Architecture & Visualisation

A master thesis on the use and efficiency of
Architecture Visualisations

Radboud Universiteit Nijmegen

Gerben Hoogeboom **August 2005**

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1. Introduction

They say Architecture is an art, therefore digital Architecture must be an art too. In my opinion this is very much so. Maybe not the way art is considered in terms of art in a gallery (which could change) but certainly art as in the following meaning from the dictionary

a. A system of principles and methods employed in the performance of a set of activities: *the art of building.*
b. A trade or craft that applies such a system of principles and methods: *the art of the lexicographer*

This thesis approaches Architecture from an Art perspective. It entails the effectiveness of visualisation of digital architectures. It would seem that making visualisations of architectures is very much an art. How do we visualise such a complex thing as architecture? Are all the details needed, or should we go by the principle of keep it simple?

In this thesis I will deal with the effectiveness of using visualisations with architecture. The usage of visualisations can have many different purposes. Sub points that will be dealt with are:

- When to use visualisation?
- What purpose does the visualisation have?
- What techniques and tools are there for visualisation
- How is visualisation used in practise and how can it be used?
- What should and shouldn't architects do?
- A test in of visualisation
- A model for visualisation

All of the above and subsets thereof will be discussed to answer the following central question of this thesis.

In what manner does visualisation and communication of information between stakeholders take place with an architecture approach to system development, how efficient is it and how can this efficiency be increased?

This thesis is written by Gerben Hoogeboom, student at the Radboud University of Nijmegen, in Nijmegen. The project is supervised by Prof. Dr. E. Proper. There is also a website related to this thesis project which can be found at www.student.ru.nl/g.hoogeboom

2. Word of thanks

This thesis is a product of my research in Architecture and visualisation. The thesis consists naturally out of theoretical information and practice information. It involved a lot of field research. Through interviews and informal conversations I was able to get a lot of information and material about visualisation and the creative process behind it. Therefore I would like to thank the following people for their time and enthusiasm:

Hans Bosma and Jan Campschroer both from Ordina; Daan Rijsenbrij, Jaap Schekkerman, Heman Hartman, and Raymond Slot al from Cap Gemini; Marlies van Steenbergen from Sogeti, Diederik van Leeuwen from Telematica institute.

I would especially like to thank the following two persons for taking the time to help me out with some of my empirical research on the benefits of visualisation. Both of them were able to arrange meetings which I could attend to measure the benefits of visualisation

Peter v/d Molen: Belastingdienst BICT
Mark Paauwe: Paauwe en partners

As mentioned, this thesis also contains a lot of theoretical information. For helping me out with the drawing up my thesis and finding what theoretical information was available I would like to thank Henk Koning from the University of Amsterdam, Stijn Hoppenbrouwers from the University of Nijmegen and my thesis coach Erik Proper also from the University of Nijmegen.

3. Thesis research plan

This thesis is the result of research after the efficiency of architecture visualisation. It is a very creative topic and has to be both theoretical and practical. Therefore the research was divided into two main sections, a theoretical and a practical section.

3.1 problem area

Due to the communicative nature of Architecture, it has become more and more important to find approaches that support this communication. Architecture is essentially about communication improvement, be it between people or devices or people and devices or organisations. One very important approach to communication is that of visualisations. However, we understand little about the beneficial effect of visualisations on the human mind. We therefore need to research what is possible in architecture visualisations and what should not be done. The communication via visualisation takes place between architects, architects and their clients and hopefully eventually between clients. Because there are different groups who need to communicate via visualisations, the visualisations will also need to differ. Thus we must research the current approach to communication and visualisation of information, its efficiency and how we can approach upon this efficiency.

3.2 Problem statement

There is little known about how best to visualise architectures. There is the ever going conflict of informal and formal visualisations and what symbols should or should not be used. We first need to refer to visualisation in general and then apply this to architecture visualisations.

The problem statement for this thesis is:
Visualisation is one of the main concepts for communicating architecture to stakeholders. However, we know little about the use of visualisation and how it can be used more efficiently.

3.3 Thesis results

The main objectives for this thesis can be stated as:

- Define what the relationship between architecture and visualisation is
- Define why we need visualisation
- Define the current problems with visualisation and adjoined areas (current efficiency)
- Define principles that can help (partially) solve these problems so that efficiency may be increased
- Define how visualisations are created
- Define how visualisations can be made more efficient and with more efficiency.

3.4 Research questions

In order to come to an increased understanding of the problem area, to indicate structure and to find possible solutions I will first define a number of questions. The main research question in this thesis is as stated in chapter 1.

In what manner does visualisation and communication of information between stakeholders take place with an architecture approach to system development; how efficient is it and how can this efficiency be increased?

This question contains several terms that need to be well defined before continuing

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 (a more exact definition will be given in chapter 4).*

Visualisation: *a mental image that is similar to a visual perception*

Stakeholder: *a person or group of persons who hold relevance and interest to the subject at hand (examples are: architects, technical personnel, business personnel, clients)*

The definition for stakeholders indicates that it can concern a number of different persons and groups. I will make a generalisation in this thesis for stakeholders, because it is not the purpose of this thesis to test the effect for one specific group of people. This is partially because the overall efficiency of visualisation needs to be determined and improved upon. However, I will consider what types of stakeholders exist in terms of visualisation usage and in the third part of this thesis a practical test is done on a random selection of stakeholders.

The main question actually consists out of a number of fragments. In order to answer the main question, the following sub questions have been defined:

What is architecture?
A definition for architecture is given

What is visualisation?
A definition for visualisation is given

What are the effects of visualisations?
This concerns how humans react to visualisation and is an important part of understanding problems in architecture visualisations

How are architecture and visualisation related?
The relationship is defined in order to indicate the problem area.

How is information interpreted in visualisations?
This concerns the interpretation of information in visualisations.

What problems are there currently with visualisation?
This is needed to determine the current efficiency

With what visualisation methods do the architect and stakeholders communicate?
It is important to understand the different approaches to visualisation

How are visualisations created?
It is important to realise how a visualisation is created in order to make them more efficient

Can a model be made for visualisation to increase efficiency?
A model can help increase the efficiency of a visualisation and the efficiency with which it is made

What other methods can be used to increase efficiency?
It needs to be determined whether there are other methods to increase the efficiency

3.5 Thesis approach

This thesis contains theoretical and practical work. The source of information for this thesis can be divided into literature and information derived from interviews. The practical part of this research has been very important, not only to gain proper information but also for the ability to apply gained insight in practice. Below the two divisions are indicated.

3.5.1 Theoretical

There is still a lot we don't know about the creative process of visualisation in general and architecture visualisations specifically. There has been some work in this area[i], but it remains unknown to most people. For the first part of the research literature study has been done, involving studies after the beneficial effects of illustrations, specific visualisation techniques, personality typing and modelling. In the bibliography you can see what books, websites and papers have been consulted throughout the project.

3.5.2 Practical

A large part of this research will be the research of architecture visualisation as used in practice. In order to comprehend architecture visualisation, you need to understand what it is that people want to visualise, why they want to visualise it, for whom they want to visualise it, and what problems there arise when visualising. This can only be done by asking those people who are directly involved (i.e. people who create them, architects, and people who must comprehend them, stakeholders). To comply with the above statement the following has been done:

- I have interviewed a number of architects and their clients (stakeholders), and a number of people who work at the universities of Nijmegen or Utrecht or Amsterdam and have been involved in theory about visualisation or modelling.

The information derived from these interviews has been analysed and used for this thesis.

- I have performed two tests at two different companies in which the efficiency of a certain visualisation for a certain type of stakeholder has been measured. In order to measure the usefulness, benefits and efficiency of architecture visualisation, the test has been divided into three parts. The first part entails questions to be asked of the architect and the clients to whom the architect will be explaining some part of the architecture with the aid of visualisation. The second part entails joining the meeting with the architect and his clients and observing both parties. The third part entails a set of question for the architect and a set of questions for the clients. All the data is then analyzed and a score chart is filled in.

3.6 Visualisations used in this thesis

I have gained permission of the owners of the visualisations in this thesis to use them for this thesis only. These visualisations may not be copied or otherwise used without permission of the owners. Some of the visualisations in this thesis have deliberately been modified or blurred. This will diminish the effects of the examples somewhat. However, it concerns mostly the visualisations themselves and not what they entail. Any critics on visualisations are in no way directed to the creators of the visualisation. It is merely an indication of what could have been done better or perhaps more structured. Any critics given are also meant to indicate how little we know of the how, what and why of visualisations, human interpretation of them and the creation of mental models and or images.

3.7 Thesis structure

The thesis can be divided into three main sections. In each section objectives and deliverables will be set. A repetition can be found here (figure1).

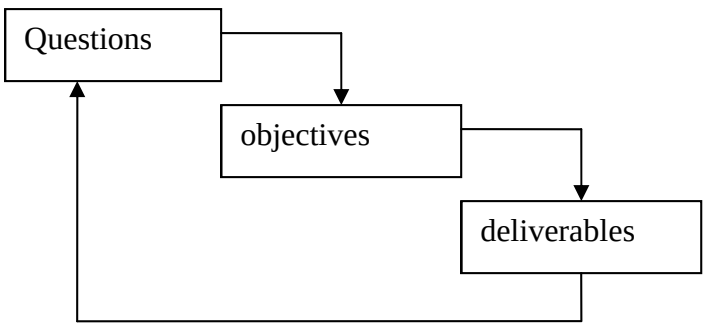


Figure 1: repetetive approach

The thesis is divided in the following manner:

Architecture and visualisation a definition (chapters 4, 5 and 6): In this section a definition for both architecture and visualisation is given and the relation between the two is indicated.

Questions are:
- What is architecture?
- What is visualisation?
- How are architecture and visualisation related?

Objectives are:
- Giving a definition of architecture
- Giving a definition of visualisation
- Explain the relation between architecture and visualisation

Deliverables are:
- A model for the relation between architecture and visualisation
- A model for the division in visualisation
- A set of principles combined with explanations that accompany the models

Architecture, the problems and the benefits (chapter 7): in this section a number of problems are listed that arise when dealing with architecture and visualisations thereof. Possible solutions to these problems are given.

Questions are:
- What is an architecture visualisation?
- What problems are there with visualisation or the architecture description?
- How can we solve or diminish these problems?

Objectives are:
- Giving a definition of architecture visualisations
- A list of problems with architecture and/or the visualisation thereof
- An indication of how to solve the current problems

Deliverables are:
- A definition for architecture visualisations
- A set of problems and a set of benefits
- A set of principles that aid in the solution of the listed problems

Architecture, the effects of visualising (from chapter 8): In this section the efficiency of visualisation is considered, modelling is considered, the relation between scientific and practical use of visualisation, the added value of 3d modelling, summary of design principles, future developments in modelling and a conclusion to this thesis

Questions are:

- Can a model for visualisation be made?
- How efficient is visualisation for different stakeholders?
- How can 3d modelling be applied?
- Which practical principles are important?
- What can change in modelling?
- How well does the scientific research in visualisation relate to the practical use of visualisation?

Objectives are:

- Measuring the efficiency of visualisations
- Answers to what a model should include and in which cases it can be used
- An answer to the use of 3d modelling
- A list of practical principles
- Possible changes in modelling and their benefits
- A view on the practicality of architecture visualisation research

Deliverables are:

- A set of visualisation measurements, which include different visualisations and different stakeholders
- A few examples to modelling
- A few examples of 3d models
- A list of practical principles to be applied
- A list of possible changes in modelling
- A conclusion to research in architecture visualisation

3.8 Readers guide

This thesis contains a lot of information to consume, depending your educational background and knowledge of architecture, some topics may or may not be interesting for you to read. Therefore I have decided to add this reader's guide, in which I indicate the topics that you should read at least in my opinion.

For readers with no or little experience in the field of architecture and visualisation:

- **Chapters 4, 5 & 5.1:** these will give you an indication of what architecture and visualisations thereof are and the relationship between the two. The models in paragraph 5.1 explain the relationship, in the corresponding tables you can find information on what each individual relation in the models entail.
- **Paragraph 5.3.** this contains important information on the effects of visualisations, which you should understand

- **Read chapter 6:** to understand more about architecture and its different stages and how visualisation is connected to this.
- **Paragraph 7.1:** this paragraph contains a table which indicates the problems that have been found in the field of architecture visualisations. Depending on your interests, you can read the possible solutions in the next chapters in the same order as listed in the table (chose those which are of interest to you). I would suggest that you read at least the problems 4, 7, 8.9, 10, 12 and 13, these are important to understand what is going on.
- **Take a look at the model in chapter 8:** it is important to realise what influences an architect in creating visualisations
- **You may want to read chapter 9:** only if you are interested in some examples of visualisations efficiency in practice.
- **Read chapter 10:** this is an important chapter to read.

For readers who work as architects or are experienced with architecture content:

- You should have a good understanding of architecture and visualisations and their relations so you can skip chapters 4, 5, 5.1 & 6. I do recommend that you read on paragraphs 5.3, 5.4 and 5.5.
- **Chapter 7:** this is an important chapter and you will recognize many of the listed problems. I suggest you read them all, because there is coherence to them. However should you not have the time for this, I suggest you read at least problems and solutions on 4, 7, 8, 9, 10, 11, 12, 13. If you are interested in 3d visualisations also read problem 6.
- **Read Chapter 8:** it is important to realise what exactly you do when creating an architecture visualisation. This is something that has gotten to little attention entirely.
- **Only read chapter 9:** if you are interested in factors that influence the efficiency of visualisations. I would recommend that you undertake such a test and apply it to your own situation.
- **Read chapter 10:** this is an important chapter to read!
- **Only read chapter 11:** if you are an architect that has always wondered about the beneficial effects of 3d visualisations and how they should be applied.
- **Chapter 12:** This gives an overview of practical principles for architecture visualisations
- **Read chapter 13:** an important indication of needed changes in modelling and theory thereof.

4. Introduction to digital Architecture

What is Architecture?

The term architecture often causes confusion with people who are not familiar in the world of IT. Most people will immediately think of architecture in the physical world. However, what we consider as digital architecture has a clear link to the word architecture.

From the dictionary:

- A style and method of design and construction: *Byzantine architecture.*
- Orderly arrangement of parts; structure: *the architecture of the federal bureaucracy; the architecture of a novel.*
- *Computer Science.* The overall design or structure of a computer system, including the hardware and the software required to run it.

Especially the explanation for the word architecture in the terms of Computer Science comes closer to what we understand as digital architecture. Architecture has been in the world for ages, the fact that recently the meaning of the word got an addition in terms of Computer Science indicates the change in what we perceive as architecture. Here an explanation should be added for digital architecture as we know it. Of course there are many definitions for what architecture is in this business, every company has its own definition.
Therefore I propose we take the definition from the IEEE standard which defines architecture as:

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.

Where:

- *Fundamental organization means essential, unifying concepts and principles*
- *System includes application, system, platform, systemof-systems, enterprise, product line, ...*
- *Environment is developmental, operational, programmatic, ... context of the system*

Now that we have a definition of what architecture is and its meaning in this thesis, we can continue with the subject of this thesis, namely Visualisation and Architecture. In order to elaborate on visualisation and its effectiveness, it must first become clear what is meant by visualisation and a bit of its history.

5. Visualisation a definition

What is visualisation?

To continue this research first a definition of Visualisation must be given. In this chapter I will consider visualisation as a subject on its own, how it is related to architecture and what visualisation does for us. Visualisation is a subject that is related to many fields of study and within these fields it has its own definition. In the dictionary the following definition can be found:

- a mental image that is similar to a visual perception

When searching in a computing dictionary, the following definition is given:

- Making a visual presentation of numerical data, particularly a graphical one. This might include everything from a simple X-Y graph of one dependent variable against one independent variable to a virtual reality which allows you to fly around the data.

I will use the first definition because it is more generic in use and applies better to the work that I will be performing on visualisation. Visualization is a cognitive process using the powerful information processing and analytical functions of the human vision system. It has always been a major factor in scientific progress and now, with the assistance of computers visualisation has become even more powerful. Within the method of Architecture, visualisation is that which represents information in a non-textual manner. Though it should be noted that visualisation does not exclude text. Visualisations as used in system development are mostly graphical representation supplemented with texts to indicate the meaning of certain shapes or its properties. The purposes of visualization should be insight, explanatory, and defining. Information visualization is useful to the extent that it increases the ability to perform these and other cognitive activities.

5.1 Visualisation as part of Architecture development.

How are architecture and visualisation related?

When examining visualisation within architecture a little more closely, it is found that there are a lot of difficulties still on its path. There is a small part that is well thought-out, but the largest part of visualisation is still amorphous. This amorphous part of visualisation is the visualisation used by the architect to define or confirm a situation within the company and the techniques and tools used for those purposes. Since this process is very much depended on individual thought, experience and skill it is hard to formalise. However, we can formalise the relationship between Architecture and visualisation. For this purpose I have created the models displayed in figures 2 and 3. Here you can see the relationship between architecture and visualisation and a detailed model on visualisation typing.

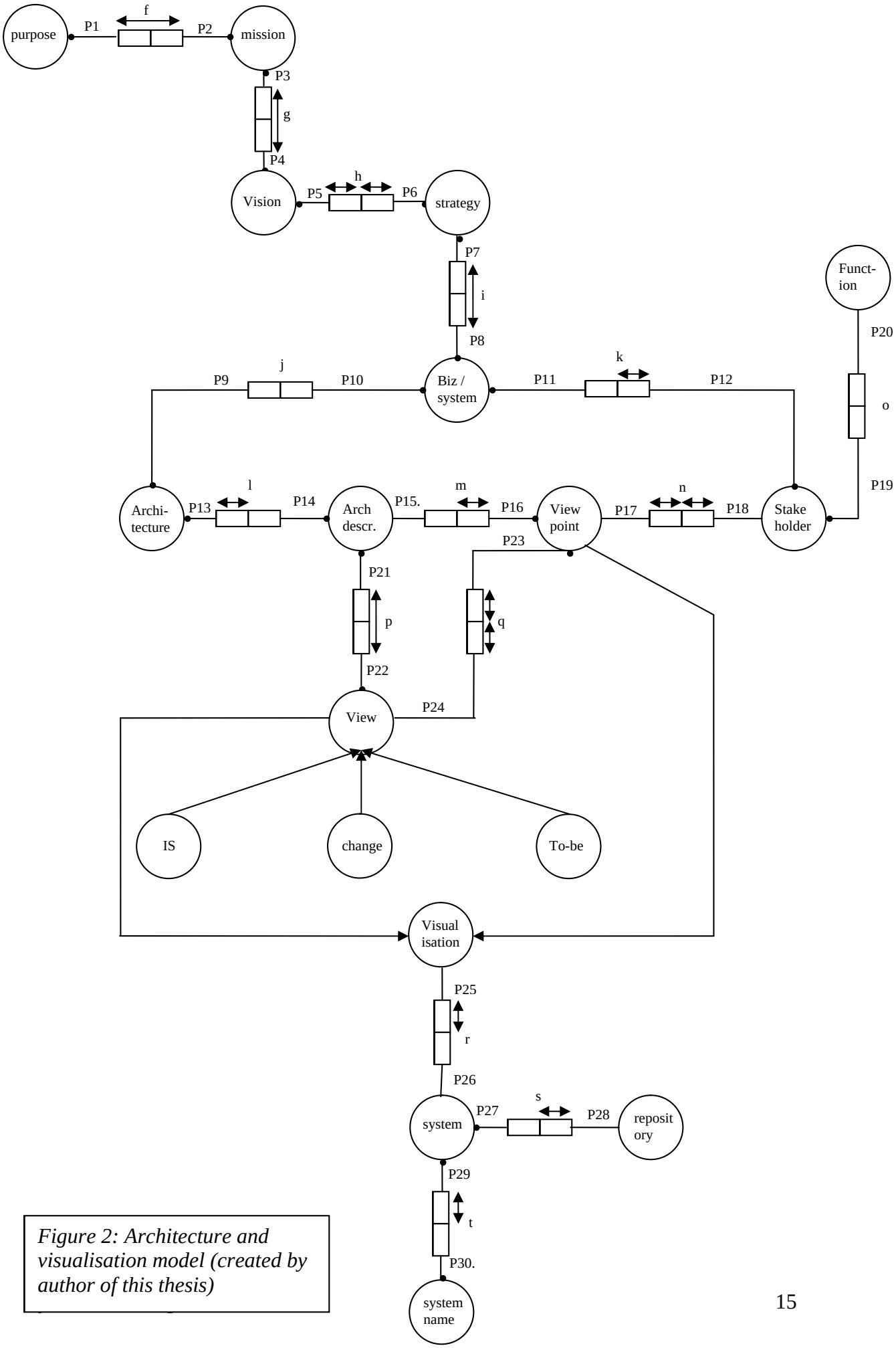


Figure 2: Architecture and visualisation model (created by author of this thesis)

Definitions
Below the definitions for the model on the previous page are given.

P = {p1 t/m p30}
F = {f t/m t}
S = ϕ
E = {purpose, mission, vision, strategy, biz/system, architecture, architecture description,
viewpoint, stakeholder, view, IS, change, To-Be, Visualisations, System, Repository}
O = {f t/m u, vision, strategy, purpose, mission, biz/system, architecture, architecture description, viewpoint, stakeholder, view, IS, change, To-Be, Visualisations, System, Repository}
G = ϕ
C = ϕ
L = {Function, system name}

Where: f = {p1,p2}, g= {p3,p4}, h = {p5,p6}, i = {p7,p8}, j = {p9,10}, k = {p11,p12}, l = {p13,p14}, m = {p15,p16}, n = {p17,p18}, o = {p19,p20}, p = {p21,p22}, q = {p23,p24},
r = {p25,p26}, s = {p27,p28}, t = {p29,p30}.

Specialisations
Viewpoint **spec** Visualisation
View **spec** Visualisation

IS **spec** View
Change **spec** View
To-Be **spec** View

Population (an example population for the model of architecture and visualisation)

Pop(Purpose) =	{purpose1, purpose2}
Pop(Mission) =	{mission}
Pop(Vision) =	{prospective vision}
Pop(Strategy) =	{approach}
Pop(biz/system) =	{management}
Pop(Architecture) =	{enterprise architecture, process architecture, system Architecture, information architecture}
Pop(Architecture Description) =	{description}
Pop(Viewpoint) =	{viewpoint1, viewpoint2, viewpoint3}
Pop(Stakeholder) =	{stakeholder1, stakeholder2, stakeholder3}
Pop(Function) =	{function1, function2, function3}
Pop(View) =	{view}
Pop(IS) =	{IS view}
Pop(Change) =	{Change view}
Pop(To-Be) =	{To-Be view}
Pop(Visualisations) =	{visualisation1, visualisation2}
Pop(System) =	{design system1, design system2}
Pop(System name) =	{system name1, system name2}
Pop(Repository) =	{repository1}

Textual explanation

The table below gives a textual explanation for each relation in the model of figure 2. The relation is accompanied by a principle and short description thereof. It is important to define these relationships, in order to get a complete impression of what is involved with architecture and visualisations.

Relation	Principle	explanation
Purpose - Mission	The Goals should fit with the mission	The purpose is the reason of existence and entails the short term goals. The mission is also the reason why the company exists. The mission includes the long term plans.
Mission - Vision	Each company must have a mission for the company and with it a unique vision of the market	The mission is the reason why the company exists. The mission includes the long term plans and influence management decisions. With that mission there belongs a vision of the market and its challenges
Vision – strategy	The strategy should ensure short term and long term goals	Based on the vision a strategy is formed which gives direction to the company
strategy - Business	The strategy should determine how the business is managed	The strategy is the roadmap to the future. Business and management decisions are influenced by it. The manner in which the company is managed should comply with the strategy
Business - Architecture	Each business has an architecture and should have this architecture explored	A business has an architecture whether management know is or not. Everything has an architecture and you should seek to understand it.
Architecture – Architecture description	Each architecture must be described by all available means, should be logged and permeated in the organisation	An architecture description is necessary. The company must be aware of its architecture so that it may seek coherence and be able to respond faster to change. These descriptions exist out of principles, rules, guidelines, standards, models, views, viewpoints,

		visualisations
Architecture description - Viewpoint	In each architecture description, viewpoints can be found	An architecture description is nothing if you can not explain it to the relevant stakeholders. Therefore you must generate viewpoints for each relevant group of stakeholders that ensure the transfer of architecture understanding
Viewpoint - Stakeholder	For each relevant stakeholder a viewpoint should be visualised	To ensure the transfer of knowledge and comprehension a stakeholder needs to see his or her position in the big picture. For each unique stakeholder there should be a unique viewpoint (a stakeholder can be a person or a group of persons)
Stakeholder - Function	Each stakeholder should have a function within the architecture	Obviously each stakeholder has a function; otherwise he or she would not be relevant.
Architecture Description - View	Each architecture description should contain a view of the architecture	The same rule applies here as to architecture. A view is always there as soon as there is a description. A view and the architecture description should be unique, otherwise there is misinterpretation
Viewpoint - View	Each View contains viewpoints and each viewpoint should correspond to the View	A viewpoint should be unique as explained above as should the view of an architecture description. Therefore the combination or rather joining of these two should be unique as well.
View – IS – Change – To-Be	A view can be specialised into a view of the IS situation the Change situation or the To-Be situation	Depending on the insight an the stage of development a view can be either one of the 3 specialisations
Viewpoint, View - Visualisation	Each view and each relevant viewpoint should be visualised	These views and viewpoints are in fact visualisations. They could be written textually, but to increase

		comprehension and transfer of knowledge these are often visualised. They should be visualised to improve the architecture description (logging) The visualisation does not have to be unique, though the visualised information should be unique.
Visualisation - System	For each visualisation a system (tool) should be available	There are (when generalized) two types of visualisation, the formal (UML, process schemata) and informal (no direct syntax, semantics). For each there should be a program. Preferably there should be only one that can deal with all.
System - Repository	There should be one repository for the or all visualisation systems	Currently there is no tool that can deal with the desired visualisation techniques. Each tool is specialised. There should either be one system that can deal with them all or there should be a primary system that combines each individual system and has a combined (single) repository
System – System name	Each system should have a name	Obviously this is just a label type. Each unique system needs a name.

In the next section a model will be given for a detailed view of visualisation. It is important to define the steps within visualisation; amongst other things it indicates the problem areas. The exact description of the model will be given in a population table and a relationship table such as the one above.

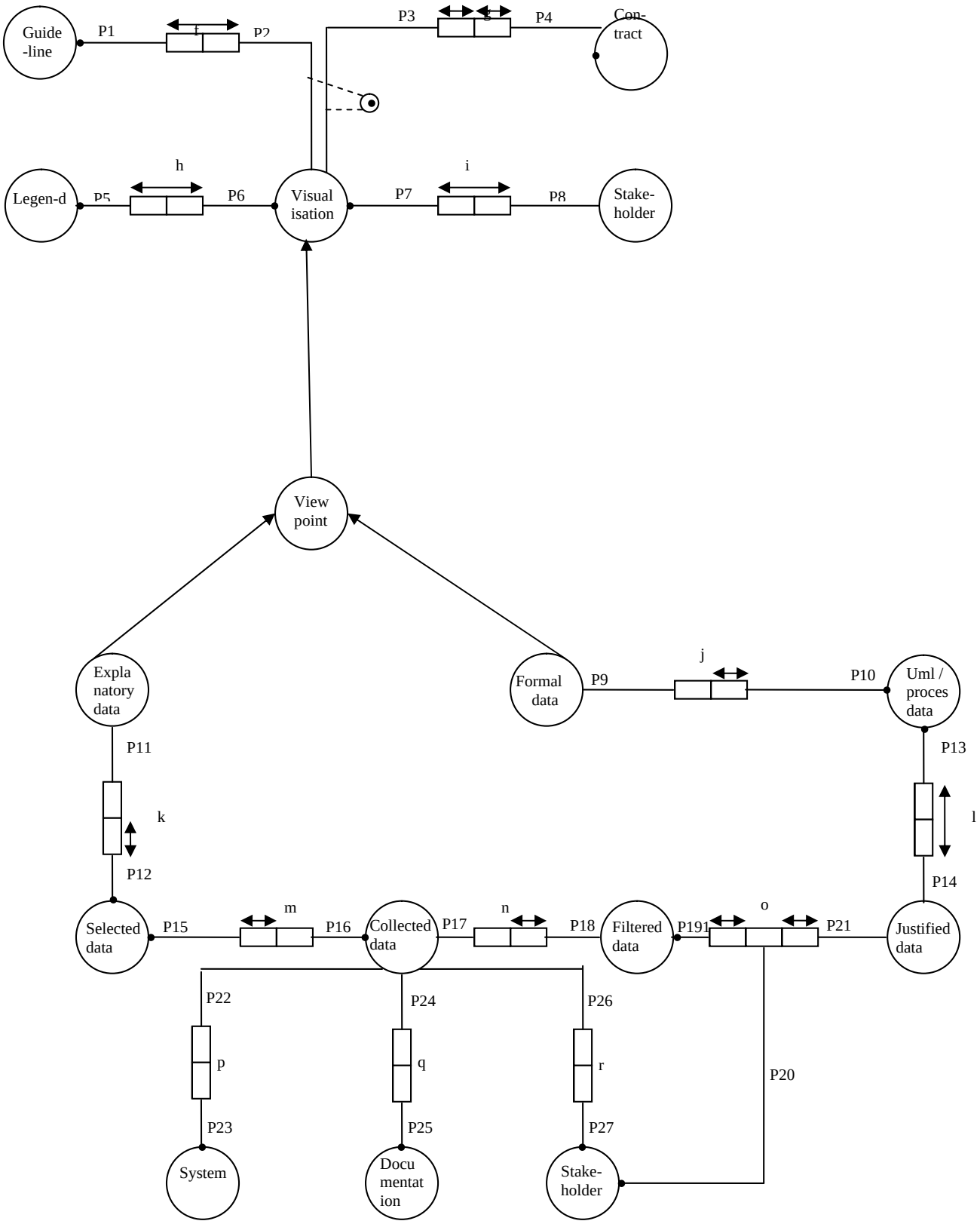


Figure 3: Visualisation a detailed model (created by author of this thesis)

In the schema above a detailed process is given of the visualisation process. This schema is best read bottom-up. Furthermore, it should be noted that a tree can be found in which the left branch leads to an informal representation and the right to a formal representation.

