parts of the visualization.

It is possible to define objectively what a visualization should present (the contents). Choosing for a specific medium is more subjective: more than one medium may serve us well, although often one or two media will clearly be more effective than others. Choosing a design line, on the other hand, is a very subjective matter. No two designers will produce the same design, even when using the same medium to convey the same message. Moreover, one designer will probably be able to come up with several designs, all of them just as good.

A design line is good if it is consistent, if it helps the human brains recognize links, patterns and ideas, and thereby understand and remember the contents of the visualization better. Furthermore, it has to present no elements that the human brains or eyes reject, such as the use of certain combinations of colours. Text must always remain readable.

In the rest of this chapter we first discuss guidelines that are relevant for the whole process of visualization, and then present guidelines per step of the visualization. Those guidelines that we consider as the most important ones are marked:

(Very Important Point).

True to the goal of this research project, the guidelines apply for visualizations made for business managers who need to understand architectures well enough to be able to make a right decision. When we speak about a visualization in this document, we therefore refer to a visualization for business managers, for the above-mentioned goal. Many of the guidelines however apply for other situations as well, possibly for any visualization.

8.4 General Guidelines

General guidelines apply for all visualizations, independent of their type. We divide our guidelines to three groups: those related to the contents, those related to the medium and those related to the design.

8.4.1 Contents

Chapters 5 and 6 discussed the contents of the message to be conveyed through visualization. We present here two contents-related guidelines for creating visualizations.

**Guideline 3: Visualizations should demonstrate that the architect speaks the business manager’s language.**  
(Very Important Point)

We have already mentioned the gap between business people and IT people. Architects are mostly considered as members of the latter group. The two groups have different frames of reference and they speak different jargons, almost different languages. They are familiar with different terms, and as the managers’ personality analysis (presented in chapter 4) shows, they think differently then the typical architect does.
Solving this communication gap would be very beneficial for both groups, and requires effort from both of them. However, this document is targeted mainly at architects, and not at business managers. We therefore emphasize how important it is that the architect learns to “speak the language” of the business manager. By using this expression we mean:

1. Be familiar with what is of importance for the manager
2. Be familiar with the business issues that the manager daily deals with
3. Be familiar with business terms and be able to use them
4. Be able to link IT reasoning to business reasoning

The first and the second points are general, and are actually required in any communication process.

In interviews conducted for this research, business managers emphasized the importance of points three and four. It appears that an architect, who succeeds in switching between his profession and that of the business managers, wins the trust of business managers.

Practical Implications:
This guideline is one of the most important ones, and yet one of the hardest to implement, which is a reason why the communication gap between IT people and business people exists. The implications of this guideline for the practicing architect are:

- An architect, even one who deals with technical issues mainly, is required to have knowledge of business.
- In every architectural study, the architect is required to gain some knowledge about the specific field of business of his client (chips production, life insurances, airlines etc).
- In every architectural study, the architect is required to investigate what the priorities of his current client are.

The by-far most important implication is:
- A critical success factor in winning the trust of managers is the architect’s ability to switch back and forth between his profession and that of the manager. We assume that if the architect does not win the managers’ trust, the architectural study will not have a successful end. The managers will either not accept the architect’s suggestion, or not back it and not support it with their commitment.

The architecture visualizations must therefore support switching between the architect’s profession and the business managers’ profession. Switching between these two professions, or two worlds, has to be a key element in the visualization. Because this implication is so crucial, we will give it the status of a guideline, and not just an implication of a guideline. It is however a medium-related issue, so we will list it in the section “Medium”.

Guideline 4: Hide complexity, be fast and short.

This guideline is one of the conclusions of the earlier presented personality analysis of our audience: business managers (see chapter 4). The background of this guideline is the heavy workload of managers, the complexity of their work and their preference for short activities. Hiding complexity is required in order to make the material understandable for business managers who do not master the art of archITectures. By being fast and short, the architect adapts himself to the work pace of managers.

One of the managers that we interviewed for this research, described visualizations as the art of omitting (“de kunst van het weglaten”, in Dutch). The trick is to find a good balance; present enough information so that the manager will understand the message, but not more than this.
Guideline 5: The way to relate “AS-IS” and “TO-BE” archITectures to each other depends on the architect’s goal.

Architects often present the present situation (called "AS-IS") and the future (desired) situation (called "TO-BE"). The decision whether to place both pictures next to each other or after each other depends on the architect’s goal.

The background of this guideline, as well as definitions of the terms Left Visual Field (LVF) and Right Visual Field (RVF), which we will use here, are given in appendix A.

Often the architect’s intention is to establish a trajectory or vector (neural spike train) that leads from one state (AS-IS) to the other (TO-BE). Then he should present the two situations sequentially in close succession (first AS-IS, then TO-BE) so that the audience can establish a direction and momentum (phase velocity) for the trajectory to become stable. If however, establishing a trajectory is not the architect’s intention, but the TO-BE situation serves as a reference, compared to the current, perceived situation (AS-IS), the two situations can best be presented next to each other (AS-IS in the Left Visual Field; TO-BE in the Right Visual Field), instead of sequentially presenting them as two different visualizations. This is due to the fact that it’s common for people to place their "past timeline" in their LVF and their "future timeline" in their RVF. In such a case, presenting the AS-IS and the TO-BE situations simultaneously in the mentioned orientation would be most effective to allow the subject to compare and contrast images. The result of this would be the incorporation of AS-IS and TO-BE as a single replicatable information pattern.

8.4.2 Medium

Guideline 6: ArchITecture visualizations must support switching between the architect’s profession and the business manager’s profession.

This guideline was discussed in section 8.4.1 (guideline 3), so the discussion will not be repeated here. We argued that switching between the two professions was identified as a key factor in winning the trust of managers. As a result, this guideline is one of the most important ones for archITecture visualizations.

Guideline 7: Use verbal communication to present an archITecture, and not textual documents.

Although this subject was already discussed in chapter 4, as part of the managers' personality analysis, we repeat some of the discussion here, for the sake of continuity. The organization theorist Henry Mintzberg states that “managers strongly favour the verbal media – namely, telephone calls and meetings. The evidence comes from every single study of managerial work.”

In [17], he explains why managers prefer this type of communication:

- Verbal communication enables to “read” facial expressions, tones of voice and gestures.
- Verbal communication enables the manager to engage in the “real-time” exchange of information.

Verbal communication is opposed to the written forms, namely reading and writing, which are ordered and sequential.

Mintzberg draws the conclusion that managers' concentration on the verbal media suggests that they desire relational, simultaneous methods of acquiring information, rather than the ordered and sequential ones.
8. Communication Design – How to Visualize?

Practical Implications:
The architect should use verbal communication for communicating with business managers at all phases of the architectural study, including meetings with the management, in which the architect presents his architecture by using visualizations:

- Visualizations must support the verbal communication with the managers, and not vice versa. Tools (as visualizations) must support the architect’s story, but not replace it.
- Visualizations can include elements in which “reading” facial expressions, tones of voice and gestures is possible. This can be achieved through using photos, films and sounds in the visualizations.
- As mentioned before, verbal communication enables the manager to engage in the “real-time” exchange of information. Visualizations should therefore be part of a discussion with business managers.

8.4.3 Design

Guideline 8: A visualization must have one consistent design line through all parts of it.

The design line has to be kept through the whole visualization, thereby helping the human brains recognize ideas and patterns, and make links between the various parts of the visualization.

By using a design line we establish a design relationship between the various parts of the visualization. When the audience recognizes this relationship, it lays the necessary link and thereby understands and remembers the contents of the visualization better.

Guideline 9: By using items that the audience recognizes, the audience identifies itself with what it sees, and is more willing to accept it.

‘Items that the audience recognizes’ might be the office where the manager works, sounds or people he knows, famous characters or known situations, such as a clerk sitting to work. These don’t have to be related to the architecture, as long as they can be linked somehow.

Using a picture of Marilyn Monroe smiling can be useful when the architect wants to visualize (client) satisfaction, for example. A smiling client is satisfied. But be ware: the architect must be able to explain why he is using these items. If the architect cannot give a good reason why he’s using Marilyn Monroe’s picture in a specific situation, then the picture should not be used, or it will seem out of place and create a negative effect.

Practical Implications:
The manager is always familiar with his office, his secretary and some of his employees. Using them in the visualization, in one form or the other, is likely to make the manager identify with what he sees, and thereby accept it.

When using items of famous people (pictures, movie clips, sounds) make sure you’re using items that practically everyone knows. Of course, you might accidentally run into a manager who does not recognize an image of Marilyn Monroe… But that’s a calculated risk.

Using personal items is not recommended, since the visualization will be used in a business connotation, and it will be presented to several managers. You can never know how a manager would react if you present something personal in the presence of other managers.

It is possible to give a hint for a joke, which includes something familiar (a known person, a situation etc). By doing so, we address the intellect of the audience. If the audience understands the hint, and therefore recognized the joke, it will feel content, since “not everyone would have understood that”. Before applying this method, it is necessary to estimate the intellectual level of the audience. Since we are dealing with business managers, the method can be used safely.
**Guideline 10: Use colours to communicate.**

As Horton explains ([13]), designed colour-graphics can add a lot to visualizations. Colour helps viewers make quicker and more accurate decisions about complex and detailed information. By organizing and classifying information, colour lets people handle more information, process it more efficiently, and apply simpler and more efficient decision-making strategies.

Next to aiding decision-making, colour also focuses people’s attention. Colours can also cause problems though, if used improperly. Though common, most of the problems with colours are easily corrected or avoided. Main problems related to the use of colours, as given in [13], are:

- Colour distracts. Excessive or irrelevant use of colour can distract viewers and hinder performance by drawing attention away from information the viewer seeks.
- Colour tires the eye. Long exposure to broad areas of colour can prove fatiguing. Red causes the greatest fatigue, blue the least.
- Prior associations interfere. The perception of colour is highly subjective and personal. Private associations may interfere with the intended message. Consider the emotional associations of colours. We turn purple with rage, go green with jealousy, blanche with fear, blush with embarrassment, develop a yellow streak of cowardice, get into a brown study, and sink into a bad case of the blues.

As this guideline states, colours should be used to communicate. In order to make sure that they are used properly, we list several rules for good use of colours. Remember that colour perception is so highly subjective, that precise rules for colour harmony and aesthetics are impossible. Still, we can use guidelines to avoid colour combinations that many people find ugly or offensive.

1. Avoid conflicting colours. Avoid putting spectrally distant pure colours, such as red and blue, side by side. Be careful also with combining red and green, or blue and yellow.
2. Use colours consistently. For unity and coherence, use the same colour scheme and colour codes. For a coherent set of colours, start by picking one dominant colour. Then select a set of compatible, secondary colours.
3. Avoid colours that people dislike. Western viewers tend to prefer colours in this order: blue, red, green, purple, orange and yellow. Prefer subtle and pleasing colours to primary colours (true for adults).
4. Use different colours for different ideas. Viewers may inadvertently associate ideas merely because they were presented in the same colours.
5. Group spatially separate items. Colours can show which of several objects are related. To show that objects are of the same class, category or type, show them in the same colour. Display similar or related objects in distinguishable but similar colours. The eye groups first identical and then complementary colours.
6. Call attention to a small object by giving it a distinct, conspicuous colour. Choose a colour that contrasts with the background and other colours.
7. Emphasize a small area by using a distinct colour with moderate lightness contrast with its background. For large areas use lower-contrast pale or dark colours, especially if they represent secondary information, ongoing themes, or motifs.
8. To de-emphasize or hide an object, display it in a colour close to the background colour.
9. Reading coloured text is often slower and more error-prone than reading black and white text. If you do use colours for text, ensure lightness contrast between foreground and background. Avoid low contrast combinations like yellow on white or navy blue on black.
10. Compensate for colour-blindness. To overcome problems caused by colour-blindness, use colours as a redundant (supporting) signal, and not as the main signal.
11. Table 16 (see next page) lists which colours you should use, based on the number of colours you need and on the background.
Guideline 11: When presenting pictures and text at the same time, present pictures on the Left Visual Field, and text on the Right Visual Field.

