Design of a process for the selection of an enterprise reference architecture

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Design of a process for the selection of an Enterprise Reference Architecture

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1.Introduction

This report presents a master project that was carried out at Eindhoven University of Technology within the Department of Industrial Engineering as well within the Department of Mathematics and Computer Science, with the cooperation of Capgemini Nederland B.V. It describes the design of a process and a toolkit for the selection of an Enterprise Reference Architecture.
This project is also a contribution to the research program to Enterprise Reference Architecture (ERA).This research is done under responsibility of School of Industrial Engineering of the Eindhoven University of Technology. This research program is set up to deliver a scientific grounded theory about ERA that explains why an ERA is needed, what it is and how it can be used. The ERA theory will deliver a coherent set of models, each with its own purpose and function in the practical work area of EA design, transformation and maintenance.
This master project was carried out in two phases. The first phase is the exploration, which is carried out in order to gather all the needed information to proceed to the second phase of the project which is the design of a process and a toolkit for the selection of an Enterprise Reference Architecture and its evaluation.

1.1. Problem Description

Enterprises are complex systems which are highly integrated and comprised of processes, organizations, information and supporting technologies (Davoudi M.R., 2009). Clearly, the dependencies and interfaces within an Enterprise share an important amount of complexity too, thus it is critical for these issues to be managed. Enterprise Architecture can provide this support. With the help of Enterprise Architecture organizational goals are achieved, resources are managed and complexity issues are solved.
Enterprise reference architectures encompass a high level of abstraction. They are generic enterprise architectures for a class of enterprises that provide the principles and design methods that are used as a foundation to build concrete enterprise architectures. (Angelov S., 2008) Due to this high level of abstraction, the architect needs to pay attention to multiple matters when it comes to selecting an enterprise reference architecture. However this is not an easy job for the architect to execute.
The goal of this project is to design a process and a toolkit that will facilitate the selection procedure of an Enterprise Reference Architecture within the given context and that will make the life of architects easier.

1.2. Description of General Approach and Structure of the document

This project was carried out in two phases. It started with the exploration phase and it moved to the design phase which also included the evaluation of the final design.
The goal of the exploration was to gather all the information needed in order to proceed to the design phase of this project. The exploration phase consists of the literature research and the conduction of a set of interviews within Capgemini Nederland BV.
The literature research and the interview set up have been executed in parallel and their relation is reflected later in this document. After that, the conduction of a set of interviews within Capgemini Nederland B.V followed. The results of these interviews combined with the literature research findings served as the main input for the design part of this project.
During the design phase, a process for the selection of an Enterprise Reference Architecture was designed. This process is explicit and it has a clear structure reflected in 6 steps (activities). Apart from the process, a toolkit was also designed in order to help in the selection of the ERA. This toolkit is embedded in the process and is composed of three tools. The mapping of the three tools within the process is shown later in this document.
The outcome of this procedure was evaluated by three architects within Capgemini Nederland B.V. Their comments and tips were of great help for this final deliverable and they can also serve as input for the future work that is going to follow.

This document starts with the description of the exploration phase and its separate stages. Each step that has been followed is described and the intermediate results are presented. Towards the end of the second chapter the main findings of the exploration phase are presented.
The third chapter describes the design phase of this project. The design approach is presented and then the design of the process and toolkit follow. Again, each step is described and the intermediate results are presented.
The fourth chapter regards the evaluation of the design. The chapter begins with the evaluation set-up, and the execution description follows. Last but not least, the results of the evaluation are presented.
The last chapter of this document discusses possible future work and also concludes this project.

2.Exploration phase

The goal of the exploration is to gather all the information needed in order to proceed to the second phase of this project, which is the design of the process for the selection of an Enterprise Reference Architecture. The exploration consists of the literature research and the conduction of a set of interviews within Capgemini Nederland B.V.
The first stage of the exploration consists of the literature research as well as the set up of the interviews. These two processes have been executed in parallel and they are described in the following sections. The research protocol is given, as well as a relation matrix between the set of papers, which has been obtained by the literature research, and the interview questions.
The second stage of the exploration is the conduction of the interviews with Architects within Capgemini B.V Nederland.
Figure 1 describes the process that has been followed during the exploration phase.

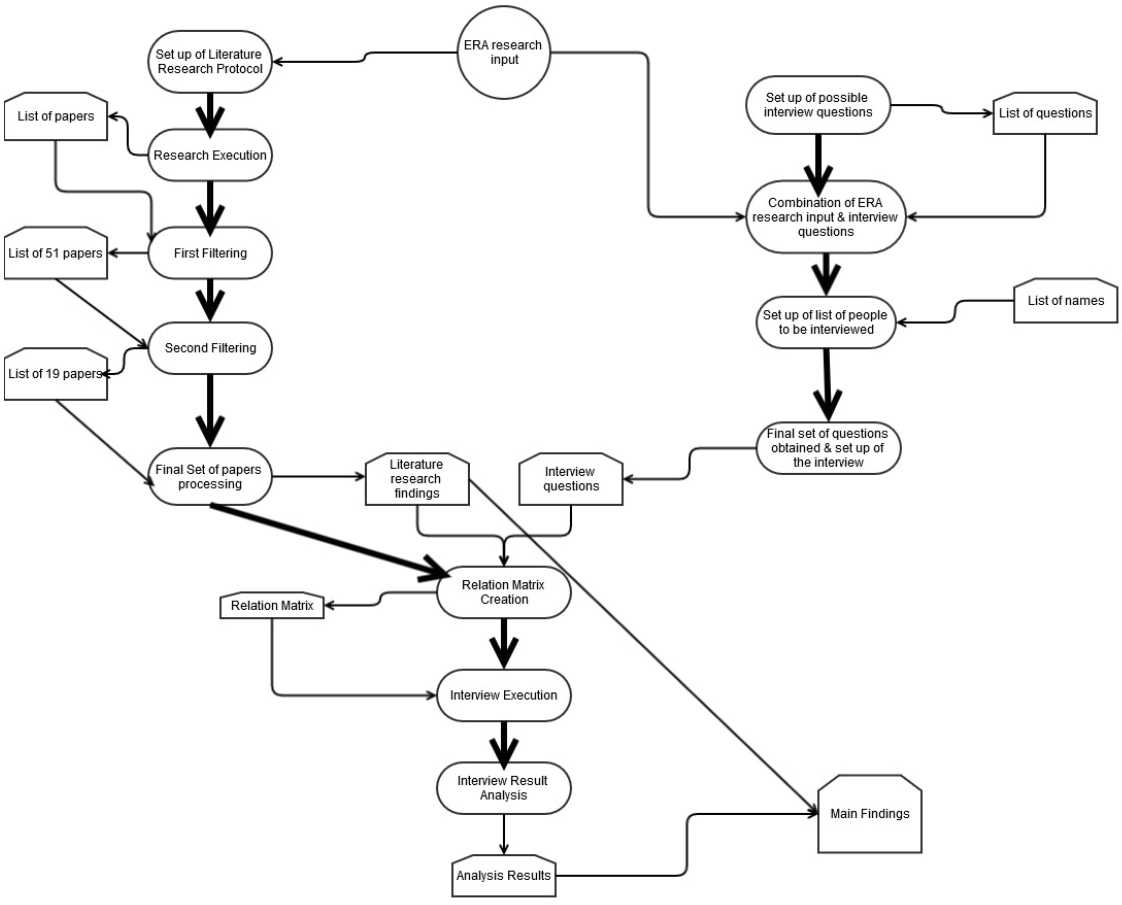


Figure 1-Exploration phase Process

2.1.Literature Research

The main idea for the research protocol of the literature research was conceived after the input of the literature research that had been done in cooperation with the research program to Enterprise Reference Architectures. This input was a set of 124 papers which were obtained after following a literature research protocol. A similar protocol was set up for this research too and resulted in a set of 94 papers. This protocol can be found in Appendix A.
The initial set of 218 papers was filtered twice. The main goal of the first filtering was to find overlapping papers as well as closely related papers. The goal of the second filtering was the selection of the final set of papers that would be the most related to the research. The description of the filtering is presented below:

2.1.1.First Filtering

There were two lists of paper titles (218 in total) that have been obtained by the combination of the two researches. This initial set contained overlapping papers, thus it was filtered in order to retrieve the overlapping papers as well as papers that were closely related.
The first filtering included the following steps:

a) Check the two lists for overlapping papers
    a. If yes, check if paper is suitable
        i. If suitable, put it in the list “First Filtering”
        ii. If not suitable, discard
    b. If no, continue
    c. Repeat until all titles are checked
b) Check the remaining papers for closely related/suitable ones.
    a. Check in terms of titles and title key words
        i. If suitable, put it in the list “First Filtering”
        ii. If not suitable, discard

The result of the first filtering was a list of 51 papers (Kotzampasaki, First filtering results, 2012)

2.1.2.Second Filtering

The second filtering had as input the list of 51 papers that was obtained after the first filtering. The filtering was done in order to obtain the final set of papers that would be closely related to this research.
The second filtering included the following steps:

a) Check the paper titles and select the most relevant.
    a. Checking being done in terms of titles and title key words.
        i. If suitable, put it in the list “Second Filtering”
        ii. If not suitable, discard
b) Check the resulting list.
    a. Read abstract and conclusion

i. If suitable, put it in the list "Final Set"
ii. If not suitable, discard.

The result of the second filtering was a list of 19 papers that constitute the final set of papers that would be processed. (Kotzampasaki, Second filtering results, 2012)

2.1.3.Paper Processing

The next step is the processing of the final set of papers.
Initially, the papers with the most general content were read. These papers include information on (enterprise) reference architecture in general and give a good insight of the field of Enterprise Reference Architectures. Next, papers that described the quality attributes of a reference architecture and their importance to each project were read. These papers are strongly related to this research and they constitute an important part of it. Papers that described frameworks and tools followed in the paper processing. Finally the rest of the papers were read. The purpose of this classification is to build a view of the research field in such a way that will be the most appropriate for the next stages of this project.
During the processing of the final set of papers, notes including key words and key phrases were made. Finally, summaries of the 19 papers together with a brief description of their relevance to this research were written.
The titles of the papers can be seen next. The 19 summaries can be found in Appendix B.