Definitions

P = {p1 t/m p27}
F = {f t/m r}
S = ϕ
E = {guideline, contract, legend, visualisation, stakeholder, view point, explanatory data, formal data, UML/Process data, selected data, collected data, filtered data, justified data, system, documentation, stakeholder}
O = {f t/m t, guideline, contract, legend, visualisation, stakeholder, view point, explanatory data, formal data, UML/Process data, selected data, collected data, filtered data, justified data, system, documentation, stakeholder}
G = ϕ
C = ϕ
L = ϕ

Where: f = {p1,p2}, g= {p3,p4}, h = {p5,p6}, i = {p7,p8}, j = {p9,10}, k = {p11,p12}, l = {p13,p14}, m = {p15,p16}, n = {p17,p18}, o = {p19,p20,p21}, p = {p22,p23}, q = {p24,p25}, r = {p26,p27}

Specialisations
Explanatory data **spec** View point
Formal data **spec** View point
View point **spec** Visualisation

Population (an example population for the model of architecture and visualisation)

Pop(guideline) =	{guidelin1, guideline2}
Pop(contract) =	{contract1}
Pop(legend) =	{legend1, legend2}
Pop(visualisation) =	{visualisation1, visualisation2}
Pop(stakeholder) =	{stakeholder1, stakeholder2}
Pop(viewpoint) =	{viewpoint1, viewpoint2}
Pop(explanatory data) =	{explanatory data1, explanatory data2}
Pop(formal data) =	{formal data1}
Pop(UML/ Process data) =	{specific data1}
Pop(selected data) =	{selected data1}
Pop(collected data) =	{collected data1}
Pop(filtered data) =	{filtered data1}
Pop(justified data) =	{justified data1}
Pop(system) =	{system1, system2}
Pop(documentation) =	{documentation1, documentation2}

note: the stakeholder is visualised twice, this could be the same stakeholder. Out of visualisation considerations the stakeholder is represented twice.

Textual explanation schema

The table below gives a textual explanation for each relation in the model of figure 3. The relation is accompanied by a principle and short description thereof.

Relation	Principle	explanation
Guideline - Visualisation	A specific visualisation should be available as a guideline to the stakeholders	A visualisation can serve as a guideline. It may be that the technique used in the visualisation is not a formal technique, it may also be that the visualisation is not formal (not complete / correct) Still these visualisations can be used as a guideline of architecture for certain stakeholders. This guideline and visualisation together should be unique. The overall picture must still be correct
Contract - Visualisation	A visualisation may be used as a contract form if the visualisation is formal and the understanding is complete	A visualisation can be used as a contract for further development. However, the visualisation technique should have semantic/syntax.. The stakeholders that agree to the contract should have a full understanding and the used technique must be unique. Only then can it be used as a contract in combination with text.
Legend - Visualisation	Each visualisation should have a legend	All visualisations must have a legend that explains the symbols used in the visualisation. It would also be beneficial if a date stamp was included in the legend. The legend and the visualisation together must be unique
Stakeholder - Visualisation	A visualisation is made for a stakeholder, this stakeholder should understand the visualisation	Each visualisation is made for a stakeholder. The combination of used visualisation and stakeholder should be unique. The visualisation must be able to aid in

		explaining relations and/or transfer knowledge about them
Visualisation - Viewpoint	Each relevant viewpoint should be visualised	Viewpoints are in fact visualisations. They could be written textually, but to increase comprehension and transfer of knowledge these are often visualised. They should be visualised to improve the architecture description (logging) The visualisation does not have to be unique, though the visualised information should be unique.
Viewpoint – Explanatory data – Formal Data	A viewpoint should be created out of either informal or formal data	What this means is that there are basically 2 types of visualisations (when generalising). The formal visualisation which can lead to contract form or the informal data which leads to a guideline form or mere explanation to the stakeholder.
Explanatory data – selected data	Explanatory data should come from a selection of data that is first gathered.	If you want to make an explanatory visualisation, you will need to select that data which helps in explaining the data / relation to the relevant stakeholder The selected data must of course be unique, otherwise it would lead to redundancy and / or contradictory data
Selected data – Collected data	From the mass of data first that data which is relevant should be selected	There will be a mass of data coming from different sources. From this data only that which is truly important should be selected. (specific technical details could for instance be omitted) Again the selected data must be unique
Formal Data – UML/ process data	A formal viewpoint can only exist if the data source is formal	This means that a visualisation technique should be used that has its own semantics and syntax, such as UML, certain

		process schemata etc. The source data should always be unique
UML/ process data – Justified data	That data which is used in preparation for formal viewpoints, should be justified data	Again the data source should be formal. From that data that is known to be correct and verified specific data is taken to create the viewpoint and thus visualisation. The combination of this data should be unique
Justified data – Filtered data	All data used in formal logging should first be justified	That data which is deemed to be important should be checked and verified before it can be used any further. The relevant stakeholders are importance to justify the data. The Justified and the filtered data should be unique
Filtered data – Collected data	From the mass of data a selection should be made of that data which is deemed to be correct and important	There will be a mass of data coming from different sources. From this data only that which is truly important and at first thought to be correct should be selected. The filtered data should be unique
Collected data – system – documentation - stakeholder	To create order first there must be chaos.	All available data should come from systems, previous documentation, stakeholders. This data needs to be collected and the relations between them understood

5.2 Visualisation a history

Having defined the relationship of architecture and visualisation and a detailed model of visualisation, it is necessary to have a closer look at visualisation. It is important to realize that visualisation has been around for a long time and thus should not be different for architecture. The following paragraph consider the effects of visualisation and why it is so important to understand these effects before any more work can be done. Visualisation is a powerful thing and has been around since the beginning of time. Communication between men may even have started with visualisation. In later ages men started to combine visualisations with grammar, as we know it in texts, this resulted into hieroglyphs. Hieroglyphs are a combination of icons, which represent something in the real world, with a certain order in which the hieroglyphs must be put in order to form sentences. From these hieroglyphs, the use of icons evolved to the use of modern letters. So our modern language is a derivation of visualisation. Icons are still used often to explain things to people, because a representation of something real still helps the process of understanding. (More on the origins of the alphabet and visualisation can be found in Appendix 1 “Visualisation and Creation of the Alphabet”)

5.3 What does visualisation do for us?

Why is visualisation so important and how is it that it helps us perceive things faster and better? Visualisation is like a language, for those of use who grew up bilingual it is easy to think in other languages. The same holds for visualisation, but how does this cognition work? To explore this we need to visit the world of cognition. Herre van Oostendorp and Susan R. Goldman have written and collected work on the role of illustration in text comprehension[ii]. Since the development of Architecture is very much so a combination of textual statements aided with visual explanations, I will discuss the work of the above mentioned persons and its relations to architecture

An important question is what precisely is the process involved when illustrations and graphics (are utilized to) facilitate memory and comprehension? To answer such a question you would have to do an extensive number of tests with a large professional distribution. A number of such tests have been done and there results will be discussed here. Though there is still much we don’t know about this area and how the mind works. For instance, the following questions are often difficult to answer

- When do you use a visualisation?
- To what purpose?
- When do you introduce this visualisation?
- Why did you create it the way you did,
- How do you imagine this will increase the comprehension of the persons you show this visualisation

On the topic of representation and purpose a lot of work has been done, for instance Johnson-laird(1983) considered that comprehension involves three levels of representation:

- a graphemic (or phonemic) representation
- a propositional representation
- And a mental model.

He regarded the second stage of text comprehension as the automatic construction of a propositional or linguistic representation of the text that is close to the surface form of the text. In the third stage of comprehension, a procedural semantics acts on the propositional representation that integrates both the text and the world denoted by this text.

A mental model is an internal model of a state of affairs, and its structure is analogical to the state of affairs it represents.

Viewed as a dynamic representation, the mental model reflects the reader's current understanding of the data, and the model is updated as reading progresses. A specific element of Johnson-Laird's theory[iii] is the notion of homomorphism to the world:

a mental model has a structure analogical to that of the situation it represents, and its content corresponds to the objects and events of the world. Therefore, because of its analogical structure, a mental model is close to a mental image of this world.

These two kinds of representations provide the readers with a non-linguistic equivalent of the world, and allow for a kind of computation close to the computation one may apply to the world itself. However, a mental image and a mental model are not to be confused. In particular, whereas a mental image is a representation of a situation from a certain point of view, a mental model would allow several points of view on the situation.

It should be clear here that there is a relevance to architecture visualisations at this point. To get full comprehension, there should be a mental image and a mental model. The mental image should be there for each involved party should understand his own point of view. There should also be a visualisation of the mental model where the big picture is mapped; each point of view should be incorporated.

Effort has been made to classify the functions of pictures. For example, Levie and Lentz(1982)[iv], and Levin, Anglin, and Carney (1987)[v], made distinctions among five main functions of illustrations.

1. The illustration can serve a representation function when it repeats the content of the text or overlaps substantially with the text (the use of a photograph, often found in narratives, is a typical instance of this kind of illustration).
2. The illustration can serve an organization function when it gives a text greater coherence (e.g., maps that make geographical relationships more transparent or diagrams embedded in procedural texts).
3. **When graphic displays illustrate the content of texts that are abstract or difficult to comprehend, providing concrete examples, then the illustrations serve an interpretation function.**

4. **Less conventional in textbooks, illustrations that target the critical information to be learned and give a way to recode it in a more memorable form serve a transformation function.**
5. Finally, illustrations may serve a decoration function when they are not directly related to the text. They are added to the text for their aesthetic properties or to increase the interest of the learner.

The visualisations of architecture often have the functions mentioned in points three and four. Processes and information streams can often become very complex. A picture can clarify the situation when implemented properly. A second function for visualisations of architecture is often that mentioned in point four. Critical information has to be remembered in order to get the big picture. Moreover, visualisations are often used as a reminder of what it is exactly we are talking about and in which situation.

Levin et al. (1987) conducted a meta-analysis of the effects of illustrations, and showed that all functions but the decorative function facilitates memory. Those that allow recoding or greater coherence benefit memory the most. More precisely, when the text is presented visually or orally, illustrations that lead to the greater benefit are, in order of importance, transformational, interpretational, organizational, and representational pictures.
One problem for the classification scheme just presented is that transformational, organisational, and interpretational pictures are also representational because some information can be presented both textually and graphically. Moreover, the classification of an illustration depends partly on the kind of text it accompanies, and partly on the task demands.

5.4 When does the beneficial effect of illustration stop?

In one experiment it was asked if the beneficial effect of illustrations on text comprehension was a transient one. This issue is important, as regard the acquisition of knowledge and the nature of the representations held in long-term memory. Does presenting an illustration allow readers to build more-permanent representations of the text content, thus helping them acquire knowledge? Or does the presentation simply allow them to process the text more easily, thus assisting them in answering questions about the content of the text after reading (and even during reading) without helping construct a more elaborated representation of the text content?

In an experiment conducted by Gyselinck (1995)[vi], subjects were presented with a picture illustrating each sentence of the text. Two pictures conditions were compared to a no-picture condition. Comprehension was tested at three different times. The online test consisted of paraphrase and inference questions that interrupted reading, and the immediate off-line test consisted of new paraphrase and inference questions subjects had to answer. In addition, subjects had to come back one day after reading to explore the time course of the representations.

- First, they had to answer a series of paraphrase questions and inference questions about the texts they had read the day before.
- Second, subjects were presented with some sentences of the texts they had read, and were instructed to fill in words or groups of words that had been removed

> from the sentences. Half of these words referred to an element named in the text and illustrated in both types of pictures. The other half correspond to a relationship described in the sentences and illustrated only in the relations pictures

Results of the online and the immediate offline test show that presenting illustrations leads to better accuracy and shorter correct response times than presenting no picture. Moreover, relation pictures proved more beneficial than elements pictures, but in this experiment this effect was observed on accuracy and response times during the course of reading, whereas it was only observed on response times in the off-line test. One day after reading, results on paraphrase and inference questions show that the beneficial effect of pictures could last even after a long delay. The rich representation built a day before seemed to allow the subjects to develop retrieval cues that helped them perform well on the retrieval task. This was confirmed by the results showing that recall was higher in the picture conditions than in the no-picture condition, and that the relations picture condition led to greater recall than did the elements picture condition. Moreover, the relations picture condition led to greater recall than the elements picture conditions only for relations missing words. The various data reported here indicate that the presentation of pictures – especially those highlighting relations together with the text – helps the readers process the text more deeply, and assists them in building connections that allow them to answer inference questions quite readily. This beneficial effect can be observed during the course of reading, and it lasts even after a delay. Therefore, it appears that the presentation of pictures has not only a superficial and transient effect on the processing of the text, but that is also leads to an elaborated and long-lasting representation.'

5.5 Illustrations and mental model theory

Illustrations can reduce the cognitive load associated with complex reasoning tasks, because diagrams are usually more concise than equivalent textual statements and because the essential information tends to be perceptually clear, (e.g., Marcus, Cooper, & Sweller, 1996[vii]). In other words, the advantage of illustrations, as well as other iconic modes of representation, is that they make relations between texts more comprehensible.

Illustrations are easier to process than the corresponding statements, thus facilitating the understanding of the situation described (and depicted).

This is a key point in the use of visualisations with architecture, often it is to complex to understand at once, thus an image might help understanding and recalling. However, nothing is said about the representations constructed. It is worth noting that Marcus et al. (1996) stated that one advantage of illustrations is that they make spatial relations explicit, "whereas a textual format requires the reader to construct a mental representation of these relations"(p. 52). But what is this mental representation? Before it was stated that a mental model is an analogical representation and that an illustration is also an analogical representation that closely mirrors the situation described in the text. A picture can be seen as one possible expression of a mental model, and presenting pictures may facilitate the construction of a mental model. Illustrations would provide support for the model by concretely illustrating the entities and the relations, and perceiving the picture may well serve to instantiate the model (Kruley et al., 1994[viii]).

6. The stages of visualisation usage

In this chapter I will consider the number of different stages in the process of system development under architecture in which visualisation can be used and the purpose in each of these stages.

Visualisation within an architecture approach to system development can be divided into three main categories:

- Visualisation of the IS situation
- Program and objectives: a mutation phase within 1 to 2 years
- Innovation: the environment to which the company strives (Towards an improved architecture)

6.1 The present

In the present situation also revered to as the IS situation, the purpose is to provide insight in the companies processes. All vital processes must be explored and mapped. An argument often heard is

"I don't have time for an analysis of the present situation, time is money. Can't you start building architecture for me?"

The essence of developing the company under architecture is not understood here. Architecture is not something that can be created (it's not an object on it self) for you like you would build a house from scratch. Every company already has architecture even if they don't realise it, it just has to be brought to the surface. This development is somewhat similar to what the sculptor Rodin said in the following quote.

"I choose a block of marble and chop off whatever I don't need."
- *Auguste Rodin*

It is important that the IS situation is mapped in order to get a proper view of which problems there are currently and how they could be solved. Moreover, the costs of taking the time to find problems in the beginning are far lower then finding these problems in a later state of development. The mapping of the IS situation should provide an overview of the present architecture and one must be able to zoom in on the specifics. Each process is to be viewed as an object with its own properties and relations, the architects use matrixes to indicate the relations between objects. These kinds of matrixes could later be used to develop a visualisation.
With every process there will be a stakeholder involved, in order to satisfy this stakeholder, his or her environment must be mapped and relations to other stakeholders indicated. This must be done to ensure that the stakeholders feel involved and understand how there work fits in the big picture.

Currently there are no techniques that excel in making these kinds of visualisations. The purpose is to map and get confirmation on the IS situation. The problems that arise here are:

- how to generate pictures for the different stakeholders (i.e. comprehensive)
- how to "hop" from one view to another
- and a more practical problem of arraying the objects and their relations in pictures

In order to have a better representation of the architecture, several issues will have to be addressed:

- Some architects mention the fact that the communication between people must improve, before we can hope to achieve anything. This is most certainly true, but it is not just the communication, it is the foundation that must improve. At this point attempts to communicate in terms of visualisation are moderate, because it has no foundation. A common language or model must be developed for visualisations.
- This "model" should be practical in use and not to complicated. The immediate question is, how do we shape this communication? What methods do we use for visualisations and its formalisation? This issue will be attended to in later chapters of this thesis.
- Terms and expressions from other visualisation techniques must not be redefined. In practice we often see that companies give there own flavour to the visualisation, which on its own is fine, but the redefinition of existing shapes/objects should be prevented. This will cause confusion and moreover will lead to bickering about which company uses them properly.

6.2 Change

Now that the companies IS situation has been mapped, a time of change can commence. During the mapping of the IS situation problems will have arisen. These problems need to be discussed and the cause of them discovered. During this phase the company and the architect must discover how these problems can be solved and what changes need to be made. Existing principles, rules and guidelines might need to change, or supplemented with a new set. In order to achieve the To-Be situation (which essentially will never be achieved, because it changes continuously), a number of steps are needed. It is not possible to go from the IS to the To-Be situation. Therefore, define a number of platforms which serve as stages to achieve the To-Be situation. These stages have their own principles. These principles serve to make change possible. Some of the old principles must have been abandoned (not all as of yet, but the company must improve) and some new principles must have been introduced (whatever happens the situation must not stay equal or become worse then before). These principles are meant as a transition phase and the To-Be situation need to be achieved yet. Each stage takes us a couple of steps towards this To-Be situation.

The role of visualisation in this phase:

- Visualising existing problems and getting confirmation on them.
  If all data on working processes has been written down, this must now be analyzed. A problem here is that all the collective data can become complex and no person has knowledge of the entire situation. Visualisations can help to map all of these problems and can serve as a reminder. Once the existing problems have all been identified, the findings need be confirmed by the involved stakeholders. In order to present the stakeholders with a complete picture, a visualisation can be used, to increase comprehension and response time.

6.3 To-Be

A visualisation should be made of the future situation. A migration plan has to be made; a set of principles should be adopted that enables a governing of the company and that serve as guidelines for the company's evolution. These principles are grouped and visualised; this is then the Architecture Map for the future. This visualisation is a remembrance to the company off its new guideline and should be placed at a prominent place within the company.

Through interviews with stakeholders a new set of principles should be made with which can be governed. These principles must be mapped, in practice UML schematics are a much used technique for this. Although UML is a software development technique, it is also starting to gain recognition outside the IT world. Although it should be said that the gross part of clients have no understanding of the meaning of UML diagrams. An important reason for the use of UML is the combination of visualisation and explanatory texts. With the mapping of objects, its attributes and relations should be included. This makes UML a reasonable candidate since it an object oriented language

There are two distinct purposes of visualisation in this phase:

- A visualisation can be made to confirm the new situation. Having mapped the problems and there cause in the previous phase, it is now time to find solutions. These solutions are made by the stakeholders and the architect. They are familiar with the cause of the problems and need to make changes or replacements in the present situation. The details of these new processes can become complex. To ensure that all stakeholders are on the same line and there is no ambiguity a visualisation should be made. When implemented properly, ambiguity can be prevented and the there is a clear overview. When the visualisation technique used is known to all stakeholders and there is no uncertainty about the symbols used this visualisation could even be used in form of a contract. *Further research on this matter should be performed.*
- When the future set of processes has been developed and visualised, there is yet another purpose for visualisation. This is the visualisation of the architecture, often seen as big posters on A0 paper format. This visualisation should represent the company's architecture and should be found in the company halls. This should in fact, consist out of a few of these posters; on each of these posters the stakeholders should be able to see the new set of

principles. The principles themselves are not visualised, but there effects are (certain objects on the poster are connected in a certain way, because the company has a set of principles that makes it so). There should be one global picture which gives a top view of the architecture. This is a basic picture in which the workings of the company can be viewed. Next to that should be a view detailed posters of that which is important to the company. This can be of its infrastructure or certain set of business processes or the companies IT. A new point in these poster visualisations is that of pride. This visualisation is related to the above mentioned posters. The difference is that the poster must look good and must be fun to look at. A technique used for this would be perceived 3d visualisations (more on this topic in the related chapter 3d visualisations).

6.4 Problems in the phases

Following are a number of problems that can occur in each of the phases when visualising.

- The visualisations only have a subliminal effect (if applied properly). Some stakeholders do not see the information that is there as a formal representation. Instead they continue with their work and mind the information they have gotten textually. However, they did store the information from the visualisation as well when it was explained to them by the architect; even though they might not always be aware of this (see the chapter on beneficial effects of illustrations). In fact the visualisation is an important tool for future application. The question that arises is: how can the stakeholder be convinced of the visualisation's significance?

- According to some people involved with Architecture projects, managers have developed what almost seems like an antipathy for pictures. Nevertheless, visualisation remains a good approach towards explaining the purpose of new principles, rules and guidelines. Indeed, here the question remains what appeals to the manager in visualisation and can (s)he accept it as a formal representation?

7. Visualisation, the good, the bad and the ugly

What is an architecture visualisation?

In the above section a definition is given for architecture, visualisation and how the two are combined. Architecture visualisation knows many different stages, not just in the phase it is used, but also the how and why of visualisations. However, what exactly are architecture visualisations? When is a visualisation an architecture visualisation?

Definition:
An architecture visualisation is that visualisation which represents in some way an architecture principle, rule, guideline or standard, be it informal or formal and has as purpose to explain data or indicate relations or confirm data.

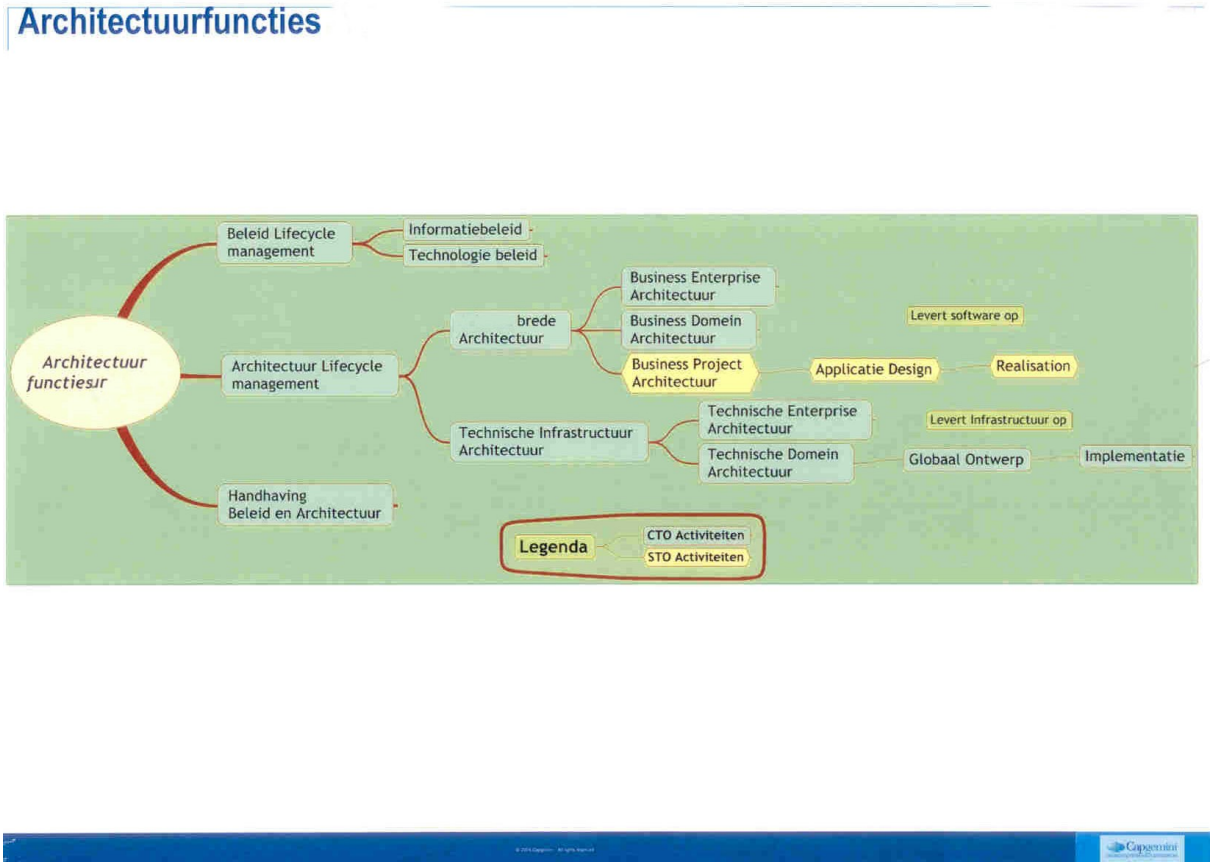


Figure 4: this is not directly an architecture visualisation, but indicates structure.

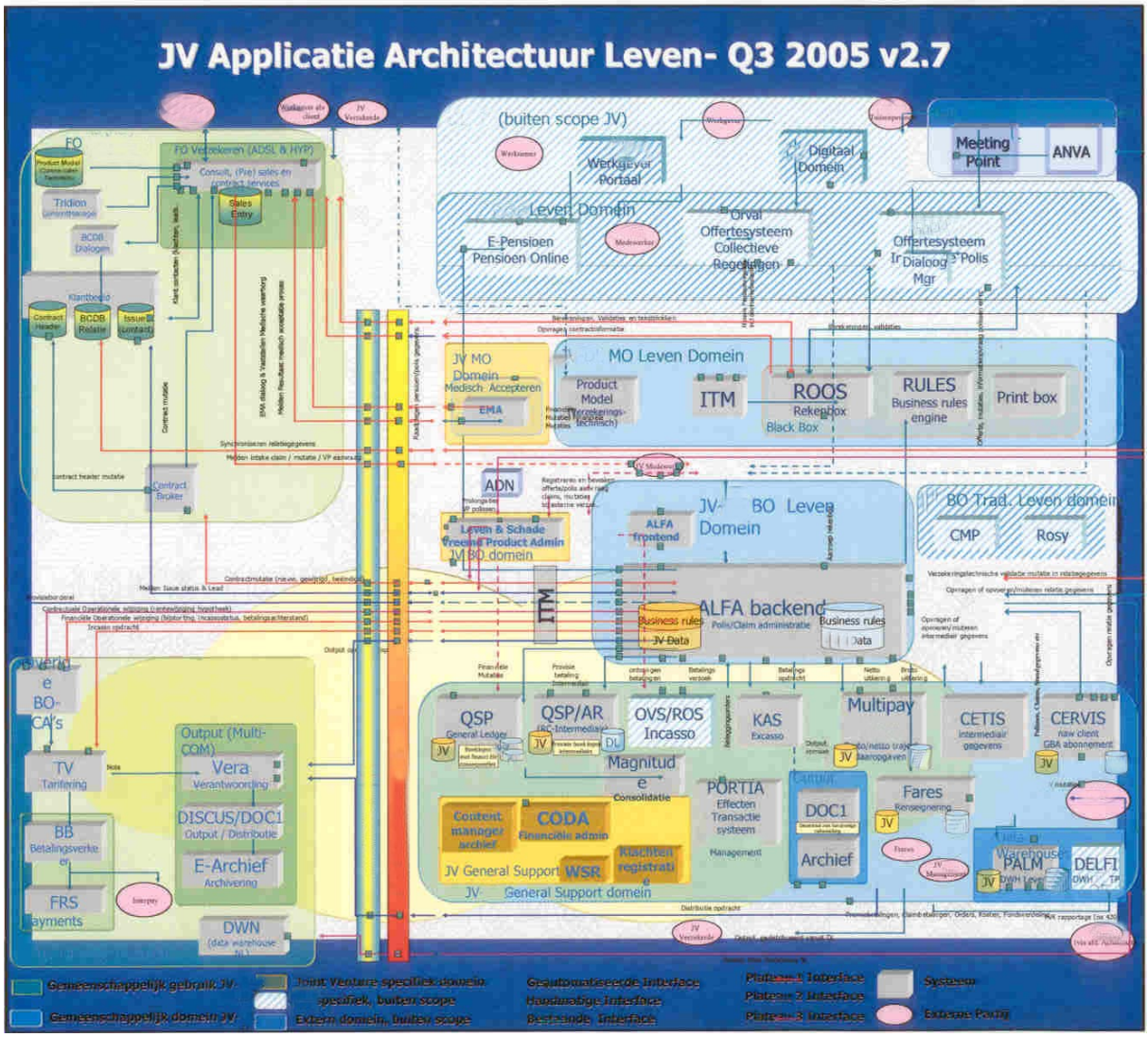


Figure 5: this is an architecture visualisation, though its merits are debatable.