The visual field is the total area where objects can be seen while the eye is focused on a central point. The Left Visual Field (LVF) is what the eye sees on the left side of that central point, and the Right Visual Field (RVF) is what the eye sees on the right side of that central point.

The background for this guideline is given in appendix A. The main idea is that the human brain is divided into a right hemisphere and a left hemisphere. The right hemisphere, which is better in processing images, sub serves the LVF, and the left hemisphere, which is better in processing text, sub serves the RVF.

Furman indicates ([3]) an increase in performance when presenting pictures on the LVF, and text on the RVF. He indicates that many different types of information processing contexts can be reliably predicted when pictures are presented to LVF and text is presented to RVF. Mixing or swapping visual fields would add time and interference to the processing effort due to the need for that information to cross back over the corpus collosum in order to generate (represent) the information pattern in the brain’s “highest convergence” cell assemblies.

<table>
<thead>
<tr>
<th>For this number of colours:</th>
<th>On a white background use:</th>
<th>On a black background use:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Red, green</td>
<td>Yellow, cyan, green</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magenta, cyan, green</td>
</tr>
<tr>
<td>2</td>
<td>Red, blue</td>
<td>Magenta, cyan</td>
</tr>
<tr>
<td></td>
<td>Red, green</td>
<td>Magenta, green</td>
</tr>
<tr>
<td></td>
<td>Magenta, green</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Red, blue, green</td>
<td>Red, blue, green, violet</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magenta, cyan, yellow</td>
</tr>
<tr>
<td>4</td>
<td>Red, blue, green, yellow</td>
<td>Red, blue, green, yellow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Magenta, cyan, yellow</td>
</tr>
<tr>
<td>5</td>
<td>Red, orange, green, blue</td>
<td>Red, orange, green, blue</td>
</tr>
<tr>
<td></td>
<td>violet</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Red, orange-red, orange</td>
<td>Red, orange-red, orange</td>
</tr>
<tr>
<td></td>
<td>yellow, yellow-green,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>green, bluish-green,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>greenish-blue, blue,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>violet</td>
<td></td>
</tr>
</tbody>
</table>

Table 16 Colour combinations

8.5 The First Step: Creating a Mental Model

8.5.1 The Mental Model Guideline

Multiple archITecture visualizations were presented by architects or discussed in the framework of this research. Almost all of them had in common that the contents of the visualization was the knowledge and information that the architects wanted to transfer to the audience about their archITecture, and not more than that. Although this sounds very normal and even expected in first instance, the research identified this point as a major weak point. According to the findings of this research, an earlier step is required, before the architect can start discussing archITecture-related information. This step is creating a mental model of architectures among the audience. Skipping this step can be compared with telling a two-years old child how much a car costs, without first explaining to him what “money” is. If
he isn’t familiar with the notion of money, he won’t be able to assess whether or not a car is expensive.

We discussed mental models in chapter 4, as part of the personality analysis of business managers. We now present it as one of the major guidelines for creating visualizations. The discussion presented earlier will not be repeated here.

**Guideline 12:** Managers require powerful mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes.

As explained in chapter 4, the mental model helps the manager “see the big picture”. Whenever an action is contemplated, the manager can simulate the outcome using his mental models.

The need for a mental model also rose during interviews with managers, performed for this research.

In the introduction to this chapter, we stated the following:

“When considering the term visualization, many people immediately think about pictures. Information systems experts often think about a subset of the term pictures: diagrams.”

Note that what we called “think about” refers to the mental model discussed here. A mental model is what a person envisions, when he thinks of something. The mental model gives a frame of reference, which is required in order to reason about any issue.

Norman defines mental models ([20]) as “the internal representations that humans develop of themselves and the objects they interact with in the world”. Mental models are incomplete, subject to change, possibly inconsistent and based on imperfect observation and inference. In spite of these drawbacks, they are absolutely necessary, as mentioned before, in order to be able to discuss anything, to simulate outcomes, and therefore also to make decisions. Norman adds in [21] that people form mental models through experience, training, and instruction.

A mental model of architectures has to give the manager a frame of reference to use when reasoning about architectures.

### 8.5.2 Practical Implications

This guideline can be translated into a simple “if… then…” sentence: if business managers do not have a suitable mental model of architectures, they will not be able to make decisions concerning architectures. Since decision-making is the ultimate goal of our visualizations, this guideline is a crucial one.

In chapter 4 we presented a reasoning, starting with statements made during our interviews and ending in the conclusion that business managers have no mental models of architectures. This reasoning is also supported by Norman’s statements on how people form mental models. In many cases the managers, who are the audience of an architect, are inexperienced with architectures. They definitely weren’t trained in it. They therefore could never have formed a mental model of architectures.

The practical implication of this guideline is easy said: architects must ensure that business managers have a good enough mental model of architectures, before they present a specific architecture. Next section discusses the implementation of this guideline.
8. Communication Design – How to Visualize?

8.5.3 Implementation Issues

Contents
As mentioned before, a mental model of architectures has to give the manager a frame of reference to use when reasoning about architectures. A visualization that aims at creating a mental model must therefore include information about the fundamentals of the architectural model. Defining these fundamentals could be a subject for many discussions, as most architecture-related debates are. We present here what we believe to be some main issues in architecture. These will guide us in creating a mental model visualization:

- Architecture is a layered model
- What are the various layers of architecture, at a high level of abstraction
- Changes and decisions in one level influence other levels as well
- Weighing interests as a result of possibly conflicting requirements of multiple stakeholders

Medium
We considered several options for visualizations that create a mental model of architectures:

- A physical (3D) model
- A slide-presentation (using PowerPoint, Director or similar tools)
- A game

A physical model is a practical way to explain that architecture is a layered model. Such a model can be placed in the manager’s room, making it something familiar, and therefore not threatening. However, it isn’t enough for creating a strong enough mental model. We’ve seen such a model built of lego in a manager’s office during the research. The model was good enough to convey the message that architecture is a layered model, but that is not enough. We did not encounter or investigate any complex physical models, which might be powerful enough to replace the other two methods (slide presentations and game). We consequently suggest that such a physical model can be used to support other visualizations, but not as the only or main visualization.

Slide-presentations, using PowerPoint, Director or similar tools, are a well-known and widely used technique for other purposes. Most architects probably are familiar at least with PowerPoint. We identified that it’s necessary that such a presentation includes, among others, one slide or image, which gives the whole picture of the architecture, from the manager’s point of view. Two issues of importance are:

- Providing the whole picture in one slide requires a very high level of abstraction, omitting most of the details.
- The slide should present what the architecture is for the manager, and not necessarily for the architect. It must therefore include information the manager is familiar with, and not a set of terms from the information systems world. Once again, the slide does not have to introduce “the architecture”, but what the architecture means for the manager.

Several companies in the Netherlands, for example Atos Origin Nederland b.v. offer a monopoly-like architecture game, which demonstrates the consequences of working under architecture and working without architecture. Managers (preferably top managers: CEO, CFO, CIO and IT manager) play the game under supervision of Atos Origin’s consultants. In an intensive game that requires cooperation between the various managers, they learn what consequences IT decisions have for the business, how business-change requires change in IT and when this change is possible or not. Aspects as short term planning vs. long term
planning, flexibility and costs of building and maintaining information systems are addressed in about 3 hours, followed by an evaluation session.

We saw also a different type of architecture game, which concentrated on the business aspect of working under architecture, instead of on the alignment between IT and business. This game was invented for internal use by an organization that considered introducing archITecture as part of its regular business. The game created among the playing managers a willingness to work under archITecture. However it was noted that if the managers do not have a positive attitude about working under archITecture in advance, the game would not reach its goal. They are not required to recognize the importance of working under archITecture in advance, but they must be willing to learn why working under archITecture is beneficial for them. This requirement wasn’t experienced as a critical success factor by the team of Atos Origin, whose game tries to create this positive attitude.

Table 17 presents a comparison between two types of visualizations that can create a mental model of archITectures.

<table>
<thead>
<tr>
<th>Slide presentation</th>
<th>Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carried out by…</td>
<td>An architect</td>
</tr>
<tr>
<td>Costs</td>
<td>1 day of work</td>
</tr>
<tr>
<td>Required time to present/play</td>
<td>A few minutes</td>
</tr>
<tr>
<td>Pre condition</td>
<td>Good preparation by the architect (who prepares the presentation and gives it)</td>
</tr>
</tbody>
</table>
| Main obstacle(s)   | No major obstacles were identified | 1. Creating a prior positive attitude towards working under archITecture  
2. Getting all managers together for half a day, without interruptions (no mobile phones!) |
| Impact             | The minimum mental model necessary | Deeper understanding; sound mental model; important tool for simulating outcomes |

**Table 17 Comparing visualization media for establishing a mental model**

**Recommendation**
As can be understood from the table, the architecture game requires more work, preparations and resources than a presentation, but has a much stronger impact on the managers.

We propose to use both a slide-presentation and the architecture game, depending on the stage of the architectural study. A slide-presentation can be given in a very early stage, when the architect accepts his task from the managers, as well as when he introduces (possibly parts of) his solution. The architecture game can be used in between. In situations where the architect is not an external expert, but works for the company that the managers manage, the game can be played, independent of any architectural study, as part of explaining to the managers how important working under architecture is for their business. A simple physical model can then be used to support the other methods, mainly by making archITecture part of the manager’s natural environment, thereby creating a positive attitude towards it.
8. The Second Step: Visualizing Architectures

A visualization for creating a mental model is a necessity, but much more time and investments are required later, when creating a visualization of a specific suggestion for an architecture (a whole solution), or parts of it (a partial solution).

8.6.1 Contents

As discussed in chapter 5, the visualization is not required to give a complete picture of all aspects of the architecture. Instead, it should focus on the aspects that are of main importance for the audience (business managers) and deal with issues that the audience has to make decisions about.

In chapter 5 we identified the following sets of concerns in architectures as most important for business managers. These are listed in table 18.

<table>
<thead>
<tr>
<th>Basic Set</th>
<th>Enterprise Architectures</th>
<th>Domain Architectures</th>
<th>System Architectures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs and benefits; Effectiveness; Facilitate change</td>
<td>Costs and benefits; Effectiveness</td>
<td>Costs and benefits; Effectiveness</td>
<td></td>
</tr>
</tbody>
</table>

Table 18 Business managers’ sets of concerns

Next to discussing the important concerns of business managers, the visualization has to concentrate on business issues that occupy the manager’s thoughts. If the reason for the architectural study is a planned merger, the visualization must concentrate on such a merger. If the reason for the architectural study is a reorganization to save costs, this has to be the main issue discussed in the visualization.

The meaning of the above-mentioned concerns was discussed in chapter 5. For the sake of continuity, we'll shortly repeat them here.

Costs and benefits

We first defined the term budgeting. Later we learned that business managers consider this term as broader. For them, it refers to all costs and benefits, whether financial or not.

Effectiveness: The capacity to enable users to achieve specified goals with accuracy and completeness in a specified context of use. (Based on the ISO/IEC standard 9126-1:2000). In the context of enterprise architectures, the goals are the business goals of the enterprise. In the context of domain architectures, the goals are the business goals of at least part of the enterprise. In the context of system architectures, the goals are those business goals of (possibly part of) the enterprise, which play a role in the definition, and usage of the information system.
Facilitate change: The degree to which the architecture and the related information systems enable future business changes, and a description of such foreseeable changes and how they are facilitated.

Feasibility and Risk assessment:
- **Feasibility:** The degree to which the requirements, design or plans for an architecture can be implemented under existing constraints. (Based on the IEEE standard 610.12-1990).
- **Risk:** A measure that combines both the likelihood that a hazard will cause an accident and the severity of that accident. (Based on the IEEE standard 1228-1994).
We consider “an accident” to be anything that jeopardises either the process of setting up a suggestion for an architecture or the process of implementing this suggestion.