Title	Author(s)
1.Understanding Architectural Assets	Eeles P.
2. The many faces of architectural descriptions	Greefhorst Danny, Koning Henk, Vliet Hans
3. The Architect's Dilemma –Will Reference Architectures Help?	Haft M., Humm B., Siedersleben J.
4. An Instrument for the development of the Enterprise Architecture Practice	Van Steenbergen M., Van Den Berg M., Brinkkemper S.
5. Characterization of Enterprise Architecture Quality Attributes	Davoudi M.R., Aliee F.S.
6.A comparative analysis of enterprise architecture frameworks based on EA quality attributes	Lim N., Lee T.-G., Park S.-G
7. Qualitative characteristics of Enterprise Architecture	Khayami R.
8.A fuzzy group multi-criteria enterprise architecture framework selection model	Zandi F., Tavana M.
9. A Tool for Enterprise Architecture Analysis	Johnson P., Johansson E., Sommestad T., Ullberg
10.The application of enterprise reference architecture in the financial industry	Ten Harmsen Van Der Beek W., Trienekens J., Grefen P.
11.Towards a method for the evaluation of reference architectures: Experiences from a case	Angelov S., Trienekens J.J.M., Grefen P.

12. An IT management assessment framework: evaluating enterprise architecture scenarios	Gammelgård Magnus, Simonsson Mårten, Lindström Åsa
13.Bottom-up planning approaches in enterprise modelling - The need and the state of the art	Reithofer W., Naeger G.
14. Business process modelling in industry – the powerful tool in enterprise management	Kalpic B., Bernus P.
15.A framework to define a generic enterprise reference architecture and methodology	Bernus P., Nemes L.
16. Management and enterprise architecture click: The FAD(E)E framework	Goethals Frank, Snoeck Monique, Lemahieu Wilfried,Vandenbulcke Jacques
17.Formal models of virtual enterprise architecture: Motivations and approaches	Goel A., Schmidt H., Gilbert D.
18.Formation of dynamic virtual enterprises and enterprise networks	Sari B., Sen T., Kilic S.E.
19.Designing the enterprise architecture function	Van Der Raadt B., Van Vliet H.

Table 1-List of literature papers

2.1.4.Literature Research Findings

In this sub-section the findings of the literature research are going to be discussed. The topics that are going to be discussed and that were the areas of interest of the literature research are reusable architectural assets, the concept of architecture, standard architectures, reference architectures, enterprise architectures, architecture maturity and finay enterprise reference architectures. The above mentioned topics were categorized in a logical sequence, beginning from the most general topic and ending to the main area of interest of this project, Enterprise Reference Architectures.

- Reusable Architectural Assets

There are three main ways for an architect to deliver an architecture. Intuition, which is based on the experience of the architect and his capability to recognize a pattern or to find inspiration for a completely new one, is the first way to do it. An architecture can also be derived by a method or a process, based on the system's requirements. Last but not least, is the use of reusable architectural assets.
There are different kinds of reusable assets that are depended on the field of interest, on the tools being used or the standards and can add value to the project and be a great help for the architect if they are used properly. Their characterization is also important for their proper use. Architectural assets can be characterized for example in terms of granularity or implementation. Large grained assets represent major architectural decisions on the project whereas finer-grained assets are mainly guided by those decisions. Architectural assets can be fully, partially or not implemented at all. The most common reusable architectural assets are architectural patterns, architectural styles,

reference architectures, application frameworks, architectural mechanisms, design patterns and frameworks (Eeles, 2008).
This research is focused on reference architectures and specifically to enterprise reference architectures.

➢ Architecture

Describing the term architecture has proven to be difficult. Architecture describes the fundamental aspects of the system, and serves as guidance to the people that actually design and build the system. (Danny Greefhorst, 2006) This description need to be documented and structured into manageable pieces, each one of which addresses a number of aspects of the architecture. (Danny Greefhorst, 2006) These pieces are not predefined but architectural frameworks can provide guidance in this area. They provide a standard approach to architecture such as a model of architectural descriptions or a method to produce these descriptions.
Architectural frameworks are in an essence an attempt to enable clustering of architectural information in a way that suits a particular context and goal. In order for a framework to be described certain dimensions are used as a criterion to partition the architectural description into segments. The main base dimensions that are defined mainly based on the existing frameworks are the following: (Danny Greefhorst, 2006)

- Type of information : The topic of the information
- Scope: The extent of the information covered
- Detail level: The amount of detail
- Stakeholder: The target audience
- Transformation: The transformation phases that the architecture needs to cover
- Quality attribute: The quality attribute that is being addressed
- Meta level: The amount of abstraction
- Nature: The nature of information
- Representation: The way architectural information is represented

The above list of dimensions can be used as basis for an architectural description or an architectural framework, in other words, as a means of communication about architecture in general.

➢ Standard Architectures

Standardisation of architectures is also a sector into which a lot of attention has been paid. An effective and efficient standard architecture would have a huge impact on the quality of the architecture work. People would work more efficiently, software reuse would be easier, past mistakes would be eliminated and project risks would be reduced. (Martin Haft, 2005) Standard architectures are not used in practice though. There are a lot of obstacles that need to be overcome in order to move towards standardisation, such as acceptance, special features, convenience and costs of implementation. For this reason Reference Architectures can be used instead.

➢ Reference Architectures

Reference Architectures are a weaker form of standard architectures. Like standard architectures, they are a set of specified abstract components, their interactions and their interfaces. However, reference architectures encompass some characteristics that make the difference:

- Reference architectures are minimal. They focus on the minimal functionality common to all concrete products. Special cases are not considered and redundancy is avoided.
- They are complete. They subsume all the functionality that is necessary for providing the essence of a component.
- Last but not least, reference architectures are disjoint. Their functionality is relevant for different user groups.

Since Reference Architectures can be characterized as reusable architectural assets, it is well understood that they can add value to the project if they are used in the right way. Reference architectures can provide the main guidelines in the design of the system and play an important role in the decision making. A Reference Architecture can be defined as a reference model mapped onto software elements and the data flows between them (interactions and interfaces) (Angelov S., 2008).

➢ Enterprise Architectures

Enterprises are complex systems, highly integrated, comprised of processes, organizations, information and supporting technologies. The interdependencies and interrelationships across their boundaries are multifaceted, thus it is clear that managing these issues is critical to achieving and sustaining enterprise performance. Enterprise Architecture can provide this kind of support. (Davoudi M.R., 2009)
Enterprise architecture does not focus only on the technical aspects but also on the various issues upon which the IT systems operate. In other words Enterprise architecture is the framework to develop IT, maintain it, to achieve organizational goals and to manage resources of this technology.
Enterprise architectures should be amenable to analysis of various quality attributes. Such quality attributes include alignment, convergence, integrity, maintainability, reliability, efficiency, security, usability and implementation.(Raouf, 2011)These attributes can be further analyzed in sub-attributes:

- Alignment :
  - Application systems alignment to goals
  - Application systems alignment to functions
- Convergence
  - Business process convergence to functions
  - Business process convergence to entities
  - Application systems convergence to business process
  - Application systems convergence to entities

- Integrity
    - Frameworks integrity
    - Data integrity
    - Application Integrity
- Maintainability
    - Analyzability
    - Changeability
- Efficiency
    - Time behaving
    - Resource behaving
- Security
    - Confidentiality
    - Integrity of data
    - Availability
- Reliability
    - Fault tolerance
    - Recovery
- Usability
    - Performing time
    - Performing cost
    - Concordant to organization
    - Concordant to IT trends

These quality attributes can be defined and characterized by using general scenarios. (Davoudi M.R., 2009) A general scenario for an Enterprise Architecture contains the following elements:

i. The stimulus that requires the architecture to respond
ii. The source of the stimulus
iii. The context within the stimulus occurs
iv. The view(business architecture view, data architecture view, application architecture view, technology architecture view)
v. Artefact , which represents the EA elements from the specified view that are involved
vi. Possible responses
vii. The measures used to characterize the architecture's response

These quality attributes can be used in order to define if an enterprise architecture will be accepted or not. An enterprise architecture that encompasses the above mentioned quality attributes, will be of high quality and will improve the organization's performance. Quality attributes are not the only criterion when it comes to accepting an enterprise architecture though.

➢ Architecture Maturity

Another factor that is important to the acceptance of an enterprise architecture and also facilitates the organization's practice is the architecture maturity. The architecture

maturity of an organization is closely related to the qualities that must be met. The maturity level of an architecture depends a lot on the alignment with the business, operations, and development process and also on the relation with the as-is state of the organization. All of these are characteristics that architects take into account when looking for a new architecture to adopt or when they are considering reusing one. The higher the maturity level of an enterprise architecture is , the easier this architecture will be accepted.

- Enterprise Reference Architectures

It has already been mentioned that Reference architectures can facilitate decision making and can add value to a project if they are used in a proper way. The value of Enterprise architectures has also been discussed. But what do Enterprise Reference Architectures do? An Enterprise Reference Architecture (ERA) is a generic enterprise architecture for a class of enterprises that provides the EA design principles, methods and models that are used as foundation in the design and realization of the concrete EA that consists of at least three coherent partial architectures: business architecture, application architecture and technology architecture. (Ten Harmsen Van Der Beek W., 2012).
Enterprise Reference Architectures can support decision making on organisation-wide issues. They are the first consideration when transferring from the "as- is" state to the "to-be" state. In addition to that Enterprise Reference Architectures are needed for the improvement of the quality of the architecture works. Since their role in the quality of the architecture is fundamental they need to be of high quality themselves too, hence they need to be evaluated. (Angelov S., 2008) This is not an easy venturing though, because of the high level of abstraction that is encompassed within the Enterprise Reference Architectures. This research is aimed at overcoming this fact and also achieve the design of a process that will facilitate the selection of a proper Enterprise Reference Architecture of high quality, that will meet the requirements and the quality attributes of the organization.