7.1 Problems with Architecture visualisations

What problems are there with visualisation or the architecture description?

Architecture visualisations have their problems and their benefits. Depending on what type of visualisation is used. In this section a number of problems are indicated. These problems and related problems will be discussed.

- What is the problem?
- Where does the problem come from?
- Who is involved?
- What type of problem is it?
- How could it be solved?

Here now an overview of the problems and benefits to visualisation (problems and benefits are not necessarily related)

Problems when visualising	**Benefits when visualising**
Visualisation on it self	*Understanding*
Low understanding of what architecture is: if the clients do not realise what architecture is and how it is always present, it will be more difficult to explain why the present situation need to be mapped and visualised	Reaching a broader public: When using visualisation you can provide inside for more of your stakeholders. They might not understand the situation of others departments/people in the company, A visualisation can help them understand
How to increase the understanding for the advantage of visualisation: Some people prefer to read texts; they do not see the benefits of visualisations.	Faster response time: When using visualisations alone or in amalgamation with text, the stakeholders will be able to respond to queries faster
The benefit of a visualisation is not clear: People make use visualisation all the time but do not recognize it as such. Others find it childish to make visualisations	Faster recognition: When using visualisation the situation in which a stakeholder finds himself is easier to see. It should match with the mental image the stakeholder has
How to make comprehensive visualisations for different stakeholders: Each stakeholder or group of stakeholders has a different approach to a problem and how they are involved with it.	Increase overall understanding: increase in understanding for the architect and other stakeholders. The architect can make a visualisation for himself and his stakeholders to get an overall image of the architecture. Instead of having to read a lot of documents and trying to remember all of it. Furthermore, stakeholders (employees) often have an understanding of their own work and that of people directly related to them. A visualisation could help them see the big picture.

Problems related to architecture	Increase in comprehension: A visualisation can make situations more comprehensive. Some situations are hard to explain textually, because the relations are complex, perhaps faulty and not logged. A visualisation can increase comprehension because it should map everything in phases
The amount of data is to large and therefore to complex to make a visualisation of. The data is to be remembered but not transferred. In order to comprehend the situation and the problems, the architect and relevant stakeholders need to read all data available. Sometimes this can entail a large quantity of data, this has to be remembered to come to a solution. It would be beneficial to visualise this data, but it is complex and takes a lot of time. The architect is there to help create solutions and improvement, not to visualise.	*Cognition*
How to indicate all relations and behold clarity: A huge problem is that of many relations. Between systems/ processes /tasks there can be a lot of relations, if these are all to be visualised. It will clog up the visualisation and it loses its intended effect.	Decrease complexity: A visualisation can decrease the complexity of work. If all is visualised strategically there will be an overview of the big picture. Visualisations of view points can for instance help decrease the complexity
There is no time to make a visualisation of the IS situation: The client indicates that there is not enough time/money to visualise the present situation and besides they already know it (but it is not logged)	Decrease ambiguity: To ensure that the architect and stakeholders and stakeholders among themselves are not being redundant and are discussing the same issues and have the same understanding of these issues, a visualisation should be used. The visualisation will clarify what it is exactly we are talking about
How to “Hop” between points of view and how to automate this. To increase the understanding of the whole architecture, it would be necessary to take a stakeholders own point of view and be able to jump to visualisation of other points of view. This can create problems in automation or time wise.	Remembrance via visualisation: A visualisation can be a remembrance. When discussing a certain issue or process it can be wise to have a visualisation of that issue or process and use it to analyse the problem, because people often forget what the exact problem was, who or what is involved and what information is used and what is meant by it
How to formalise a visualisation: how to make a visualisation that reduces ambiguity as much as possible and is it possible to make a contract form of a visualisation?	Aid in thinking: A visualisation can help in finding solutions. If a situation is unclear or not understood. It can help to visualise it. It does not matter if the visualisation is correct or not.

What technique / tool to use	Easy way to discuss cases: When you want to create a new set of principles, rules and guidelines; you need to know what the situation is that you are discussing and what exactly happens in this situation. So set up a visualisation of a case, and use it as a walkthrough to see if all possibilities fit in the case.
How to decrease the time of making visualisations: How can we decrease the creation time of visualisations? Can we develop a model that decreases the creation time?	*Communication benefits*
The doubt of what technique to use (UML, process schema, Yourdon, simple drawing, other). A much discussed issue is that of what technique to use. What should be the roots of the visualisation? Do we need a formal visualisation? What is best to use in practice?	Faster problem solving: This benefit is directly related to the above mentioned benefits of comprehension and aid in thinking. A decrease of solution time is something we all want
The technique used is to complicated: A lot of complaints are about the complicated techniques. Stakeholders do not understand what you are showing them when using a technique like UML. It may be scientifically sound, but is it usable?	When creating a model, one can make visualisations faster
Poorly made tools for visualisations: A huge problem with tools is that they do not offer enough support. There is a different tool for every type of model. Visualisation holds great promise for architecture or other fields in computer science, provided we can meet the immediate and long-term needs of both toolmakers and tool users.	Better logging of data: Often data is only logged textually. The complexity of data can be decreased by visualisations. A visualisation can also serve as an overview which allows quick access to data also textually logged. A summary if you will.
Syntaxes and semantics of the visualisation is indistinct: Visualisation techniques are used over and over again, companies adjust them to their own style, agreed upon semantics are changed and thus a lot of confusion is created	Better heritage for future changes: A visualisation can ensure better conveyance of knowledge

In the above table a set of problems is logged, I have no intention of being complete here; some problems arise out of others or are directly related. These problems and their related problems will be described in the following section. The benefits that are logged above are related as one to many to the logged problems. Visualisation can have many purposes, but the most important is insight. The main goals of this insight are discovery, decision making and explanation. Information visualisation is useful to the extent that it increases our ability to perform these and other cognitive activities

7.2 Problems and their possible solutions

In the following section all problems are discussed, who are involved and how the problem could be solved or partly solved. It is important to register these problems, in order to determine the current efficiency of architecture visualisation and how this efficiency may be improved upon.

7.2.1 Low understanding of what architecture is

If the clients do not realise what architecture is and how it is always present, it will be more difficult to explain why the present situation need to be mapped and visualised. As with all IT related projects, the costs of solving found problems increase as the project progresses. It is necessary to start with the IS situation. Architecture has become somewhat of a fashion word. Everyone wants to do something with architecture even if they don't know what it is or what it entails. Before an architecture project is started, the client should be asked what he thinks architecture is and why the client wants to do "something" with it. Today there are to many people who are not familiar with the term (digital) Architecture, this needs to change. An overall understanding should be created, media can help in this. Companies like IBM and Microsoft buy commercial time and advertise about business integration or dot net solutions etc. The same could be done for architecture, a commercial in which the term architecture is explained and a global impression of what it entails. A problem here might be that digital architecture is not completely recognised. There is still vagueness around the use of the word architecture and who should be allowed to use it. This problem needs to be solved as well.

Problem	***Stakeholder***	***Principle***
Low understanding of what architecture is:	The architect, management, other staff	*Architecture needs to be well defined and comprehended throughout the company, before it can change*

7.2.2 How to increase the understanding for the advantage of visualisation

Visualisation is acknowledged when people have had an opportunity to experience its benefits over and over again. We daily experience the beneficial effects of visualisations, yet we do not recognize it as such. People who work for instance in the field of IT, have a somewhat better understanding of visualisation. They write reports in which data and relations needs to be explained, often some form of visualisation is used. This has a number of beneficial effects:

- The data is represented in a way that can clarify the structure and relations between them
- It can help people to create their own mental image
- It is a welcomed interruption to textual explanations

However, now we need to understand why we create visualisations when we do. Clearly, we think this might aid in comprehension, but does it aid the persons you are trying to transfer knowledge too or does it aid the creator or both? If we wish to increase the understanding of the advantages of visualisation we first need to understand why we feel the need to visualise. A problem with increasing the understanding is that people take visualisations for granted. In order to increase their understanding, data must be represented without visualisation and later with visualisation. Two things might happen now, which both will increase the understanding of advantages of visualisation:

- The knowledge from the data did not transfer and people need to be explained again this time with the aid of visualisation
- The knowledge did at first not transfer, until these people made a visualisation for themselves to increase their understanding.

Visualisation needs to be taken into educational programs at universities and colleges and private education businesses. Presently, visualisations are taken into account, but implicitly. The focus is on learning different modelling techniques. It is good to have knowledge of modelling techniques, but when should you use which modelling technique? The educational program should be extended with at least the following two subjects:

- The practical use of different modelling techniques, their relation and target group
- The use of informal visualisations, icons, metaphors and their merit

If you are making a visualisation you need to ask yourself a number of questions

- How do my thoughts process the data that I am reading?
- Do I think I understand the data that is represented to me?
- What does the mental image I created look like?
- Do I feel the need to visualise this data?
- Do I feel the need to write down key words of this data?
- Why do I feel the need to visualise?
- Who am I visualising it for, myself or others or both?

- If I am visualising for someone else, what do I think they will need from that visualisation?
- What is the background of the person I am making a visualisation for?
- What data exactly am I trying to visualise?
- How should I shape the visualisation?
- What do I hope to achieve with this visualisation?
- Should I write down what I want to visualise before creating the visualisation?

This is a list of questions that most of us will recognize. Some of these questions are answered in our mind implicitly, whilst others never occur to us. For instance, if you care making a visualisation it is important to write down in a few sentences or keywords, what it is you are going to visualise and why. Most people will not do this, instead they start visualising and thereby increasing the chances of making a visualisation that is not as effective as it should / could be.

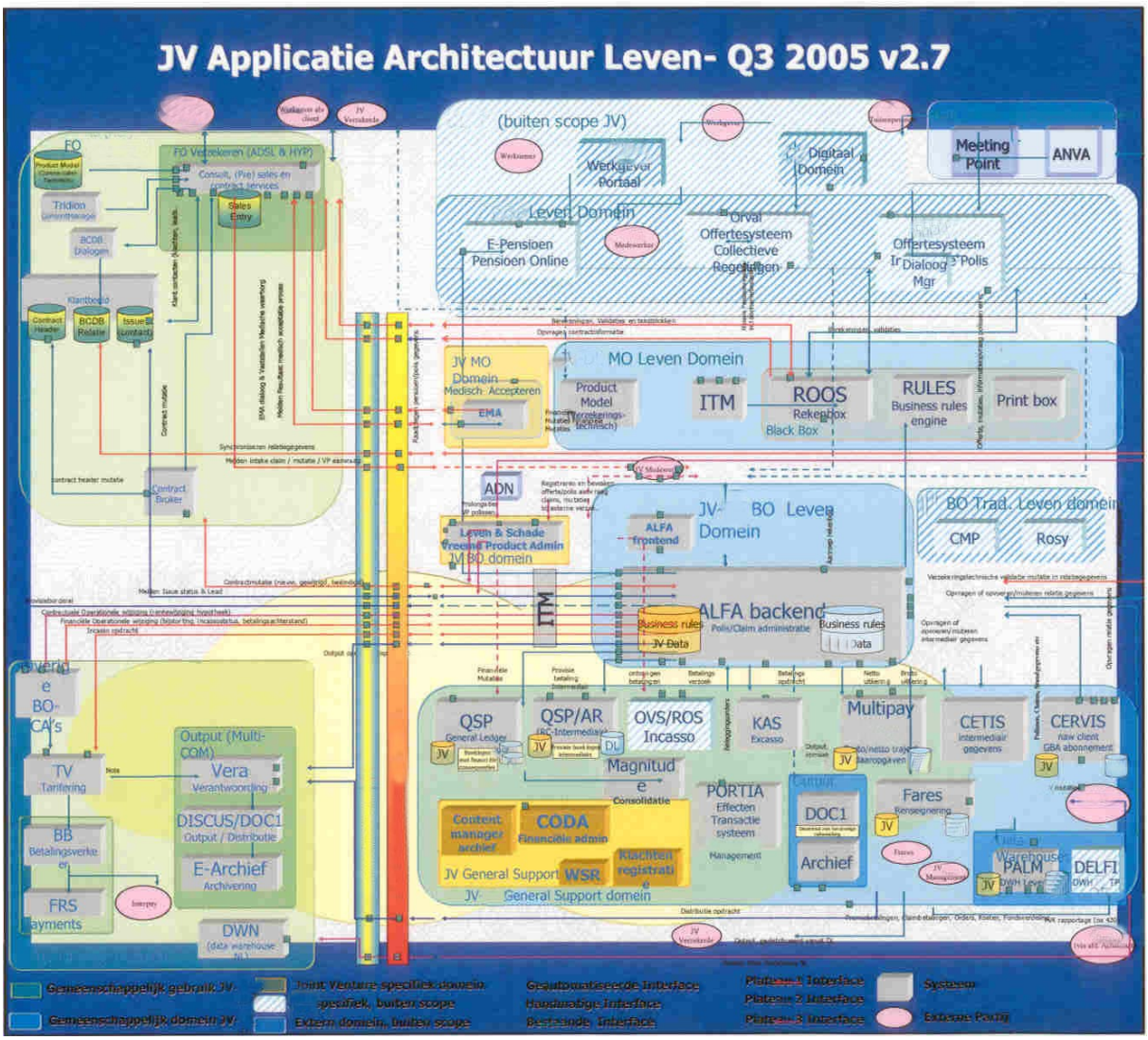


Figure 6: here is an example of what not to do.

This visualisation forgoes its purpose. Probably it wasn't clear upfront what and exactly

how to visualise. It would have been better had it been grouped and zoomed in on each relevant part.

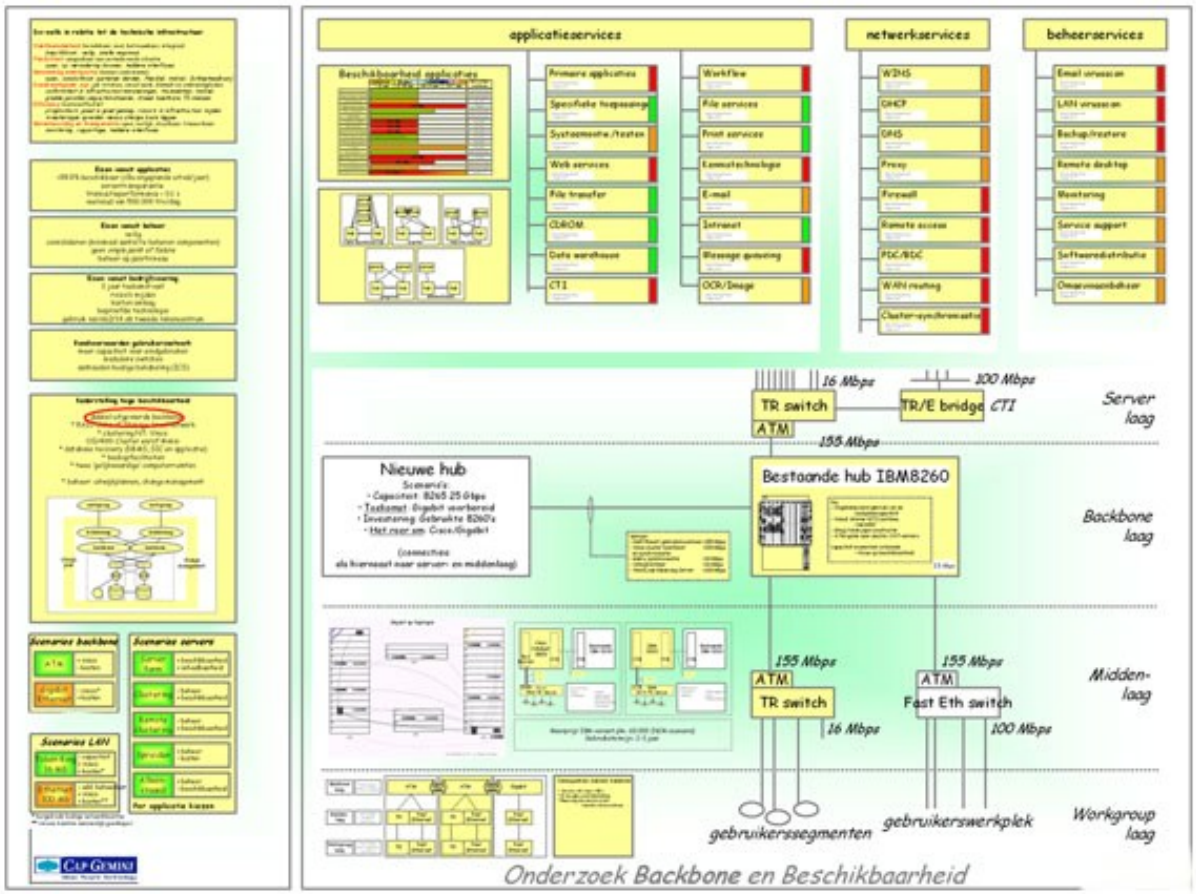


Figure 7: this visualisation seems to have more structure to it. Probably it was created in steps. It is also directly derivable from the IAF framework if you view the division

Problem	***Stakeholder***	***Principle***
How to increase the understanding for the advantage of visualisation	The architect, universities, colleges, private educational businesses	*Visualisation must be a part of all ICT related educations and must be recognized as an important part of communication and human reasoning*

7.2.3 The benefit of a visualisation is not clear

This problem is closely related to the previous problem. People make use visualisation all the time but do not recognize it as such. Others find it childish to make visualisations. It should be understood that in this case visualisations is comprised of those visualisation that are used to explain and clarify data and to transfer the essentials of the visualised data. Some people prefer texts to visualisations, though most people desire a combination of both. However, it must be easy to create a visualisation and to understand it. A visualisation must be adjusted to the target group. Again human reasoning is an important factor. The benefit can only be shown through practical use.

To have your clients acknowledge the benefit of visualisation:

- Start to transfer data to them
- As soon as this data does not register
- Make use of the visualisation and explain the workings of the visualisation to them.

It helps to create a meta-model of the visualisation through which the clients can see how it is all related to the bigger picture.
A second benefit of visualisation is that of placing data on record. Visualisations help to increase the understanding of data and their relations. If you put these visualisations in the records it will aid others in the future, who need to know how things were arranged in the past or presently still are. The client needs to know that with only textual recording, it will be more difficult in the future to study the business.
A third benefit is that of using architecture visualisations as a guideline. Make people understand that if they want to change, they need to stay within the bounds of the architecture model. A visualisation, though not formal and precise, can help to understand how changes should be made. For the exact details the formal visualisations are needed, but these are of no concern to the stakeholders mentioned here. The client needs to know that the visualisation is not just a picture, but also a quick overview for them to be remembered of how things should be arranged within the business.

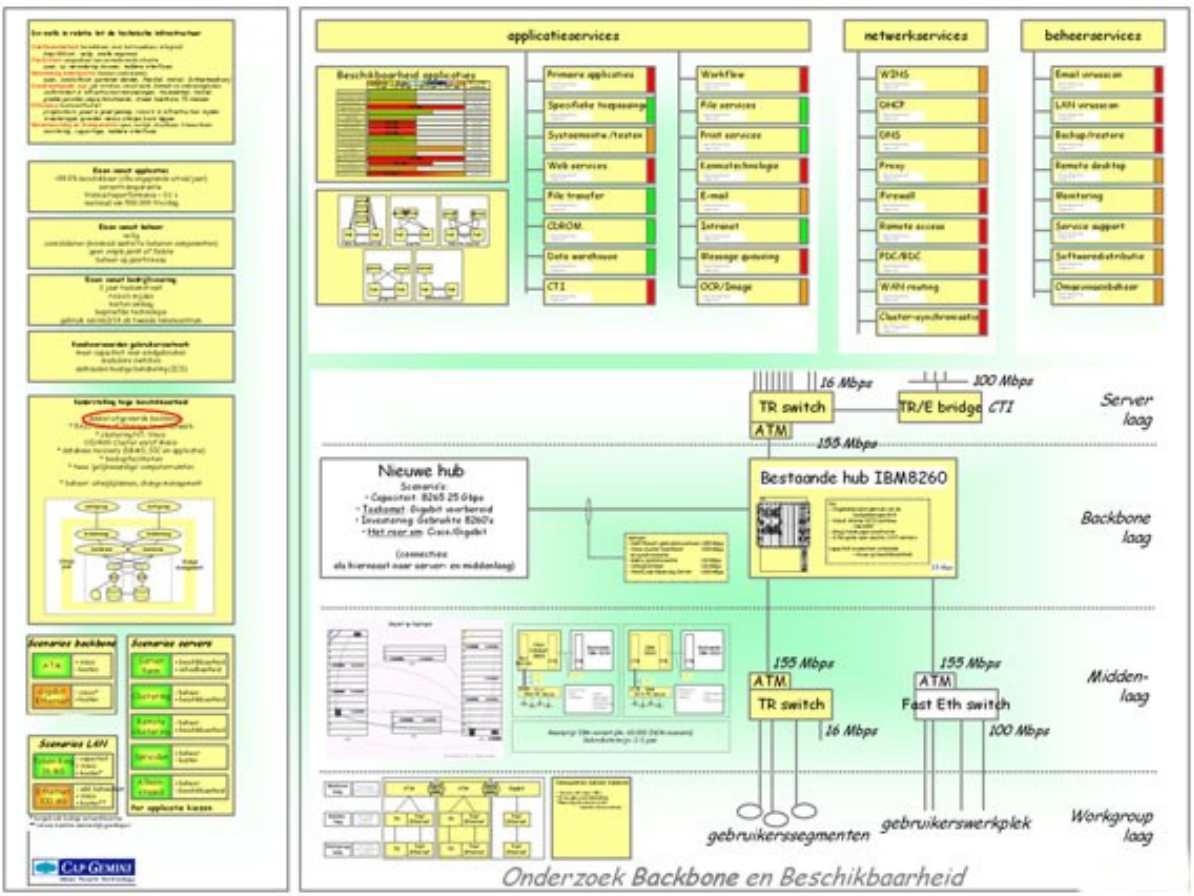


Figure 8: architecture visualisation

This visualisation clearly indicates informal architecture visualisations. This visualisation could be derived from the IAF framework. IT clearly indicates a number of sections within the visualisation and has a good description section on its left. IT could serve as an explanatory visualisation

Problem	***Stakeholder***	***Principle***
The benefit of a visualisation is not clear:	The architect, universities, colleges, private educational businesses, relevant stakeholders	*The benefits of visualisation must be shown through practical use* *Each visualisation should be focussed on its intended target, should be comprehensible and should contain a legend and timestamp.* *The client needs to know that with only textual recording, it will be more difficult in the future to study the business*

		The client needs to know that the visualisation is not just a picture, but also a quick overview for them to be remembered of how things should be arranged within the business.

7.2.4 How to make comprehensive visualisations for different stakeholders

Each stakeholder or group of stakeholders has a different approach to a problem and how they are involved with it. It should be understood that there are a lot of influences that make people approach a certain problem in a certain way. Two factors are important here:

- Who is your stakeholder and what is his background?
- Human reasoning: do you know the person that is the stakeholder?

Stakeholder and background

It is important to know in what the position of the stakeholder is in the company and what education the stakeholder has enjoyed. These two factors will influence the understanding of the data and the manner in which the stakeholder approaches the problem. It also influences the expectations of the stakeholder. Will the stakeholder expect textual explanation, visual explanation or a combination of both? If you differ from the stockholder's regular pattern, will the stakeholder understand?

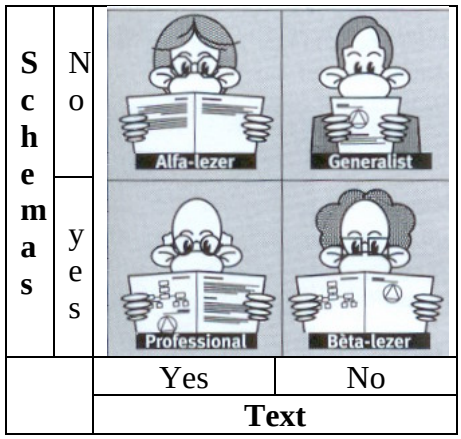


Figure 9: Stakeholder analysis

In this visualisation four different types of stakeholders are represented. It is a generalisation, but still gives an impression of what needs to be accounted for, when making a visualisation for a certain stakeholder. Each type of stakeholder is used to view data in a certain manner and to interpret it in a certain manner. In this visualisation the views are represented. There are four types of readers[ix], the professional, the beta-reader, the alpha-reader and the generalist.

The professional, reads both texts and schemas and knows the value of these combinations. The professional is not often found in organisations. People such as architects should fit in this classification.
The alpha-reader, has no love for schemas and models because of the time (s)he must invest to understand the symbols, method etc. The alpha-reader prefers text and in his/her view this is a powerful method to transfer data. This type of reader is well represented in organisations.

The beta-reader, prefers schemas and models for architecture analysis. These schemas are clear to the beta-reader and allow him/her to quickly get an overview of the data and the relations. Textual explanations are illogical to him/her and often not comprehensible enough. The connection between data becomes clear to him/her after studying the schema's and models. Beta-readers can be found in ICT positions; they too are often skilled in making schemas and models.

The generalist wants to quickly comprehend the data that the other person is trying to transfer to him/her. The generalist is not interested in details and wants a quick overview of what is important to him/her. Both text and schemas are possible, as long as they are concise and serve their purpose. The generalist can often be found in management positions.

Clearly, one type of visualisation for all four of these groups would not suffice. Therefore, the architect should have a complete overview of the data and adjust the visualisation to the stakeholder. This is the creation of viewpoints. Furthermore, the architect should consider whether (s)he will represent the visualisation on paper or digital, both methods have their merits. Two issues need to be taken into account here:

- Does the visualisation need to be interactive?
- What type of stakeholder am I dealing with?

Interactive visualisation: Sometimes it is beneficial to have an interactive visualisation in which progress can be shown. Furthermore, with digital visualisation one could allow the clients to brows through different view points and find his/her own place in the big picture.

Type of stakeholder: Since a lot of people work with computers these days, there is no objection to digital visualisation. However, it is known that if a person has to look at data for a longer time and study the data, they prefer to see it on paper instead of a monitor. When creating visualisations it can be beneficial to do this on paper, depending on the type of visualisation and if the stakeholder is currently present.

Human reasoning
It is important to know the stakeholder to whom you are trying to transfer knowledge. Not just his/her educational background is important. There are many other factors that should be taken into account.

- What is his/her cultural background?
- What is his/her position in the company?
- What is important to him/her?
- Is (s)he involved in other activities related to other areas
- What is his/her capacity to see the big picture and to approach things from different points of view?

To know all this, it will be clear that an architect must be very skilled in communication and human reasoning. To know what is on people's minds, you need to be involved with them and understand what keeps them busy. Without this knowledge, proper visualisations and data transfer cannot be achieved.

The following visualisation uses a point of view to display certain information architecture. Here a certain stakeholder is the centre and the real life stakeholder can recognize him or her self in this picture.