Integration: The process of combining components into an overall system. (Based on the IEEE standard 610.12-1990).
In the context of enterprise architectures, we consider integration of business processes of multiple enterprises and their information systems.
In the context of domain architectures, we consider integration of business processes of multiple enterprises and/or various parts of one enterprise and their information systems.
In the context of system architectures, we consider integration of one specific system and its environment with other systems (possibly systems of multiple enterprises) and their environments.

Schedule: All matters that concern time regarding the setting up of a suggestion for an architecture and implementing it.

We mentioned already that visualization is part of a communication process, the goal of which is informative; the architect wants to provide managers with information they require for decision-making. The contents of the visualization should comply with this goal, meaning that facts must be presented – both positive and negative facts. One should not try to “sell” the architecture to the managers, since that does not serve our long-term goal.

**Guideline 13:** The visualization of an architecture must be related to the mental model visualization.

Earlier we mentioned the fact that the design of both presentations has to be consistent. We now refer to the contents of both visualizations: those aspects that we emphasized in the mental model visualization (architecture is a layered model, and the layers are related to each other; possibly conflicting interests must be weighed) should also be emphasized in the visualization of a specific architecture. This way, the manager recognizes what he sees, and can use his mental model in order to reason about the architecture. If the manager doesn’t link both visualizations to each other, they are not good.

**Practical Implications:**
This guideline determines our strategy in implementing the visualization of an architecture. The main issues in our mental model visualization are, as mentioned earlier:
- Architecture is a layered model
- What are the various layers of architecture, at a high level of abstraction
- Changes and decisions in one level influence other levels as well
- Weighing interests as a result of possibly conflicting requirements of multiple stakeholders
These issues must therefore receive a central role in the visualization of a specific architecture as well.
This statement might seem to be in contrast with what we said earlier: concentrate on the most important concerns; but there is no contradiction. The right thing to do is to present a visualization of a layered model, emphasize the various layers and their interactions and discuss stakeholders with their conflicting requirements. Concentrate on the important concerns within this process.
The starting point should therefore be a model of interacting layers; the interaction should concentrate on the important concerns.
The wrong way would be to take the important concerns and discuss them, independent of the layered model. This is wrong, since it does not match the mental mode that we created, meaning that the manager cannot use his mental model. The starting point should therefore not be the concerns, but the model of interacting layers.

8.6.2 Medium

Choosing the right medium is crucial for ensuring the success of the communication process. When choosing a medium, the following guideline plays an important role, next to the earlier mentioned guidelines:

**Guideline 14: Architecture visualization must be dynamic.**

Three major aspects of architectures require a dynamic approach:
- Decisions taken regarding one layer of the architecture influence flexibility and possible ways of action in other layers.
- Consequences of decisions often become visible some time after making the first decision.
- Businesses keep changing as time goes by, requiring constant change in architectures. Dynamic visualizations also have a design-related aspect: it keeps the audience alert. On the other hand, the effect of a dynamic tool becomes weak when it is used excessively. It is therefore necessary to bring static and dynamic into balance: if the visualization is mainly static, the audience will be bored; if the visualization is mainly dynamic, the effect of dynamics is lost.

**Practical Implications:**
A static visualization is not suitable for reflecting constant change. Neither can it express consequences as a function of time well enough. In order to visualize these aspects of architectures, a dynamic medium has to be used.

We considered the following media:
- Computer games
- Movies
- Slide-presentations (using PowerPoint, Director or similar tools)
- Physical models
- Posters

**Computer Games**

Architectures are often compared to those of the “physical world”. Enterprise architectures are compared to city planning, domain architectures are compared to architectures of neighbourhoods, and system architectures are compared to architectures of houses.
ArchITectures describe structures and relationships (as well as other things), like in the “physical world”. Two rather known computer games exist which manage to visualize structures in a good way. These are SimCity and DOOM.

**SimCity** is a simulation learning game. The player is the mayor of a city that he is responsible for building and managing. SimCity is a system simulations game, where the system is a city. The player is provided with a set of rules and tools that describe, create and control a real or imaginary city. The challenge is to figure out how the system works and take control of it. Then, as master of the system, the player is free to use the tools to create and control an unlimited number of systems - cities - within the framework and limits provided by the rules.

The rules are based on city planning and management; resource management, factors influencing land value, human factors, strategies for dealing with disasters, unemployment, crime and pollution, and the quality of life in a city. Some of the tools provide the player with the ability to plan, layout, zone, bulldoze and re-zone a city, build roads, airports and sea ports, set up and maintain a power grid and more. But the most important tool is a simulator with which the player can test his plans and ideas as he watches the city grow or shrink through the immigration and emigration of industrious Simulated Citizens (Sims). Sims will move in and build homes, hospitals, churches, stores and factories, or move out in search of jobs or a better life elsewhere. The success of a city depends on the player's design and management skills.

**DOOM**, unlike SimCity, is not a simulation game. If simplified to the core idea, DOOM is a game in which the player moves around a virtual-reality building, shooting at anything that moves and trying to find his way out of the building, thereby learning how the building is constructed.

Both games have features that can be of use in archITecture visualizations. If we adopt the SimCity approach, then an archITecture simulation tool could be developed with which managers would be able to create archITectures, and thereby learn the implications of their virtual decisions. This may help them understand archITectures better than any other tool.

A DOOM-like visualization of archITecture (without shooting) would not provide a simulation mechanism. The playing manager would have to travel in his virtual city, neighbourhood or house (standing for an enterprise archITecture, a domain archITecture or a system archITecture) and explore how it is built: of what pieces and how the pieces are connected to each other.

Both tools sound rather promising, especially SimCity, since it provides the possibility to simulate outcomes of decisions. Such a game provides the necessary dynamics (guideline 14) and can be given to a manager on a CD, or on a laptop, and the manager could then start to play, and thereby learn.

However, we found out that this medium is not suitable for business managers, due to several reasons:

- It is practically impossible to create such a good tool for visualizing archITectures; the number of questions that managers may pose is huge, and the questions cannot all be foreseen. A computer game would have to give an answer for all these questions, which is not feasible.
- A computer game poses a too high an obstacle for managers; it requires that they install it and learn how to use it; only then can they start using it. This requires too much time and effort.
- Managers do not like computer games. The term ‘computer game’ by itself is enough to ensure that they will not use this tool. They won’t spend time playing a computer game.
- Managers might think that we don’t take them seriously, if we let them play computer games.
• It is important that the architect establishes contact with the managers, and uses verbal communication to convey his messages (guideline 7). This is not the case with a computer game, which managers would play alone.
• Both games do not hide complexity (guideline 4); on the contrary, the player gets to see the smallest details.

Recommendation
The idea of using a computer game as a medium was rejected due to two main reasons: building such a tool is not feasible, and the type of tool is not suitable for business managers’ character.

Movie Clips
Movies can be shot especially for the sake of architecture visualization. It’s also possible to use an existing movie clip, which was shot for another occasion but is coincidentally also suitable for this one. The latter type is very hard to find, and therefore often not feasible.

Movies have several characteristics that make them very suitable for visualizing architectures:

• Movies are a dynamic medium (guideline 14); they enable presenting change-scenarios and consequences of architectural decisions.
• Movies enable to “read” facial expressions, tones of voice and gestures, and to engage in the “real-time” exchange of information. As mentioned in guideline 7, these are the reasons that managers prefer verbal communication to textual communication. Movie clips are therefore likely to be favoured by managers.
• Movies can be shot in the natural environment of the manager (his office, or his firm). This would add to his willingness to accept the contents of the movie (see guideline 9).
• A movie clip is presented to the manager by the architect, and a discussion is very likely to follow. It therefore supports the need for personal, verbal communication between the manager and the architect (see guideline 7).

We consider two types of visualizations by means of movies: movies as part of a visualization, and a movie as a complete visualization.
A movie as a complete visualization would have to be long: probably at least 15-30 minutes long.
The other option is shooting one or more short scenes of 10-60 seconds, and embedding them in another type of visualization.
The option of a long movie was rejected immediately due to very high costs and a very long period required for producing it.
Short movie clips have the earlier mentioned characteristics that make them very suitable for our task. Being very short, they have to be embedded in a larger slide-presentation (see later in this section), which enables combining methods for achieving the best result.
Architects, communication experts and managers were asked for their opinion about this medium; all of them reacted positively, due to the above-mentioned characteristics.

Movies are more dynamic than the other media, but their main drawback is that they are relatively difficult to produce. Scenarios have to be written, where not only the contents play an important role; also the scene, timing, face expressions, clothes, tones of voice, background sounds and light must be considered in advance. The architect can do all this, if he is creative enough, but it is recommended that a filmmaker also is involved. Several roles are required for creating a movie:
8. Communication Design – How to Visualize?

- Actors
- A person to shoot the movie
- A person to edit the movie
- A person to handle sound
- A person to handle light
- A film director

Note that also in a low-budget movie production these roles are required, even if the same people perform several roles.

Taking care of such a film production quickly becomes a major operation, which requires major organizational efforts from the architect. This effort could be spared, if the architect’s organization had a communication department that is experienced in producing short movie clips, for example for marketing goals. This appears mostly not to be the case, which means the architect has to organize and supervise the work. Since architects don’t have experience with such work, and professionalism is desirable in order to achieve good results, such an operation may pose a big psychological threshold, resulting in not carrying it out.

A semi-amateur movie can be produced as well, but it requires having colleagues that are willing to cooperate, and have the right capabilities. Colleagues from the manager’s firm can and should take the roles of actors, since they are a familiar element. If a colleague can be found who is experienced in using a film camera, he can take the technical roles. Together with the architect and the actors, he can create good enough movie clips, unless the architect is not willing to compromise on the professionalism of the movie clips.

Resources, mainly time and money, are also an important issue in determining which visualization medium to use. Since shooting a movie is an activity that architects often are not familiar with, we collected some estimations of how much resources are required. These are not exact numbers, since it also depends on what one wants to achieve.

Preparing movie clips of (in total) ca. three minutes costs about one week of work (five days), not including writing the scripts (scenarios). Shooting the movie clips would cost 2-3 working days, and then the film has to be edited (but the actors are no longer required). If the production is done by young professionals, people related to some educational institute such as the Rietveld academy or the film academy, production costs may be several thousands of euros, much less than some estimates we heard during interviews. This estimate takes into account that the actors are not hired professionals, but people from the manager’s firm.

If however the architect can find a colleague to shoot the movie as well, and a somewhat less professional result is also acceptable, the only costs are the working days of the various employees, and possibly renting a film camera, if none is available. One of the architects to whom we talked has produced such movie clips in the past, the semi-amateur way. He experienced it as very effective, and said the audience had been fascinated by it.

A technical drawback of using movie clips is their big size. If the visualization is to be put on CD’s, one cannot use a lot of film material. To come up with statistics, we compared a dozen movie clips and found out that small clips, of about 352X240 pixels, take 10-15 MB per minute. A movie clip for our goals would require at least 500X400 pixels, which means more than 2.3 times as big (23-35 MB per minute). A regular full screen movie clip (recommended) would require 800X600 pixels, more than 5.6 times as big (56-84 MB per minute). Taking into consideration that not more than 650 MB of information can be put on a normal CD, and that the movie clips have to be embedded in another presentation (which also takes some space), the amount of high resolution movie material that can be placed on a CD may be limited to 7-10 minutes. The presentation cannot be mailed or copied on a floppy disk due to its size. If it cannot be burnt on a CD, it becomes practically useless, since transferring it from
one computer to another – even for the sake of giving the presentation only – becomes a major operation as well.

**Recommendation**

Films have better characteristics than any other medium we investigated, but two main drawbacks: the relative difficulty to produce them and their size.

We recommend to use films whenever possible. The ideal situation is that communication departments of IT firms that provide architectural services have people who can produce movies. These people can also produce marketing movies and PR movies for the firms. IT firms should consider producing movie clips as part of the architectural study, which is a service that they give to their clients. Firms that do architectural studies on a regular basis can investigate whether it’s cheaper to have a filmmaker working for the firm, or to outsource this service.