2.2.Interview Set Up

Apart from the literature research, there was the need of conducting interviews with people within Capgemini Nederland B.V. in order to obtain more information on the field of exploration as well as some useful tips for the design phase of the project. Hence, an interview with open questions was set up, in parallel with the literature research.
The semi-structured interview that was set up for the purposes of the research program to Enterprise Reference Architectures was used as input.

First, a set of possible interview questions was constructed. These questions aimed at obtaining all the useful information for the next phases of the project. This set of questions was combined with the questions of the semi-structured interview that was set up for the purposes of the research program to Enterprise Reference Architectures. In order to come up with the final set of questions for this interview, it was necessary to also define the list of people that were going to be interviewed. Knowing the professions and the general background of these people would help in using the most appropriate questions and also in the easier construction of the interview. The list of people to be contacted was defined and communication with them was initialized.
Finally, the set of interview questions was completed and the interview was set up. (Interview : Enterprise Reference Architectures, 2012)
The interview questions can be found in Appendix C.

2.3.Relation Matrix

After the literature research and the set up of the interview a relation matrix of the interview questions to the papers that were processed was constructed. This matrix gives an insight of the relation of the literature research to the interview questions and helps in obtaining a clearer view of how the papers are related to the questions and how the interview was set up.

The input for the construction of this matrix was the set of 19 papers as well as the interview questions. After the study of the 19 papers, summaries of them were made, that helped in defining the relation of each paper to the interview that has been set up.
This matrix represents the relevance of the final set of papers to the interview questions. The relevance is described as follows:

- ++ => very relevant
- + => relevant
- * => not relevant but gave insight

Papers/Questions	ERA Definition & Shape	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q 10	Q 11	Q 12
Understanding Architectural Assets	++	*	*	*	*	*	*	*	*	*	*	*	*
The many faces of architectural descriptions	++	*	*	*	*	*	*	*	*	*	*	*	*
The Architect's Dilemma – Will Reference Architectures Help?	++									++	*	++	
An Instrument for	++			+	+	++	++	+	++		+	+	*

the development of the Enterprise Architecture Practice													
Characterization of Enterprise Architecture Quality Attributes	++		+	+	++	++	++	+	+	++	++	++	
A Comparative Analysis of Enterprise Architecture Frameworks based on EA Quality Attributes	++	*		+		++	++				++		
Qualitative characteristics of Enterprise Architecture	++				++	++	++			++	++	++	
A fuzzy group multi-criteria enterprise architecture framework selection model	+					*	*				*		
A Tool for Enterprise Architecture Analysis	*				++	++		+	+				
The Application of Enterprise Reference Architecture in the Financial Industry	++	++	++		++				++	++			
Towards a Method for the Evaluation of Reference Architectures: Experiences from a case	++				+	+	+			+	+	++	*
An IT management assessment framework: evaluating enterprise architecture scenarios	+		++	++	++	++	++	++	++	+	++	++	++
Bottom-up planning	*	++	+	++					++				

approaches in enterprise modelling - the need and the state of the art													
Business process modelling in industry - the powerful tool in enterprise management	*									*		*	
A framework to define a generic enterprise reference architecture and methodology	+	*		+		+		+					+
Management and enterprise architecture click: The FAD(E)E framework	++					+	+				+		
Formal Models of Virtual Enterprise Architecture: Motivations and Approaches	++					*	*	*	*				
Formation of dynamic virtual enterprises and enterprise networks	*			*		*							*
Designing the Enterprise Architecture Function	+	*	*	+	+							++	

Table 2-Relation Matrix

2.4.Interview Execution

After completing the process of the literature research and the interview set up, communication with Capgemini architects, that were chosen to be interviewed, was initialized. Within a period of 3 weeks, seven interviews were executed. The interviewees were architects within Capgemini B.V. Nederland with a broad experience in enterprise architecture.

The interviews took place at the Papendorp Office of Capgemini in Utrecht and at the Meeting Point of Capgemini in Amsterdam. The length of the interviews was on average 40 minutes.
The results of these interviews were combined with the main findings of the literature research and were used as the starting point for the design phase of the project. Moreover, these results are also a contribution to the research program to Enterprise Reference Architectures.
A statistics table as well as the summaries of the seven interviews can be found in Appendix D.

2.4.1.Interview Result Analysis

After executing the seven interviews, the answers were processed and analyzed. An analysis of the answers per open question follows:

Question 1.

Which enterprise reference architectures do you use in your existing architecture practice?

In this question the answers were varying. This was expected, as the interviewees work in different domains, for different clients and in different environments. The architectures that are used by the interviewees are NORA, CORA, MARE, BIAN (IBM s architecture). The domain depended RAs of Capgemini were mentioned too. Capgemini has RAs for almost every sector, thus these are used by architects within the company. All of the interviewees that gave an answer in this question mentioned though that they do not just stick to these architectures. They also use Architectural frameworks (TOGAF, NAF) and also parts of standard architectures that they have used in the past. Another interesting point was that three of the interviewees answered that they do not use any reference architectures. They either use parts of reference models they have come across in the past or make up their own architectures.

Question 2.

Who do you consider (potential) users of enterprise reference architectures?

In this question all seven answers were similar. Architects are considered to be the users of enterprise architectures. 2 of the interviewees pointed out strongly that no one else except for the architects can use ERAs. An ERA is a tool for the specialist and if someone is not used to thinking as an architect will not be able to use it. It was also mentioned though that the use of ERAs is also possible by other groups of stakeholders (customers, project managers, high level decision makers) and it can be really interesting for them, but this should only be done under the supervision of architects, or after the architects have clearly explained the architecture, otherwise it is likely that the architecture will not be used properly.

Question 3.

What are their needs regarding enterprise reference architectures?

As it was expected, the span of answers in this question was big. There were certain answers though, into which there was consensus. According to the interviewees a good documentation of the reference architecture, the principles and the standards is essential. Role maps and governance rules were also mentioned as two of the needs of the users. Other needs of the users according to the interviewees include that the architecture is up to date, concrete, comprehensible, easy to use and able to provide a quick start to the project.

Question 4.

How are Enterprise Reference Architectures used (or can be used) by you in your work to design and realization of concrete enterprise architectures?

This question encompassed a lot of consensus too. Enterprise Reference Architectures are mainly used as a starting point in the architecture work, and as a tool that provides the architects with ideas and speeds up design work. The use of reusable blocks is equally frequent too. In addition to that it was also mentioned that an ERA can help the architect in preventing mistakes that have been made in the past and shows the best practices that have been used. Summing up all the answers, one can say that an Enterprise Reference Architecture is the toolbox that the architect uses in his daily architecture work.

Question 5.

Which criteria do you use when selecting an enterprise reference architecture?

Relevance to the sector the organization belongs in and to the project was the most common answer to this question. The interviewees answered that the most important criterion is that the architecture is applicable to what it needs to be done and fits to the domain the organization belongs in.
Another criterion that was mentioned a lot was acceptance. Acceptance is even preferred to the usability of the architecture. An architecture that is widely accepted and less useful will be preferred to the architecture that is useful but not accepted. Last but not least, ease of use of the architecture was mentioned too. The easier an ERA is to use, the better will help the architect.

Question 6.

What quality of an ERA do you consider to be of most importance?

There were various answers in this question too, as the qualities that each architect considers important might vary. There was consensus though in some of the main qualities that an ERA shall encompass. These qualities are applicability (in terms of an architecture that is relevant to the domain and the project), flexibility, availability, reusability,

maintainability, understandability and acceptance. Future-proofness was also mentioned a couple of times showing that a good reference architecture that has potential to be valid and accepted in the future would be desired.

Question 7.

When are enterprise reference architectures used (or can be used) during the architecting process?

This was one more question that all the interviewees agreed in. They said that an ERA can be used at the beginning of the architecting process. It was interesting though when an interviewee mentioned that a good ERA can be used during the whole process, even before the start of the project, while seeking for a customer, or after the end of the process when someone wishes to review the concrete architecture.

Question 8.

Why are enterprise reference architectures used or should be used? In other words what are the benefits that ERA can bring to enterprise architecture design, realization and maintenance?

The main benefits that were mentioned in this question were the speeding up of the design work and the use of best practices, together with the avoidance of past mistakes. These answers were given by almost all the interviewees. Other benefits that were mentioned were standardization, reusability, reduce of costs, quality improvement, exchangeability, simplicity, creation of a common language and completeness.
Another interesting answer to this question was that ERA can improve the line of thinking of the architects and make decision making a lot more efficient. This is achieved easily as ERA forces the architects to follow certain steps that cannot be skipped. This leads to a specific line of thinking, thus decision making is more conscious and effective.

Question 9.

What is the impact enterprise reference architecture can have on decision making regarding investments? In other words what are the benefits that ERA can bring to decision making about the project portfolio?

In this question there were four interviewees that answered that they could not see how ERA can have an impact on decision making about the project portfolio. They said that the actual Enterprise Architecture could have impact on the project portfolio, but the ERA not. There were three interviewees though, that mentioned that since ERA can speed up the design work and improve the quality, it can reduce the cost of the project. In addition to that, ERA can help in setting priorities, thus the impact in decision making about the project portfolio is significant.

Question 10.

Please Prioritize the benefits below.

The benefits that were given in order to be prioritized were:

- Speeding up design work
- Structured work
- Reusability
- Interoperability
- Use of best practices
- Establishment of a common architecture strategy in the organization

Three of the interviewees put "speeding up design work" among the top two benefits, and 1 among the bottom two. "Structured work" was only mentioned by one interviewee among the top two benefits and three interviewees mentioned it in the bottom two. "Reusability" was mentioned by two interviewees at the top two benefits and by four interviewees at the bottom two. "Interoperability", probably is not considered as a too important benefit since it was mentioned four times in the bottom two benefits." Use of best practices" was mentioned three times among the top two benefits, whereas only one in the bottom two. The clear winner though was the "Establishment of a common architecture strategy in the organization" that was mentioned four times among the top two benefits, and zero in the bottom two.