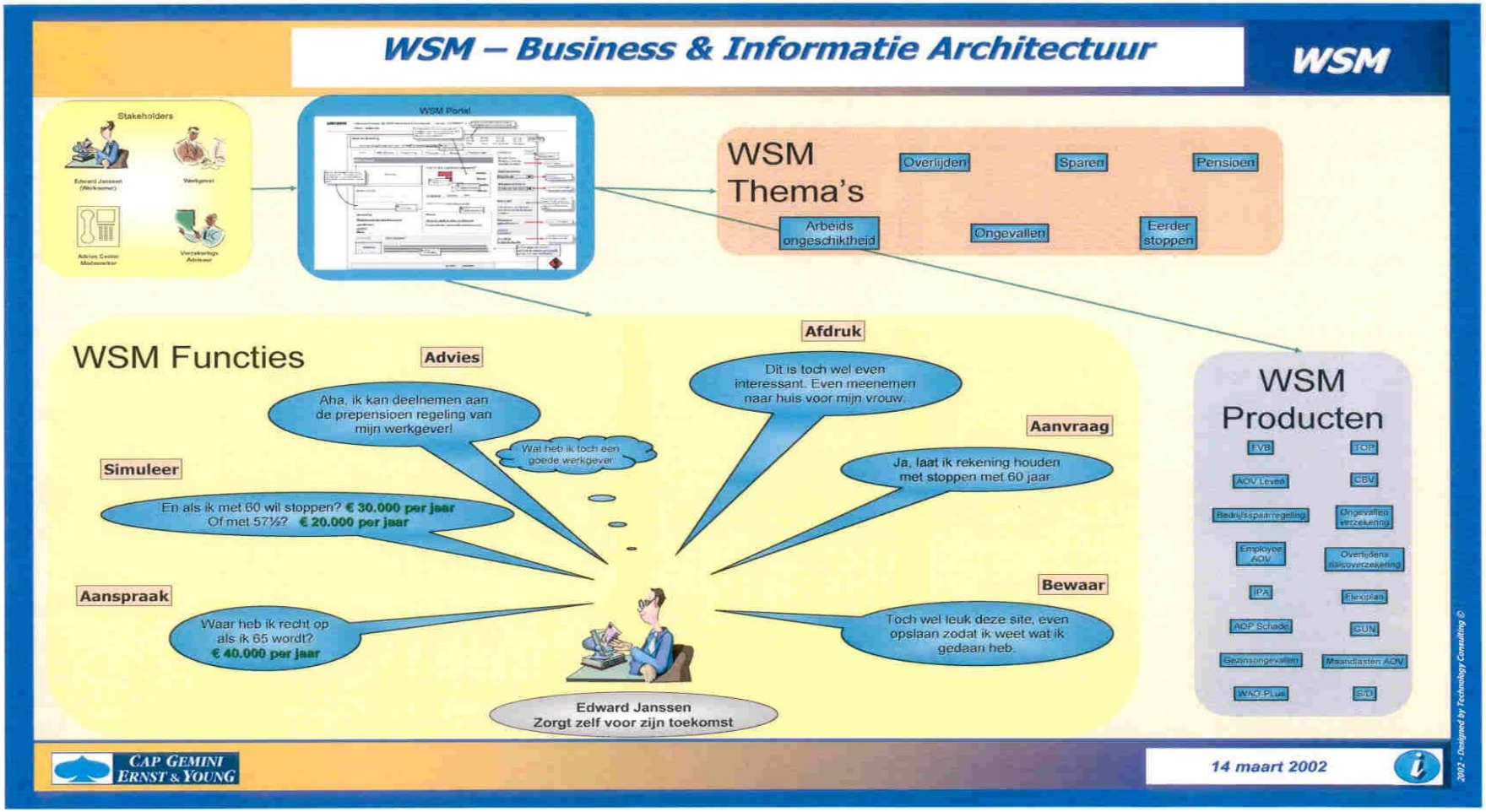


Figure 10: Stakeholder visualisation

Problem	***Stakeholder***	***Principle***
How to make comprehensive visualisations for different stakeholders:	The architect, universities, colleges, private educational businesses, relevant stakeholders	For each group of stakeholders a different visualisation must be made, this is the creation of viewpoints. It must be possible for the stakeholder to "hop" from one viewpoint to another, so (s)he may comprehend the bigger picture and better comprehend his/her own position. When creating a visualisation the stakeholders educational background must be taken into account. When creating a visualisation the stakeholder type must be determined. An architect must be able to communicate and socialise with people. Before creating a visualisation for a stakeholder, one must determine if this should be digital or on paper. Before creating a visualisation for a stakeholder, the architect needs to determine what needs to be visualised for this stakeholder.

7.2.5 Data complexity

In order to comprehend the current architecture and the problems, the architect and relevant stakeholders need to read all available data. Sometimes this can entail a large quantity of data; no one person can remember all of it. Yet, the data has to be remembered to come to a solution. It would be beneficial to visualise this data, but it is complex and takes a lot of time. The architect is there to help create solutions and improvement, not to visualise. The amount of data is to large and therefore to complex to make a visualisation of. The purpose in this case is that the data is to be remembered but not transferred. Indeed, there is the tendency to not visualise, simply because it takes to much time. A problem closely related to this is the lack of a tool that can increase the speed with which you can visualise. A tool is needed that can cope with different types of visualisations (formal and informal and different techniques) and shares one repository. This repository must have proper constraints, yet the user must be able to not visualise certain relations which (s)he deems unimportant. If a better tool were available for visualisation and a model available, this problem would be partly solved. There is still the fact that there is a lot of data to be consumed and it takes time to figure out all the relations between them. However, if the organisation is to continue on its own with architecture, it is necessary that all these relations are recorded. It would be beneficial to visualise it for future purposes. The data needs to be recorded, if it is recorded textually only, the same problem will soon arise again. Though the data might be more organised, it is still a lot of data to consume and this will become incomprehensible over time. It is sensible to teach those stakeholders that will continue with managing the architecture how to visualise and what to visualise. A meta-model is needed to indicate the global relations of different visualisations and a model for those visualisations is needed.
The following two visualisations are examples of a visualisation with a meta-model for that visualisation. The first visualisation is change-architecture visualisations. The figure below is the meta-model for that visualisation which indicates the relation of the first.

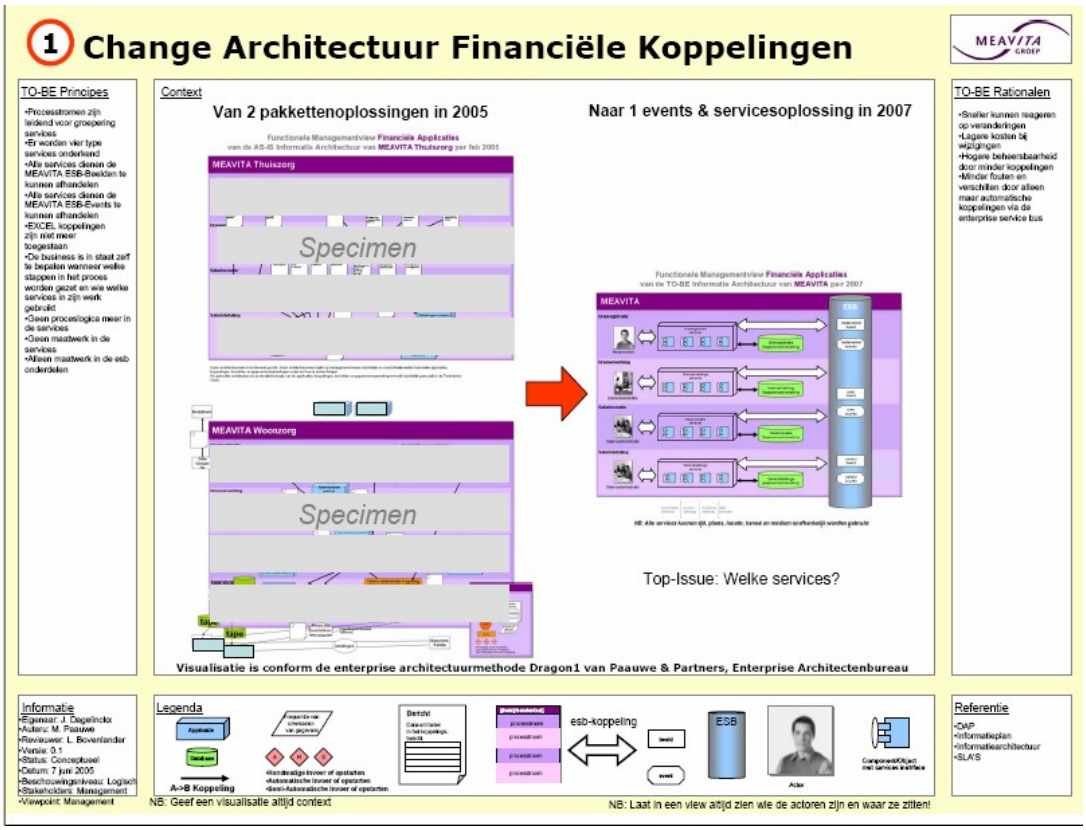


Figure 11: change architecture Dragon 1[x]

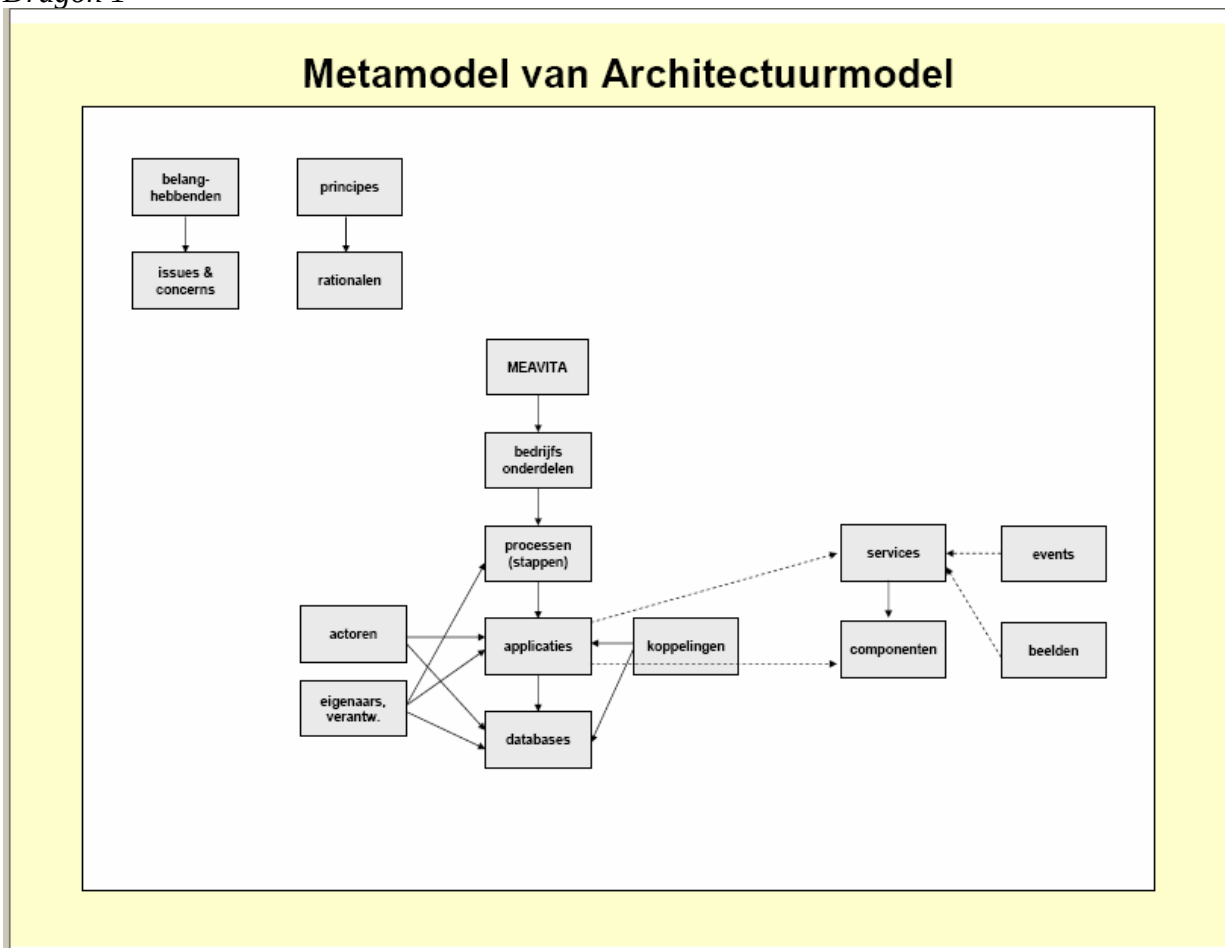


Figure 12: meta-model

Problem	***Stakeholder***	***Principle***
The amount of data is to large and therefore to complex to make a visualisation of.	The architect, stakeholders	Architecture visualisations need to be created in 1 system or master system that contains a single repository A meta-model must be made to indicate the relations between visualisations. A model for visualisations must be made Those stakeholders that will manage the architecture must be thought how to visualise No matter how complex the data it must be recorded with the aid of visualisation in order to keep it comprehensible for future development.

The following two problems are closely related and will therefore be discussed after each other.

7.2.6 How to indicate all relations and behold clarity

A big problem is that of many relations. Between systems/ processes/tasks there can be a lot of relations, if these are all to be visualised, it will clog up the visualisation and it loses its intended effect. There are complains about tools on the market that can make the desired visualisations but do not allow the user to omit relations. If the relations are not important for the visualisation, the user should have the possibility to omit those relations. Moreover, it is useless to visualise many relations all at once because the human mind can't cope with it. Only a few relations will be remembered, this number will probably be reduced by the fact that the relations seem overwhelming. On a related topic G.A. Miller [xi]wrote the foundations. He considered the observer to be a communication channel. The experiment entailed a problem in which to increase the amount of input information and to measure the amount of transmitted information. If the observer's judgement is accurate then nearly all of the input data will be transmitted and will be recoverable from his responses. However, if he makes errors, the transmitted information may be considerably

less than the input. It is expected that as the amount of input information is increased, the observer will begin to make more and more errors; the limits of accuracy of his absolute judgement can be tested. If the human observer is a reasonable kind of communication system, then when we increase he amount of input information, the transmitted information will increase at first and will eventually level off at some asymptotic value. This asymptotic value we take to be the channel capacity of the observer: it represents the greatest amount of information that he can give us about the stimulus on the basis of an absolute judgement. The channel capacity is the upper limit on the extent to which the observer can match his responses to the stimuli we give him. In our case the many relations system will resolve into an overflow for the observer. The observer has so much information to process that he will start making errors and thus is able to transmit less and less of this information. This in turn negates the purpose of our visualisation.

So what needs to be done can be divided in to two decisions

- Decide not to visualise and go for textual explanation only: The benefit of this is that the data does not overwhelm the stakeholder. The drawback is that it will take a lot of time to read all the data and comprehend what it states and what the relations are
- Decide to visualise it, but you need to think of a method to visualise it in such a manner that the stakeholder is not overwhelmed by information and still gets to see the overview

The second decision of course raises the question of how to visualise. This also leads to a number of decisions to be made.

- Firstly, consult with your self what it is that you want to visualise. For this purpose use the list from the chapter on understanding visualisation

Questions before visualising
How do my thoughts process the data that I am reading?
Do I think I understand the data that is represented to me?
What does the mental image I created look like?
Do I feel the need to visualise this data?
Do I feel the need to write down key words of this data?
Why do I feel the need to visualise?
Who am I visualising it for, myself or others or both?
If I am visualising for someone else, what do I think they will need from that visualisation?
What is the background of the person I am making a visualisation for?
What data exactly am I trying to visualise?
How should I shape the visualisation?
What do I hope to achieve with this visualisation?
Should I write down what I want to visualise before creating the visualisation?

- Secondly, it is probably best to keep the visualisation digital in order to work in phases. For the visualisation to improve you will have to work in phases. Do not show all the relations at once. This impairs the cognitive effect and will leave you with a confused stakeholder.
- Thirdly, in order to present all the data but preventing the many relations from overwhelming the stakeholder, you need to group them and work in layers. When looking closely at the relations you can probably find some way to group them in either importance or subjects. If you group these relations together, you can make multiple visualisations. Use multiple visualisations and overlays to increase the channel capacity of the stakeholder. Also, remember to use enough white space.
- Fourthly, look into the merits of 3d visualisations, this can help organize the many relations and give more insight. A 3d visualisation (when implemented properly) can give a better overview of relations. You still have the many on many relations, but you can use dimensions to keep them apart and zoom in to each group of objects that you find important and want to explain. However, it does require the architect to know if the relevant stakeholder(s) can think in three dimensions and it requires the architect to be skilled in the making of 3d visualisations. More on the benefits and drawbacks of 3d visualisations can be found in chapter 11.

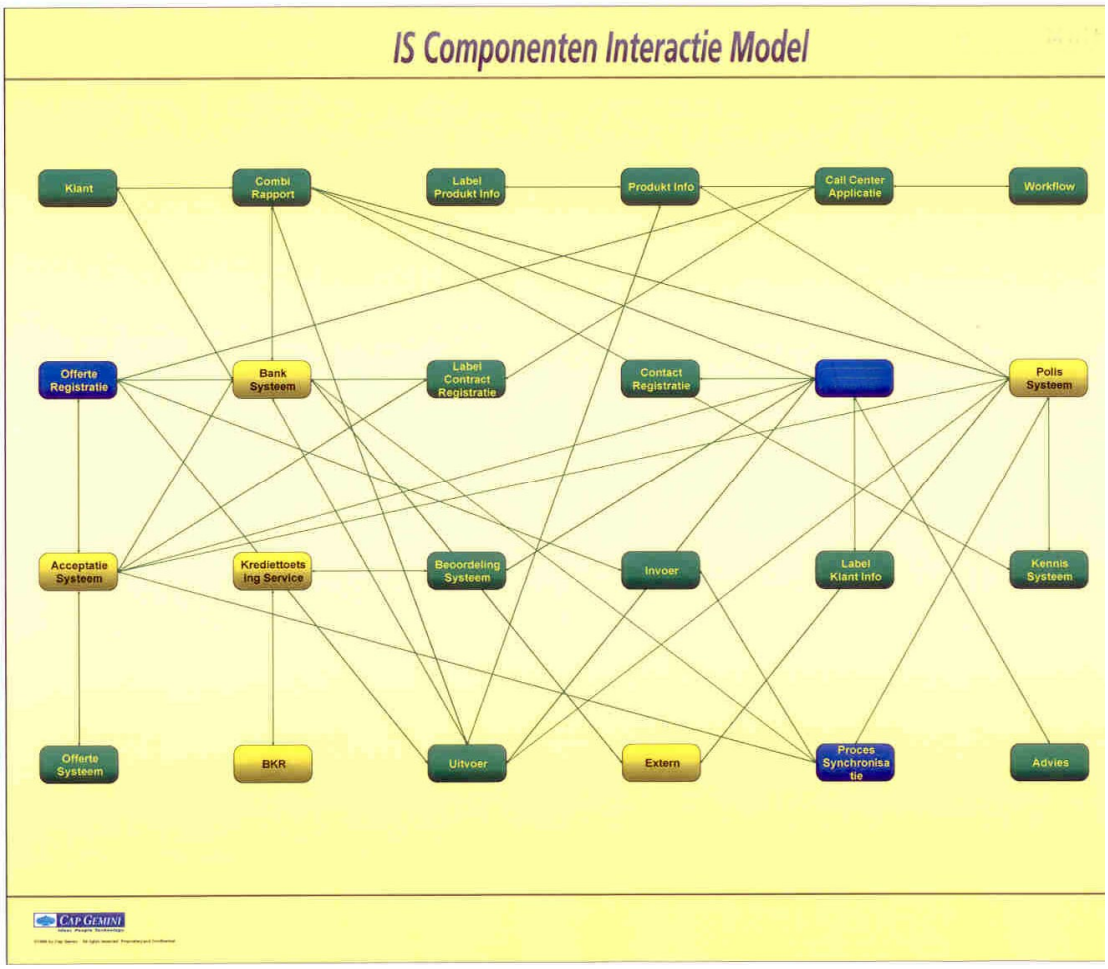


Figure 13: an example of many on many relations in a visualisation. This visualisation quickly loses its intended effect.

Problem	***Stakeholder***	***Principle***
How to indicate all relations and behold clarity:	The architect, stakeholders, universities, colleges, private educational businesses	Keep to the rule of 7 plus or minus 2 when dealing with many relations. Decide how complex the many relations are and if and how it needs to be visualised. Consult with yourself what and how to visualise using the visualisation question list. When dealing with many relations you must find a way to group them and work in layers. When dealing with many relations you need to decide if the use of three dimensions will benefit the visualisation.

7.2.7 Poorly made tools for visualisations

This problem is somewhat related to the previous problem, but entails much more. The related problem is that of presenting all relations in forms of lines, which clog up the visualisation, how should these tools be adjusted to make them of better use? In this section the use of visualisation tools is discussed. Visualisation holds great promise for architecture or other fields in computer science, provided we can meet the immediate and long-term needs of both toolmakers and tool users. A lot of more work needs to be done in the field of visualisation tools. There are a lot of tools on the market such as Metis, BizzDesign or Aris, but none of them meet enough of the criteria.
A tool that has come far indeed is the ArhiMate tool[xii], but this to is not complete yet. What is a good initiative in the ArchiMate tool is the ability to import existing models from a number of different languages and translate them into the ArchiMate language, this leads to a unified language and models can be related to each other. A model that indicates the workings of the ArchiMate tool can be seen in the figure below.

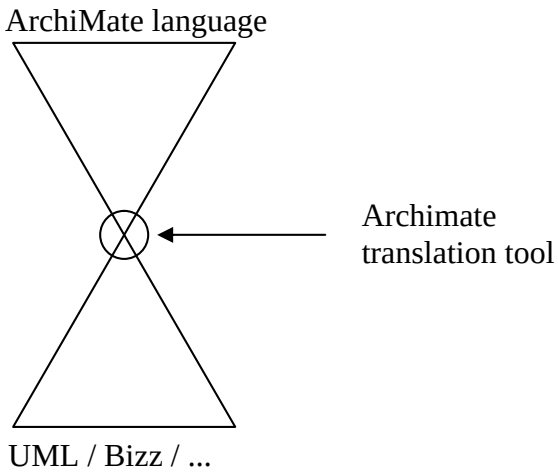


Figure 14: conversion figure archimate

The benefit of this tool is that most companies already have existing models that can be used in future developments or at the least to log the IS situation of a company. ArchiMate allows the user to import existing models and translate them into the ArchiMate language. However, there is somewhat of an issue that is debatable, if you wish to adjust the model, you need to adjust it in the original model, so you need to change the UML or Bizz or process model. You can't change the model in the ArchiMate language. The benefit of it is that the creators of the original models can work in their own language which they understand. The Disadvantage in it is that it does not aid in the total comprehension for other people and the inconsistency in languages remains. Only when imported and translated, the coherence becomes clear. It would be more beneficial in my opinion if the user could continue to work from the imported models and save these. It is possible to start a new model in the ArchiMate tool and these can be saved. Also relations can be indicated between different types of models.

To read more about the ArchiMate tool specifically, I refer to the ArchiMate book by Marc Lankhorst et al[xiii]. I have no intention of discussing what the tool exactly can and can not do. However, the ArchiMate tool is a good start for automated support for Architecture visualisations. Therefore, I will take this model and indicate a few points which are missing or not highlighted enough in my opinion and could add to the value of a tool.

- The ArchiMate tool does not use a database to save the fundamentals of the visualisations in, because it is only a translator. All changes must be made in the original models, which would require you to use different tools for these models. It should be researched if it is possible to import the models and adjust and or add to them in the ArchiMate tool in the ArchiMate language. This will require some work in issues of saving the data and how constraints should be placed and stored.
- A tool such as this should also allow the use of architecture descriptions. Each architecture visualisation should have description and explanation in a few words. In practice the architect will often want to add what principles are displayed in the visualisation and it is beneficial to add a legend for symbols, mainly for those people who are not familiar enough with the language yet and to prevent ambiguity. Especially the indication of what principles are visualised is important, it aids in the comprehension at all times. A few keywords of that which is visualised may aid in this as well, if these words are not ambiguous.
- A tool should allow for other techniques to be used as well. These tools mostly relate to the official modelling languages such as UML. However, a lot of visualisations include informal visualisations. These visualisations make use of icons, pictures etc. They are meant to be explanatory, entertaining and perhaps not entirely correct. It should be possible in a tool to import and use icons and pictures in order to clarify models and for instance indicate how a certain stakeholder is involved in the model. Most beneficial would be if these informal visualisations are derived from the formal visualisations. Disregard the detailed data which you do not need and add data (pictures, icons etc.) which makes the models more presentable. Basically you take a view (view here means a view as in database theory) of the data used in the formal visualisation and work with this view to create that visualisation which has the desired effect.
- There will be a number of visualisations created all from a different viewpoint. For the stakeholder to obtain total comprehension it should be possible for this stakeholder to “hop” viewpoints. This would require a database in which viewpoints are stored and in which relations between viewpoints are indicated (from which object in viewpoint 1 can you go to viewpoint x?).
- The ArchiMate tool visualises in the following manner:

  -
  - There is a certain point of view from which you look at a model (essentially the data you use to create a visualisation) and this leads to a view of the data. In some cases (if you want to save a point of view to create a network of viewpoints) it might be beneficial to translate back

from the view to a viewpoint. However, since it is not desirable to lose data, this would require a new data view which is saved separately.

- A tool should be able to optimise the use of lines or a visualisations needs to be changed in order to prevent the spaghetti visualisations we all know to well.

Further research needs to be done in the development of visualisation tools. This should be a research after market demands and the developer's views.

A list is given below of what a tool should be able to support ideally. I have no intention to be complete, but it is an indication of that which is needed.

Tool criteria:

- An integration is needed and more support for modelling languages in one tool
- Not just the formal languages should be supported, but also the informal visualisations (i.e. the use of icons pictures)
- A tool should support architecture descriptions
- A tool should have the ability to import various languages and translate them to one language
- A tool needs to support the ability to create new models
- A tool should be able to store all relations and constraints between data
- A tool should be able to store views (data selection of data) and viewpoints
- A tool should allow for "hopping" between viewpoints
- If data is changed in a visualisation it should be able to make adjustments for this change throughout all the related visualisations (i.e. consistency)
- It should be possible to import data into the tool, not just from existing models but also data from the architect with which (s)he wants to create visualisations (this ofcourse should be bound to specific criteria)
- A tool needs to support the ability to omit certain relations which the user deems to be irrelevant for the visualisation
- A tool needs to support the ability to group relations lines (arrows) in optimal positions.
- The GUI of visualisation tool needs to improve to support above mentioned criteria.

Problem	***Stakeholder***	***Principle***
Poorly made tools for visualisations:	The architect, stakeholders, universities, colleges, private educational businesses, deliverers of visualisation tools	A tool should support multiple languages A tool should be able to optimize line positions A tool should be able to save data, viewpoints, views A tool needs to support "hopping" between viewpoints.

		A tool should support the use of icons and pictures A tool should support architecture descriptions

7.2.8 There is no time to make a visualisation of the IS situation

The client indicates that there is not enough time/money to visualise the present situation and besides they already know it (but it is not logged). One of the issues here is that the client thinks they know the present situation. However, this is often not the case. It might be true that they have process schema's, some written reports and a good impression of what is going on, but this does not mean that they have an understanding of the current architecture in the company. All principles, rules and guidelines must be explicitly researched before there is any hope to change. You can not change something that you do not know about. A second reason is often the costs consideration. It is true that mapping the IS situation costs more, but it will save in the long run. As with all IT related projects, the costs of solving found problems increase as the project progresses. Architects need to make their clients aware of these facts.

Problem	***Stakeholder***	***Principle***
There is no time to make a visualisation of the IS situation	The architect, management	Before starting any architectural change, the IS situation must be mapped Architects and their employers need to work on making the their clients aware of architecture

7.2.9 How to "Hop" between points of view and how to automate this

People in the field of digital architecture are always referring to how important it is for the architecture to be understood throughout the organisation. While this is certainly true, in practice this is often not implemented. To increase the understanding of the whole architecture, it would be necessary to take a stakeholders own point of view and be able to jump to visualisations of other points of view. There are two issues to consider here

- Does the stakeholder want to be informed of the big picture?
- Is there enough time to make these visualisations if not, perhaps it can be done afterwards?

The first issue depends on the type and scale of organisation. There are those stakeholders that would be interested in seeing the big picture. Even though they may not understand all, it will give them an indication of the synergy that is strived after through architecture. Whether this is or is not to be implemented is something the architect should decide, based on the impression (s)he has of the company, its culture and its people.

What does it mean to "hop" viewpoints?
The hopping of viewpoints originates from the principle that architecture should be known throughout the company. Often a stakeholder will not have a mental image of the big picture and how (s)he fits in this big picture. The "hopping" of viewpoints is meant to increase this understanding. It is much like a game in which the stakeholder can navigate through the architecture. First you need to take this stakeholders (person or group) point of view and visualise it. This stakeholder will have relations with other groups of stakeholders and systems and they have their own relations etcetera. The stakeholder needs to be able to click through a process of viewpoints. All viewpoints are somehow related, if the stakeholder is able to navigate through them, this will increase his/her understanding of the big picture and the understanding of why certain principles are maintained and what is his/her fit.

It is of course time consuming to make such a network of view points. However the benefit is that of recognition of principles, rules, guidelines etc. Some of these viewpoints will be developed when implementing architecture. Others could be made afterwards. The beneficial effect remains and the viewpoint network is a good addition to the architecture reports. It is not necessary for the architect to create all these viewpoints, there will be certain stakeholders who will manage the architecture, they can complete this network of viewpoints. Which also increases their understanding and it is good practice.

There is the question of how to automate this. From the database of objects and relations views are taken which in their turn resolve into visualisations. These are essentially the viewpoints. Therefore a relation must exist between views, indicating which views are related and thus to which viewpoints a stakeholder can "hop". Of course a suitable interface is needed for the stakeholder to indicate what his/her point of origin is and to which viewpoint (s)he would like to "hop".

Problem	***Stakeholder***	***Principle***
How to “Hop” between points of view and how to automate this:	The architect, engineers, stakeholders	Architecture must be know throughout the organisation. In order to increase the understanding of the big picture, stakeholders need to be able to find themselves in the big picture. The “hopping” of viewpoints will increase the understanding of the big picture. The creation of a network of viewpoints is needed to increase the transmission capacity of the architecture. A stakeholder needs to be able to navigate through the network of viewpoints. All viewpoints must be related in some way. The architect needs to determine whether the environment is suitable for a complete visualisation of viewpoints.

7.2.10 How to formalise a visualisation

How to make a visualisation that reduces ambiguity as much as possible and is it possible to make a contract form of a visualisation? More research should be done in this area, but it is possible to make visualisations into contract form. These visualisations are meant to report changes. The visualisation must indicate how that part which is visualised will be performed in the future. It is the new way of working. The use of contract form is limited; visualisations can be further employed as guidelines. These guidelines do not have to be formal, for instance the following visualisation clearly indicates the principles and the visualisation thereof. To the left principles are indicated, below a legend and to the right explanatory phrases.