If long movie clips are required, their physical size should be made smaller, so that they fit on a CD. Otherwise, they can be big. Once (future) CD’s can contain much more information, this restriction will be lifted.

**Slide Presentations**

Slide presentations are a tool every architect is familiar with. Most of the working and studying population probably encountered some PowerPoint presentation in their career, and many can also prepare (at least simple) PowerPoint presentations.

A slide presentation is a sequence of slides (screenshots). Each slide may include text, images and/or special objects. Very often most of the slides include just text, and sometimes images as well. Special objects like sound and movie objects can be embedded in presentations as well.

Being a sequence of screenshots, slide presentations are a static medium. However it is possible to produce dynamics by using a sequence of similar images. By presenting two or more similar images in which some details differ, it seems like the one situation (first image) changes into the other (second image), which is the feeling we are trying to produce with dynamic visualizations.

By embedding movie clips in slide presentations, this medium can be made as dynamic as movies.

Slide presentations have the following characteristics that make them suitable for visualizing architectures:

- Every slide of a slide presentation is independent of the rest, which enables the architect who gives the presentation to switch between subjects. He can therefore use this medium to switch back and forth between his own profession and that of the business managers (see guideline 6).
- They can be made dynamic (see guideline 14).
- Through embedding photos, sounds and possibly movie clips, slide presentations enable – just like movies – to "read" facial expressions, tones of voice and gestures, and to engage in the "real-time" exchange of information (see guideline 7).
- Photos and possibly movie clips can be shot in the natural environment of the manager (his office, or his firm). This would add to his willingness to accept the contents of the movie (see guideline 9).
- A slide presentation is interactive, thereby supporting the verbal communication between the manager and the architect (see guideline 7).
Enabling to switch between the architect’s profession and the manager’s profession was identified as a crucial characteristic. It is the main positive characteristic that this medium has, and movies do not.

A practical pro of slide presentations is that most of the architects already know how to prepare such presentations, using Microsoft’s PowerPoint software.
A different tool for slide presentations is Macromedia’s Director. This tool is by far stronger than PowerPoint; it supports self-designed flow of control, import of many types of files, extensive usage of colour and picture processing functions and much more. Comparing Director with PowerPoint for preparing slide presentations is like comparing the newest airplanes with bicycles for international trips. One to two weeks should be enough for an architect to learn how to use this tool well enough.

Recommandation
We recommend the use of slide presentations for visualizing architectures. This medium supports the most important guidelines for visualization. If it is used well, it can support all of them.
We recommend the use of Macromedia’s Director, instead of Microsoft’s popular PowerPoint, mainly because Director enables creating much more dynamic presentations. A slide presentation made with Director will almost always look much more professional than a similar PowerPoint presentation.
Embedding movie clips in a slide presentation is also recommended, to achieve the best of both media.

Physical Models
The use of physical models for the main visualization was considered, but not investigated further, since physical models are static, and thereby improper for our goals. We therefore do not recommend the use of this medium.

Posters
Posters in A0 format can be hung in boardrooms or in the office of a business manager, making information accessible for the manager.
The major advantage of hanging a poster in a manager’s office is making the architecture part of the manager’s daily life. Whenever he has a visit, he can “show off” by presenting his company’s architecture and how he understands it. Showing off requires that he really understands at least some of it. If the manager wants to show off, the architect reaches his goal: making sure the manager understands the architecture. This way, the visualization is used as a psychological tool.

The main disadvantage of posters is that they are static, thereby not supporting the need for a dynamic medium. Since posters present screenshots, just like slides, it is possible to print a series of similar posters, thereby creating some dynamics, but not enough. Being static, posters also do not support the need to switch between the architect’s profession and the manager’s profession (guideline 6).
The ability to embed sounds and movie clips is another characteristic of slide presentations that posters do not have. They therefore are less dynamic and support verbal communication to a lesser degree (see guideline 7).
Other characteristics of posters are similar to those of slide presentations.
Recommendation
Being a dynamic medium, supporting the switching between professions and supporting verbal communication are three main guidelines in visualizing architectures. Since posters do not support these guidelines, we do not recommend relying on them as a main means for visualization. Instead, we propose to use them as a supporting psychological tool. They should not include new information, but only information that was also presented in a different way. The posters then add accessibility for that information.

8.6.3 Design
As explained in section 8.3, a good design is a much more subjective matter than the other aspects of visualizations. We mentioned in section 8.3 what is considered to be a good design, and we will discuss the design of our example visualization in chapter 9.

8.7 Conclusion
We suggest a set of fourteen guidelines that visualizations should comply with. Many of these guidelines can be applied in many situations, but we restrict ourselves to our goal; the criterion for the guidelines is that they support an informative communication process between architects and business managers, for the sake of decision-making. This chapter uses the knowledge and information, presented in earlier chapters, in order to define fourteen guidelines for visualization. Knowledge of the various disciplines we investigated is combined here. We thereby hope to be able to use knowledge that is available in various fields of science, for the sake of another field: architectures. The mental model guideline is a main conclusion of this chapter. It is an example of using knowledge that is available in some field of research (management theory) to improve processes within a different field (archiTectures).

We analysed several media for implementing visualizations. To create a mental model of architectures, we propose to combine an easy-to-implement slide presentation, which can be presented several times, with an architecture game, which has a stronger effect. For visualizing architectures we propose the use of a slide presentation, in which movie clips are embedded.
9 Example Visualization

9.1 Chapter Summary

We implemented the theory given above, creating two visualizations for business managers:
1. The first visualization aims to create a mental model of architectures
2. The second visualization aims to inform business managers about a specific architecture, thereby making it possible for them to make decisions regarding the architecture. To this end, we address those issues that are important for business managers.

The first visualization is targeted at business managers in general, whereas the second visualization uses elements of a specific architecture: the architecture of the Dutch insurance company *Univé Verzekeringen*.

In this chapter we discuss the implementation of both visualizations.

9.2 Introduction

Multiple visualizations may be just as good, if they support the decision-making process of business managers to the same extent. The theory presented so far provides guidelines for the various aspects of visualizations and of the communication process. We believe that a good visualization should comply with these guidelines.

As our guidelines prescribe, we didn't just create an architecture visualization, but also a mental model visualization.

To make the visualization more "real", we pretended it is meant for a real client, the insurance company *Univé Verzekeringen*. The visualization includes several issues that are of importance in *Univé*s architecture, but the numbers we use are not true numbers. The presentation bears *Univé*'s logo, and was presented to the manager of a business unit in this company.

Note that our implementation is an example one. The guidelines can be implemented in different ways, and all of them can be just as good.

Although the mental model visualization is a critical success factor, most of the resources are spent on visualizing a specific architecture or parts of it, for a specific business.

In chapter 5 we draw the conclusion that the following six concerns are of greatest importance for business managers: *costs and benefits, effectiveness, facilitating change, feasibility/risk assessment, integration* and the *schedule*. Note that

Our example visualization of an architecture concentrates on four of these six concerns: *costs and benefits, effectiveness, facilitating change and integration*. We did not include *schedule* and *feasibility/risk assessment* in our example visualizations due to time limitations.

However, the approach to visualizing them is similar to the other concerns.

Note that every architectural study may present other important concerns, based on the type of the architectural study. It is the architect's task to identify these concerns and add them to the list of concerns he discusses in his visualizations.

9.3 A Mental Model Visualization

9.3.1 Contents

As mentioned before, the main issues we discuss in the visualization are:
• Architecture is a layered model
• What are the various layers of architecture, at a high level of abstraction
• Changes and decisions in one level influence other levels as well
• Weighing interests as a result of possibly conflicting requirements of multiple stakeholders

9.3.2 Medium

We implemented a visualization by means of a slide presentation. As mentioned before, for best results we recommend combining all three media we discussed: a physical (3D) model, a slide-presentation and the architecture game. The game and the physical model will not be part of an architect’s presentation in which he also presents a specific architecture. The slide presentation, on the other hand, can serve for that goal. We first used PowerPoint for this visualization, which is a strong enough tool for such a visualization. Later on, when we implemented the visualization of a specific architecture, we used a much stronger tool: Director. As a result, for the sake of compatibility and consistency, we created the mental model visualization using Director as well.

9.3.3 Design

The mental model visualization is a very short one (it takes five to six minutes, including explanations). Probably the most important issue is to avoid any unnecessary details, including design elements that might make the presentation more attractive to the eye, but at the same time might distract the audience from the main elements of the visualizations. This visualization is supposed to give managers a frame of reference for dealing with architectures. We do not want any unnecessary elements to interfere with this frame of reference, and possibly disturb it. We use a very neutral background image (colour) that is also used in the second visualization. On the one hand, it “breaks” the cold white background, but on the other hand, it is so light, that it hardly is noticed as an extra element in the visualization. We use four colours for the four architectural layers. These are the same as in the second visualization, and will be discussed in section 9.4.3, when we discuss that visualization.

9.3.4 Discussion

In this section we discuss how the given guidelines can be traced back in our mental model visualization. We will first discuss three of the most important guidelines, and then the rest, in a sequential order. We use Cap Gemini Ernst & Young's Integrated Architecture Framework (IAF), which includes four layers: business, information, applications (information systems) and infrastructure. A thorough explanation about this model can be found in [25]. Screenshots of the visualization are provided as figures 3 through 12. Since it is a short visualization, most images are provided. Note that the dynamic aspect of the visualization – moving elements and changes in size – cannot be expressed in screenshots. Those present only how a slide looks like after all transitions have taken place. Note that when printed using a black-and-white printer, the screenshots loose some of their effect.

Guideline 12: Managers require powerful mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes.
This guideline is the driver behind the mental model visualization. The visualization was presented to managers in order to test whether it is effective, and the feedback was quite enthusiastic.

**Guideline 3:** 
**Visualizations should demonstrate that the architect speaks the business manager’s language.**
We comply with this guideline by presenting the business layer and what it includes in the same detail as other layers, and by using business terms to do this (see also guideline 2). However, this guideline is by far more important in the second visualization (see section 9.4).

**Guideline 7:**
**Use verbal communication to present an archITecture, and not textual documents.**
By using a slide presentation, which is verbally presented by an architect, and which gives space for discussions, we comply with this guideline.

The rest of the guidelines are discussed in a sequential order.

**Guideline 2:**
**Refrain from using Jargon.**
The whole visualization uses very few terms, and none of the terms requires special knowledge of any subject, since this visualization is supposed to present a very high level of abstraction of archITectures. We therefore comply with guideline 2.

**Guideline 4:**
**Hide complexity, be fast and short.**
A main idea behind the mental model visualization is presenting the main issues only. The essence of this visualization is summed up in guideline 4. By presenting no more than main principles of archITecture, we comply with guideline 4.

**Guideline 8:**
**A visualization must have one consistent design line through all parts of it.**
As mentioned in section 9.3.3, the design of this visualization is very minimal. The design line is consistent throughout the mental model visualization: most of the slides consist of the previous ones, and add some new elements. These are of the same shape and size as those of earlier slides. Also the background image remains constant throughout the whole presentation.
We will consider the consistency of the mental model visualization and the main archITecture visualization in section 9.4.3.

**Guideline 9:**
**By using items that the audience recognizes, the audience identifies itself with what it sees, and is more willing to accept it.**
This guideline was not implemented in the mental model visualization, since it doesn’t support the high level of abstraction that is required.

**Guideline 10:**
**Use colours to communicate.**
Our visualization uses colours, as prescribed in the guideline. The guideline consists of eleven points to consider.
The colours we used for the four layers of the archITecture-model are spectrally close: all are variations of green and blue (point 1). The same colours are consistently used throughout the whole presentation (point 2). The colours we use are two of the three most preferred colours (point 3). We use a different colour for every layer of the archITecture-model (point 4). All components of one architectural layer have the same colour (point 5). Not much text is used in the visualization, but lightness contrast is ensured between the text and the background (point 9). The use of colours makes the visualization easier to comprehend, but it can still be understood if only black and white would be used. The colour is therefore a supporting, redundant signal (point 10).