Question 11.

Which are the main problems you are facing when attempting to select an ERA? Are these problems related to the possible challenges you are facing when you actually use an ERA?

Finding an ERA related to what the architect needs to do is one of the most common problems the architects come across with. This problem is mainly caused by the scattered knowledge that exists and makes it difficult for the architect to have a proper look into all of the ERAs that are out there. Acceptance of the ERA by the customer, huge documents, no clear structure, poor documentation and difficulty in understanding the ERA were also problems that were mentioned a lot. The answers of the interviewees show that it is not easy to find an enterprise reference architecture and consequently to use it too. A lot of effort needs to be made by the architect, and there is room for improvement in the knowledge management of the existing reference architectures.

Question 12.

When selecting an ERA for your organization, do you prefer to use an ERA focused on a specific domain or a more generalized one?

In this question the interviewees agreed that whether they will select a domain specific ERA or a generalized one depends on the organization, the project and the maturity of the

organization. They mentioned that in each case the selection is a different process. Different criteria are being used and different people are involved, hence this is not something that can be answered positively.
The maturity of the organization, they said, is really important too. The less mature an organization is , the more likely it is to select a general ERA. On the contrary, if an organization is in a high level of maturity the ERA that will be selected will most probably be domain specific.

➢ Table of consensus

Below there is a table of the questions showing the level of consensus or disagreement of the interviewees.
++ => a lot of consensus
+=> varying answers but not disagreement
-=>disagreement

Questions	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Level of Consensus	+	++	+	++	++	+	++	+	-	+	+	++

Table 3-Table of consensus

In the table it is clearly shown that there was consensus in the answers of the interviewees during the interviews.
In five out of twelve questions, the interviewees totally agreed. These were the questions that the answers seemed to be trivial, like for example "Which are the (potential) users of Enterprise Reference Architectures" or "When are Enterprise Architectures used (or can be used) during the architecture process". The interviewees gave similar answers. However, through their answers interesting points also came out.
In six out of the twelve questions we got various answers. There was not disagreement though. This is reasonable, as these are the questions that the interviewees had to list the benefits or the qualities of an ERA, the criteria they use when selecting an ERA or the problems they are facing when attempting to select an ERA.
It is also interesting that in only one question there was disagreement among the interviewees. In question "*What is the impact enterprise reference architecture can have on decision making regarding investments? In other words what are the benefits that ERA can bring to decision making about the project portfolio?"* four interviewees answered that they could not see how ERA can have an impact on decision making about the project portfolio. They also said that the actual Enterprise Architecture could have impact on the project portfolio, but the ERA not. There were three interviewees though, that answered that ERAs can have an impact in decision making about the project portfolio. ERA can speed up the design work and improve the quality, hence it can reduce the cost of the project. In addition to that, ERA can help in setting priorities, thus the impact in decision making about the project portfolio is significant. It is interesting that two out of the three interviewees that answered that ERAs can have an impact on the project portfolio, where the interviewees with the most years of experience.

2.5.Main Findings

In this section the main findings of the exploration phase are discussed. The literature research findings are combined with the interview results analysis to bring us to conclusions on Enterprise Reference Architectures, their users and their needs, the selection criteria of Enterprise Reference Architectures, their use and the benefits of using an Enterprise Reference Architecture as well as the difficulties in selecting an Enterprise Reference Architecture.

- Enterprise Reference Architectures

An Enterprise Reference Architecture (ERA) is a generic enterprise architecture for a class of enterprises that provides the EA design principles, methods and models that are used as foundation in the design and realization of the concrete EA that consists of at least three coherent partial architectures: business architecture, application architecture and technology architecture. (Ten Harmsen Van Der Beek W., 2012).
Enterprise Reference Architectures can be used in many ways and make the life of the enterprise architect easier as they are considered to be reusable assets. First of all, an ERA can be used as a starting point for the architecture that has to be delivered. It can reduce design time, as the architect has a basis for thinking and does not need to begin from scratch. In addition to that, building blocks of an existing ERA can be reused and add value to the project. Delivery time will again be reduced and the use of a practice that has already been used in the past will make the architecture easily accepted. Moreover, an ERA can also serve as a map of lessons learned. Drawbacks of the past can be prevented, or even corrected and improved. Last but not least an ERA supports decision making. This leads the users to adopt a line of thinking and to follow specific steps that they cannot be skipped. This procedure makes the decision making easier and the final decisions more conscious. This can have an impact not only in the effectiveness of decision making but also in the project overall, since the cost will be reduces and the quality will be improved at the same time. There are more benefits that can be brought by the use of ERAs. These benefits will be analysed later in this section.

- Users of Enterprise Reference Architectures and their needs

The obvious users of enterprise reference architectures are architects of all kinds. Enterprise architects, domain architects, business architects, technology architects, application architects and data architects. While executing the interviews for this research, all of our interviewees agreed on this particular fact. Enterprise Reference Architectures can only be used by architects. Of course, other groups of stakeholders (customers, project managers, high level decision makers, CEOs) can make use of ERAs, but this should always be done together with the architects, or after the architects have explained the RA. An ERA is the architect's toolkit for the creation of the concrete architecture, a tool for specialist. People that are not used in thinking in the same way as the architect cannot use an ERA.
Architects have certain needs regarding ERAs. First of all, it needs to be related to the domain the organization belongs in. Also, a good set of documentation consisting of

explanation and guidelines on how to use and apply the reference architecture, is of high importance. Principles and standards are also very important and they should be documented very well indicating what is the principle (or the standard), what is the reasoning behind it, as well as what the consequences are. An ERA must always be up to date and the user must be able to find the most up to date version of it. The architects also need to be able to use the reference architecture easily so that they can indeed save time. Moreover, an ERA has to be easily comprehensible. Users must be able to understand what it means, either by the establishment of a common language or by a glossary. It is also important for a reference architecture to be concrete and unambiguous. It does not make much difference how detailed a reference architecture is, if it is not concrete and clear. Another need of high importance is that the architecture is tested and accepted. Last but not least, a flexible and future-proof reference architecture is always preferred by the architects.

- Enterprise Reference Architecture selection criteria

When attempting to select an ERA, architects look for certain criteria that will make this selection easier. As it comes out both from the interviews and the literature, the main criterion is the relevance of the RA to the domain the organization belongs in. Another criterion is the maturity of the organization. The more mature an organization is the more specific the reference architecture will be. If the organization level of maturity is low, the architect will select a more generalized reference architecture. What is more, if the reference architecture is concrete, well documented and loosely coupled is more likely to be selected.

- Use of Enterprise Reference Architectures

An ERA is mainly used at the beginning of projects, as a starting point. It is not a blueprint that defines what exactly has to be done, but it is a basis for discussion and can help the architect to get ideas and to avoid repeating mistakes that have been made in the past. A good ERA though, can also be used in other steps of the project. If someone reviews the architecture or checks the architecture's quality, the ERA can again be used.

- Benefits of the use of Enterprise Reference Architectures

The impact that the ERA has in the project is clear. An ERA can bring a lot of benefits in the architecture work. In order to achieve this, an ERA has to be of high quality. The quality of an ERA can be measured in terms of quality attributes which are non-functional properties that have meaning in all aspects of the enterprise and they can be characterized by the use of general scenarios that can adapt to any kind of enterprise. These scenarios can be analyzed and measure the quality of the ERA. (Raouf, 2011) Flexibility, reusability, interoperability and concreteness are the quality attributes that seem to matter the most among the users of enterprise reference architectures.
If an ERA is of high quality it can bring a lot of benefits to the architecture work. First of all it can speed up design work. ERAs provide the main guidelines in the design of the system. The architect does not have to begin from scratch, and has a basis for discussing the architecture. Moreover, the use of best practices can increase the quality of the

architecture to be created and drawbacks of the past can be avoided. The work becomes structured and effective and this has also a positive impact on the delivery time. An ERA can also help in the establishment of a common architecture strategy within the organization. They also provide support in decision making and make it effective and efficient. All of the above can additionally have an impact on the overall cost of the project. The less time it is needed for an architecture to be developed the less the cost is. The cost is also reduced by the use of best practices and the prevention of mistakes. Moreover an ERA of high quality can help in setting priorities and help in the proper budget's distribution. However, there is disagreement among architects on this topic. There are architects that claim that Enterprise Reference Architecture cannot affect the decision making about the project portfolio whereas Enterprise Architecture can. More experienced architects though argue that ERA not only has an impact on the project portfolio, but also this impact is significant. The latter opinion is also supported by the literature. ERA takes as an input the project activities and creates a path for them. The decision making becomes clear and effective, and this impacts the project portfolio too, as well as the decisions about it.

- Difficulties in selecting an Enterprise Reference Architecture

However, when architects attempt to select an ERA for their organization, they face different challenges that they must overcome. One of the main challenges is actually finding a RA relevant to the area of interest and then accessing it and using it. Attempts to select the proper reference architecture (or group of architectures) for a project can be facilitated by the use of Architecture frameworks. Architecture frameworks offer a standard approach to architecture. This approach can be a certain model or method for an architecture. Architecture frameworks can also help in the structure of architecture and aim either at the specific applications or at the business-units or parts of the organization. Even if the above issue is set aside, we come across another problem. There are many existing RA, and all of the knowledge around them is rather scarce. This makes it difficult for the architects to select a proper reference architecture since they cannot look into everything that exists. This might lead them to use the same reference architectures all over again and leaving out other reference architectures that might be more applicable for a specific case. Architects often require a knowledge base that would inform them on what the RA is and what it can do. This would facilitate the selection of a proper reference architecture, since knowledge on each existing architecture would be available, and hence more architectures would be used. Another issue, related to the scarce knowledge around the existing reference architectures, is that most of them are very big. NORA (Nederlandse Overheid Referentie Architectuur) for instance is a large document. It is hard for the architect to read it all and find the parts that he wants to use. A more concrete and clear architecture would solve this problem. Architects also come across with the issue of acceptance of the architecture. Customers often prefer more generalized architectures that are widely recognized and accepted. This can be another barrier for the architect's work.