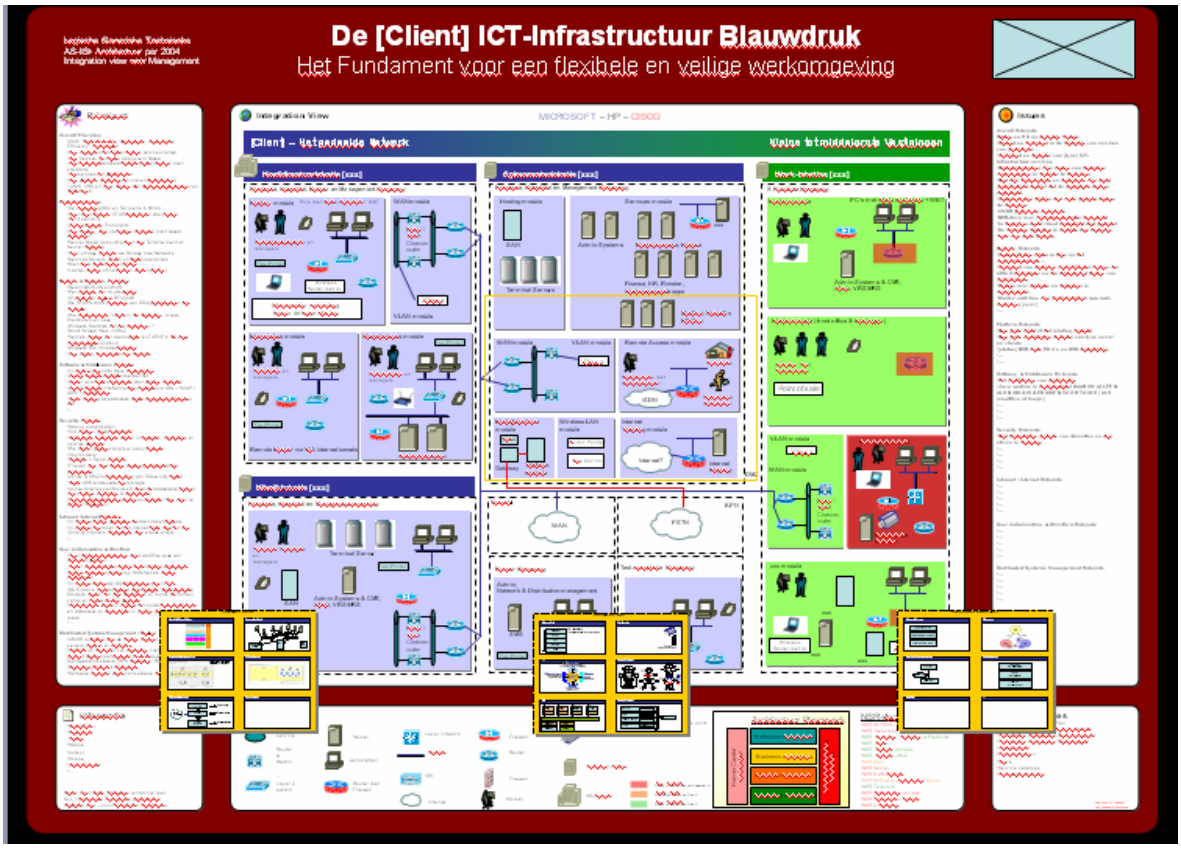


Figure 15: guideline visualisation Dragon1[xiv]

A technique such as UML is a bit more formal, because it doesn't allow for much interpretation and works with constrains. Another possibility for visualised contract form is the technique used in the chapter visualisation a definition. This technique has been developed elaborately. However, such techniques are only understandable for a select group of people. Remember the stakeholder background analysis in which the types of stakeholders were indicated. This type of schemas is beneficial for the Beta-reader, others such as the alpha-reader will not completely understand the meaning and reasoning of the schemas and therefore it is useless as contract form. For those who are Beta-readers it could be used, still not all beta-readers have knowledge of these types of schema's and would have to be educated in them. Therefore, it concludes that for a select group of stakeholders it could very well work, these stakeholders are likely to be in IT related functions. There are a number of criteria that need to be met:

- The visualisation technique must be formal (have semantics and syntax)
- The relevant stakeholders must agree on its interpretation
- The relevant stakeholders must fully understand the meaning of the schema's otherwise it is useless and can not be used as contract form
- The visualisation technique used must be unambiguous

The visualisation will be used as an explanatory schema which entail the principles with which should be governed and aids in recognition of complex data. It is more strict then the guideline version.

On the following page there is an example of what a contract able model should look like. It is the same model as used for explaining visualisation into debt. With such a model the proper population and constraints documentation is needed (such as written in chapter 5.1).

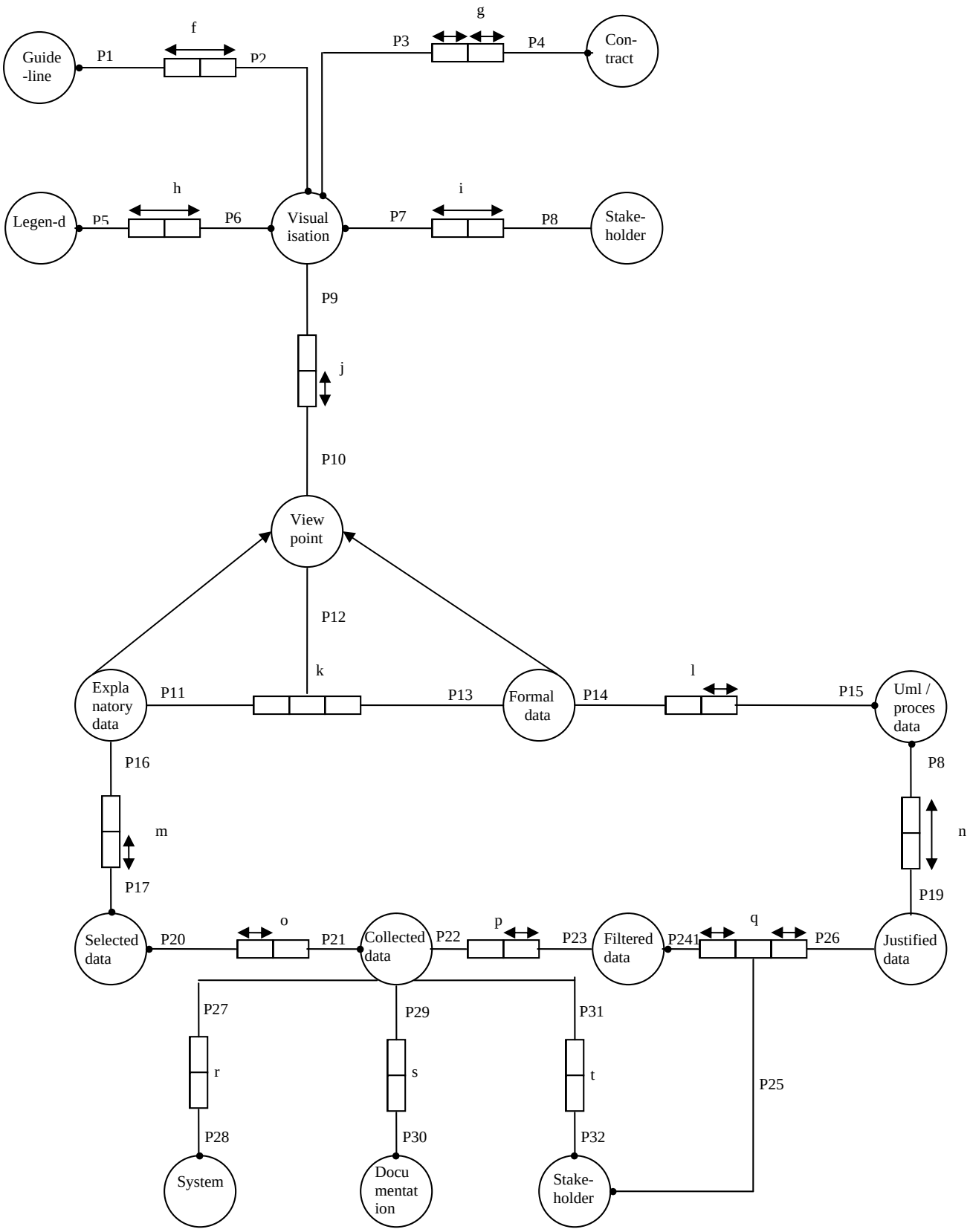


Figure 16: example of contract able schema (created by author of this thesis)

Problem	***Stakeholder***	***Principle***
How to formalise a visualisation:	The architect, universities, colleges, private educational businesses, relevant stakeholders	The visualisation technique must have a formal semantic and syntax The visualisation technique must not be interpretable in multiple ways The contract form should only be used for those stakeholders that have a full understanding of what it entails and can explain it to others A legend with the relevant semantics and syntax should be present There may be no derivations of the original technique unless faults are encountered Before using the contract form the architect needs to perform a stakeholder analysis Architects, universities, colleges etc should strive to make such techniques better known to those for whom it is relevant (not just IT people)

7.2.11 How to decrease the time of making visualisations

How can we decrease the creation time of visualisations? Can we develop a model that decreases the creation time? An argument often made is that an architect is not there to visualise, and will omit it when there is not enough time or the benefits are not high enough in his/her opinion. Indeed this can be true, but visualisations do aid in comprehension during and after architecture development. It will still be time consuming to create visualisations, but if there are models and standards with which to work, the creation time can be decreased. This issue mainly concerns those visualisations made with informal techniques (in PowerPoint, with shapes, icons and metaphors).Perhaps It could be applied to formal techniques too but more research would have to performed. With formal visualisation techniques you create visualisations that will have different patterns each time. However, it may be true that these patterns can be reused. This would require the architect to keep an archive of visualisations. The merits of archiving visualisations need to be researched. When looking at those visualisations created with informal techniques, there is a different path. The visualisations that we want to create a model for concerns architecture views and viewpoints. These are essential visualisations that can take a long time to create. This has to do with a number of causes:

- The required data is not present or vague
- The data can be found in numerous locations and needs to be gathered, but first we need to find out where that data must be coming from
- It is unclear where the problems are and what needs to be visualised
- It is hard to form a mental image of that which needs to be visualised
- Each time a new model for the visualisation is made, there is no or little reuse

The first two problems are simply related to the work of the architect and this will always be true for as long as there is no structure and complete up-to-date reporting of data in companies. The other three problems however are something that can be partially solved. The first thing to do is to ask your self those questions listed in the table below. It is not possible to just start visualising data, if you do this then the visualisation will often miss its intended goals.

Questions before visualising
How do my thoughts process the data that I am reading?
Do I think I understand the data that is represented to me?
What does the mental image I created look like?
Do I feel the need to visualise this data?
Do I feel the need to write down key words of this data?
Why do I feel the need to visualise?
Who am I visualising it for, myself or others or both?
If I am visualising for someone else, what do I think they will need from that visualisation?
What is the background of the person I am making a visualisation for?
What data exactly am I trying to visualise?
How should I shape the visualisation?
What do I hope to achieve with this visualisation?
Should I write down what I want to visualise before creating the visualisation?

The second thing to do is to create a model in which each of your visualisation can be created. It is important to adept the visualisation to the styles and culture of the company that you are working for, but this does not mean that there can't be a model which encompasses it. This model should include:

- space for the principles
- a legend
- a timestamp
- The type of visualisation (is or change or to-be)
- explanations in key words

The visualisations can be reused and there should a fixed spot for each part of the architecture in your visualisation (information, systems, and infrastructure). Depending on the size of the visualisation, the visualisation may have to be made in phases and overlays. More data on the creation of models can be found in chapter 10.3.

Problem	***Stakeholder***	***Principle***
How to decrease the time of making visualisations:	The architect, universities, colleges, private educational businesses, relevant stakeholders	Visualisations should be made to improve current and future comprehension Visualisation models need to be created in order to cut down on creation time A visualisation can't be made before the architect has a good impression of who, what and how. A meta-model of the visualisation should be made in order to decrease creation time. A visualisation should always have a fixed room for the essentials (information, system, and infrastructure) and should include space for the visualised principles, explanation in key words, the type of visualisation, a legend and timestamp.

The following two problems are closely related and will therefore be discussed as one.

7.2.12 Techniques and complications

The doubt of what technique to use: (UML, process schema, *Yourdon, simple drawing, other):*
A much discussed issue is that of what technique to use. What should be the roots of the visualisation? Do we need a formal visualisation? What is best to use in practice?

The technique used is to complicated:
A lot of complaints are about the complicated techniques. Stakeholders do not understand what you are showing them when using a technique like UML. It may be scientifically sound, but is it usable?

In each organisation there will also be a division of people. Some will comprehend the formal models, but a lot of them do not or will not understand them. Although all organisations are different, there are certain types of organisations. It should be possible to have an idea of what type of people work in an organisation before working on architecture and visualisations thereof. When inside the company further stakeholder analysis needs to be done. However, beforehand you can type an organisation and thus know what type of people to expect. If you know this then you also know what type of visualisation you can expect to be using, the formal visualisations or the informal visualisations.

The reason we use formal visualisations is to decrease ambiguity and be exact for system developers. So are we not talking about system development here instead of architecture visualisations? The answer is both. It can be part of system development, but it can also be part of architecture visualisations. If you take a closer look at those people who do understand the formal visualisations you will find that a large group can indeed be found in system development. However, within that group there is also group of people who started from a business point of view but have a good understanding of these formal schema's as well due to for instance mathematical backgrounds or having experience with database theory. So the formal visualisations have a broader use then system development and there will always be a group of people, who are amendable to them, but this is different in each company and the architect needs to judge for him/ her self who these people are. We definitely need these formal visualisations in order to conceive architecture. However, there is more to it, than just the distinction between formal and informal. Depending on the type of data and people, the informal visualisations could very well be derived from the formal visualisations. The visualisations then need to be simplified and perhaps icons and pictures need to be added, to create a more human feeling. Informal visualisations on their own are not enough, because they lead to much ambiguity and the idea that the creators do not exactly know what they are talking about. It would lead to vague descriptions and leave a lot of work for system developers.

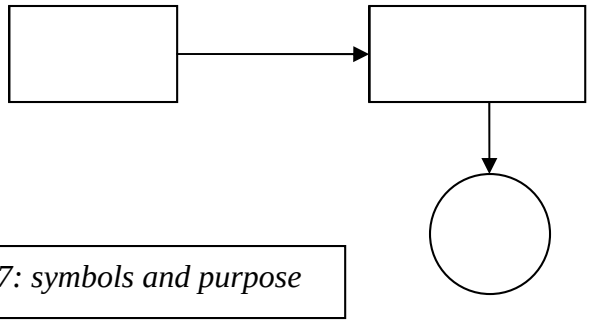


Figure 17: symbols and purpose

For instance if does not really matter what possible texts in these figures would say, the figures on their own have no meaning or if they are supposed to have a meaning, it would be widely interpretable due to the large number of visualisation techniques we have seen over the years. However, this does not mean that when text is added and a verbal explanation is added, the visualisation has no meaning. It could be perfectly usable as explanatory visualisation. The visualisations should not be one to remember, just to conceive an idea. The reason why these shapes are chosen is simply because they are elemental or remind people of some sort of visualisation technique which they do not fully understand, but do recognize the symbols used.

So what technique do you need to use?

- First of all it depends on who you are trying to inform and what his/her background is.
- Secondly, it depends on what the visualisation is meant to achieve
- Thirdly, perhaps the informal visualisation can be derived from the formal visualisation
- And last but defiantly not least, perhaps you do not need to choose. If you are thinking of using different modelling languages, a tool like ArchiMate can integrate them into one language for you. Ofcourse such a tool needs to be launched for the market first.

Both of the above problems are related to the duality of visualisations techniques.

Problem	***Stakeholder***	***Principle***
The doubt of what technique to use: The technique used is to complicated:	The architect, stakeholders, universities, colleges, private educational businesses, deliverers of visualisation tools	There is no choice between formal or informal visualisations Make sure you know who can cope with formal visualisations and who can not or will not. (do not disregard to easily) Derive your informal visualisations from your formal visualisation if you

		need to decrease creation time (and think it is viable) Essentially different languages can be integrated into one language, make use of this. (which means further development of tools and commercialisation of a tool such as the ArchiMate tool). Informal visualisations can conceive an idea; it does not matter if they have no syntax and semantics. Use them to conceive an idea only. Use formal visualisation for detailed reporting. With informal visualisations use elemental shapes, icons, and pictures to remind the stakeholder of data and objects relevant to him/her, this will increase understanding.

7.2.13 Syntaxes and semantics of the visualisation is indistinct

This problem is related to that of using visualisations as contract form, but is a problem on its own as well. Visualisation techniques are used over and over again, companies adjust them to their own style, agreed upon semantics are changed and thus a lot of confusion is created
When looking at contract forms of visualisation from a scientific point of view, it would have to be a visualisation technique that has a formal syntax and semantics. The regular process schema's which are often used in companies do not comply with this criteria. However, it is such a well known technique that most people understand it and know what the symbols mean. What is preventing us from using it as a contract form is not just that it has no formal syntax but also the many varieties that have been created on it over the years. Companies have started to adjust them and use their own symbols. This leads to ambiguity and confusion about symbols. Some process schema's are to widely interpretable, which can not be if it is to be used as contract form or simply explanatory. In order to use them, the used symbols must be well defined in the company, and all involved stakeholders must agree on their semantics. It is not a good idea to adjust techniques for your own company. If a technique does not comply with your demands, you need to use a different technique. There are a lot of techniques which each have their

focus on different aspects. It is preferable to use multiple techniques then to adept one that is a standard. This is not only important for the companies' reports but also for its employees. These employees will at sometime come to work for another company who might uphold different standards which then causes confusion between employees and the possibility of misinformation. When using formal techniques at this point in time it is best to first consider what you want out of a visualisation, and then decide what technique to use.

Problem	***Stakeholder***	***Principle***
Syntaxes of the visualisation is indistinct:	Companies and stakeholders	There may be no derivations of the original technique unless faults are encountered. It is more beneficial to use multiple techniques then to develop a specialisation of an existing technique.

8. Architecture, the effects of visualising

The main issue in this thesis is the efficiency of architecture visualisation as it is used currently and the efficiency of visualisations in general. Visualisation has many beneficial effects; some of these are listed in the table of chapter 7.1**.** Many are aware of these beneficial effects, but do not know how to use them to there full extent. This is because our understanding of the effects of visualisation isn't complete. It probably never will be, because some thing can't be measured. Additionally it is not only the visualisation that has an effect, but also factors such as remembrance and experience, which alters ones interpretation of a visualisation and is individually determined. What is important to remember is that a good visualisation and thus efficiency thereof starts with knowing the source and the destination. The visualisation must not be an exact copy of your own mental image, though this will be a good source to start from. After you have made a visualisation of your mental image you need to adjust it for your destination (stakeholder). This means estimating how your destination will interpret the visualisation you have created.

8.1 A model on visualising

The visualisation on page 73 indicates how a visualisation is created and what goes on inside the head of (in this case) the architect. The visualisation is relatively easy in setup and therefore leaves little room for interpretation. The above mentioned criteria are ofcourse also applicable to this visualisation. The visualisation can be viewed as a meta-model for creating visualisations. Now I shall discuss the visualisation, how it must be read and what the influencing factors entail.

- Use of colours: It is important that you chose colours for your visualisation that are pleasant to look at. The colour on it self does not have to have a meaning, but it must be pleasant to the eye for most people. It is important when using multiple colours to ensure that they support coherence. The colours used in this visualisation see to that. The separating white lines indicate that the 3 part are separate things, but somehow related, because of their proximity. The reason for both the top and the bottom bar being the same colour is that they are both influencing the architect somehow, who is represented in the green bar.
- Use of symbols: The circles indicate a process; all the circles can be viewed as such. The unlined circles indicated that these processes take place in the mind of the architect. The squares indicate influencing factors, there is no particular reason for them being squares. It is important to use different shapes for different objects; elemental shapes are the logical first choice. The visualisation shape indicates a card or something other then text documents in standard flowchart techniques.
- Use of arrows: the arrows indicate the direction in which relations are formed.
- How to read: Mostly the visualisation works with the basic reading rules. It is important to keep to these standards as much as possible. There are those exceptions where you have to view a visualisation bottom up instead of top down; this is the difference between reading visualisations and texts.

1) This visualisation starts at the top with outside influences. The stakeholder and the relevant data influence the architect and the visualisation (s)he is going to make.
2) The architect forms a mental image of what he thinks needs to be visualised. This image is a picture that is in the mind of the architect. When visualising, most people feel an urge to write something down in texts, this is essentially a good idea and helps to focus your visualisation. The architect also has a certain view on the data which shapes the visualisation.
3) This mental image leads to writing down key words or short phrases which support the creation of the visualisation. Based on the key words and the mental image a visualisation is then created.
4) From this point the visualisation can best be read bottom-up. The squares in the bottom bar indicate those factors that influence the visualisation or directly influence the mental image of the architect. The latter is indicated by an arrow running from the bottom of the influence factors to the mental image.

The above explanation of the visualisation brings us to a new point to visualisation. The visualisation isn't hard to understand, yet to fully explain it I needed the four point mentioned above. A visualisation will almost always need to be accompanied by a small textual description or a verbal explanation (preferably both).

The influencing factors:

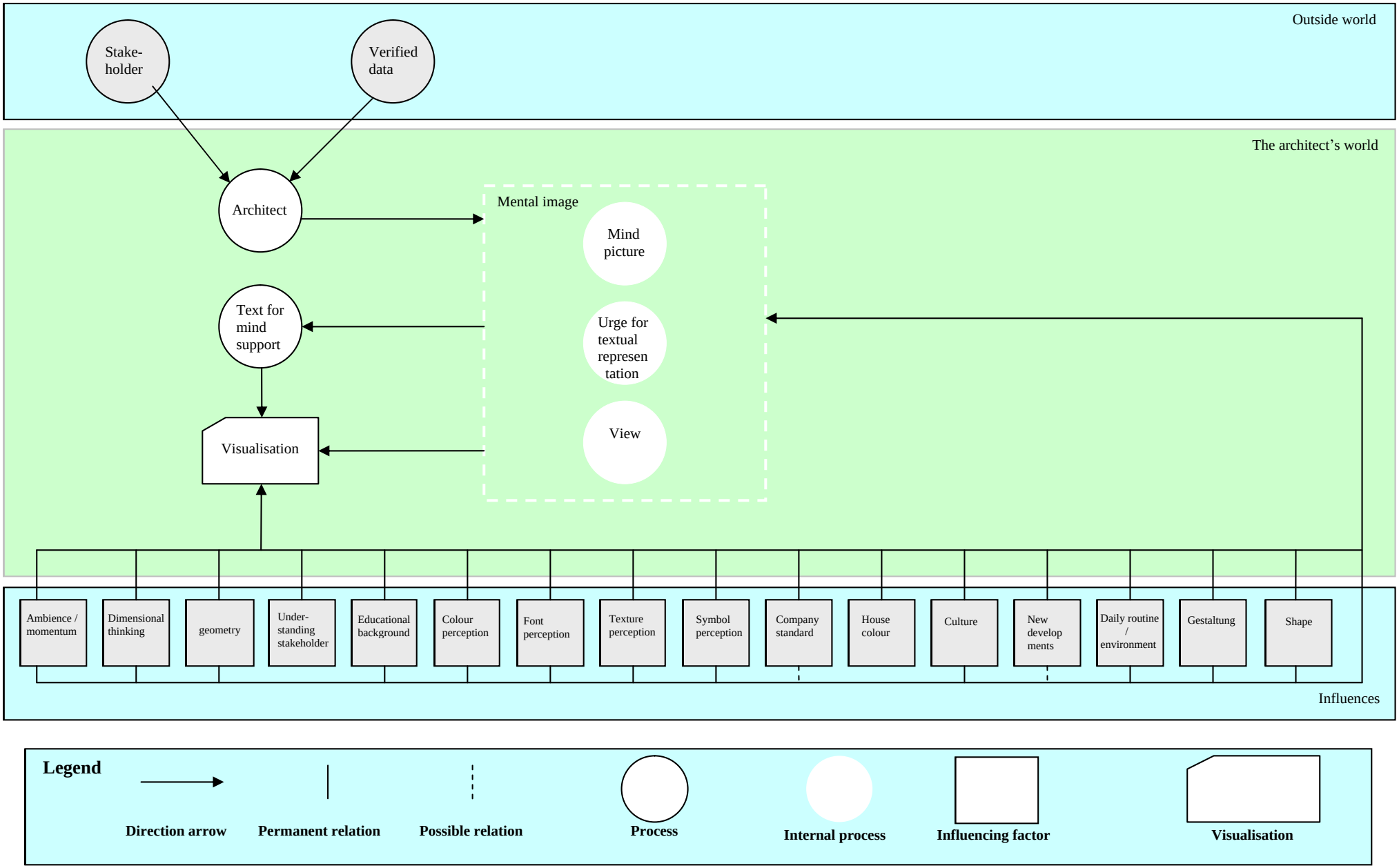
- Ambience momentum: the feel and momentum at the time of creation are important influences to both the visualisation and the mental image. The working ambience determines greatly how we visualise (colours, shapes efficiency). How exactly this alters our perception is a subject for further research.
- Dimensional thinking: every individual has a different way to cope with dimensions. The ability to think in multiple dimensions can add value to your visualisations. However, this ability does not come natural to most people. Practice in multi dimensional modelling is needed. Depending on how the architect and the stakeholder for which the visualisation is to be created, multiple dimensions can play a key role in visualisations and comprehension.
- Geometry: how we cope with geometry influences the visualisation and mental image we create. The more knowledge and experience in geometry we have obtained, the more our visualisation and mental image will contain personally standardized shapes. It determines why we use circles, squares, triangles etc. and which shape/size they will have.
- Understanding stakeholder: This point has been made clear throughout the thesis. This understanding will not directly influence the mental image, because most people initially create a mental image for themselves and adjust it to the stakeholder when actually visualising it.
- Educational background: the educational background of an individual greatly influences the manner in which (s)he creates and views and interpret visualisations. For instance, people with a mathematical background will look

differently upon visualisations then those with an artistic background. In this case it matters if a person has been educated in modelling techniques and visualisation techniques (UML, Process schemas, 3d modelling etc.).

- Colour perception: the way in which we perceive colours influence or mental image directly. There is the simple factor of colour preferences, but also the theoretical significance of colours[xv]. Leonardo da Vinci created an overview of colours and their associations in which for instance the colour blue is associated with infinity, space, travel, eternity and meditation, and green with spring, peace and prosperity, youth, might and autonomy.
- Font perception: In most architecture visualisations, key words have been added to indicate certain processes or relations or simply names. When visualising the font perception influences both creating and receiving party. Each individual has a preference for a certain font type. The font type influences the readability and enjoyment of a visualisation. The matter of digital texts or texts on paper also influences the font perception. Digitally, people prefer to read a font without decoration, on paper the opposite is true.
- Texture perception: the manner in which objects are textured influences a visualisation and the mental image. If a person has a lot of experience with textures and its use, it will directly influence the mental image (s)he will create. Textures can give the impression that certain objects belong to each other, that one is more important then the other or that certain objects are faulty. Textures can be very helpful, but the creator needs to be careful of unintentional effects that may influence the perception of others.
- Symbol perception: the usage of symbols can benefit a visualisation. It aids in comprehending the situation that is visualized. The knowledge of those symbols used in a company or generally can influence the architect when he is forming a mental image and creating a visualisation. Symbols can increase comprehension by means of coherence.
- Company standards: some companies will have a standard way of visualising or at least a few examples of how to. These standards will often influence the architect when he is creating a visualisation. However, by no means is it necessary that it also influences the mental image. It could influence the mental image if a person has been using the standard for a long time and has grown into it. Usually the mind is creative enough to create a unique mental image of that which is to be visualised. The actual visualisation will be adapted to company standards. It should be noted that with architecture visualisations there are almost no standards within companies. At the most, there will be some examples or design principles are taken into account such as those assembled by Henk Koning[xvi].
- House colours: An architect will often adept his/her visualisations to the company (s)he is working for. This means that a visualisation must be adapted, using the colours of the company. For instance Rabobank uses hues of blue and orange. This creates a sense of uniqueness (which is in essence not true) and involvement. This factor will only have influence ones the visualisation is being created. On this note, colours are an important factor, if you can use company colours then do so. Be careful not to enforce this, sometimes the colour combinations in architecture visualisations will lead to overwhelming transference of information.

- Culture: A very important factor in general and thus also to architecture visualisations is that of culture. Different cultures have different norms and values. It influences perceptions of colours, symbols etc. For instance, white in America is associated with peace, goodness, angels etc. whilst in Japan it is the colour of war. The culture of the visualisation creator will directly influence his/her mental image, (s)he may have to adjust the actual visualisation (s)he creates to comply with the proper norms and values of the relevant stakeholders' culture. Especially with the recent trends of off-shoring this is an important issue.
- New developments: new developments on the market and inside a company will influence the creation of the visualisation and may influence the mental image. This can be anything from new modelling techniques, new tools to new technology shapes and ideas from new developments will influence the thought process of an individual.
- Daily routine / environment: the daily routine and environment of an architect will influence the visualisations that he creates and the mental image. Those shapes, colours and other influences we see in our daily live, influence our way of thinking. For instance if the furniture at home is modern or classical, then the shapes and the colours used in this furniture will influence your work (adored or sober). These shapes and colours etc. are imprinted on your mind and most likely have a relation with your own preferences, because they are imprinted on your mind they will reoccur in other works.
- Gestaltung: a term much used in the world of psychology and art. Gestaltung influences the way we group and form shapes in our mind and in visualisations. It is the process of giving shape to your thoughts and thus your mental image. It is also the process of clustering and shaping forms in your visualisations and basically the entire process of visualising. Gestaltung is our natural inclination to shape, cluster and form objects.
- Shape: there are some widely accepted standard shapes. These shapes will appear over and over again. This could be a good thing or not. It will however influence the creation of visualisations and the mental image we create for ourselves.