Guideline 11:
When presenting pictures and text at the same time, present pictures on the Left Visual Field, and text on the Right Visual Field.
The mental model visualization is very short, and includes very little text; nevertheless also this guideline can be traced back in the implementation. The first slide of the visualization presents a principle saying that archITecture is a layered model. To increase the effect of this slide, an image of an onion is presented, assuming that if the manager remembers the image, he will remember that archITecture is a layered model. The image is presented on the Left Visual Field, and the text is presented in the Right Visual Field.

Guidelines 1, 5, 6 and 14 are not relevant for the mental model visualization, but only for the visualization of a specific archITecture.

Guideline 13 refers to both visualizations, and is discussed in the section 9.4.5.

Figure 3 Mental model visualization (screenshot 1)

Figure 3 presents the first screen of the mental model visualization. Its goal is explaining that archITecture is a layered model. The onion is used as a supporting metaphor. The next screen, presented in figure 4, shows which are the layers of the architectural model.
Figures 5 through 7 present elements of various layers. These figures show that every layer comprises of multiple components, and provide some examples for such components. Figure 5 presents business processes, which are components in the business layer of architecture; figure 6 presents information domains, which are components in the information layer of architecture; figure 7 presents infrastructural services, which are part of the infrastructure layer of architecture. For brevity, we do not present here examples of components of the applications layer, but they exist in the implementation as well.
9. Example Visualization

Figure 6 Mental model visualization (screenshot 4)

Figure 7 Mental model visualization (screenshot 5)
The result of the process sketched in figures 5 through 7 is the architecture model of figure 8.

In figure 9 we visualize the fact that components and layers are related to each other and dependent on each other.
The possible results of replacing a component by another one are presented through figure 10: the interfaces between that component and other components may not function anymore.

Figure 10 Mental model visualization (screenshot 8)

We use figure 11 to explain that multiple stakeholders are involved in the process. They may have differing requirements; possible conflicts have to be solved according to the policy that is laid down in the four layers of archITecture.

Figure 11 Mental model visualization (screenshot 9)
Figure 12 presents the last screen. It repeats an earlier screen, in order to make sure that the audience remembers the four layers of the architectural model. Later on, we will see that it also opens the visualization of an architecture, thereby creating a link between the two.

Figure 12 Mental model visualization (screenshot 10)

9.4 Architecture Visualization

9.4.1 Contents

Our starting point was the list of most important concerns, given in chapter 5: costs and benefits, effectiveness, facilitating change, schedule, feasibility and risk assessment, and integration.

Due to time limitations, we decided to concentrate on four of these concerns:

- Costs and benefits
- Effectiveness
- Facilitate change
- Integration

9.4.2 Medium

Based on the earlier given recommendations, we implemented a visualization by means of a slide presentation. True to our recommendation, given in section 8.6.2, the tool we used is Macromedia's Director. The various characteristics of Director that led us to using it are listed next to our recommendation.
9.4.3 Design

Our design line consists of few elements, which are consistently used throughout the whole visualization. The low number of design elements supports the user-friendliness of the visualization and ensures that the design does not attract attention instead of the contents.

Colours
We decided to use four colours to represent the four layers of the architecture-model. Since these four layers are fundamental for our visualization, so is the choice of colours. These colours are used in every slide throughout the whole visualization. We chose for different variations of blue and green to represent the four layers of architecture. These four colours form a spectral sequence. As a result, it is obvious to the eye that although the layers are different entities, they still are related.

Our visualization always focuses on one of the layers of architecture, switching from one layer to the other through a default screen with the four architectural layers. Whenever we focus on one of the layers, we use the colour of that layer as a background colour (see figures 14 and 17 through 20 below). By doing so, we help the audience create the link between the contents of the visualization and the relevant architectural layer. For the default screen we use a rather neutral grey background.

Images
An important issue in a design line is ensuring consistency among images. Consider, for example, images of people. These can have several characteristics:

- Images of young, dynamic people, or images of conservative, serious people.
- Coloured images or black and white images.
- Images of people dressed up in one style or the other.
- Cartoons or photos.

To help human brains create the requested links between images, it is necessary to ensure consistency among the images. In our presentation we chose to use coloured photos of young dynamic people. No other images of people appear in our presentation. Only few images other than images of people are used.

Our presentation uses images in a “smart” way twice:

1. The visualization presents a business scenario called “Mother company and branches work as one entity”. To support the text and help the human brains remember this, we use an image of an athletic businesswoman, representing the mother company, and several smaller men, representing the branches. By placing the branches under the mother company, as if they are inside her, we make it clear that they all are working as one entity, and that the mother company has the highest place in the hierarchy (see figure 14 below).

2. We use a simple image of a database to represent all the information systems of the company. By hiding details and complexity this way, we make the information systems accessible for business managers (see figure 18 below).

Linking pin
Throughout the whole visualization we want the audience to keep in mind that we are discussing some layer of architecture, which is part of a bigger model. We use colours to achieve this goal. To ensure a stronger impact, we use other means as well. Whenever a specific layer of the architecture-model is discussed, a small image of the four architectural layers appears on the upper right corner of the screen; the layer which is being discussed at that moment, has the original colour, and the other layers are de-emphasized. This way, the human mind automatically places the contents of the visualization into one of the layers, and the relation to other layers exists as a background (see figures 14 and 17 through 20).
9.4.4 Implementation

In this section we describe our visualization, so that the reader will be able to follow the discussion in the next section. Screenshots of some of the slides are provided in figures 13 through 21.

Note that our example visualization is not complete; it covers several aspects we consider as very important, but others can be added. It should be used as a reference; visualizing other concerns in architectures can be done the same way as we visualized some of the concerns.

Since the visualization is targeted at business managers, the business aspect of architecture takes the lead in the whole visualization: the main issue is business, and the visualization analyses doing business while working under architecture. For that reason, business scenarios are the starting point of the visualization. The main idea is that the architect has to identify business scenarios that are of major importance to his client. The visualization then has to focus on these scenarios. Choosing the right scenarios to visualize – those scenarios that are of great importance and relevance for the managers – is a key success factor. If the visualization concentrates on a scenario that doesn’t occupy the manager, he will not be interested in it. Furthermore, the visualization has to open a discussion between the architect and the managers. To this end, the most critical issues for the business must be addressed.

In our example-visualization, we implemented a business scenario called “Mother company and branches work as one entity.” This scenario obviously concentrates on integration issues. A different scenario, which we have also designed, is called “Mother company and branches work as different entities.” This scenario concentrates on working without integration. Since the goal of our communication process is informative, and not persuasive, both scenarios try to present a neutral position, by providing the correct information, and not taking a stand for or against any of the scenarios. Both scenarios have a sound business logic; the visualization therefore presents benefits of both of them.

In our mental model visualization we concentrated on the fact that architecture is a layered model. In order to enable the business managers to use the mental model that we gave them, also this visualization should present the same idea. To maintain this consistency we use a default screen, which presents four rectangles, standing for the four levels of the IAF architecture-model. This screen ended the mental model presentation, and is now used to navigate through our visualization of a specific architecture.

Another important issue in the mental model visualization is that multiple layers influence each other. This idea is presented in the second visualization as well by concentrating on two levels of the architecture, and switching between them. The architect should always investigate which of the architectural layers are of most importance in his architectural study, and focus on them. Since the visualization is meant for business managers, the business layer will always be one of the most important layers. In our case, we concentrate on the business layer and on the applications layer.

Understanding these principles of our visualization, it now is possible to explain how the visualization itself is built. It is built of seven phases:
1. The default screen (with four layers of architecture) starts the visualization. See figure 13.

![Figure 13 Architecture visualization - phase 1 (screenshot 1)](image)

2. We then concentrate on the business layer, which becomes big and covers the whole screen. This is the Business Screen. We discuss a business aspect. See figure 14.

![Figure 14 Architecture visualization - phase 2 (screenshot 2)](image)
3. Once we finish discussing the business aspect, the Business Screen becomes small, and the default screen reappears. The Business Screen disappeared into the business layer of the default screen. We then draw an arrow from the business layer to the applications layer. See figures 15 and 16.

Figure 15 Architecture visualization - phase 3 (screenshot 3)

Figure 16 Architecture visualization - phase 3 (screenshot 4)
4. We then concentrate on the applications layer, which becomes big and covers the whole screen. This is the Applications Screen. See figures 17 and 18.

![Figure 17: Architecture visualization - phase 4 (screenshot 5)](image1)

**Implications for IT:**
- Integrate information systems of mother company & branches
- No stand alone systems
- No redundant applications

![Figure 18: Architecture visualization - phase 4 (screenshot 6)](image2)

5. Once we finish discussing the applications aspect, the Applications Screen disappears into the applications layer of the default screen, and the default screen reappears. We then draw an arrow from the applications layer to the business layer. This phase is similar to phase 3 (figures 15 and 16).
6. We concentrate again on the business layer, which becomes big and covers the whole screen. The Business Screen has reappeared. In this Business Screen we then analyse the business scenario, with relation to the applications level, through the concerns that we identified as important for business managers. These are the important concerns: costs and benefits, effectiveness, facilitate change and integration. See figures 19 and 20 below.

![Figure 19 Architecture visualization - phase 6 (screenshot 7)](image1)

![Figure 20 Architecture visualization - phase 6 (screenshot 8)](image2)
7. The visualization terminates with the Business Screen disappearing in the business layer of the default screen. See figure 21.

![Figure 21 Architecture visualization - phase 7 (screenshot 9)](image)

The first Business Screen (phase 2) presents the business scenario and main business implications of that scenario. These are formulated in few words only, on a very high level of abstraction.

The Applications Screen (phase 4) presents the implications that the earlier presented business scenario has for the applications layer. Also these are formulated in few words only, on a very high level of abstraction. The whole applications aspect of the business scenario has to be summed up in few statements, with which the business managers can cope. Doing this is definitely not a piece of cake, but it is essential. If too many technical details are given here, the audience may lose its interest in the presentation at this early stage. We also provide an example for working under this scenario. The idea behind this example is strengthening the mental model of the manager, and focusing it on this specific scenario, thereby helping him to simulate outcomes regarding this scenario.

The second Business Screen (phase 6) presents a business analysis of the business scenario, including the applications-related aspects of it. The analysis takes place through the important concerns. Note that integration is not mentioned explicitly, since this concern is intertwined in the whole visualization, which is about doing business in an integrated way.

To visualize costs, we decided to adopt the TCO method of the Gartner Group, since the Gartner Group presents information that managers are interested in, in a way that managers feel comfortable with.

Hard benefits are presented in the TCO analysis as well: lower costs are a hard benefit. For the rest of the concerns, it suffices to say that visualizing them should comply with the earlier presented guidelines, and their contents are dictated by the conceptualisation presented in chapter 6.
9.4.5 Discussion

We will now discuss how the given guidelines can be traced back in our visualization. We will first discuss the six most important guidelines, and then the rest, in a sequential order. As explained before, we analyse a business scenario by relating two layers of the architecture to each other. The same method can be used to discuss relationships between other layers.

Guideline 6: Architecture visualizations must support switching between the architect's profession and the business manager's profession.

In our visualization we switch back and forth between the business layer and the applications layer. Although architecture is not equal to applications, architects are mostly viewed as IT people. Switching between their profession and that of the managers is therefore translated into switching between the applications layer and the business layer of the architecture, while relating them to each other. This issue was also discussed in section 9.4.4.

Guideline 7: Use verbal communication to present an architecture, and not textual documents.

We use a slide presentation, which is verbally presented by an architect, and which gives space for discussions. The presentation includes little text, and many ideas are presented by using images. No slide consists of blocks of text.

Guideline 13: The visualization of an architecture must be related to the mental model visualization.