Summing up, Enterprise Reference Architectures are without a doubt a helping hand for the architect. If the architects manage to overcome the obstacles they face when selecting an ERA, the benefits they will receive will be significant. What needs to be done

is to define the way to overcome the above mentioned obstacles. A process that would help the architect select an ERA that would best fit the project's requirements could be a solution. This is the design part of this project.

3.Design Phase

During the design phase of this project, a process for the selection of an Enterprise Reference Architecture was designed. The process is explicit, but not strict and it incorporates a clear structure. Apart from the process, a toolkit was also designed in order to help in the selection of the ERA. This toolkit is embedded in the process and is composed of three tools.

3.1.Design Approach

Enterprises are complex systems which are highly integrated and comprised of processes, organizations, information and supporting technologies. (Davoudi M.R., 2009)The interdependencies and interrelationships across their boundaries are multifaceted, thus it is clear that managing these issues is critical to achieving and sustaining enterprise performance. Enterprise architecture can provide this support. It is the framework to develop IT, maintain it, to achieve organizational goals and to manage resources of this technology. (Raouf, 2011)
Due to the high level of abstraction that Enterprise Reference Architectures encompass, the architect needs to pay attention to a lot of aspects when it comes to selecting an Enterprise Reference Architecture. Such things are the relation of the enterprise reference architecture to the domain the enterprise belongs in as well as to the given requirements of the project. The enterprise reference architecture needs to be applicable to what it has to be done. But finding such an ERA is not always easy. There exist a big volume of ERAs that are scattered and the architect is not always able to search among all of them. Moreover, ERAs are large documents and if they lack good documentation the job of the architect gets harder. If someone also considers that there are often issues of acceptance of the ERAs from the customer, it is understood that selecting an appropriate Enterprise Reference Architecture is not an easy job. (Interview : Enterprise Reference Architectures, 2012)
The initial thought for the design of this project was that the selection process of an Enterprise Reference Architecture needs to be facilitated. In order to achieve this, and to give optimal solutions to the issues faced by the architect, a process for the selection of an Enterprise Reference Architecture was designed. This process embeds a toolkit that makes the process user friendly and facilitates the selection procedure even more.
In order to design the process and the toolkit, a number of design questions had to be answered and a number of design decisions had to be taken. These questions came up after the interview execution of the exploration phase. The analysis of the results of the interviews conducted during the exploration phase, brought up significant points that one should take into account when selecting an Enterprise Reference Architecture. These points and the way that they shall be approached, formed the design questions and help in making the design decisions.

3.1.1. Design Questions and Decisions

1. **Which are the problems that the architects are facing when it comes to selecting an enterprise reference architecture? Where do these problems lead and what can be done?**
    - Finding an ERA related to what the architect needs to do and also fits the domain the organization belongs in, is the most common problem the architects come across with. This is mainly caused by the scattered knowledge that exists and makes it difficult for the architect to thoroughly search all the ERAs that are out there. Apart from that, ERAs are not always well documented ERAs, and often they are not yet widely known and accepted. (Interview : Enterprise Reference Architectures, 2012)Thus, the selection of an ERA is a time consuming job for the architect, not only because of the large number of ERAs that exist but also because the knowledge is scattered and the architect is unable to have a complete view of the domain. In order for these issues to be eliminated, structure in the selection procedure has to be added. Additionally, improvement on the knowledge management can also help. The design of this project will aim at resolving these issues and facilitate the ERA selection procedure.

2. **What is it going to be designed?**
    - The design of this project will be a process that will facilitate the selection of an Enterprise Reference Architecture. A simple toolkit will also be embedded, which will make the process user friendly and will help the architect even more in the selection of an appropriate ERA.

3. **Who will use this process and toolkit?**
    - The main users of this design will be the architects. Architects are the main users of Enterprise Reference Architectures and they are also the main people that are involved in the procedure of selecting an Enterprise Reference Architecture for the organization since they are the ones that can actually use an Enterprise Reference Architecture. Hence, this design is mainly addressed to the architects. Other stakeholders can be involved too, but always together with the architect. (Interview : Enterprise Reference Architectures, 2012)

4. **Why a process?**
    - The selection of an ERA is a time consuming job for the architect and it can also be complicated. The design of this process will give structure to this procedure. The architect will have to follow certain steps , each of which will have an intermediate result as an output. Using these intermediate results together with his personal experience, the architect will be able to select an ERA in a simpler and faster way. Moreover, this structured approach will prevent the architect from getting lost within the large amount of knowledge that exists, and it will help him avoid making many steps and loops that can be useless.

5. **What will the toolkit be?**
    - The toolkit consists of tools that will be embedded within the process in order to facilitate the user in the selection procedure. During the exploration phase of this project, 7 interviews were executed. (Interview : Enterprise Reference Architectures, 2012)The result analysis of these interviews is used in the design of the toolkit. The goal of the toolkit is to help the architect that uses the process to save time and to work in a structured way. Since the tools will be designed using the past experience of the architects that were interviewed, best practices will be used.

3.1.2. General Requirements

The answers to the aforementioned design questions form the overall requirement set of this design.
The process and toolkit shall solve the problems the architects face when they select an Enterprise Reference Architecture. The issue of scattered knowledge has to be overcome or at least to be levelled. Bad documentation shall also be confronted in a way that will not be a problem for an architect that tries to see if an architecture is suitable for his needs. The design of the process and toolkit shall also help in terms of time and cost for each project. The procedure of an ERA selection is a time consuming job, thus a good selection process and useful toolkit shall save time for the architects and consequently will also reduce the overall cost in the long term. The process and toolkit shall also be user friendly in terms of implementation since they are going to be used by new architects as well. The overall design shall guide the architect through the process and facilitate the selection procedure. Last but not least this design shall also be realistic in terms of feasibility in implementation, cost and human resources.
These are only general requirements of the design of the process and toolkit of this project. Functional and non-functional requirements are presented in detail later in this document.

3.2.Process

In this section the design of the process of selecting an Enterprise Reference Architecture is described. The purpose for designing this process is explained, the stakeholders are depicted, and the process is described.

3.2.1.Purpose

When architects are attempting to select an Enterprise Reference Architecture for their organization they come across various issues regarding the selection process. The main issue they are facing is actually finding an Enterprise Reference Architecture, as the existing knowledge is scattered and makes it difficult for the architects to have a holistic view of the field of ERAs. Apart from that, there exist documentation and acceptance issues. Customers prefer enterprise reference architectures that are recognised and accepted, and this fact can be a limit for the architect. (Interview : Enterprise Reference Architectures, 2012)The difficulty in finding and using an Enterprise Reference Architecture is clear.
Moreover, when they find an ERA that they believe it fits their needs, they have to apply it and take advantage of all the benefits that an ERA can offer. Speeding up design work and also clear structure are the most mentioned benefits. (Eeles, 2008)
In order to help the architects overcome the above issues and also take full advantage of the benefits an ERA can provide, this process has been designed. Its purpose is to speed-up the selection process of the Enterprise Reference Architecture as well as to make it concrete and structured. It addresses the issue of the scattered knowledge with the use of a tool that gives useful pointers to the architects. It also makes the selection process more structured, as the architect is forced to follow some certain steps that can guide him through. Finally it speeds up the design time, since the selection is facilitated by the toolkit that it is embedded in the process.

3.2.2.Stakeholders

In order to design a concrete, structured and useful process, the groups of stakeholders have to be defined too.
In order to define the groups of stakeholders, the interview result analysis was mainly used. (Interview : Enterprise Reference Architectures, 2012) The interviewees were asked who the users of Enterprise Reference Architectures are. This question was asked because those who actually use the Enterprise Reference Architecture, can be important stakeholders (if not the only ones) in the selection procedure.
The users of Enterprise Reference Architectures are all kinds of architects. Enterprise architects, business architects, domain architects, technology architects, application architects, data architects are groups of architects that can use Enterprise Reference Architectures depending on the project. ERAs constitute a tool for the specialist (i.e. the architect) and if someone is not used to thinking as an architect cannot use it properly. However other groups of stakeholders, such as project managers, high level decision makers or even customers can use the Enterprise Architecture, but only under the

supervision of the architect or after the architecture is clearly explained by him. These groups have different influence on the Enterprise Reference Architecture selection and their interest can vary. Moreover, their knowledge on Enterprise Reference Architectures is usually limited, thus the ERA needs to be explained by an architect.
There can be a categorization of stakeholders depending on their influence on the Enterprise Reference Architecture, and their interest. This categorization can be shown in figure 2 (OGC, 2007)