Figure 18: a visualisation model (created by author of this thesis)



9. Efficiency of visualisations

In this section I will consider the efficiency of architecture visualisations. In order to determine this efficiency, theoretical and practical research needs to be performed. The theoretical aspects have been examined in the previous chapters. The practical research will be discussed in this chapter. This work entailed a test during an active conversation about architecture and the visualisation used for explaining certain principles. This test consisted out of three separate phases:

- A list of questions to be asked of the architect and the stakeholders (separately)
- Participating in the conversation and determining how well a visualisation performs and what aspects of it make it work. These aspects have been rated on a score list.
- A list of questions to be asked of the architect and the stakeholders (separately) after the conversation.

The intention was to perform this research with a number of different companies. However, due to the sensitive information that is concerned with this research, many felt that even though the research on itself is a good idea, it is not implementable (at least not for an outsider). Due to the unwillingness to cooperate with this research its true value has been diminished. I have been able to perform two research projects, of which one could not be fully implemented. The question list could not be answered in one of the two cases, because the interaction between people from different sections was to sensitive. These questions may or may not be able to cause insecurity, and conflicts between people and or divisions. Nevertheless the score list could be filled in through observation. It would have been more beneficial could this research have been performed to its full extend, but due to sensitivity of communication and information this could not be done. In the following section the two researched visualisations will be considered.

9.1 Efficiency test of a mutation model

In figure 19 an informal visualisation can be seen. This visualisation represents a number of processes and their directions (it indicates the principle by which this work is currently performed). The purpose of the conversation and of the visualisation was to get a clear picture of what processes exactly still needed to be automated. The architect involved in this conversation was guiding the conversation and leaving decisions as much as possible to the stakeholders (this is the work of a good architect, the work of a coach). Afterwards this purpose had been partially achieved. The reasons for partial success will be considered with the examining of the visualisation.

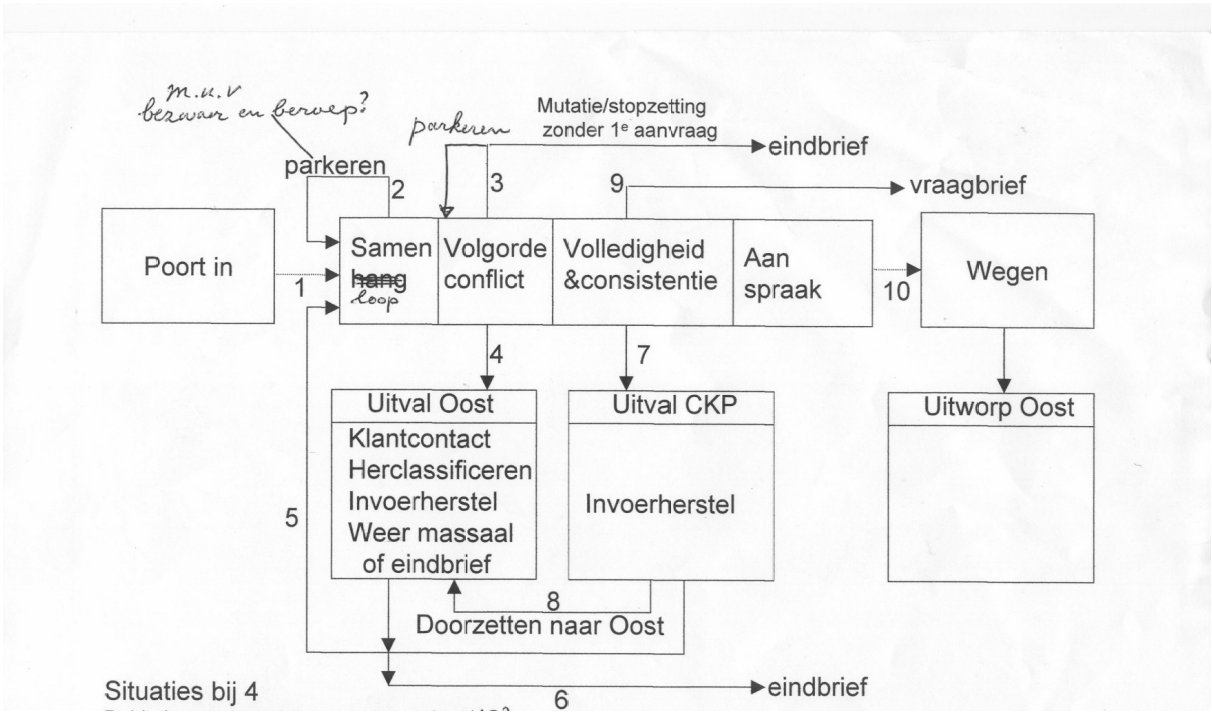


Figure 19: mutation model

First, in the table below the factors are listed on which a visualisation can score. These factors have their own weight and therefore some can have more influence then others. The factors listed here are those objects or definitions which are important in visualisations. The manner in which they are implemented will have a different effect on each individual. The purpose is to obtain a result for certain standard stakeholders and the effect a visualisation has on them.

Influencing factors
Visual and text (what is the added value of this combination?)
Meaningfulness objects (what do objects mean?)
Meaningfulness arrows (what do they mean, without text?)
Number of dimensions (how many dimensions in the visualisation?)
Order in visualisation (positioning of objects?)
Formality (can the visualisation serve as contract form?)
Use of legend (is there an explanatory legend available?)
Use standard method (is a known method applied?)
Use of icons (in which manner are icons being used?)
Use of metaphors ((in which manner are metaphors being used?)
Understanding visualisation without explanation (is it clear without explanation?)
Understanding visualisation with explanation (is it clear with explanation?)

In the two score lists on page 78 and 79, the scores for the visualisation in figure 19 can be found. This test has been filled in for two different types of stakeholders. There were different types of stakeholders present; I chose two who are in significant different roles. However, as you can see the visualisation did not affect one more then the other. I will now examine this score list more closely.

Visual and text: An outsider would understand little of what this visualisation means. The texts added to the visualisation do help for insiders. However, it did not help these two stakeholders enough because of the ambiguity of the words. The same terms in different contexts were viewed differently by the stakeholders (not just these two). For the process analyst the terms could have a different meaning then for the manager, this leads to confusion.

Meaningfulness objects: The top squares hold absolutely no value. Without the texts inside the square, they would become meaningless. The bottom square however, reminds us of UML diagrams somewhat. It has an object names and properties. However it is not implemented properly.

Meaningfulness arrows: The use of arrows here is meant to indicate directions of information flows. Where the lines cross additional arrowheads are indicated to ensure the proper reading of the arrows. However, one still need know a lot about these processes to understand why these arrows are the way they are.

Number of dimensions: The number of dimensions can increase the comprehension of visualisations. In this particular visualisation the use of dimensions has not been applied to its maximum. It is a flat 2d visualisation; a 3rd dimension could increase the understanding of the relations between these objects. The understanding of how to read this visualisation was at first (without explanation) low with both stakeholders.

Order in visualisation: The stakeholders understood the order of the objects in the visualisation. To them this is a proper alignment of the processes that they know. For an outsider this ordering would be without meaning. The question that remains is why some objects are bigger then other, what does this mean? It appeared that the size had no significant meaning and thus this visualisation is not properly made. The stakeholders were not bothered by the size difference, and thought nothing of it. This is still an error often made in visualisations. The size of objects usually does have a meaning even if it is not intended. The creator of an architecture visualisation should always remember that applying different sizes in objects is equal to indicating importance of these objects.

Formality of visualisation: This factor is not applicable to this visualisation. It is not intended as a formal visualisation, it is merely mind support for the stakeholders. The visualisation holds no formal meaning.

Use of legend: This factor is also not applicable to this visualisation. The visualisation exists out of basic shapes that hold no meaning and thus no legend is needed.

Use of standard method: As indicated before, the lower objects remind us of UML diagrams. They are not fully implemented as thus. However, the desired effect of object and relations did occur to both stakeholders. This is an example of how a formal technique can be made informal and still hind at its intended meaning. Even though it is not truly a standard method, it does give the impression to be so. It could be argued that the use of basic shapes can be a standard for that company if they all know what is meant by the shapes and how to use them.

Use of icons: This factor is also not applicable to this visualisation because no icons are used.

Use of metaphors: Even though this visualisation contains no metaphors. It did encourage people to come with explanative metaphors, which increased the understanding for both stakeholders. The visualisation on its own is not very informative, but it did force the stakeholders to think about these situations and use metaphors and examples to explain situations. Therefore, the effectiveness of this visualisation is increased.

Understanding the visualisation without explanation: The visualisation is not comprehensible unless you know what each process and each term exactly means. The difference here is that obviously the process analyst knew more about the processes then the manager. Therefore the effectiveness of the visualisation is higher for the process analyst. The overall efficiency of this visualisation could be increased by choosing better terms and perhaps a legend for the processes that are indicated here.

Understanding of the visualisation with explanation: This visualisation emphasises the importance of verbal explanation. The visualisation served as mind support for the stakeholders and forced them to think about processes and why they are the way they are. The stakeholders needed to explain the data to each other which is the best way to increase understanding

Score list visualisation: Manager with sympathy for IT													
	0	1	2	3	4	5	6	7	8	9	10	N.A.	Explanation
Visual and text (what is the added value of this combination?)							■						Without text not comprendible
Meaningfulness objects (what do objects mean?)					■								Only the lower squares indicate meaning
Meaningfulness arrows (what do they mean, without text?)							■						Arrows indicate direction
Number of dimensions (how many dimensions in the visualisation?)						■							
Order in visualisation (positioning of objects?)							■						
Formality (can the visualisation serve as contract form?)												■	To global
Use of legend (is there an explanatory legend available?)												■	
Use standard method (is a known method applied?)							■						
Use of icons (in which manner are icons being used?)												■	
Use of metaphors ((in which manner are metaphors being used?)							■						Leads to metaphors
Understanding vis without explanation (is it clear without explanation?)					■								The processes are unclear
Understanding vis with explanation (is it clear with explanation?)								■					The processes are unclear

Total score visualisations and comprehension	5,04

objects to meassure	%
visual and text. Combo, low weight	1
meaningfulness objects, medium weight	3
meaningfulness arrows, Medium weight	3
number of dimensions, medium weight	3
ordening in visualisations, low weight	1
formality visualisation, large weight	5
use of legend, medium weight	3
use of standard method, large weight	5
Use of icons, medium weight	3
use of metaphors, medium weight	3
comprehension visualisation without expl., large weight	5
comprehension visualisation with expl., medium weight	3
Total	38

Figure 20: Score list BD

Score list visualisation: proces analyst													
	0	1	2	3	4	5	6	7	8	9	10	N.A.	Explanation
Visual and text (what is the added value of this combination?)							■						Without text not comprendible
Meaningfulness objects (what do objects mean?)					■								Only the lower squares indicate meanin
Meaningfulness arrows (what do they mean, without text?)							■						Arrows indicate direction
Number of dimensions (how many dimensions in the visualisation?)						■							
Order in visualisation (positioning of objects?)							■						
Formality (can the visualisation serve as contract form?)												■	To global
Use of legend (is there an explanatory legend available?)												■	
Use standard method (is a known method applied?)							■						
Use of icons (in which manner are icons being used?)												■	
Use of metaphors ((in which manner are metaphors being used?)							■						Leads to metaphors
Understanding vis without explanation (is it clear without explanation?)							■						The processes are unclear
Understanding vis with explanation (is it clear with explanation?)								■					The processes are unclear
Total score visualisations and comprehension	5,81												

objects to meassure	%
visual and text. Combo, low weight	1
meaningfulness objects, medium weight	3
meaningfulness arrows, Medium weight	3
number of dimensions, medium weight	3
ordening in visualisations, low weight	1
formality visualisation, large weight	5
use of legend, medium weight	3
use of standard method, large weight	5
Use of icons, medium weight	3
use of metaphors, medium weight	3
comprehension visualisation without expl., large weight	5
comprehension visualisation with expl., medium weight	3
Total	38

Figure 21: score list BD2

9.2 Efficiency test of a change model

In the following section a more elaborated test will be examined. This test was performed at the Meavita group.

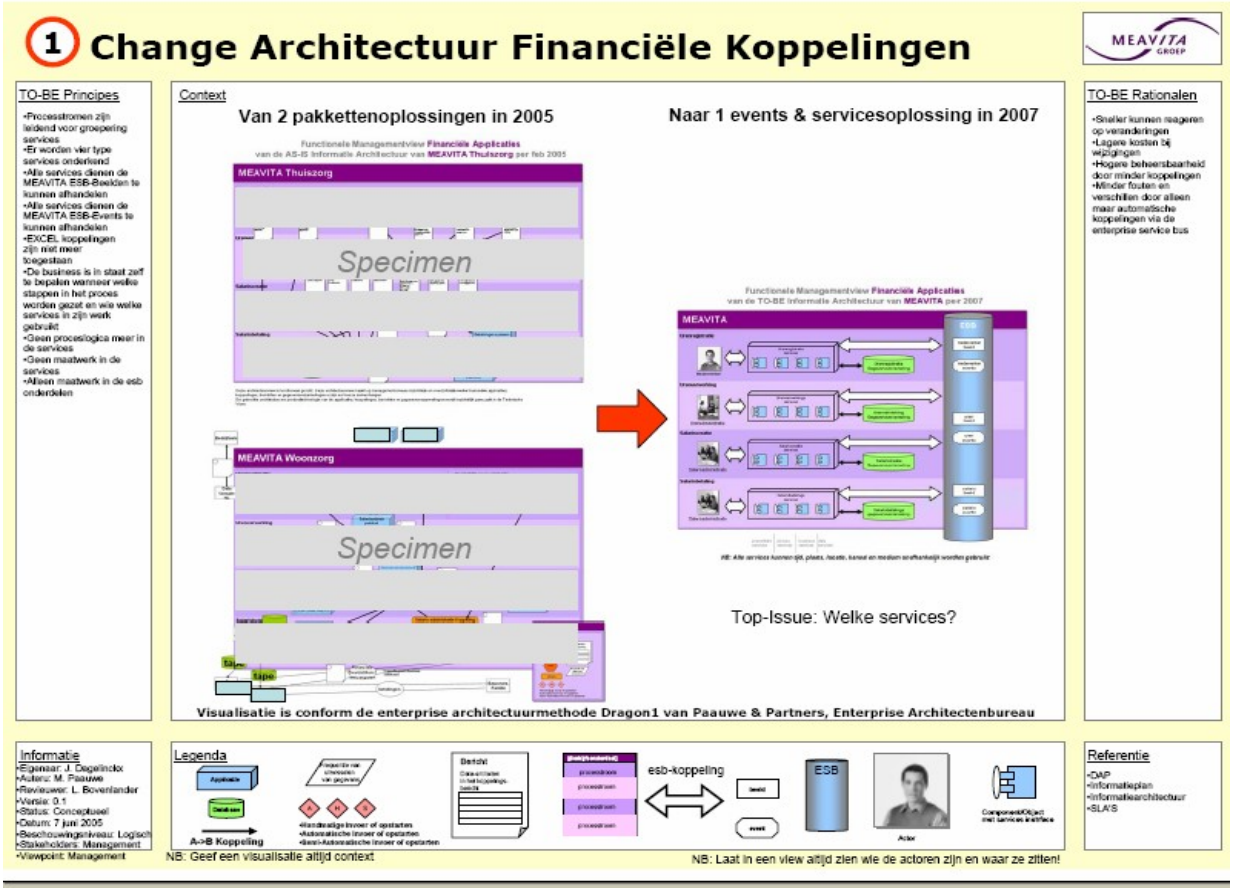


Figure 22: the visualisation used by the architect to explain the changes (has been altered for use in this thesis)

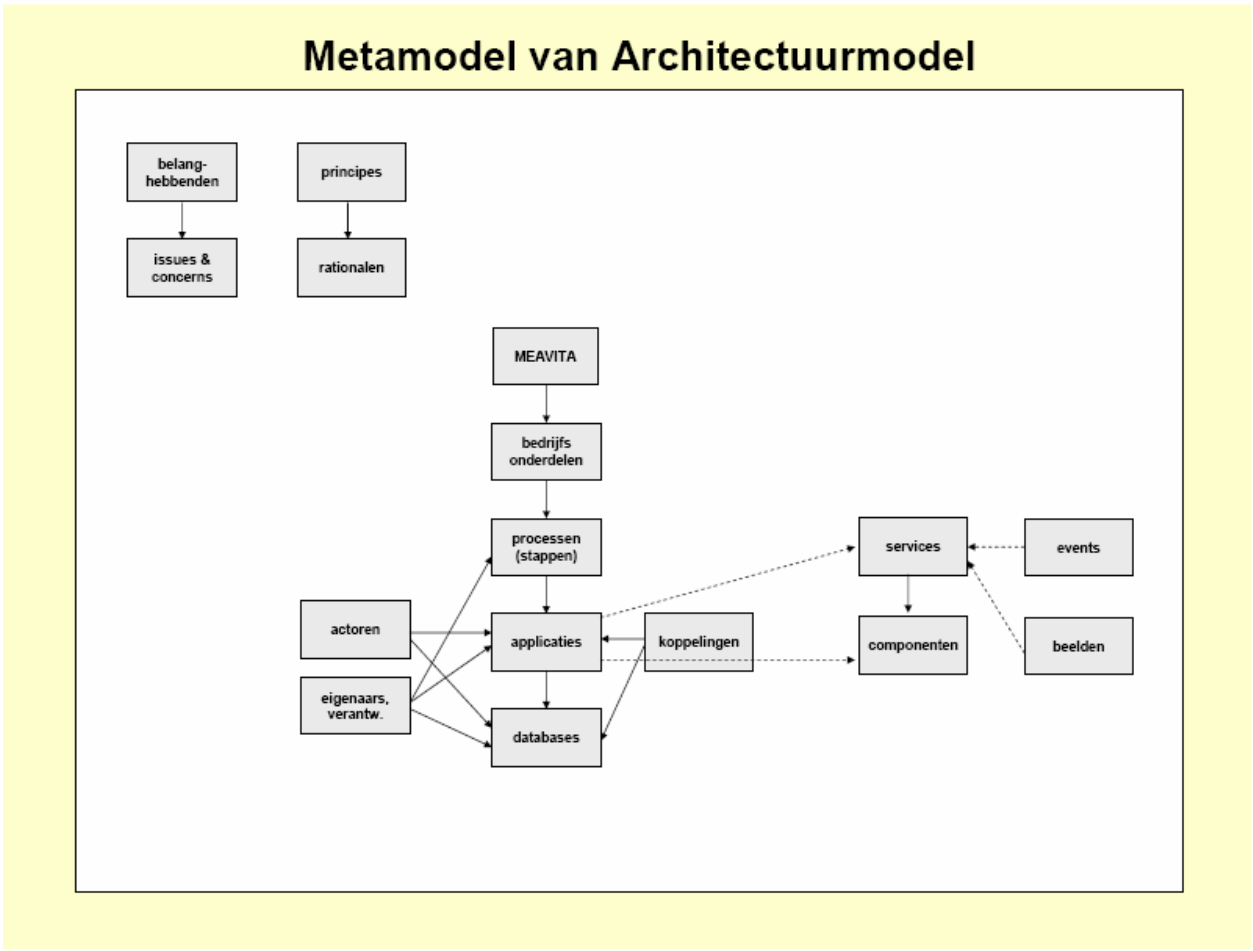


Figure 23: a meta-model for the visualisation in figure 22

Efficiency test at the Meavita Group:

The efficiency test at the Meavita group was fortunately somewhat more elaborate. Questions were asked before and after the conversation. During the conversation I was purely an observer. However, the stakeholders involved did know the purpose of my presence and thus elaborated on there understanding. In the following section I will examine the effectiveness of the visualisation and it's meta-model as presented in figures 22 and 23**.** The score list can be found on pages 84 and 85**.** The answers to the question list have been located in appendix 3**.**

The factors in the score list and their appliance to the Meavita visualisation
In this case the effect of the visualisation on the stakeholders has been determined largely by the answers to the questions that accompanied the score list. Their functions (service manager and application manager) are closely related, but these two individuals have different educational backgrounds (not IT related).

Visual and text: Clearly the visualisation used is a combination of visualisation and texts. The efficiency of the visualisation is increased by using the same keywords as the stakeholders use (they are not ambiguous) and by the addition of the textual presented principles and rationalization (respectively to the left and the right of the visualisation). Both stakeholders indicate that the visualisation were comprehensible enough to them without verbal explanation

Meaningfulness objects: The visualisation is accompanied by a legend that explains the symbols and icons that are used. The meta-model also increases the understanding because it represents how the visualisation fits in the big picture. For the service manager the efficiency was a little less, because he was less familiar with the use of objects and layers.

Meaningfulness arrows: The arrows in the meta-model indicate the relationship between the objects. What these relations entail was explained verbally, but is not indicated in the meta-model itself. The arrow used in the visualisation itself is explained in the legend. Based on the answers of the question list and observation during the conversation it can be derived that there was no misinterpretation of the arrows.

Number of dimensions: In the visualisation a layering technique has been used. It would appear that the visualisation has multiple dimensions and gives the impression to be 3d. The use of layers helps to separate the different processes that are indicated here. By the additional use of colours and proximity to each other it is indicated that these processes belong together. The use of layers and the impression of 3d has aided in the comprehension.

Order in visualisation: Again the layering is very important; it influences the order of the objects and gives the impression to form a complete object. Also notice the use of the blue ESB bar which spreads over all the processes indicating it is used by all of them. The order in this visualisation has been done well.

Formality of visualisation: Even though this is not truly a formal visualisation in the sense of it having syntax, it is considered by the stakeholders to be of formal value. For them it indicates exactly what is of importance and the principle and rationalization aid in

the formalisation of the visualisation. It will be used as a formal visualisation in the sense that it will be used as a foundation for changes.

Use of legend: There is a legend present in this visualisation that explains most of the symbols used in the visualisation. The stakeholders indicated that it did indeed aid in their comprehension of the visualisation. However, the legend does not explain the symbols as intuitively as it might. To people unfamiliar with the terms it may still seem unclear what these symbols mean.

Use of standard method: This visualisation is created with the method dragon1. Most of the objects are very standard and widely known such as the use of symbols for databases, objects and layering. This method also entails the textual explanation of the visualisation with principles, rationalisations and a legend. The layout used, increases the standardisation of the visualisation. A fixed array of principles, visualisation, legend, rationalisation and type of visualisation is used. These parts can be used in every visualisation and leads to a model for visualisation.

Use of icons: This visualisation does make use of icons and effectively so. Especially the use of pictures of individuals (in essence icons) aided the comprehension of the stakeholders. The stakeholders were very font of this and said that it is important to realize in their company that they are talking about people. It is of importance to human reasoning.

Use of metaphors: Again the pictures in the visualisation serve as metaphors and increase the understanding of the stakeholder.

Understanding the visualisation without explanation: The layout of this visualisation (principles, legend etc) helps in comprehending the visualisation. The meta-model explains the situation of the visualisation. All these factors lead to an increased understanding and thus efficiency of the visualisation.

Understanding of the visualisation with explanation: The architect himself indicated that every visualisation needs an explanation. If only just to ensure that the visualisation is properly viewed. The stakeholders indicated that the architect was able to transfer the data of the visualisation with ease. This indicates the skill of the architect but also the high efficiency of the visualisation.

Score list visualisation: application manager													
	0	1	2	3	4	5	6	7	8	9	10	N.A.	Explanation
Visual and text (what is the added value of this combination?)								■					notions around visualisation help
Meaningfulness objects (what do objects mean?)								■					
Meaningfulness arrows (what do they mean, without text?)								■					
Number of dimensions (how many dimensions in the visualisation?)								■					
Order in visualisation (positioning of objects?)								■					
Formality (can the visualisation serve as contract form?)							■						
Use of legend (is there an explanatory legend available?)								■					More conversation on this is needed
Use standard method (is a known method applied?)									■				
Use of icons (in which manner are icons being used?)									■				
Use of metaphors ((in which manner are metaphors being used?)									■				Event driven
Understanding vis without explanation (is it clear without explanation?)								■					
Understanding vis with explanation (is it clear with explanation?)								■					

Total score visualisations and comprehension	7,15

objects to meassure	%
visual and text. Combo, low weight	1
meaningfulness objects, medium weight	3
meaningfulness arrows, Medium weight	3
number of dimensions, medium weight	3
ordening in visualisations, low weight	1
formality visualisation, large weight	5
use of legend, medium weight	3
use of standard method, large weight	5
Use of icons, medium weight	3
use of metaphors, medium weight	3
comprehension visualisation without expl., large weight	5
comprehension visualisation with expl., medium weight	3
Total	38

Figure 24: score list Meavita

Score list visualisation: service manager													
	0	1	2	3	4	5	6	7	8	9	10	N.A	Explanation
Visual and text (what is the added value of this combination?)								■					notions around visualisation help
Meaningfulness objects (what do objects mean?)							■						
Meaningfulness arrows (what do they mean, without text?)								■					
Number of dimensions (how many dimensions in the visualisation?)								■					
Order in visualisation (positioning of objects?)								■					
Formality (can the visualisation serve as contract form?)							■						
Use of legend (is there an explanatory legend available?)								■					More conversations on this needed
Use standard method (is a known method applied?)									■				
Use of icons (in which manner are icons being used?)									■				The use of icons and human reasoning
Use of metaphors ((in which manner are metaphors being used?)									■				
Understanding vis without explanation (is it clear without explanation?)								■					
Understanding vis with explanation (is it clear with explanation?)									■				

Total score visualisations and comprehension	7,15

objects to meassure	%
visual and text. Combo, low weight	1
meaningfulness objects, medium weight	3
meaningfulness arrows, Medium weight	3
number of dimensions, medium weight	3
ordening in visualisations, low weight	1
formality visualisation, large weight	5
use of legend, medium weight	3
use of standard method, large weight	5
Use of icons, medium weight	3
use of metaphors, medium weight	3
comprehension visualisation without expl., large weight	5
comprehension visualisation with expl., medium weight	3
Total	38

Figure 25: score list Meavita2

9.3 Comparison of visualisations

Both visualisations had their own purposes. The first visualisation in figure 19 was purely meant for mind support and to increase the ability to reason about the problem. The second visualisation in figure 22 was much more explanatory and serves now as a basis for future work. Furthermore, the second visualisation uses more techniques and the symbols and icons used have better semantics. It is not surprising that the second visualisation has a higher efficiency. A number of important factors in efficiency of visualisations clearly are:

- Colours
- Layers
- Legend
- Textual explanation of principles and rationalization
- Involvement of stakeholders in the visualisation
- Being able to understand what the visualisation entails by using the proper keywords.

10. The how and why of a model for visualisations

Can a model for architecture visualisations be created?

The question of the possibility to create a model for architecture visualisations has a duality to it. On one side there is the question that is directly related to the actual creation possibility of the model, on the other side there is the question of feasibility of an architecture visualisation model. With this second issue I mean the effects and acceptance of an architecture visualisation model. The second issue is a very important one and must be discussed before we can consider the actual creation of a model.

10.1 Acceptance of an architecture visualisation model

There are many modelling techniques available in the IT world, Most are formal such as UML or the modelling technique used in chapter XX of this thesis, but there are informal techniques as well, which could also be considered as modelling though in a different context. Here I am considering modelling in the sense of creating a standard layout for architecture development. Within it there is the possibility of modelling techniques such as UML to be used, or more freestyle such as process relations and icons. So a model must be created but its contents can be versatile. If UML or some such formal technique does not comply with the intended goal, you need to use a simplified version of the technique or any other visualisation technique that does suit your purposes. Furthermore, within the model different content can be displayed, the model only ensures a fixed framework.
A lot of work has been done on modelling; an example from the Radboud University of Nijmegen is the article[xvii] on requirements on modelling techniques, by E. Proper, S. Hoppenbrouwers and T. van der Weide. It considers modelling with a communication driven approach and the meaning of action research. It gives a good impression of the relationships between modelling, visualising and social aspects. Here exactly lies the problem of creating a model for architecture visualisations. Modelling has many benefits and the creation of models is widely accepted, because it aids us in our work and routines. However, in the context of architecture there is one big problem; People!
This specifically relates to the more creative visualisations in which icons and metaphors are used. We would love to standardise and create models to decrease our own performance time, but people are not machines who can process the same shapes (gestaltung) of data sets over and over again. Architecture visualisations have many different purposes and destinations (wide spread of people to reach). The usefulness of a model can only go so far. The problem is cyclic and lies with sender and receiver.

- On the sender's side: because those who are using visualisations thoroughly have a need to be creative.
- On the receivers side: because they expect something fresh and new, yet compliant to something of their own.