As the guideline prescribes, our starting point is a model of interacting layers. When presenting the interaction, we concentrate on the important concerns. In our implementation, we have a default screen, in which the four layers of the IAF architecture-model are presented. We focus on one of the layers, and then show how this influences a different layer. Throughout all screens, a small picture of the four layers maintains a visible link to the default screen of the four layers. This way, we are related to the mental model visualization.

We place the important concerns in the business layer, since they are business managers’ concerns. We discuss the concerns when presenting the business layer, as part of the interaction between layers. The Linking pin principle, explained in section 9.4.3, helps us maintain the consistency.

Guideline 14: Architecture visualization must be dynamic.

Director, the tool with which we implemented our visualization, enables making very dynamic presentations. Many transitions are possible: shape, size, location, transparency and more. We introduced a dynamic motive in our visualization, which is being used repeatedly in order to make the audience understand that the layers of the architecture-model influence each other. To achieve this, we introduced a default screen in which the four layers of the IAF architecture-model are presented. The whole visualization is then a game of switching between these layers: first focus on one layer, then focus on a second layer, and see the implications of what you have seen in the first layer. Then focus again on the first layer, and see what implications the second layer has on the first one. The transitions always take place through the default screen. Every time you focus on one layer, that layer of the architecture-model becomes bigger and takes over the whole screen. When you finish focusing on that layer, the screen shrinks, and disappears in the original layer of the architecture-model.
The notion of time is implemented by using sequences of images, supported by text labels. By presenting scripts in a sequence, stating that time elapsed, the audience understands that time has elapsed. The same method is often used on TV and in movies.

**Guideline 3:**

**Visualizations should demonstrate that the architect speaks the business manager’s language.**

We comply with this guideline by concentrating on business scenarios as a starting point, by analysing IT issues through business glasses, and by using business terms (see also guideline 2).

**Guideline 12:**

**Managers require powerful mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes.**

This guideline is mostly relevant for the mental model visualization. In this visualization we strengthen the managers’ mental model, by giving an example script of doing business within this business scenario. With this example in mind, the manager is able to simulate situations and outcomes.

The rest of the guidelines are discussed in a sequential order.

**Guideline 1:**

**Present hard benefits first, and then soft benefits.**

Since our visualization is about a way to present information, and does not try to be complete, we did not discuss all of the concerns. Hard benefits were not directly discussed. Nevertheless, we discussed costs before soft benefits. The costs analysis also presents hard benefits: it presents a Total Costs of Ownership per user. By choosing for one option or for another one, the costs are influenced. Therefore by choosing for one way of action, the costs drop, which is a hard benefit. Only after presenting the TCO analysis, do we discuss soft benefits.

**Guideline 2:**

**Refrain from using Jargon.**

As mentioned before, we use business terms in our visualization. Presenting an image of a database, which stands for all information systems, reduces the complexity and the “psychological threat” that information systems pose to business managers. No IT-jargon is being used. When we presented the visualization to a business manager who is not familiar with IT issues, we asked whether any unfamiliar terms were used; this was not the case.

**Guideline 4:**

**Hide complexity, be fast and short.**

We comply with this guideline by hiding most of the technical details from the managers, and using a high level of abstraction in treating architectural issues. For example: we present the issue of integration. Images show what integration means – both business integration and information systems integration – but we do not go into details of standards and communication protocols, which are required for such integration. We also reduce the implications that a business scenario has for both business and IT to a minimum of several statements. We reduce the whole concept of IT to one image of a database.

**Guideline 5:**

**The way to relate “AS-IS” and “TO-BE” architectures to each other depends on the architect’s goal.**

Architecture Visualization
We presented neither an “AS-IS” architecture nor a “TO-BE” architecture in our visualization.

Guideline 8:
A visualization must have one consistent design line through all parts of it.
Section 9.4.3 discusses how we comply with this guideline in the visualization. Also the consistency between this visualization and the mental model visualization is guaranteed:
• The same default screen is used in both visualizations
• The same colours are used for the four layers of architectures in both visualizations
• The background that we use in the mental model visualization is the same as we use for the default screen, in both visualizations
• The same images are used in both visualizations

Guideline 9:
By using items that the audience recognizes, the audience identifies itself with what it sees, and is more willing to accept it.
We intended to use three types of items that the audience would recognize:
• Logos
• Photos taken in the manager’s firm
• Images of famous people
Eventually, we only used logos, and decided not to use the other items, for a design reason. We have collected quite a few high quality images of people, all of them present a young dynamic personality. These images are photos made by professional models for commercial goals. The photos we took ourselves in the manager’s firm were of a lower quality, and less dynamic. They therefore didn’t fit well into the rest of the – high quality – images. The same goes for the images of famous people (our candidates were Charlie Chaplin and Marilyn Monroe; we have collected many photos of them).
In order to keep our design line consistent (guideline 8), we refrained from using images of items the manager would recognize.

Guideline 10:
Use colours to communicate.
We comply with this guideline for the same reasons as presented for the mental model visualization (see section 9.3.4, guideline 10).

Guideline 11:
When presenting pictures and text at the same time, present pictures on the Left Visual Field, and text on the Right Visual Field.
This guideline was not implemented in our visualization. In places where text and images had to be presented together, they had to be very close to each other in order to ensure that they are related to each other. Separating them to “left” and “right” would cause the text to loose its context.

9.5 Conclusion

The theory presented in previous chapters guided us in the implementation of example-visualizations. We created two visualizations: one for the establishing of a mental model of architectures, and one that visualizes an example-architecture. We then argued that both visualizations comply with the earlier given guidelines.

Both visualizations were implemented as slide presentations. We didn’t embed films in the slide presentations mainly due to resources limitations.
Note that our architecture visualization includes no diagrams of information systems, since the contents analysis did not identify this as a high priority aspect for the decision-making process of business managers. We believe that such diagrams can be used as a supporting psychological tool, after good faith in the suggested solution has been established (see also section 8.6.2). These diagrams would be of greater importance when dealing with another stakeholder: IT managers. Instead, visualizations must concentrate on business scenarios that business managers are concerned with, and analyze working under architecture in these scenarios, through the important concerns.
10 Validation

10.1 Chapter Summary

Validation is a phase in research, in which theory is being tested. If the theory is not based on sound facts and good arguments, it will not pass the scientific validation test. In this chapter we discuss the validation process of the theory presented earlier. Validation was done based on the visualization examples that we created, in which our theory is implemented.

10.2 The Validation Process

Many theories in exact sciences can be validated in a mathematical way, using formulas to calculate outcomes. Theories that cannot be translated to mathematical equations are more difficult to validate, because they involve subjective impressions.

This is also the case with visualizations. What makes a visualization good? What is good for one manager, might not work with another. But in all cases, the visualization is good if it achieves its goal(s).

We present architecture visualization as a support tool for decision-making, with an informative goal. The validation must therefore concentrate on the question whether the visualization has indeed given business managers insight into the subject, and assisted them in the decision-making process.

We presented also a mental model visualization, as a first step in architecture visualizations. This visualization tries to establish a mental model of architectures. To validate the theory, we ought to test whether the visualization has succeeded in creating a good mental model of architectures among business managers.

The validation of the theory concerning the question “how to visualize?” consisted of two parts: validating the mental model visualization and validating the visualization of an architecture itself.

To validate the mental model visualization, we first introduced a draft version to business managers, and asked them for their opinion, which was quite enthusiastic. They indicated that the visualization succeeds in explaining within few minutes only what the basics of architecture are. At a later stage, we introduced business managers with a new version of the visualization, which included some more details. In order to learn whether they understood the main issues of architectures that we tried to visualize, we presented a questionnaire to them. It consisted of a list of terms, for which the managers had to indicate whether they identify this term with architectures or not. Some of these terms were symptoms or working under architectures. The symptoms can be related to principles. In order to determine whether the visualization has established the desired mental model, we checked per principle, whether the manager has identified the related symptoms. Some examples for principles and symptoms are given in table 19.

<table>
<thead>
<tr>
<th>Principle</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interaction between layers</td>
<td>Multiple domains that influence each other</td>
</tr>
<tr>
<td>Weighing interests</td>
<td>Conflicting requirements</td>
</tr>
<tr>
<td>Weighing interests</td>
<td>Considering a “quick and dirty” solution for the sake of a new campaign</td>
</tr>
<tr>
<td>Multiple groups of stakeholders</td>
<td>Conflicting requirements</td>
</tr>
</tbody>
</table>

Table 19 Validation: relating symptoms to principles
The validation of the architecture visualization is more complex. In order to fully validate it, a long process is required in which the decision-making process of business managers is analysed before and after presenting the visualization to them. Such a process was not feasible in our research. Instead, we tried to assess how much the visualization has improved the decision-making process. We did this in two ways:

1. Indirectly letting managers assess it. We asked the managers to name issues that were discussed in the visualization, and are important for them. The managers were then requested to assess the contribution of the visualization for decision-making regarding every one of these aspects.

2. Own assessment. We named several important issues in architectures, and asked managers to assess how clear we presented these issues in the visualization. Examples of such important issues are:
   - Business and IT depend on each other
   - Working under architecture is not an IT matter, but a business matter
   - Business integration has consequences for the IT
   - Information systems integration has consequences for the business

The shortcomings of our validation process are discussed in section 11.4.
11 Conclusions

11.1 Chapter Summary

In this chapter we evaluate our study, discuss its implications and limitations, and present recommendations for future research.

11.2 Conclusions

The main question posed in this research project was how archITectures can be visualized to support the decision-making process of business managers. Typical to people who deal with IT, we first thought that the question can be answered mostly within the world of IT. But reading this question carefully reveals that the problem at hand is of a multidisciplinary character. It involves archITectures, with which we were familiar, but also visualization techniques, decision-making, business and management.

Coping with the question at hand therefore required that we draw knowledge from various fields in order to further our research. We hope to have contributed knowledge to these fields in return.

Recognizing that the question at hand is a multidisciplinary one, is of main importance in this research. Architects and business managers need to communicate; the communication gap between them stems partially from the fact that not enough effort is made to get to know each other’s world. Just like diplomats, who must be familiar with the customs of the country they are sent to, architects also need to be familiar with the customs of business managers. The reverse is true as well, but is not the topic of our research.

Like any important activity that we want to succeed at, the communication between architects and business managers must be planned. Its goals must be identified, and proper preparations are necessary. Architects are most often masters in structuring. They can decompose any piece of their archITectures into a well-built set of components, and explain what goes where, when and why. The structured way of working ensures a thorough treatment of the archITecture. It is required because archITectures are a complex matter; the structuring makes it manageable. We argue that the same structured way of working is necessary for the communication process between architects and business managers. This process is also complex. To ensure higher chances of success, the process has to be structured and well prepared. Architects should therefore apply their way of working when they communicate with their clients as well. We explained the steps of the communication process in chapter two.

When preparing a football team for an important match, you have to know the other party. The same counts for architects, who want to win the trust of business managers. To this end, we listed some characteristics of business managers. These characteristics present an outline of how business managers think and act; architects should take these characteristics into consideration, and adapt themselves to the managers’ way of thinking and working in order to ensure good results. The use of verbal communication methods and the need to hide complexity cannot be overestimated in the communication process between architects and managers. The need for a powerful mental model in order to simulate outcomes and make decisions is also a very crucial conclusion of the managers’ personality analysis. Without a suitable mental model of archITectures, managers will not be able to simulate outcomes, and therefore make decisions regarding archITectures. We therefore conclude that before the architect discusses a specific archITecture, he must be sure that the managers have a powerful enough mental model of archITectures.
As stated in the Introduction, it’s not necessary to visualize the whole architecture for a certain stakeholder; it’s enough to visualize those aspects that this stakeholder considers important. We found that the aspects that interest different stakeholders differ substantially. Moreover, a stakeholder has different interests in different types of architectures. We found that the most important concerns of business managers are: costs and benefits, effectiveness, facilitating change and the schedule. For domain- and enterprise-level architectures, feasibility and risk assessment is also of main concern. Mostly on the enterprise level, integration plays a major role as well. This list can serve as a starting point in architectural studies, but has to be refined in every situation, since no two architectures are the same. These concerns should be related to relevant business scenarios.