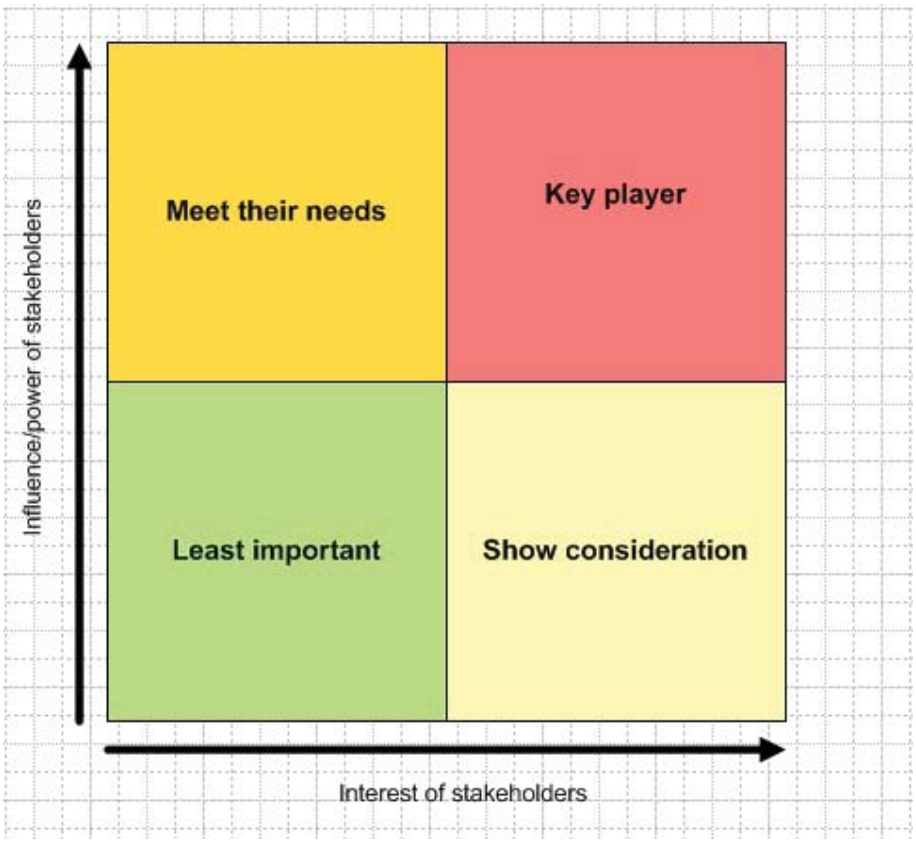


Figure 2-Categorization of stakeholders according to their influence and interest

Figure 2 presents a categorization of stakeholders in terms of their influence (power) vs. their interest. When the stakeholder's both interest and influence is high, they are categorized as "Key players". When the interest is low and the influence high, they are categorized as the group of stakeholders that their needs should be met. High interest and low influence is a group of stakeholders that should be taken into account. When both interest and influence are low then this is the group of the least important stakeholders.

In the case of Enterprise Reference Architectures, the groups of stakeholders that have already been defined by the interview result analysis are the following:

- Architects (enterprise architects, business architects, domain architects, technology architects, application architects, data architects)

- High level decision makers
- Project managers
- Customers
- Developers
- Other groups of the organization

The mapping of these groups to the above picture is shown in Figure 3:

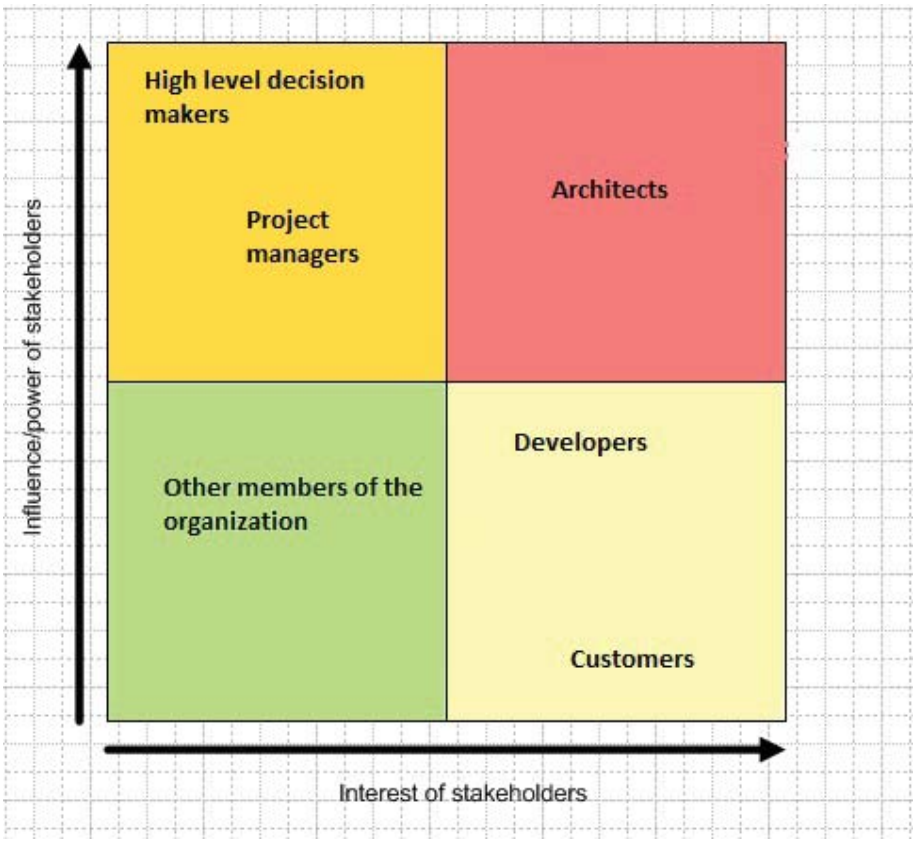


Figure 3-Mapping of the stakeholders to the categories

The groups of stakeholders are mapped according to their influence and interest on the Enterprise Reference Architecture that is going to be selected.
High level decision makers and project managers have influence on the project, but their interest on the Enterprise Reference Architecture is limited. It is important that their needs are met (meet deadlines, costs, limitation of risks etc.). On the other hand, customers constitute a group of stakeholders that have to be taken into account. Their interest on the project and Enterprise Reference architecture is high, but their influence low because their knowledge on the subject is limited. Thus, they should be shown consideration. The group of developers can be categorized at the same category too. They are interested on the Enterprise Reference Architecture that is going to be selected because they are going to use it later in the project. However they cannot influence the decision. The “Key players” are the architects. They have great influence on the final selection since they are the specialists and those who are going to use the Enterprise Reference Architecture and also their interest is high. The other members of the

organization are categorized to the least important group of stakeholders, since they do not have influence and they are not that much interested too.
Summing up, the process will be mainly addressed to the "Key Players" in the ERA selection procedure, i.e. the architects. However it will also show consideration to the customers (what they want, what they need) and the developers that are going to implement the work and it will meet the needs of the high level decision makers and project managers.

3.2.3.Process Description

Figure 4 depicts the process for selecting an Enterprise Reference Architecture

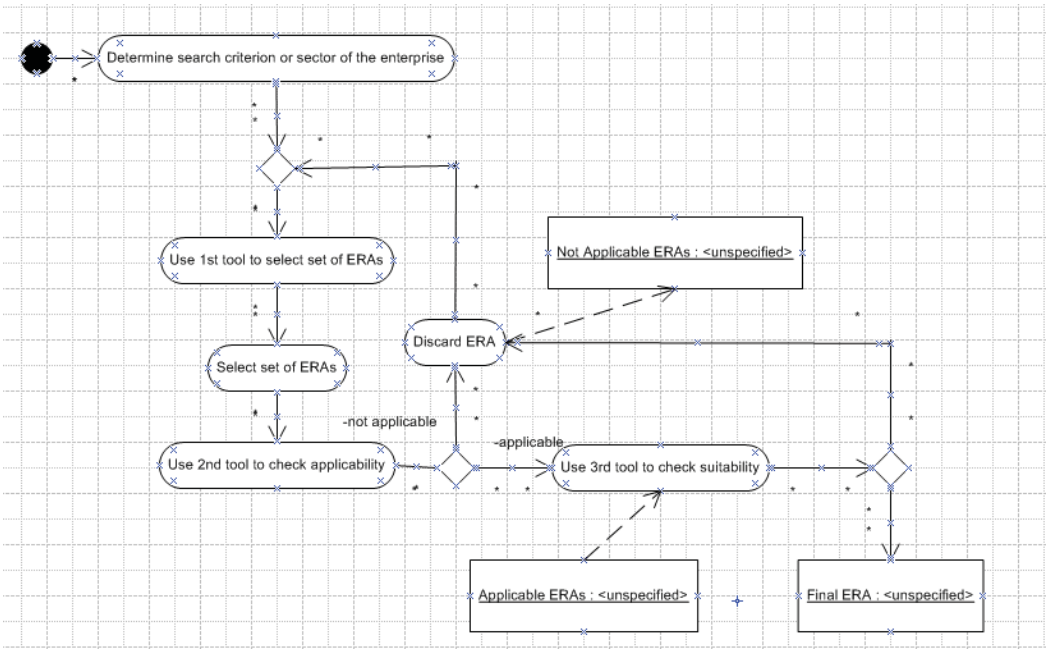


Figure 4-Process for selecting an Enterprise Reference Architecture

I. **Determine search criterion or sector of the enterprise**
The user determines the search criterion he will use or the sector of the enterprise, in other words he determines the domain the organization belongs in or the primary criterion he wants to use.
   a. **Input** : Personal experience, experience of colleagues
   b. **Process**: The architect, using his personal experience or the experience of other architects, thinks about what kind of ERA he is looking for. He determines the primary criterion he is going to use or the sector the organization belongs in so as to be able to select the proper set of reference architectures later on. If the organization is part of more than one domain, the architect can identify them all as the enterprise's domains and select the set of ERAs by making combinations.
   c. **Output:** Decision on the criterion to be used or the sector of the Enterprise.

II. **Use 1st tool to search for ERAs.**

The user uses the first tool of the toolkit in order to search for ERAs related to the domain the organization belongs in or to the criterion he has determined.

a. **Input**: Criterion/ sector of the Enterprise, first tool, experience
b. **Process**: The architect uses the first tool, which is an application that aims at gathering useful information regarding the places where ERAs can be found. By the use of this tool the architect comes across reference architectures that have been used in the past, are known and accepted, gather some of the best practices and last but not least that are relevant to the domain the organization belongs in. Additionally he sees architectures that he is not aware of. Apart from that the architect also uses the experience of other architects (colleagues) and also his personal experience in order to select the set of ERAs that he is going to examine.
c. **Output**: Set of ERAs

III. Select set of ERAs

The architect selects a set of ERAs that are relevant to the domain of the organization or to his search criterion.

a. **Input**: Results of the search process, experience
b. **Process**: The architect uses the results of the search he has executed. These are the results that the first tool has provided as well as the suggestions of other architects. Using these aspects together with his personal experience the architect selects a set of ERAs that is relevant to the domain of the organization or to the predetermined criterion.
c. **Output**: Set of ERAs relevant to the domain the organization belongs in or to the architect's predetermined criterion.