It is almost like entertainment. A model (especially when badly received) can become a drag when used often and targeted at the same destination group, which is something you definitely do not want to strive for when trying to commit people to architecture. Because

there is such a wide spread of receivers, the visualization needs to be original and creative. People must not tire of it; otherwise it loses its purpose and power. Thus you can only go so far in creating a model for architecture visualizations. Do not predefine exactly how to visualise and what technique to use, rather create a frame in which a visualisation can be made. This will still increase creation speed somewhat and it gives direction to your visualisation.

10.2 The architecture visualisation models

The visualisations used in figures 15, 22 and 23 are excellent examples of such models. In my research I discovered that it is necessary to indicate in what context a visualisation needs to be viewed. It would be best to add a short description, principles, timestamp and legend a visualisation. The visualisations used in figure 8 and 22 are excellent examples of how far you should go with a model for architecture visualisations. These visualisations have been created by Paauwe en Partners another possibility for a model is to derive it from an existing framework such as the IAF framework, it can work according to the same principles.

The following figure indicates the base of every visualisation model developed by Paauwe and Partners. Additionally the house colours of the company can be used in the visualisation to create a feeling of uniqueness. This is an example of a standard model which could be applied continuously. In this case the visualisation has a yellow background, this can ofcourse be variable. Furthermore, a meta-model such as seen in figure 23 can aid in the comprehension of this model. This model will also cut down on creation time.

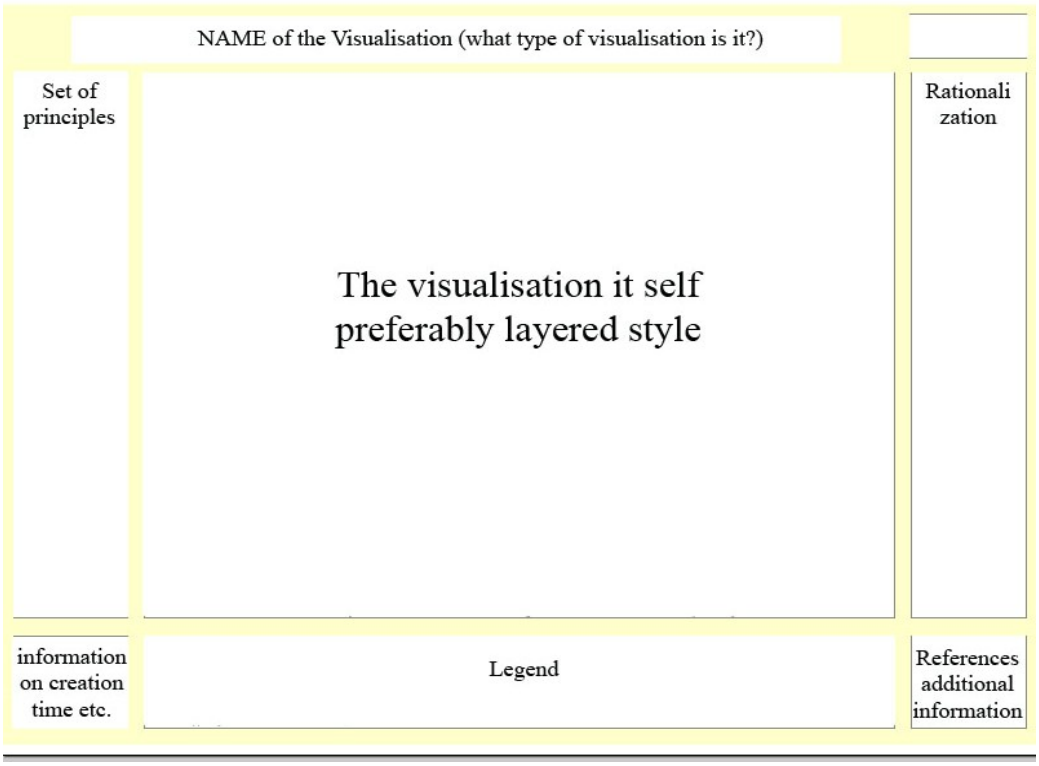


Figure 26: A visualisation model based on the method dragon1 (created by author of this thesis)

In the two figures below a second possibility for a architecture visualisation model is given. This model is derived from the visualisation in figure 8 and the IAF framework, both from Cap Gemini. This type of model could work well for creating architecture visualisation. It is slightly different then the above model in the sense that it uses the layers as in the IAF framework and ofcourse the layout differs. It should also be noted that in this case the technology layer is the largest, the order and size of the four layers can ofcourse differ depending on what you wish to visualise and the importance of the layers. Unfortunately this model is not being used in Cap Gemini at this point of time.

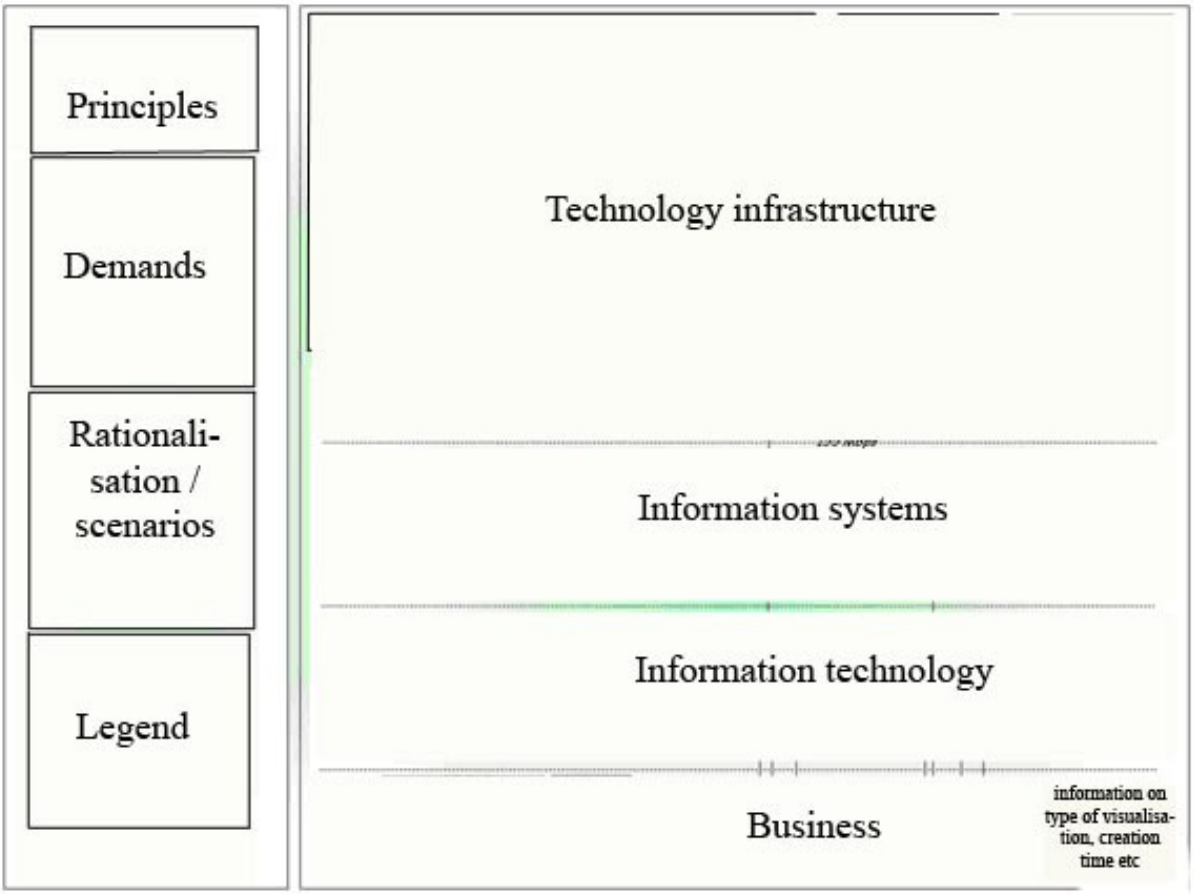


Figure 27: a second possible model, derived from the IAF framework (created by author of this thesis)

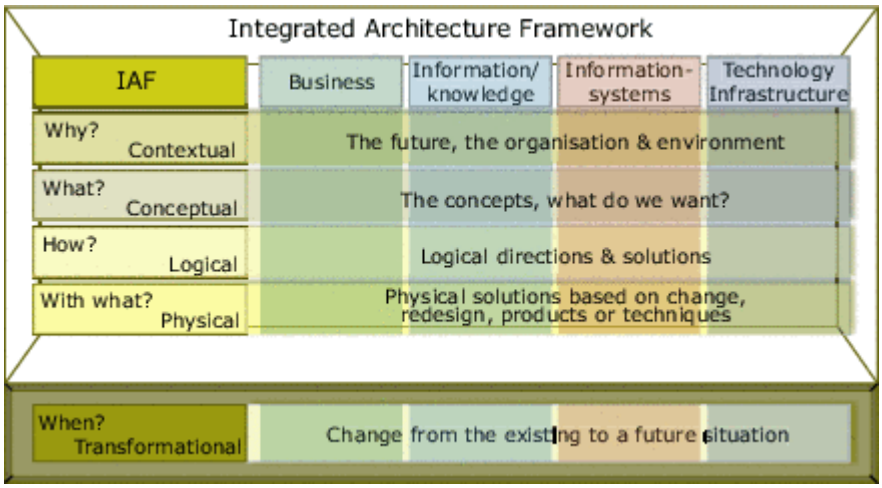


Figure 28: the IAF framework

These two models show how you can apply some what of a standardisation for visualisation yet remain versatile. They are meant to increase the comprehension of the data that is visualised, to cut down on creation time and to increase the overall efficiency of architecture visualisations. With these models there are a number of principles that you need to keep in mind:

- Use the house colours of the company within the model
- You should always use a reference model for the visualisation in the model
- You should determine what you want to visualise before you start visualising (especially with the second model)
- Always make use of the principles and the rationalization, this will increase comprehension, but make sure you use the right terms and be brief
- A legend is always needed
- Scenarios are a short list of possibilities; these should be used to simplify complex data.
- See to it that the model is understood, preferably have your client make a similar model for themselves if possible

These two models are standard models which can be used for any type of architecture visualisations. The second model has a division according to the IAF framework, ofcourse the architect needs to adjust the division according to which part of the architecture (s)he wants to visualise. It would be preferable to classify different types of architectures and to classify the type of visualisation structures (models) that are required for these architecture types. This could make them more applicable to specific fields.

11. What to do with 3d modelling?

When looking at informal visualisations (and some formal) it appears that a 2d presentation leaves for wanting. The information in such a visualisation is subordinate to the visualisation itself, because there are to many objects in one visualisation. One way to solve such a problem is adding a dimension to the visualisation, thus coming to three dimensional visualisations. From conversations with architects it appears that opinions on the usefulness of 3d visualisations are divided. To understand the use of 3d visualisations first we must get a better understanding of our current options for the use of 3d.

Even though 3d visualisations have been on the market for a long time, it never truly took off. The reason for this is the failure in presentations and technology. For instance, a lot of people will remember the 3d helmet from the 1990's which could be used to get the impression of 3d images and movies. Two of the reasons why this did not work are the technology behind it and the comprehension of the human mind. With the 3d helmet you have images directed at you from different angles which make it appear to be 3d, whilst in truth they are a combination of 2d pictures. Moreover, with the interaction of the user moving his head the images need to change as well, when there is to much delay in this process, people will tend to get nauseated. For these reasons the commercial use of this product failed and the technology behind it had to improve before being able to try again. One of the key problems with 3d visualisations is the technology behind it, which truly makes it 3d. The visualisation in figure 28 appears to be 3d but ofcourse it is not. At this point in time we need a 3d lab in order to make a true 3d image, there is no commercial tool available as of yet. Only those tools that can make visualisations appear 3d such as in figure 30**.** Though it should be noted that work in this area is being performed and in terms of commercial objects, Philips is developing a monitor that can give the impression of 3d images with the aid of lenses, other companies are improving the 3d helmet technology. Until we can truly create 3d images we will have to settle with the above mentioned technology and software tools that create the impression of 3d visualisation such as VRML, 3d Studio Max or FormZ, keep in mind that most of these tools aren't truly suitable for creating architecture visualisation with speed.

11.1 Current possibilities with 3d modelling

What can we do with 3d at this time?

The important thing is to remember that there is a clear relation between 3 dimensional thinking and architecture (in all forms). The following quote indicates this.

"There are three forms of visual art: Painting is art to look at, sculpture is art you can walk around, and architecture is art you can walk through"

- Dan Rice

The use of 3d visualisations is limited, but there are some options for which it may be useful. When modelling, it may be useful to work in layers or in 3d. The purpose of 3d modelling is to gain insight in the relations between objects. By adding space and positioning objects the overview can be maintained whilst in 2d this overview is lost and

the visualisations becomes pointless. The main utilization for 3d visualisations lies with the informal visualisations in which the architect tries to transmit information. Whilst the value is that of adding dimension and understanding in relations, it is not to be used for all types of visualisation. In the following sections, I will give two examples of the practical use of 3d visualisations and what should or should not be done.

One of the topics this thesis is concerned with is that of the visualisation of many on many relations (see chapter 7.2.6). Sometimes the creators of visualisations try to maximise the use of one sheet of paper, by putting all objects and all their relations in one visualisation. Whilst this is never a good idea to start with, I will give an indication of the usefulness of 3d visualisation here.

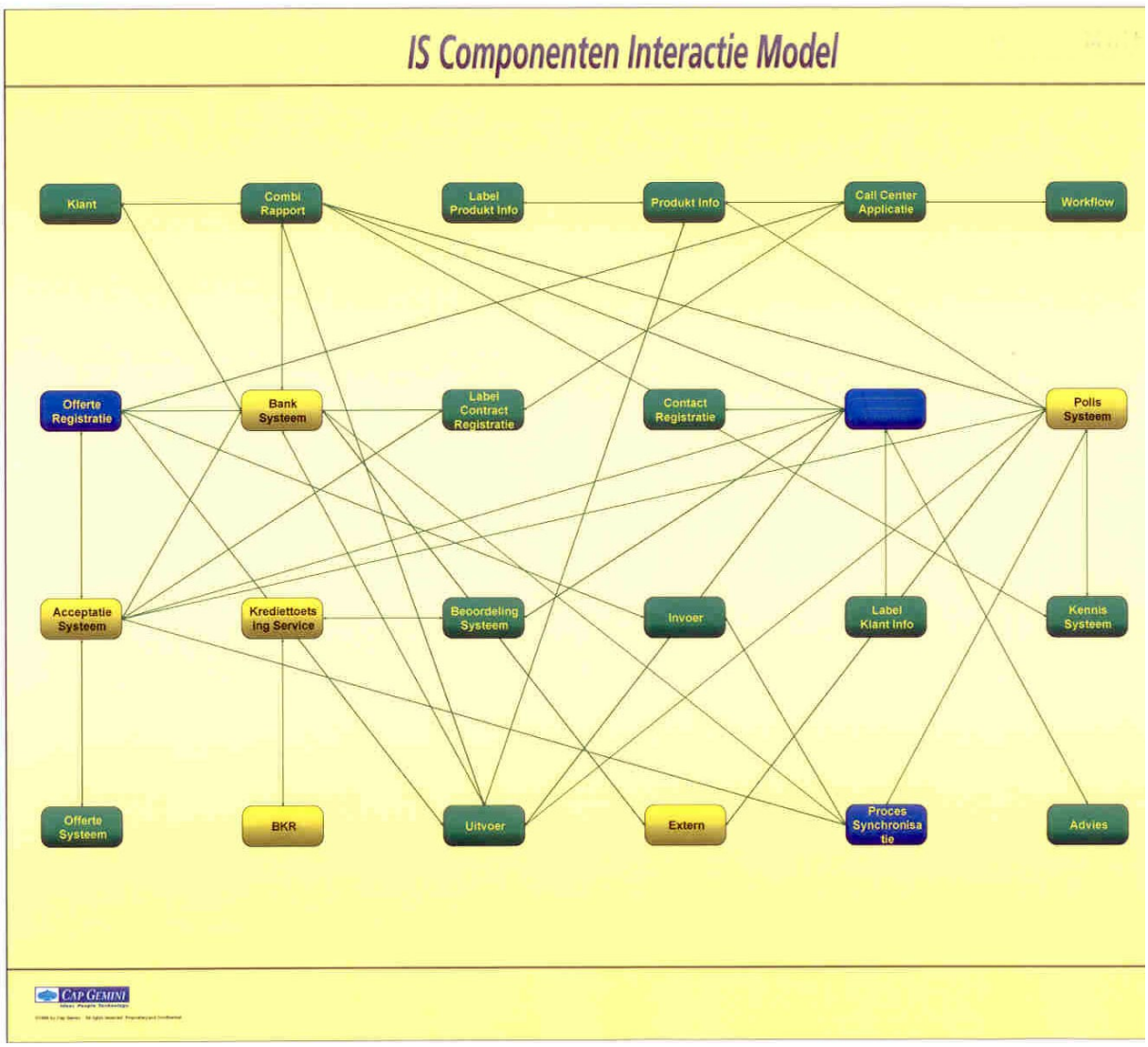


Figure 29: an example of many on many relations

In the interaction model above, you can see spaghetti of relations. Apparently almost all objects have relations with many other objects. This visualisation on itself loses its purpose. To solve this problem it should either be represented in a different manner, or it must be divided into sections where the creator is to zoom in on the most important aspects and their relations.

To continue with the first option of an alternative representation I will show one such possible alternative, that of 3d, in the following figure.

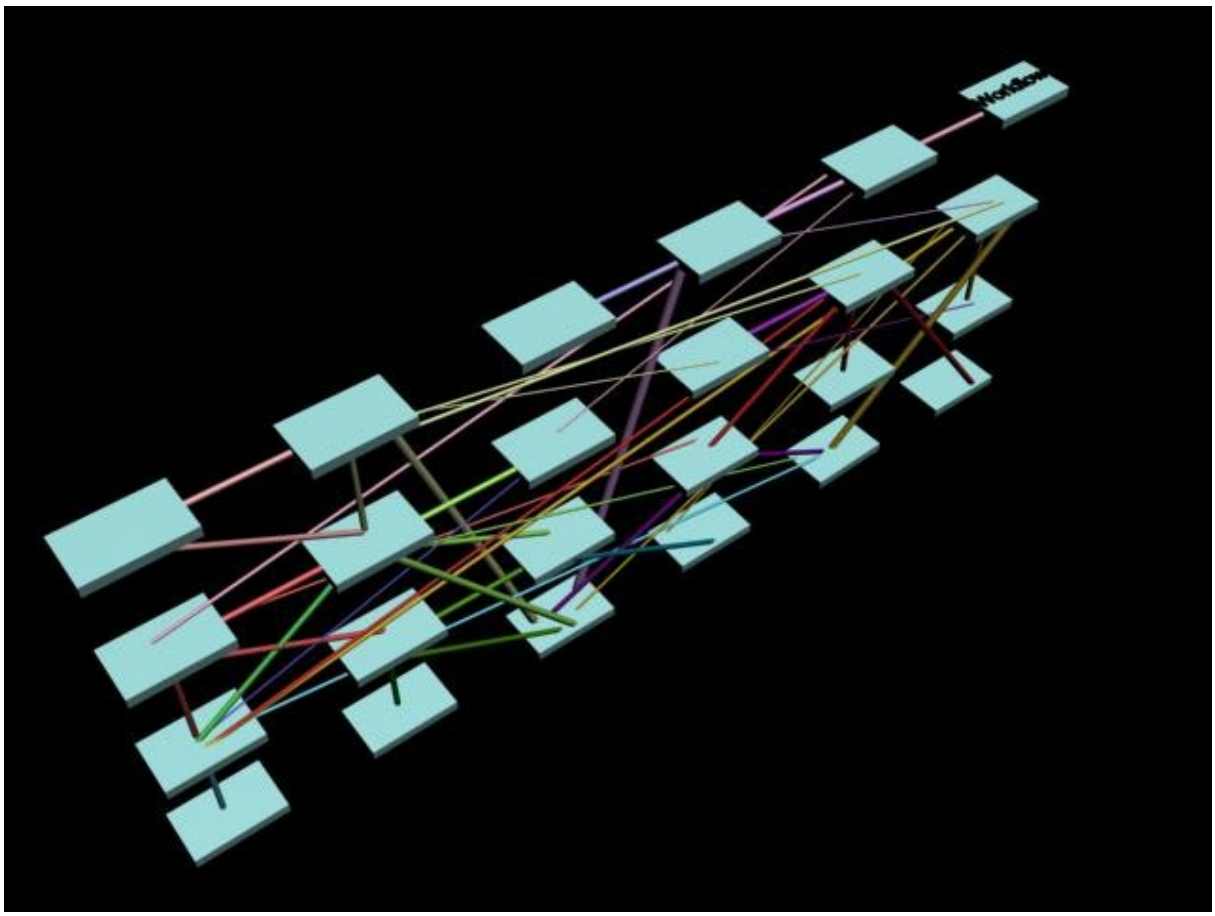


Figure 30: A 3d visualisation of the interaction model (created by author of this thesis)

This visualisation gives the impression of having three dimensions. In a 3d modelling tool, different camera positions can be chosen, of all the possible positions this position is the best. In order to clarify the relations between objects, the lines have gotten multiple positions and each line has a corresponding colour to its originator. Clearly this visualisation does not aid in comprehension, perhaps the relations are represented a little bit better, but it is still a chaos of lines and incomprehensible. Moreover, due to the camera position, the text corresponding to the top right object is not readable. Thus concluding that 3d visualisation in this case is not a viable option. However, this is not an entirely just conclusion. The original visualisation to begin with was not viable either. A number of rules have been ignored, such as the number of objects in one visualisation. If the number of objects were to be reduced, then the 3d visualisation might add more value.

In figure 32 a 3d visualisations is displayed of the IAF model. By adding a dimension it becomes clearer that we are dealing with the same concepts in different layers. If this visualisation is truly of more value then the original visualisation is depended on the individual. I think it does add some value, but not all to much.

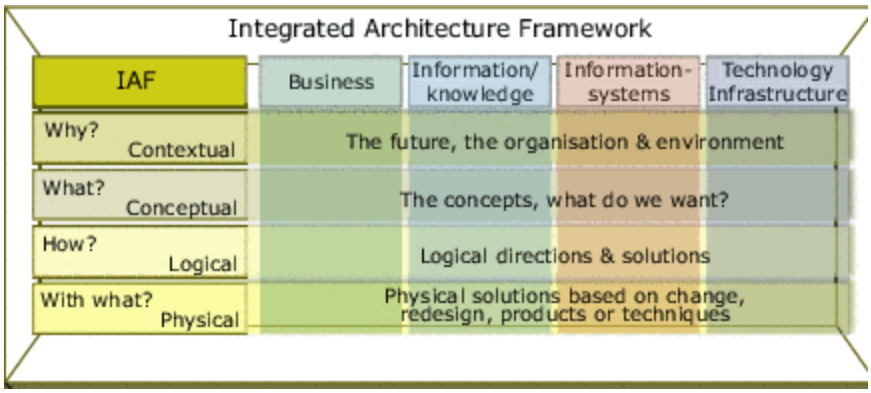


Figure 31: The IAF framework old style

Figure 32: The IAF framework in 3d (created by author of this thesis)

As you can see the 3d model visualises the impression that the 2d visualisation gives (with the aid of horizontal and vertical lines). The additional value of the 3d model lies in the positioning of the camera (point of view). It seems that the four factors on the left are influential to all of the four top factors. By adding the same colours to each layer and adding an encompassing blue square, the impression of coherence is given. When making such a 3d model some visualisation factors require additional attention.

Things to remember when visualising in 3d:

- Text: when adding text to a three dimensional visualisation, you must remember that the text will also be made to appear three dimensional. If you are adding texts to objects such as the visualisation above, this text may seem to waver or be misdirected. In some cases it may be beneficial to have the text unaligned; it gives people the impression that in fact it is aligned. Moreover, if you are using a different angle in your camera view you may need to enlarge texts that are further away from the camera or at least make them bolder or kerned.
- Colour: when using colours in 3d visualisations, keep in mind that the further from the camera the darker they get. This does not only concern the camera position but also the lighting. All 3d visualisation tools use some type of light points to create the impression of three dimensional visualisations. Because of this influence on colours you need to choose colours that are more distinct then those you would normally chose.
- Shapes: One of the reasons why 3d visualisations aren't widely used is because it plays tricks on the mind of humans. We are not accustomed to looking at artificially created 3d images. When creating objects (shapes) you must account for this by adjusting shapes to the right size and position them correctly. The latter is very important for the value of three dimensional visualisations.
- Space: when creating 3d visualisations, the positions of objects and the relative space you leave between them is very important. In 3d, a visualisation seems to be somehow wrong if you leave to little or to much space. In the visualisation above for instance there is just enough space between the objects to still create the impression of coherence, any farther and it would seem otherwise. An example of how space and positioning can go wrong can be seen in the two visualisations on the following page. Here the front view seems in order, but the first visualisation clearly indicates a badly positioned object.
- Light: As indicated above the positions of lights are very important in a 3d visualisation. Every 3d visualisation has one standard light. As soon as you add a light you automatically reset the standard light and create shadows where you might not want them. For instance, the 3d visualisation of the IAF framework contains 3 different lights to make it appear as it does. Leave one of them out and additional shadows would be created. The effects of this can be seen in the visualisation on the following page.

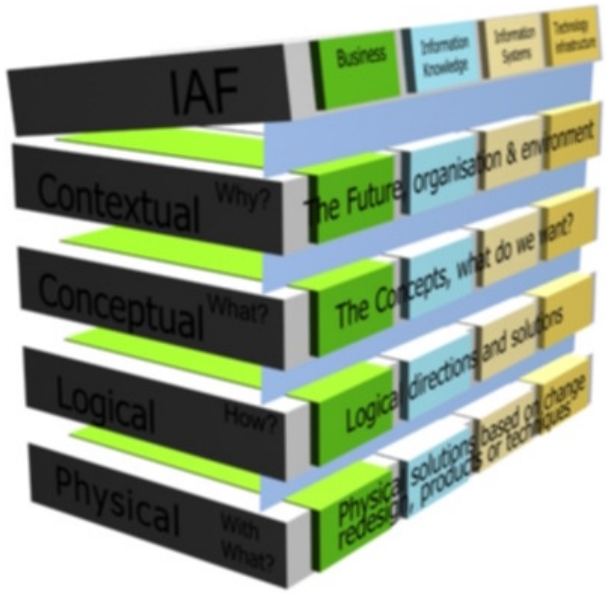


Figure 33: The same model without 1 spotlight and falsely positioned object

Figure 34: the same model as above, front view

11.2 Other purposes for 3d visualisations

What other use for 3d visualisations?

The true value of 3d visualisations has not been highlighted yet. The value lies with visualisations of architectures that are meant to be explanatory and hold no true formal value. These visualisations are meant to be fun, yet informative. An example of a visualisation that can envision a company with certain architecture is given below. This visualisation is incomplete, due to the lack of available objects in the tool 3d Studio Max. This tool contains several standard architectural objects such as walls, doors, stairs and windows. It even has the possibility to create plants and trees for decoration. However, to use it for architecture visualisations it would need additional objects such as symbols for

computers, workspace, database, infrastructure etc. If these objects were added, you could make fun explanatory architecture visualisations with relative ease. It could help to make architecture fun and to relate it more so to the company itself.