Conceptualising the concerns taught us what we expected to learn: different stakeholders understand different things when using the same terms. For that reason, it is important to find out what information the stakeholder expects to obtain, and not only which concerns he considers important. Before buying a car for someone, you’d ask him what kind of a car he prefers, and what he expects of the car. The same is true here: conceptualising the concerns is a necessary step before providing the business managers with information. We found a main difference between how IT people and managers interpret the term integration: IT people refer to systems integration, whereas business managers refer to business integration (which mostly requires also systems integration).

The above leads us to conclude that visualizations for business managers must discuss business scenarios that the managers have to make decisions about; within these scenarios, the architect must concentrate on the important concerns.

We provided a list of fourteen guidelines, with which visualizations should comply. We identify six of these as the most important ones (guidelines 3, 6, 7, 12, 13 and 14). These six most important guidelines are also six important conclusions of this research:
- Visualizations should demonstrate that the architect speaks the business manager’s language.
- Architectural visualizations must support the switching between the architect’s profession and the business manager’s profession.
- Managers require powerful mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes.
- The visualization of an architecture must be related to the mental model visualization.
- Use verbal communication to present an architecture, and not textual documents.
- Architectural visualization must be dynamic.

In table 20 we indicate the research of which field yielded every guideline.

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Field of research which yielded the guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Architectures</td>
</tr>
<tr>
<td>2</td>
<td>Communication theory</td>
</tr>
<tr>
<td>3</td>
<td>Communication and management theories</td>
</tr>
<tr>
<td>4</td>
<td>Communication and management theories</td>
</tr>
<tr>
<td>5</td>
<td>Brain functioning</td>
</tr>
<tr>
<td>6</td>
<td>Management theory (source: own interviews)</td>
</tr>
<tr>
<td>7</td>
<td>Management theory</td>
</tr>
<tr>
<td>8</td>
<td>Graphic design</td>
</tr>
<tr>
<td>9</td>
<td>Graphic design</td>
</tr>
<tr>
<td>10</td>
<td>Brain functioning</td>
</tr>
<tr>
<td>11</td>
<td>Brain functioning</td>
</tr>
<tr>
<td>12</td>
<td>Management theory</td>
</tr>
<tr>
<td>13</td>
<td>Communication theory and graphic design</td>
</tr>
<tr>
<td>14</td>
<td>Architectures</td>
</tr>
</tbody>
</table>

Table 20 Relating guidelines to fields of research
11. Conclusions

The six most important conclusions were drawn from research in the fields of management theory (four of the six) communication theory (two of the six) graphic design (one of the six) and archITectures (one of the six).
The conclusion we draw from this table is that knowledge of multiple disciplines has to be used in order to cope well with the question at hand.

11.3 Research Evaluation and Future Work

The question how to visualize archITectures is relevant for many architects. For that reason, quite a few architects agreed to cooperate in this research; “I'm very interested in the results of your research” is something we heard at the end of many interviews. The need for better communication between architects and business managers exists; there is no doubt about it. As part of the literature research we conducted, we also looked for other research on the same topic. We found very little information, and whatever we found focused on some specific issue, or tool, and was not broad enough.

In the limited time that we had, using only limited resources, we combined knowledge from several fields of research into one whole, that can be used by practicing architects.
We cannot compare our research with other research, since we found no other research of equal scope.
The various fields we investigated seem not to be related, but the most intriguing part of the research was relating them to each other. We consider this research as a preliminary examination of the subject. Much longer and deeper research is required to formulate more sound answers for the question we tried to tackle. Such research would require the cooperation of experts from all disciplines involved: archITectures, management science, communication science, brain functioning, decision-making, graphic design and possibly more. Together, they have to investigate the implications that the various fields have for practicing architects.

Many questions and issues remain unsolved and still require further investigation. Examples are how much information business managers require about archITectures, and completing the sets of important concerns per combination of stakeholder and archITecture. Also the implications of the fact that the management process requires the development and simultaneous utilization of right hemispheric processes (see appendix A), are not yet known to us. We believe there are important implications though.

For the scientific community, this research presents a preliminary research of a “hot topic”, based on theoretical research, as well as empirical research. It combines the theoretical knowledge of several researchers, as listed in the list of references, with empirical observations of both practicing architects and business managers. The conclusions we draw are based on an analysis in which we related the theoretical research to the empirical one.
Our research contributes to the practicing architect by giving him guidelines that he should apply in order to communicate better with business managers. Practicing architects are encouraged to adopt our thoughts, claiming that the architect has to be open for more than his own profession, in order to achieve better results.
By bringing management theory and archITecture together, this research also contributes to bridging the communication gap between architects and business managers.
Some of the guidelines we present can be applied also in other situations than visualizing archITectures, but we do not discuss other situations in this document. We leave it up to the reader to use his common sense in order to decide when he can apply those guidelines.
11. Conclusions

11.4 Shortcomings of this Research

We present this research as a preliminary one. It is not broad and thorough enough, and therefore not complete. It is however as broad and complete as possible, using our limited resources.

The question “what to visualize?” could have occupied several years of research. Since it was not the main issue in our research, we only investigated it to a certain extent, giving us a good enough basis to continue with the research for only one group of stakeholders. In an ideal situation, more time would have been invested in establishing this basis. We believe that we managed to identify at least some of the most important concerns of business managers. The research done on this field was enough to pass the scientific test, but suffered from limited resources. We are confident of our conclusions, but we might have overlooked some.

The literature research on the field of management theory and brain functioning was good enough to identify some main implications of these fields on our topic. A much deeper research is required however in order to fully understand these implications.

Managers’ time is very precious, as we all know. It was indeed very difficult to ensure enough involvement of business managers in this project. A set of presentations for managers and questionnaires filled in by managers would be required in order to validate the theory well. Our validation of the theory suffered from the lack of access to business managers. Some managers participated in the validation phase, and we are very thankful for that. We recognize however that in order to achieve a sound validation, the commitment of many more managers would be necessary, as well as more time to validate the theory.

An important aspect in dealing with communication issues is cultural differences. By using certain terms, expressions, colours, gestures etc in certain cultures, you may offend people without even being aware of that. All these signals may have differing meanings in various cultures. We have chosen not to consider this issue in our research due to its broad scope and our limited resources. We discuss visualizations for the Western culture.

Last and least, the lack of a common definition of the discipline “archITectures” is also a shortcoming. Several conferences have been held in the last years, during which endless discussions were conducted about this term. One important thing we learned from these discussions is not to start them. The glossary of this document uses the IEEE standard 1471-2000 in order to have some “standard definition” of the term architecture, but we doubt whether this definition is very practical. However, as stated before, this is a discussion we do not want to start.
Appendix A – The Two Hemispheres of Human Brain

The functioning of human brain has proven to be an important field of research in deciding how to present information for best results. We therefore present a short summary of those aspects of brain research that we identified as relevant for our research. We believe though, that more research would identify more aspects of brain functioning, which are of importance for architecture visualizations for business managers.

This appendix is mostly based on [4].

Two Visual Fields
The visual field is the total area where objects can be seen externally (perception/pattern incorporation) as well as internally (memory/pattern replication), while the eye is focused on a central point. The Left Visual Field (LVF) is what the eye sees on the left side of that central point, and the Right Visual Field (RVF) is what the eye sees on the right side of that central point.

Two Hemispheres
The human brain is divided into two main sections, called hemispheres. Each hemisphere has a different cellular structure, allowing for different types of function. The left hemisphere underlies discrete sequential and semantic aspects of language and some verbal skills (articulatory motor movement), and the right hemisphere underlies visual-spatial skills as well as tonal, emotional and analogue aspects of language.

One hemisphere or the other may be more dominant, depending on the function performed. For every function or "behaviour" that a human brain can generate, there must be a network of cell assemblies that have the "final say" in how that behaviour manifests ([3]). So it would not be accurate to say that one hemisphere as a "whole", is more dominant than another "absolutely"; dominance will always be relative to the class of information being incorporated, replicated, cleaved, re-combined and transmitted. A simple example of this is the fact that for most right hand dominant people, most aspects of syntax and semantics of spoken language (involving sequencing of symbolic forms) are more easily supported by the cellular structures of the left hemisphere while most tonal / emotional / analogue aspect of auditory processing and interpretation of language are best served by the right hemisphere.

Hemispheres and Visual Fields
The right hemisphere of the brain sub serves the LVF, whereas the left hemisphere sub serves the RVF. The right hemisphere can perform some functions better than the left hemisphere, while the left hemisphere performs other functions better. As a result, the visual field through which information is observed (pattern incorporation), may be of importance. Some type of information is processed better when presented at the LVF, whereas other information is processed better when presented to the RVF.

Brain cells in occipital area of the right hemisphere have very broad overlapping receptor fields. Because these receptor fields are so broad, fewer are needed to encode an image than in the RVF (left hemisphere), where the receptor fields of brain cells are much smaller and non-overlapping. The processing speed of the LVF will be faster than the RVF because less neurons are involved in the encoding and decoding process. Since the speed of image replication is faster in the LVF than the RVF, any retrieved image will assemble quicker, with less energy expenditure, in the LVF.

Another issue related to the overlapping receptor fields of the right hemisphere is grasping the whole picture versus seeing its fragments. Due to the overlapping receptor fields, information presented to the LVF can be best comprehended as a whole, while information presented to the RVF is more tightly focused (like a zoom lens) and can be fragmented (cleaved and recombined) which can in some cases increase comprehension and in some

4 Reviewed by Dr. Mark Evan Furman
cases decrease accuracy of recall (as in spelling words that must be remembered as an inseparable string).

Table 21 compares the functioning of the right hemisphere with the functioning of the left hemisphere. It is valid for right hand dominant people.

<table>
<thead>
<tr>
<th></th>
<th>Right hemisphere / LVF</th>
<th>Left hemisphere / RVF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of information processed best</td>
<td>Images</td>
<td>Text</td>
</tr>
<tr>
<td>Processing speed for images</td>
<td>Faster</td>
<td>Slower</td>
</tr>
<tr>
<td>Speed of assembling retrieved image</td>
<td>Faster</td>
<td>Slower</td>
</tr>
<tr>
<td>Are moving images retrieved efficiently?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Timelines</td>
<td>Past timeline</td>
<td>Future timeline</td>
</tr>
<tr>
<td>Which colours are processed best?</td>
<td>Black, white, grey</td>
<td>Other colours</td>
</tr>
</tbody>
</table>

Table 21 Comparing the functioning of the two hemispheres

Hemispheres and the Management Process

Since this document and research discuss visualizations for business managers, it is interesting to ask ourselves what implications the brain research has for the management research, which we use in order to understand how to create good visualizations. If we manage to identify such implications, we might learn how to create better visualizations for business managers.

According to the organization theorist Henry Mintzberg ([17]), the management process is based very strongly in the faculties of the right hemisphere of the human brain. He quotes research in the fields of psychology and neuroscience, about the division of the brain in two hemispheres. This research has been used to explain the rational and non-rational in management. The left hemisphere is responsible for the logic, rational and analytic functions, and the right one takes care of the non-logical, impulsive, creative and intuitive functions. According to Mintzberg (see [19]), managerial work appears to be more simultaneous, holistic, and relational than linear, sequential, and orderly; all these are characteristics of the right hemisphere. Mintzberg suggests that top managers have well developed right-hemispheric processes. Planners, on the other hand, have well-developed left-hemispheric processes (which explains the title of [17]).

This is very much related to an earlier discussed personality characteristic of business managers (see chapter 4). It states that managers desire relational, simultaneous methods of acquiring information, rather than the ordered and sequential ones. And indeed, as opposed to the left hemisphere, which processes information one bit after the other, the right hemisphere is specialized for simultaneous information processing; it operates in a more holistic, relational way.