IV. Use 2nd tool to check applicability of the ERAs

The architect checks whether the ERAs he has selected are applicable.

a. **Input**: Set of ERAs, second tool
b. **Process**: The architect now uses the second tool and applies it to each one of the enterprise reference architectures belonging to the input set. The second tool is an application consisting of a checklist of guidelines that an ERA should follow. These guidelines include important criteria as well as benefits that the architecture can provide to the project. The architect applies the check list to each one of the architectures in the set and decides if the reference architecture is actually applicable or not. If the ERA is applicable, it goes to the "Applicable ERAs" set, otherwise the ERA is discarded and goes to the "Not applicable ERAs" set.
c. **Output**: "Applicable ERAs" set.

V. **Use 3rd tool to check suitability**

The architect uses the third tool in order to make the final selection for the ERA that he is going to use.

a. **Input**: "Applicable ERAs" set, third tool, experience
b. **Process**: The architect now has as an input a set of applicable ERAs for the case under consideration. In order to make the final selection of the ERA, he uses the third tool. The third tool is an application that includes basic important quality attributes of Enterprise Reference Architectures. Each of these quality attributes has a weight. The architect applies the third tool on each ERA of the input set, checks each quality attribute that the certain

ERA has and gives a "grade" to each quality attribute. This procedure gives to each ERA a value. The ERA with the greatest value will be the one selected. If more than one Enterprise Reference Architectures gather the same result, or results that are really close, the architect needs to use his personal experience and intuition in order to make the final selection. If the architect is not satisfied by the results he gets, or he cannot find a suitable ERA he can repeat the overall process.

c. **Output**: Final ERA

3.3.Toolkit

In this section the toolkit designed to be embedded in the process of selecting an Enterprise Reference Architecture is described. The toolkit is composed of three different tools that are described in detail.
For each of the three tools of the toolkit, the conceptual model including the description, requirements and behaviour, is presented in detail. The logical model for all the tools is also presented in this section.

3.3.1.First tool

The first tool is part of the second step of the process and helps the architect select the initial set of Enterprise Reference Architectures that he is going to filter later on, in order to choose the Enterprise Reference Architecture that he is going to use.

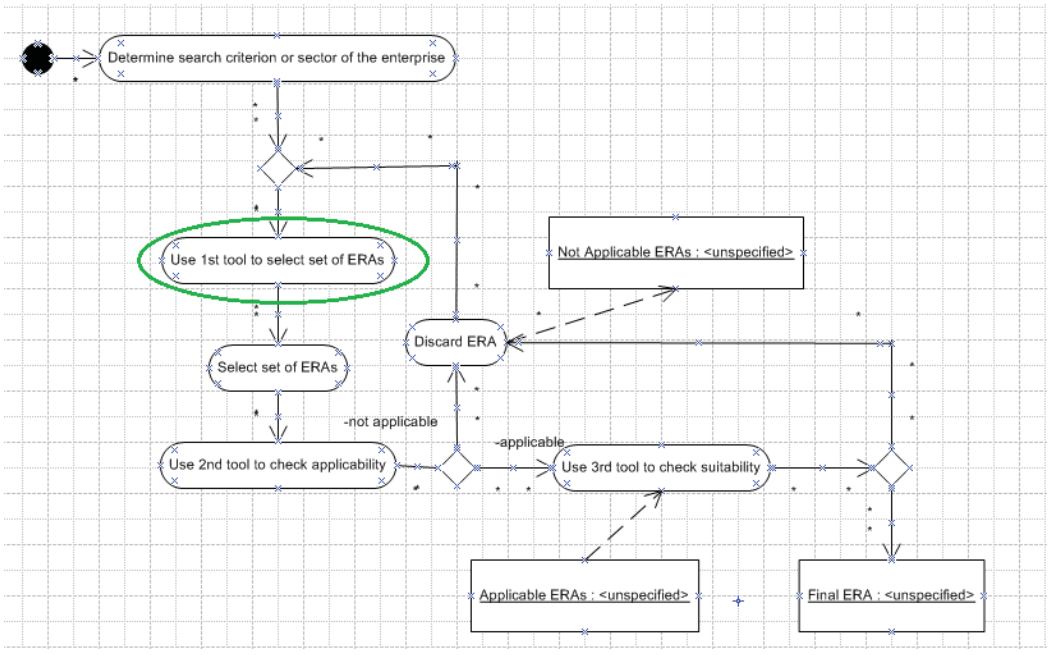


Figure 5-Mapping of the first tool in the process

Selecting an Enterprise Reference Architecture is certainly not an easy job. The big amounts of scattered knowledge prevent the architects from having a holistic view of the

domain of Enterprise Reference Architectures. A way to abridge this scattered knowledge is to define the domain the organization belongs in. However, there is still a large number of sources that an architect can look into in order to find the ERA that suits his needs. It is almost impossible for the architect to have a proper look into everything that exists.
The first tool is offering a helping hand to the architect in this first difficult step of the process. After defining the domain the organization belongs in, the architect can use the tool and select an initial set of Enterprise Reference Architectures that he will filter later on in the process. Moreover, the architect can base his selection on the organization's maturity level and decide whether the Enterprise Reference Architectures he will choose will be specific or of a general nature. During the exploration phase of this project (interviews and literature research) it became clear that the maturity level of an organization, with regard to its architecture practice (Marlies van Steeenbergen, 2007) or the organization as a whole is really important. The less mature an organization is, the more likely it is for an architect to select a general Enterprise Reference Architecture. On the contrary, if an organization is in a high level of maturity, the ERA that the architect will select will probably be more domain specific.
This tool aims at gathering all the sources that exist so that the architect has a clearer view on where to look. Apart from that, these sources are categorized in order to make the process of the selection of the initial set easier and more concrete.

Conceptual Model

Description- Information Objects

The first tool is an application that will help the user in the first step of the selection process of an Enterprise Reference Architecture. When selecting an Enterprise Reference Architecture the architect comes across different obstacles that he must overcome. Scattered knowledge is one of these obstacles. (Interview : Enterprise Reference Architectures, 2012) The architect cannot have a complete view of the domain of Enterprise Reference Architectures, thus his choices are limited to what he already knows or has used before. This tool attempts in gathering all of this scattered knowledge and make the life of the architect easier.
During the interview execution of the exploration phase, the interviewees were asked about which Enterprise Reference Architectures they use in their everyday work practice. (Interview : Enterprise Reference Architectures, 2012) They were also asked about where they search when they attempt to select an ERA. As it was expected the answers varied as the interviewees come from different business domains. Whatsoever, their answers gave a good base in order for the first tool to be designed.
The input of this tool is the information the user provides. This information is mainly the domain the organization belongs in. Alternatively, it can be any search term the user wishes for and is related to the kind of Enterprise Reference Architecture he is looking for. The output of this tool is a set of ERAs that are relevant to the search terms the user has inserted or to the domain the organization belongs in.
The processing part of the application has the form of a website. This is the website that will also host the rest of the three tools which are part of the selection process of Enterprise Reference Architectures. The webpage is a guide through the sources where an

architect can search for an ERA. These sources resulted from the above mentioned question of the interviews that were executed during the exploration phase of this project. After defining the domain of the organization (or any other search term he considers relevant), the architect can search for ERAs relevant to his requirements. For this purpose a search engine is developed. This search engine searches through a database containing information from all the "sources" defined in the interviews. This database is updated and organized once a month by a senior architect. This makes the first tool future proof and always up-to-date.
The above mentioned sources are organized in categories according to the nature of each of the sources, e.g. "forums", "websites", "search engines" etc. There is also a categorization according to "existing knowledge" and "knowledge to be explored" as well as according to organization maturity levels and to enterprise architecture practice maturity levels. This feature gives the user the opportunity to browse through the information without using the search engine.
When the architect uses the first tool he gets as a result a set of ERAs relevant to his initial basic requirements. This output is going to be used in the next steps of the process, it will be filtered and checked in terms of quality and will lead to the final selection of an applicable Enterprise Reference Architecture.

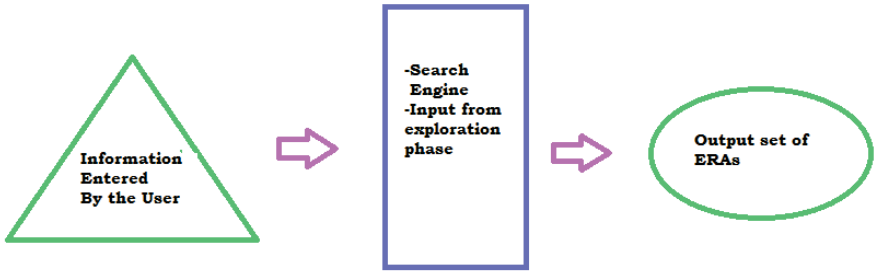


Figure 6-Conceptual Model of the first tool

Requirements

Functional Requirements

Must-have:

1. The tool is an application that helps the user select an initial set of Enterprise Reference Architectures.

2. The tool gets as input information entered by the user.
3. The tool gives as output a set of Enterprise Reference Architectures relevant to the search of the user.
4. The tool incorporates a search engine and a database.
5. In the database all the data is stored. This data is information gathered from the sources defined in the exploration phase of this project and all of the future updates.
6. The sources defined in the exploration phase should be categorized according to the nature of each of the sources, e.g. "forums" , "websites", "search engines" etc., according to "existing knowledge" and "knowledge to be explored" as well as according to organization maturity levels and to enterprise architecture practice maturity levels. This is done in order for the user to browse by himself through the information.
7. The user enters a search term within the search box and the application returns the respective results.
8. The results returned by the application will be specifications of the ERAs contained in the sources.
9. The results returned by the application will be in a form such that the user will be able to make a selection.
10. There will be two default selection choices. "Select all" and "Select none". The user can select one of these or alternatively some of the results of his search.
11. The user can save his final selection and submit it later.
12. The user can begin a new search the results of which can be added to his saved output set or into a new output set.
13. The final output set of the application will be defined by the user.