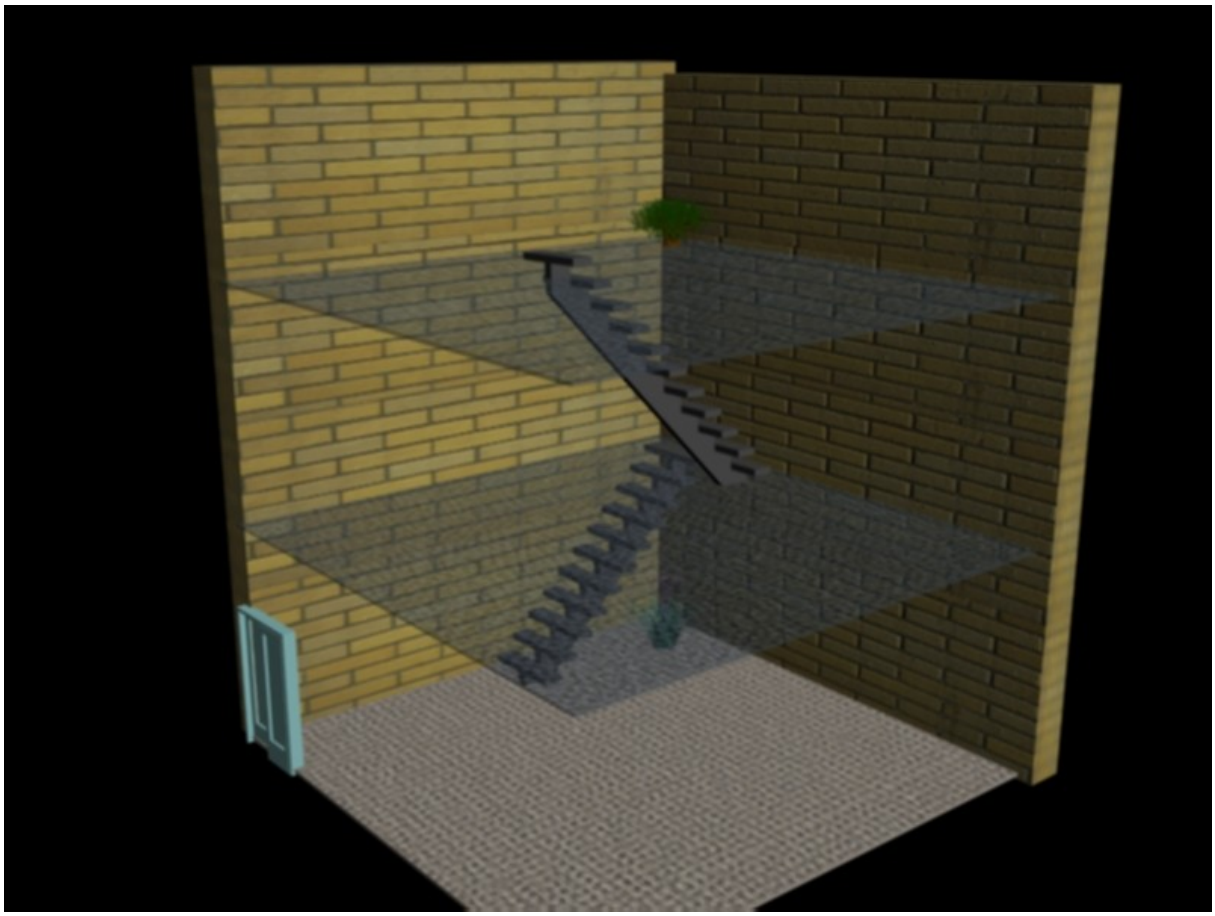


Figure 35: A standard layout with transparency that could be filled to make fun explanatory visualisations (created by author of this thesis)

One of the benefits of 3d visualisations is that it allows you to indicate dependencies on different levels it also gives insight into what roles are played where. It should be noted that at the moment there is no tool available that can support these types of visualisations. The tools do support 3d modelling excellently, but they miss a number of standard icons that would be needed. Such as icons of computers, people, databases, documents etc. Until there is a tool that will support these types of icons, there is no point in trying to make 3d visualisations like these, because it will simply take to much time. Each architect or creator of visualisations would need to be an expert in 3d modelling.

Problem	***Stakeholder***	***Principle***
How do we apply 3d visualisation?	Architect, stakeholders, tool developers, universities, higher business schools, commercial educational institutions	When creating a 3d visualisation you must first have a good understanding if your stakeholder can cope with 3d visualisations When modelling in 3d, you need to pay additional attention to text, colour, shapes, space and light Use 3d visualisations to increase the comprehension of multiple levels and dependencies. Do not include to many objects and relations in one 3d visualisation When visualising in 3d, keep in mind that details are hard to create and visualise properly, thus only use 3d visualisations for simple explanatory visualisations or relatively small formal models

12. Design principles for Architecture visualisations

Throughout this thesis I have come to a number of principles which are directly or indirectly related to architecture visualisations. In this paragraph I will make a summary of these principles. The principles mentioned are derived from the current problems in the area of architecture visualisations. Some additional important principles will be added to this list. Furthermore, I would like to point out the work performed by Henk Koning on design and readability[xviii]. This is a collection of guidelines for many different subjects such as the use of colours, layers, icons etc. Even though this work is very important, the practicality of it is somewhat less. There are so many of these guidelines that it is overwhelming. With the set of principles in the table below I indicate which principles are currently important to increase the efficiency of architecture visualisations. It is a selection of principles that can be found in this thesis

Principles in advance of visualisation
Visualisations should be made to improve current and future comprehension
Consult with yourself what and how to visualise using the visualisation question list.
When dealing with many relations you must find a way to group them and work in layers. The creation of a network of viewpoints is needed to increase the transmission capacity of the architecture
Principles about stakeholders and design
When creating a visualisation the stakeholder type must be determined.
When creating a visualisation the stakeholder's educational background must be taken into account.
Before creating a visualisation for a stakeholder, the architect needs to determine what needs to be visualised for this stakeholder.
Those stakeholders that will manage the architecture must be thought how to visualise
Principles about visualisation
Each visualisation should be focussed on its intended target, should be comprehensible and should contain a legend and timestamp.
It must be possible for the stakeholder to "hop" from one viewpoint to another, so (s)he may comprehend the bigger picture and better comprehend his/her own position.
Use the house colours of the company within the model
Keep to the rule of 7 plus or minus 2 when dealing with many relations.
A visualisation can't be made before the architect has a good impression of who, what and how.
Principles about views and viewpoints
For each group of stakeholders a different visualisation must be made, this is the creation of viewpoints.
The architect needs to determine whether the environment is suitable for a complete visualisation of viewpoints.
A stakeholder needs to be able to navigate through the network of viewpoints.
All viewpoints must be related in some way.
Principles about formal VS informal
There is no choice between formal or informal visualisations
Derive your informal visualisations from your formal visualisation if you need to

decrease creation time (and think it is viable)
Essentially different languages can be integrated into one language, make use of this. (which means further development of tools and commercialisation of a tool such as the ArchiMate tool).
Informal visualisations can conceive an idea; it does not matter if they have no syntax and semantics. Use them to conceive an idea only. Use formal visualisation for detailed reporting.
With informal visualisations use elemental shapes, icons, and pictures to remind the stakeholder of data and objects relevant to him/her, this will increase understanding.
Principles about visualisation models
A meta-model must be made to indicate the relations between visualisations.
A model for visualisations must be made
A visualisation should always have a fixed room for the essentials (information, system, and infrastructure) and should include space for the visualised principles, explanation in key words, a legend and timestamp.
You should always use a reference model for the visualisation in the model
Scenarios are a short list of possibilities; these should be used to simplify complex data
Principles about the use of 3d
When dealing with many relations you need to decide if the use of three dimensions will benefit the visualisation.
When creating a 3d visualisation you must first have a good understanding if your stakeholder can cope with 3d visualisations
When modelling in 3d, you need to pay additional attention to text, colour, shapes, space and light
Use 3d visualisations to increase the comprehension of multiple levels and dependencies.
When visualising in 3d, keep in mind that details are hard to create and visualise properly, thus only use 3d visualisations for simple explanatory visualisations or relatively small formal models
Principles about design tools
A tool should support multiple languages
A tool should be able to optimize line positions
A tool should be able to save data, viewpoints, views
A tool needs to support “hopping” between viewpoints.
A tool should support the use of icons and pictures
A tool should support architecture descriptions
Architecture visualisations need to be created in 1 system or master system that contains a single repository

13. What can change in modelling?

When looking at modelling and how it is currently being applied. It can be observed that there is too much restriction. An Issue that is much discussed of late is that of symbol usage and the choice between semantics or syntax approach to development. When looking at modelling we see that there are those who try to unify modelling languages into one or take a derivation from UML to make less formal models. For instance, if we take a look at the Archimate language, we can see that the developers have tried to create a method to unify the modelling language. Although this is a good development, it does not help in practice. The Archimate language as currently used seems to be a communication method for architects. It is too informal for system developers to be of any use, and too formal for non-IT related personnel to understand. It should be noted that there can not be one modelling technique which both sides will understand and can work with, thus this should not be attempted. This is not to say that a language such as Archimate can not be used as a starting-point. From this language more formal and more informal models could be derived. These would have to be made by those who benefit from them and need them in their work. The architect can assist in this work at first. The general message is that you should not try to make a model that is understandable for all sides, unless modelling becomes a fixed subject in every education (which is unlikely). Therefore it is best to create a meta-model which allows you to create both formal and informal models. This means that you need to define a set of symbols for possibly three or more sides:

- Non – technical (quite possibly there is a division within here as well)
- Architect
- Technical

Though a symbol set should be defined for each of these three, it is not desirable that a model (visualisation) is depended on a fixed set of symbols for each one of these three. The symbols may be fixed in the sense that there can be no other symbol with overlying semantics, but not fixed in the sense that only those symbols may be used. A division can be made here

Informal: Semantics are important for this type of model. The symbol set must be intuitive, may not overlap, but must be extendable. The problem with this type of modelling is that there will always be another object that is needed to make clients understand what is being visualised. It should be able to add icons and pictures, but not additional symbols. **General Understanding is the important aspect.**
Architect: As always a bit of both worlds is needed here. The models must be semi-formal. No additional objects should be added, but the set of symbols does not need to exist with a full set of syntax. **Communication is the important aspect.**
Formal: These do need a fixed set of symbols with corresponding semantics and syntax. The syntax is very important for this type of modelling. **Defining is the important aspect**.

Where possible the same symbols with the same semantics should be used throughout all three of these model types. Other symbols need to be simplified or formalized versions of the originals.
Modelling, in general needs to be more focussed on its purpose and less on its definition.

14. A conclusion to the thesis

It would seem that currently there are still a number of problems with architecture visualisations and adjoined areas. These problems have been considered in this thesis and principles that should at least partially solve the problem have been defined. However, the main problems will be dealing with different types of stakeholders, the seemingly mistrust between stakeholders and the slow trajectory of development towards generic visualisations.

The objectives of this thesis have been met, though some areas require some more research which is material for another research projects (such as the testing of efficiency of architecture visualisations in practice). In order to determine how information is visualised, how efficient architecture visualisations currently are and how the efficiency can be improved:

- I have first Defined the relationship between architecture and visualisation with the aid of a model.
- Defined what exactly the beneficial effects of visualisations are when applied in a certain manner.
- Defined a number of current issues, to determine efficiency of the IS situation of architecture visualisations
- Given a set of principles that should at least partially solve these problems

Continuing with work on how to increase efficiency:

- I have first considered how a visualisation is created and which factors influence such a visualisation.
- Created two possible models for the purpose of increasing efficiency with which architecture visualisations are created.
- Considered the possible added value of 3d visualisations which was an issue that architects were only vaguely familiar with
- Given a summary of practical principles which need to be maintained in practice, in order to increase efficiency
- And a brief definition of what can change in the approach of creating visualisations / models

With this set of deliverables I have met the objectives set at the beginning of this research project and it can be concluded that a lot of work still needs to be done in this area and that the mindset about visualisations and the creating methods thereof needs to change. Furthermore, practical visualisations are needed. First a visualisation for the architect self should be created, other simplified or formalized visualisations can be derived from this. A couple of important reasons for the poor efficiency of current architecture visualisations are:

- Not knowing what exactly needs visualising
- Proper abstraction is missing (zoom in to what is important)
- No proper tool support
- The insecurity and unwillingness of using a standard/model for visualisations

Answers and directions towards solving these issues have been given in this thesis. In the end, it is people who need to change and become more mature in this area of work. In conclusion to this research it is determined that a number of steps need to be taken in continuation to this research.

- A test should be performed to see who can and who really can't deal with formal visualisations and what the benefits of educating would be.
- More research into modelling, mainly from a practical point of view (some modelling technique that can be applied in practice for those stakeholders who do not understand the formal models)
- More research into creating a network of viewpoints
- The development of 3d. This research is in the area of creating actual 3d models and displaying them 3d. Which is not an area directly related to Architecture.
- More research in the development of tools that support architecture visualisations and how to bring such a tool to the market.

Appendix 1: Visualisation and the creation of the alphabet

If we trace the origin of the art of writing we have to go back in history for thousands of years. There is a Greek legend that tells of a Phoenician named Kadmus who was the first to bring knowledge of letters into Europe. Some say that the Phoenicians in turn got their knowledge from the Egyptians or Babylonians. Scholars first believed that the Phoenicians source was the Egyptian hieroglyphs, whilst other scholars believed their source was the Babylonian wedge characters. Hitherto there is no certainty as to the origin of the first alphabet and when it was created. Suffice to say that it took ages to develop the alphabet and it belongs to one of men's greatest inventions. Man learned how to write by slow and painful stages. It is probable that the conception of an analysis of speech sounds as would make the idea of an alphabet came at a very late state of social evolution, and as the culminating achievement of a long series of improvements in the art of writing. The precise steps that marked this path of intellectual development can for the most part be known only by inference; yet it is probable that the main chapters of the story may be reproduced with essential accuracy.
To find out more about the essence of writing and speech, we need to go far back into history. Man has always felt the need to express himself, this started by cave-men who drew pictures of their wars and victories. The American natives did essentially the same thing, but if we look at the Aztec or the Maya people, we see a much more developed way of communication. They had developed systems of pictographs or hieroglyphs that would doubtless in the course of generations have been elaborated into an alphabetical system had not the Europeans disrupted their civilisation. What the Aztec and Maya were developing had happened thousands of years before in the Oriental nations. In Egypt at the time of the pyramid builders, and in Babylonia at the same time period. The people had developed a system of writing. This system enabled them to do more then just present a limited range of pictographs; it gave a more elaborate meaning to the expressions. The man of that period made military and business records and gave expression to his moral and spiritual aspirations in a way strangely comparable to the manner of our own time. He had perfected highly elaborate systems of writing. The most picturesque and suggestive system was the hieroglyphic system of the Egyptians. It is made up of the crudest stages of picturesque writing, in part of symbols having the phonetic value of syllables, and in part of true alphabetical letters. In a word, The Egyptian writing represents in itself the elements of the various stages through which the art of writing has developed. It is conceived that new features were added from time to time, while the old features, curiously enough, where not given up. Though the Egyptian system started with unintelligible lines and pot-hooks, there are also pictures that are recognizable as hawks, lions, ibises and the like, the system evolved to a more intelligible representation. Some genius thought up the idea of representation (iconic usage). The bird for instance might stand for strength, courage or speed. After that it was discovered that the human voice was capable of reproducing of producing different intonations and modulations, and that by selecting an arbitrary symbol to represent each one of these elementary sounds it would be possible to make a written record of the words of human speech which could be reproduced (re-phonated) by some one who had never heard the words and did not know in advance what this written record contained. This is what every child learns to do now in the primer class. They used symbols as phonetic equivalents very frequently, but they never learned to depend upon them exclusively. The scribe always interspersed his

phonetic signs with some other signs intended as graphic aids. After spelling a word out in full, he added a picture, sometimes even two or three pictures, representative of the individual thing, or at least of the type of thing to which the word belongs. Two or three illustrations will make this clear.

Among another people, named the Babylonians, a new writing system was being developed. It is pretty certain that they started out with visualisation too, and in due course developed their own syllabary. They however discarded the old symbols when a better method was discovered. Their new writing system ensured that they could cease to use pictorial aspects. What had been pictures of objects became represented by mere aggregations of wedge-shaped marks. The essential thing is that the Babylonian had so fully analyzed the speech-sounds that they felt entire confidence in them, and having selected a sufficient number of conventional characters – each made up of wedge-shaped lines—to represent all the phonetic sounds of their language, spelled the words out in syllables and to some extent dispensed with the determinative signs which played so prominent a part in the Egyptian writing. Yet a system that stopped short of perfection by the wide gap that separates the syllabary from the true alphabet. The step to a true alphabet was somewhat difficult, because in order to simplify the system, it needed a lot of work. Instead of one symbol for a word, it was now proposed to use 4 symbols for that word. This may seem redundant, but each symbol allowed for a word to form and consonants and vowels to go with it. Many were against the basics of the idea that is now the alphabet. Yet, in the end, conservatism always yields, and so it was with opposition to the alphabet. Once the idea of the consonant had been firmly grasped, the old syllabary was doomed.

We started to use the Arabic alphabet to communicate and form different languages, and here lies the problem. Moreover, what do two people do when they do not speak each others language; they visualize. These visualisations are brought back to the most basic of forms, which represent something in reality. The problem with visualisations in terms of schematics and explanatory pictures these days is the same as that of languages, we have thought up to many of them. This makes the visualisations confusing, obscure, and unwanted.

Appendix 2: Report of the meeting at the Dutch tax office (in dutch)

Verslag dinsdag 22 maart 2005
In het kader van mijn afstudeeronderzoek naar visualisatie en architectuur heb ik een proces bespreking bijgewoond van de belastingdienst. Dit is mogelijk gemaakt door Peter van der Molen, werkzaam bij BCICT als regie architect. Het doel van het gesprek was om duidelijkheid te krijgen over processen en welke functies wel of niet in de eerste versie van het systeem geautomatiseerd worden.

Aanwezig bij dit overleg waren:

- Architecten
- Proces ontwerpers
- Systeem ontwerpers
- Eind gebruikers
- Manager van de betrokken afdeling
- Medewerkers BCA
- Vertegenwoordiger eindregie

Het belangrijkste punt op de agenda was autorisaties in het nieuwe systeem. Welke processen mogen wel of niet geautomatiseerd worden, hoe moeten deze dan geautomatiseerd worden en wie mag er gebruik van maken.

Het gesprek begint aan de hand van een visualisatie. De visualisatie heeft een relatie met architectuur in de zin dat het processen van het bedrijf uit beeld die ter sprake komen voor automatisering in het nieuwe systeem. De visualisatie (zie bijlage) heeft geen directe relatie tot een standaard methode voor tekenen zoals bij processchema's of UML. Echter er is getracht enige structuur aan te brengen zo zijn de onderste vierkanten getekend als tweedeling, wat doet denken aan visualisatie zoals we zien bij object oriëntatie. Voor dit onderzoek is een scorelijst opgesteld met een aantal punten waarop een visualisatie al dan niet kan scoren. De punten waarop gescoord kan worden zijn:

- Visueel en tekst: Wat is de toegevoegde waarde van de combinatie plaat met tekst, m.a.w wat betekent de plaat zonder tekst en wat betekend het met tekst?
- Veelbetekenendheid figuren: Wat zeggen de pijlen in de visualisatie? Zijn ze van belang? Is er een reden waarom deze pijlen zo staan. Wat zegt de eventueel aanwezige tekst over de pijlen?
- Aantal dimensies: Wordt er in de plaat gebruik gemaakt van meerdere dimensies ter verduidelijking van de visualisatie of om een bepaalde ordening aan te geven?
- Ordening in visualisatie: Wat is de betekenis van de plaats toekenning en verhoudingen?
- Formaliteit plaat: Zegt deze plaat in combinatie met uitleg voldoende om het als officieel contract te beschouwen?
- Gebruik legenda: Wordt een legenda gebruikt ter verduidelijking van de figuren?
- Gebruik standaard methode: Wordt er een standaard methode toegepast of een eigen methode?
- Gebruik iconen: Wordt er gebruik gemaakt van iconen om situaties te verduidelijken?

- Gebruik metaforen: Wordt er gebruik gemaakt van metaforen om situaties te verduidelijken?
- Begrip plaat zonder uitleg: Als naar de plaat wordt gekeken zonder uitleg. Is het dan duidelijk wat er bedoeld wordt?
- Begrip plaat met uitleg: Als naar de plaat wordt gekeken met uitleg, Is het dan duidelijk wat er bedoeld wordt?

In de scriptie is te zien hoe de visualisatie gescoord heeft ten opzichte van de bovenstaande punten. In dit geval komt het voor dat niet alle punten van toepassing zijn.

De visualisatie die het uitgangspunt voor het gesprek vormt visualiseert alle processen en taken die voor het doel van dit gesprek voor belang zijn. De visualisatie is niet duidelijk genoeg. Vaak worden er vragen gesteld door de aanwezigen. Dit blijkt echter niet aan de visualisatie te liggen. De visualisatie geeft voor mensen met achtergrond kennis duidelijk weer wat de verschillende stappen zijn en in welke volgorde deze uitgevoerd worden. Tevens staat er in tekst onder de visualisatie een aantal scenario's. Het probleem ligt hier bij spraakverwarring en incomplete kennis van de processen. Aanwezigen met verschillende achtergronden verstaan iets anders onder de term Samen loop zoals in vakje 1 aangegeven staat. Het verschil in gedachten zit voornamelijk bij de mensen van ontwikkeling, de manager en de proces ontwikkelaars. Een van de doelstellingen van dit gesprek is om duidelijkheid te krijgen over de processen. In mondeling overleg komt de groep uiteindelijk tot een conclusie over de loop en betekenis van het proces. Dit wordt genotuleerd. Handig zou zijn om toekomstige verwarring te voorkomen en hier een processchema of andere manier van visualisatie te maken. Waarschijnlijk zullen de aanwezige proces ontwerpers dit ook doen.

De communicatie blijkt vooral mondeling te gaan. De plaat dient als geheugensteuntje voor het verloop van de processen en welke punten nog behandeld moeten worden. De mensen creëren een model in hun hoofd wat zijn aan de werkelijkheid identificeren, afhankelijk van de kennis, zal dit plaatje al dan niet compleet zijn. Het schema benodigd uitleg in die zin dat de processen niet voor iedereen even duidelijk zijn. De woorden die bij de pijlen staan zijn ofwel acties of processen (zoals parkeren). De pijlen zijn genummerd, dit is significant voor de opvolging van de processen. Er zijn verschillende opvattingen over de betekenis van de visualisatie bij de procesontwerpers is het beeld over het algemene het duidelijkste.
De CKP manager heeft veel vragen met betrekking tot de processen en de mondelinge uitleg die andere mensen geven. Hier zou een gedetailleerdere visualisatie op zijn plaats zijn, die zou echter tijdens het gesprek gemaakt moeten worden. Het nut van de visualisatie zou groot zijn omdat in dit geval de manager begrip heeft voor automatisering.

Tijdens het gesprek wordt uitgedragen dat er voor bepaalde situaties principes en regels moeten komen, op dezelfde manier zoals we dit kennen bij architectuur ontwikkeling. Het gesprek is af en toe erg verwarrend door de verschillende meningen die mensen uit dragen. Uiteindelijk bedoelen zij hetzelfde, maar ze praten dicht langs elkaar heen. Hier zou een visualisatie wenselijk zijn om meteen duidelijkheid te creëren en daarmee tijd te besparen en tegelijk als geheugensteun te dienen.

Een populaire uitspraak tijdens het gesprek is: "Dat zal ik even proberen te schetsen". Dit zou impliceren dat mensen een model in hun hoofd hebben van de werkelijkheid op basis

waarvan ze mondeling gaan uitleggen wat er bedoeld wordt. Dit is in principe inefficiënt. Een van de problemen die hier aan de grond ligt is dat het vaak moeilijk is om het model wat in het hoofd van mensen zit ook daadwerkelijk te visualiseren. Dit is vaak een deel van de plaat en de rest is instinctief duidelijk voor de persoon. Wellicht dat dit een reden is waarom vervolgens getracht wordt mondeling het model uit te leggen.

Lang niet alle processen zijn opgenomen in de plaat, alleen de globale processen. Het is een algemene plaat op top niveau. Veel platen zouden tijdens het gesprek geschetst moeten worden, maar is dit wenselijk? Het zou zeker meer duidelijkheid geven, de vraag is of mensen ook het geduld hebben om elke keer op een visualisatie te wachten, aangezien dit tijdens het normale werk en andere overleggen niet zo vaak gedaan wordt.

In de vergaderruimte is een bord met papier aanwezig waarop dingen uitgewerkt kunnen worden. Hier wordt weinig gebruik van gemaakt. In totaal zijn er 2 schetsen gemaakt door een procesontwikkelaar en door Peter van der molen.

Een probleem dat duidelijk naar voren komt in het gesprek is dat men moeite heeft met het totaalbeeld van het systeem te overzien. Er wordt veel gesproken met voorbeelden, een soort van casussen om iets duidelijk te maken of om een uitzondering aan te tonen. Voorkomens bepaalde situaties die bepalend zijn voor het systeem worden besproken. In het schema zou je moeten aangeven hoe vaak deze situaties zich dan voor doen en op basis daarvan een beslissing nemen.

Appendix 3: report of the meeting at Meavita

Below a number of questions with there answers have been listed. These questions were asked of the architect and his clients before the conversation and afterwards. The questions help determine the comprehension of the clients and the efficiency of the visualisation.

Questions for the customer in advance to the conversation
What do you expect from this conversation?

Service manager: I expect more information about the position of Meavita. We have been overwhelmed with information about Architecture. Now we want more clarity and information about architecture, we want to learn about architecture.

Application manager: “ “ “ “

Do you find explanations with the aid of visualisations useful?

Service manager: Yes, it is supportive to the story. Without it, the context would be unclear

Application manager: Yes, it is useful. However, one must not be distracted by nice pictures.

Do you use visualisation in your own work?

Service manager: Yes I do, these consists mainly out of process diagrams.

Application manager: Yes several visualisations such as network diagram, product breakdown schema, and systematic diagrams.

Have you more experience with conversations in which visualisations are actively used?

Service manager: Not as elaborate as with architecture visualisations. We do use process schemas a lot in conversations. These are made in Visio.

Application manager: Yes, I do. Not all of those experiences were good. Previously someone tried to use visualisations too, but he tried to put to much information in one visualisation.

Are you familiar with certain visualisation methods?

Service manager: Yes, mostly process schema’s

Application manager: Yes, mostly process schema’s

Has this method been widely applied within this company?

Service manager: Yes

Application manager: Yes

What do you think of the methods that have been applied here (the architecture visualisations)?

Service manager: They are very comprehensible and supportive. The comprehension is good, of both formal and informal visualisations. Especially the use of icons and visualisations of stakeholders (foto's, pictures of people) is very good, indicating that it is about human beings, which is very important.

Application manager: The expression of humans and the essence being about people is something I have seen very little. This human reasoning is a good thing.

Questions for the clients after the conversation

What did you think of the conversation?

Service manager: I think the goal of this conversation has been achieved

Application manager: I had expected a more detailed conversation and visualisation, especially because of the agenda that was used for the conversation. However, I am glad this was not the case; it might have been overwhelming otherwise. To learn about the scope and the meta-model is a good thing.

Did it meet your expectations?

Service manager:

Application manager:

What did you think of the visualisation that was used?

Service manager: You must have experience to understand the visualisation, but the content is very comprehensible.

Application manager: The icons and people in pictures were getting my attention; the use of it is very good. The total of dimensions and use of arrows is good; it helps creating the coherence and synergy.

Do you think this visualisation to be formal or informal?

Service manager: Yes, I think it is a formal visualisation

Application manager: I concur.

Did you understand the visualisation without verbal explanation?

Service manager: Yes, the coordination of thing has become more apparent. I understand the processes, but architecture sometimes requires a different way of thinking.

Application manager: For the largest part yes. I understand the visualisation and what it represents, but what is the purpose of all these things. Some further explanation is needed but it is good to do this in stages.

Do you have to deal with these types of visualisations more often?

Service manager: We helped to create some architecture visualisations. Before that we mostly made process schemas

Application manager: I have also taken a course in Prince. We also helped create some architecture visualisations

Additional comments: We thought that the use of pictures of stakeholders is a very good thing. It helps to remind people that it IS people we are talking about in this organisation. The visualisation was good and very explanative. The architect played an important role in the effectiveness of the visualisation. He explained what was visualised and why. Furthermore, the presence of the architect is very noticeable, he has the ability to transfer information fast and you learn from him.

Questions for the architect in advance to the conversation

What do you wish to achieve, with this conversation?
The aim of this conversation is to explain the financial coupling (in terms of systems) There are some faults in the administration system. I want them to deal with the present problems and to explain why I am using this model for it.

How do you make use of visualisations in this conversation?
I will be using a meta-model to explain the visualisation and in which context it is to be viewed. The visualisation itself will explain the financial couplings.

Do you use a standard method or is it a customized visualisation?
I am using my own method, Dragon1.

Is the visualisation comprehensible without text?
Yes it is, because of the principles and explanative phrases that surround the visualisation. Additionally I let them make the visualisation of the old situation themselves. This helps in their comprehension.

Do you use multiple dimensions?
Yes, this can be seen in the visualisation

Do you make use of metaphors?
Yes, whenever they are helpful

What is the purpose of the division used?
The division helps in understanding; every visualisation should be joined with its principles, the creation time and what it is, a legend, and rationalization.

Do you expect that your client will understand the visualisation?
Yes, the visualisation is pretty clear and accompanied with rationalization. Additionally they helped in creating a visualisation of the old situation so they have an understanding of the visualisation and its use.

Are the symbols used known, or did you use a legend for this purpose?
A legend accompanies the visualisation.

Questions for the architect afterwards

Did you achieve what you wanted to achieve?
Yes, I do believe I have done so. The purpose is that they get a better understanding of what architecture and the terms are. They have to help complete the visualisation. They also have to convince people to work with architecture

Did the visualisation help to obtain your goal?
Yes, especially the meta-model helps. Without the meta-model, the big picture wouldn't be comprehendible. You need to use a relatively simple structure with that you can achieve understanding. The meta-model is the cornerstone for visualisations.

Do you think the visualisation was clear immediately or did it require explanation?
With a poster like this, explanations are always needed. Complex data is in need of explanation. You must give them the structure in the visualisation that they need. The principles and rationalisations and legend aid in this.

Do you think this visualisation can be seen as a formal document?
Yes, this is already being used as such. The visualisation is the key to change. The milestones are also important. This all leads to additional demands for software selection and the project itself. The visualisation principles are used throughout the project.

Did you use a legend or do you think you should have used it?
Yes I did use a legend (see answer to question 3 and the visualisation).

Would you change the visualisation if you had to do it again?
Yes, I would involve the stakeholder visualisation aspect even more. The added value of the visualisation is good.

Would you use metaphors for this?
Yes, photo's of stakeholders. Visualising architecture terms with symbols or metaphors.

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