To prevent mistakes, it has to be emphasized that both hemispheres are important for the manager’s work; as Mintzberg formulates it in [17]: *The great powers that appear to be associated with the right hemisphere are obviously useless without the faculties of the left. The artist can create without verbalizing; the manager cannot.*

We believe that the fact that management process requires the development and simultaneous utilization of right hemispheric processes, can have implications for the way visualizations ought to be created for business managers. However, we did not manage to identify these implications; we had only little resources to deal with this issue. We believe that a thorough research about these implications can be very fruitful.
Appendix B – Glossary

Architect: The person, team, or organization responsible for architecture. (Based on the IEEE standard 1471-2000).

Architecture: 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. (IEEE standard 1471-2000).

Architecture: An architecture of one of the following types: enterprise architecture, domain architecture or system architecture.

Communication process: Committing perceptible encoding and decoding activities between one or more senders and one or more receivers.

Compatibility: (1) The ability of two or more systems or components to perform their required functions while sharing the same hardware or software environment. (2) The ability of two or more systems or components to exchange information. (IEEE standard 610.12-1990).

When considering architecture compatibility, we refer to the compatibility of the eventual information systems.

In the context of enterprise architectures, the enterprise-wide information systems of an enterprise must be compatible with each other and with those of other enterprises.

In the context of domain architectures, the domain-wide information systems of an enterprise must be compatible with each other and with those of other enterprises or other domains within the same enterprise.

In the context of system architectures, an information system must be compatible with other information systems of the same enterprise and possibly also with those of other enterprises.

Completeness: The degree to which a full implementation of the required functionality is assured by the architecture ([16]).

Concern (in architectures): An aspect of architectures that is of interest for a specific stakeholder, involved in the architecture process.

Consistency: The degree of uniformity, standardization and freedom from contradiction among the documents or parts of the system or component. (IEEE standard 610.12-1990).

Context definition: Setting a "border" to the architecture. It includes two aspects:
- Stating what is not required of the architecture (for example: it is not requires that the architecture enables implementing a new channel for sales activities in the future)
- Stating which interactions the eventual information systems must have with other information systems (interfaces).

Detail for design: The degree to which the architecture includes the details required for implementation.

Domain architecture: the architecture of a specific part of an enterprise architecture.

Effectiveness: The capacity to enable users to achieve specified goals with accuracy and completeness in a specified context of use. (Based on the ISO/IEC standard 9126-1:2000).

In the context of enterprise architectures, the goals are the business goals of the enterprise.

In the context of domain architectures, the goals are the business goals of at least part of the enterprise.
Appendix B – Glossary

In the context of system architectures, the goals are those business goals of (possibly part of) the enterprise, which play a role in the definition and usage of the information system.

**Enterprise architecture:** Defines the overall structure of the business, the information and technologies necessary to support the business, and the transitional processes necessary for implementing changes. These changes may be in providing services and in using new technologies, in response to changing business needs.

**Evolution guidance:** An analysis of how the architecture can evolve in the future.

**Facilitate change:** The degree to which the architecture and the related information systems enable future business changes, and a description of such foreseeable changes and how they are facilitated.

**Feasibility and Risk assessment:**
- **Feasibility:** The degree to which the requirements, design or plans for an architecture can be implemented under existing constraints. (Based on the IEEE standard 610.12-1990).
- **Risk:** A measure that combines both the likelihood that a hazard will cause an accident and the severity of that accident. (Based on the IEEE standard 1228-1994). We consider "an accident" to be anything that jeopardises either the process of setting up a suggestion for an architecture or the process of implementing this suggestion.

**Governance:** Organizational and procedural measures related to IT. This includes issues as responsibilities, auditing, making sure the systems operate according to the guidelines and checking whether the business goals related to the information systems are met. In the context of architecture governance, we refer to the governance of the eventual information systems.

**Infrastructure architecture:** defines the overall structure of the resources used by all levels above it. This includes not only the technical infrastructure, but also humans, basic business functionalities etc.

**Integration:** The process of combining components into an overall system. (Based on the IEEE standard 610.12-1990). In the context of enterprise architectures, we consider integration of business processes of multiple enterprises and their information systems. In the context of domain architectures, we consider integration of business processes of multiple enterprises and/or various parts of one enterprise and their information systems. In the context of system architectures, we consider integration of one specific system and its environment with other systems (possibly of multiple enterprises) and their environments.

**Mental Model:** The internal representations that humans develop of themselves and the objects they interact with in the world.

**Modifiability/Flexibility:** (1) The ease with which an architecture, and the related systems or components can be modified for use in environments other than those for which they were specifically designed. (Based on the IEEE standard 610.12-1990). (2) The ease of changing existing functionalities or adding new ones.

**Perceive:** To gain knowledge of, through one of the senses; discover by seeing, hearing etc.

**Performance:** The degree to which an architecture assures that the related information systems accomplish their designated functions within given constraints, such as speed, accuracy or memory usage. (Based on the IEEE standard 610.12-1990).
In the context of architecture performance, we refer to the performance of the eventual information systems.

**Requirements traceability:**
- **Traceability:** The degree to which a relationship can be established between two or more products of the development process, especially products having a predecessor-successor or master-subordinate relationship to one another; for example, the degree to which the requirements and design match. (Based on the IEEE standard 610.12-1990).

In the context of requirement traceability, we consider any set of two or more products, one of which is the set of requirements relevant to the other products.

**Return On Investment (ROI):** A measure of corporate performance; it is the result of dividing net income before taxes by total assets ([28]).

**Schedule:** All matters that concern time regarding the setting up of a suggestion for an architecture and implementing it.

**Security:** The capability to protect information and data so that unauthorised persons or systems cannot read or modify them and authorised persons or systems are not denied access to them. (Based on the ISO/IEC standard 12207:1995).

In the context of architecture security, we refer to the security of the eventual information systems.

**System:** An integrated composite that consists of one or more of the processes, hardware, software, facilities and people, that provides a capability to satisfy a stated need or objective. (Based on the ISO/IEC standard 9126-1:2000).

**System architecture:** Defines the system conception of one information system in its environment.

**System stakeholder:** An individual, team or organization (or classes thereof) with interests in, or concerns relative to, a system. (IEEE standard 1471-2000).

**Trade-off analysis:** An analysis of conflicting requirements (possibly set by various stakeholders) and a reasoning, which of them received a higher/lower priority and why.

**Usability:** The capability to be understood, learned, used and attractive to the user, when used under specified conditions. (Based on the ISO/IEC standard 9126-1:2000).

In the context of architecture usability, we refer to the usability of the eventual information systems. This includes several issues: How easy is it for the user to learn to use the system? Does the system make the user’s job easy? Does the system respond fast enough? Does the system anticipate and avoid user errors? Does the system help the user recover the errors?

**User:** An individual that uses the system to perform a specific function. (Based on the ISO/IEC standard 9126-1:2000).

**Value On Investment (VOI):** The total measure of benefits derived from soft initiatives. The softness stems from the underlying assets (e.g., human knowledge, digitised information, enabling software and networks), which are intangibly connected to “hard” ROI ([8]).

**Visualize:** To make perceptible to the mind or imagination.
List of Guidelines

Guideline 1: Present hard benefits first, and then soft benefits. ..............................................45
Guideline 2: Refrain from using jargon. ................................................................................46
Guideline 3: Visualizations should demonstrate that the architect speaks the business manager’s language. .................................................................49
Guideline 4: Hide complexity, be fast and short. .................................................................50
Guideline 5: The way to relate “AS-IS” and “TO-BE” architectures to each other depends on the architect’s goal. .................................................................51
Guideline 6: Architecture visualizations must support switching between the architect’s profession and the business manager’s profession. ........................................51
Guideline 7: Use verbal communication to present an architecture, and not textual documents. ........................................................................51
Guideline 8: A visualization must have one consistent design line through all parts of it. .................................................................................................52
Guideline 9: By using items that the audience recognizes, the audience identifies itself with what it sees, and is more willing to accept it. ..................................................52
Guideline 10: Use colours to communicate. ........................................................................53
Guideline 11: When presenting pictures and text at the same time, present pictures on the Left Visual Field, and text on the Right Visual Field. ........................................54
Guideline 12: Managers require powerful mental models of those things they must understand within the organization and its environment, in order to be able to simulate outcomes. ..................................................................................55
Guideline 13: The visualization of an architecture must be related to the mental model visualization. ...........................................................................................59
Guideline 14: Architecture visualization must be dynamic. ...............................................60
List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Research structure</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Phases in the communication process</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Mental model visualization (screenshot 1)</td>
<td>70</td>
</tr>
<tr>
<td>4</td>
<td>Mental model visualization (screenshot 2)</td>
<td>71</td>
</tr>
<tr>
<td>5</td>
<td>Mental model visualization (screenshot 3)</td>
<td>71</td>
</tr>
<tr>
<td>6</td>
<td>Mental model visualization (screenshot 4)</td>
<td>72</td>
</tr>
<tr>
<td>7</td>
<td>Mental model visualization (screenshot 5)</td>
<td>72</td>
</tr>
<tr>
<td>8</td>
<td>Mental model visualization (screenshot 6)</td>
<td>73</td>
</tr>
<tr>
<td>9</td>
<td>Mental model visualization (screenshot 7)</td>
<td>73</td>
</tr>
<tr>
<td>10</td>
<td>Mental model visualization (screenshot 8)</td>
<td>74</td>
</tr>
<tr>
<td>11</td>
<td>Mental model visualization (screenshot 9)</td>
<td>74</td>
</tr>
<tr>
<td>12</td>
<td>Mental model visualization (screenshot 10)</td>
<td>75</td>
</tr>
<tr>
<td>13</td>
<td>Architecture visualization - phase 1 (screenshot 1)</td>
<td>78</td>
</tr>
<tr>
<td>14</td>
<td>Architecture visualization - phase 2 (screenshot 2)</td>
<td>78</td>
</tr>
<tr>
<td>15</td>
<td>Architecture visualization - phase 3 (screenshot 3)</td>
<td>79</td>
</tr>
<tr>
<td>16</td>
<td>Architecture visualization - phase 3 (screenshot 4)</td>
<td>79</td>
</tr>
<tr>
<td>17</td>
<td>Architecture visualization - phase 4 (screenshot 5)</td>
<td>80</td>
</tr>
<tr>
<td>18</td>
<td>Architecture visualization - phase 4 (screenshot 6)</td>
<td>80</td>
</tr>
<tr>
<td>19</td>
<td>Architecture visualization - phase 6 (screenshot 7)</td>
<td>81</td>
</tr>
<tr>
<td>20</td>
<td>Architecture visualization - phase 6 (screenshot 8)</td>
<td>81</td>
</tr>
<tr>
<td>21</td>
<td>Architecture visualization - phase 7 (screenshot 9)</td>
<td>82</td>
</tr>
</tbody>
</table>
List of Tables

Table 1 Stakeholders’ level of interest in architectures ..................................................20
Table 2 Results of the stakeholders-and-concerns matrix...............................................24
Table 3 Number of important concerns per stakeholder and architectural level.........24
Table 4 Business managers’ important concerns in enterprise architectures ..............26
Table 5 Business managers’ important concerns in domain architectures ...................26
Table 6 Business managers’ important concerns in system architectures ......................26
Table 7 IT managers’ important concerns in enterprise architectures .........................28
Table 8 IT managers’ important concerns in domain architectures ...............................29
Table 9 IT managers’ important concerns in system architectures ...............................29
Table 10 Users’ important concerns in enterprise architectures ...................................31
Table 11 Users’ important concerns in domain architectures .......................................31
Table 12 Users’ important concerns in system architectures .......................................31
Table 13 Business managers’ sets of concerns .............................................................34
Table 14 IT managers’ sets of concerns .......................................................................34
Table 15 Users’ sets of concerns ...................................................................................34
Table 16 Colour combinations .......................................................................................54
Table 17 Comparing visualization media for establishing a mental model .................57
Table 18 Business managers’ sets of concerns .............................................................58
Table 19 Validation: relating symptoms to principles ....................................................87
Table 20 Relating guidelines to fields of research .........................................................90
Table 21 Comparing the functioning of the two hemispheres ..................................94
References