Nice-to-have:

1. The user must be able to review his last searches as well as the respective results he got.
2. The user interface shall be developed to be used by a non-expert.
3. The content of the application shall be developed to be used by an expert.
4. After defining the final output set of the application, the user will have the opportunity to review his selection.
5. The user will have the opportunity to change his selection before submitting the final output set.

Behaviour

The tool behaves as follows:

- The user is at the beginning of the selection process of an Enterprise Reference Architecture, and he has already defined the domain the organization belongs in.
- The user uses the search engine of the tool in order to find an initial set of Enterprise Reference Architectures, relevant to his requirements.
- The user can also browse through the categories of sources and decide if he wants to search through a specific category or if he wants to search manually, without making use of the search engine.
- The user enters a search term within the search box of the engine. This can be any term, e.g. domain of the organization, maturity level.
- A senior architect, searches once a month through the sources and updates the database with the relevant information. In other words, he does the work of a web crawler, by fetching information from all the sources.
- The user can select all of the results or some of them and submit them as a final output set. He can also choose not to select any of the returned results and repeat his search.
- Before submitting the final output set, the user can review his answers, save them for later and begin a new search the results of which can be added into his saved set or into a new output set.
- When the user submits his final output set, he has finished.

Logical Model

Description- Information Objects- Information Technology

Figure 7 describes the first tool:

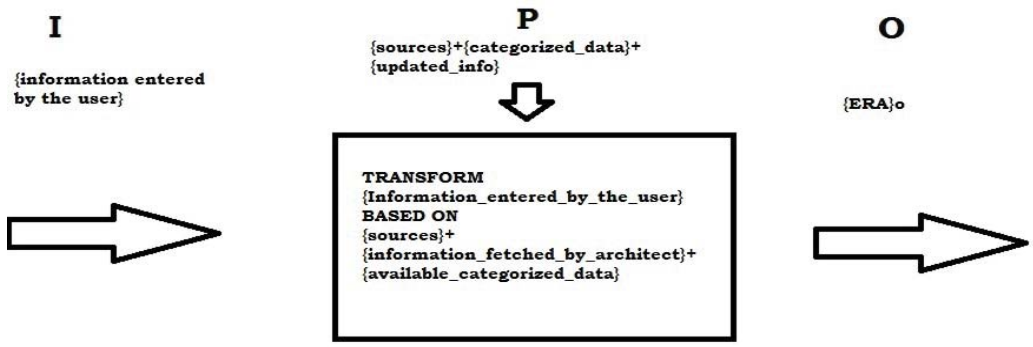


Figure 7-Logical Model of the first tool

The tool is an application that will help the user in the first step of the selection process of an Enterprise Reference Architecture. It gathers scattered knowledge from several websites and categorizes the results.
The input of this tool is the information the user provides. This information is mainly the domain the organization belongs in. Alternatively, it can be any search term the user wishes for and is related to the kind of Enterprise Reference Architecture he is looking for.
The tool uses a search engine and a database including information from the web pages. This information is updated and organized once a month, manually by a senior architect.
The output of this tool is a set of ERAs that are relevant to the search terms the user has inserted or to the domain the organization belongs in.
After defining the domain of the organization (or any other search term he considers relevant), the architect can search for ERAs relevant to his requirements. For this purpose a search engine will be developed. This search engine will search through a database containing information fetched by the sources indicated in the exploration phase. The functional and non-functional requirements of the first tool can be found in Appendix E.

Behaviour

Figure 8 shows how the first tool behaves:

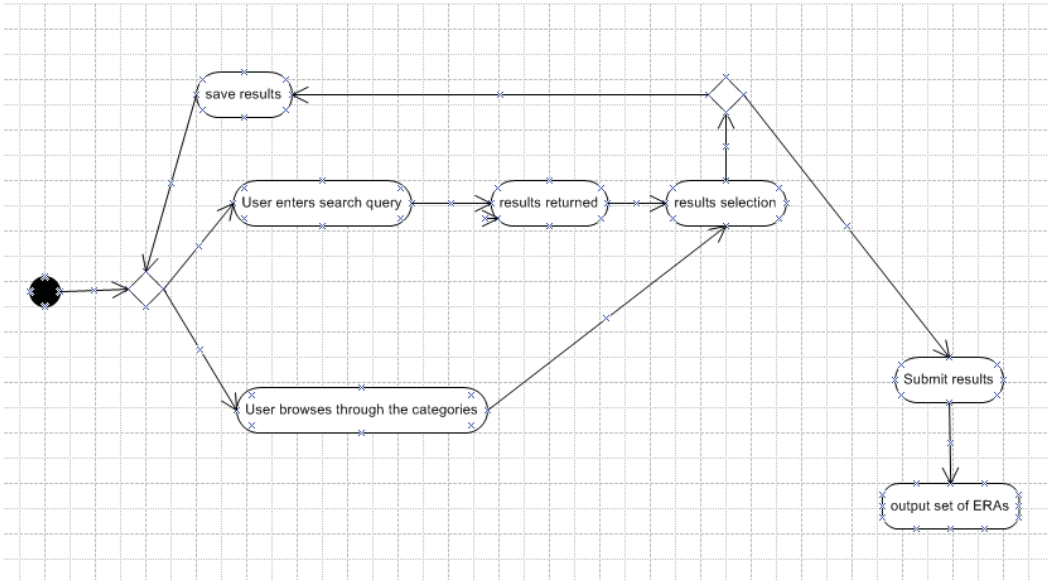


Figure 8-Behavior of the first tool

3.3.2.Second Tool

The second tool is part of the fourth step of the process and helps the architect check the applicability of each ERA of his input set.

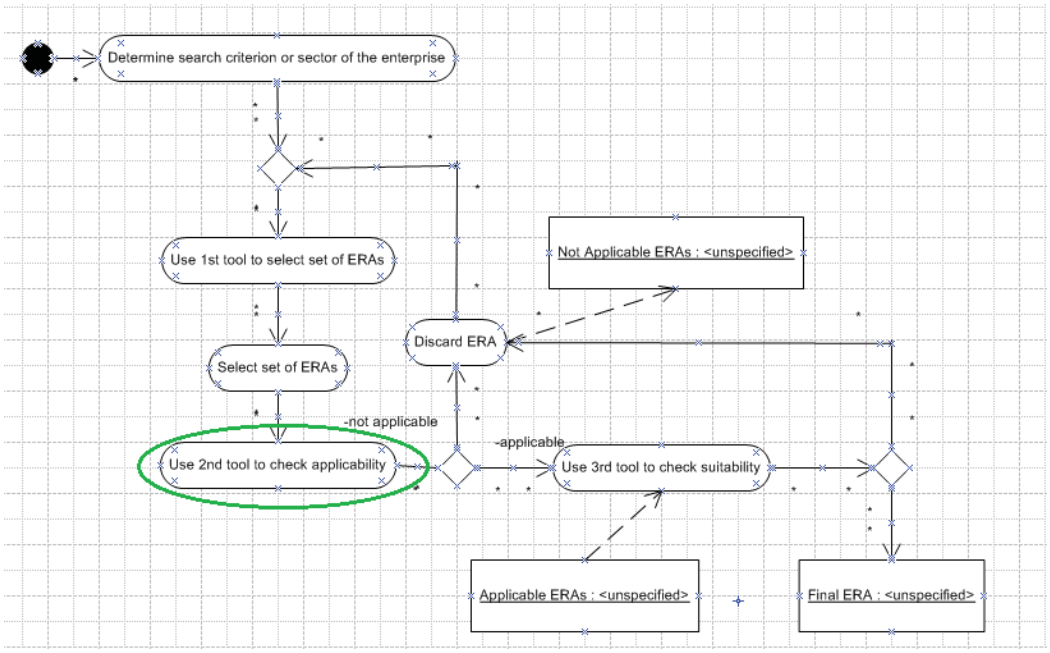


Figure 9-Mapping of the second tool in the process

During the interview execution in the exploration phase of this project, the interviewees were asked about the criteria they use when selecting an Enterprise Reference Architecture. The span of the answers was big, but the main criterion was the same among all the interviewees. This was the relevance of the ERA to the domain the organization belongs in. The rest of the criteria varied.
Moreover, the interviewees were also asked about the benefits that an ERA can bring to the organization and to the project, as well as which are the needs of the users of an ERA. Again the span of the answers was big and gave a good insight of what an architect needs from an ERA and what he expects to get.
When selecting an Enterprise Reference Architecture, the architect has certain needs such as good documentation of the reference architecture, role maps, governance rules, concreteness etc. Selection criteria that cover these needs are used and the respective benefits from the use of the ERA are expected. These needs, criteria and benefits have been used in the design of the second tool which represents a first applicability check of the architecture or in other words a first filtering of the initial set of Enterprise Reference Architectures that have been selected after the first step of the process. The second tool is an application with a user friendly UI.

Conceptual Model

Description-Information Objects

The second tool is a user friendly application that performs a first applicability check of the enterprise reference architectures that have been used as input. The tool gets as input a set of enterprise reference architectures. This set is processed when the architect makes use of the second tool. One by one, the ERAs are checked with regard to selection criteria, needs and expected benefits, defined by the interviewed architects of the exploration phase. If the enterprise reference architecture is applicable it goes to the resulting set of applicable enterprise reference architectures, which is the output of the second tool. If the enterprise architecture is not applicable, it is discarded.

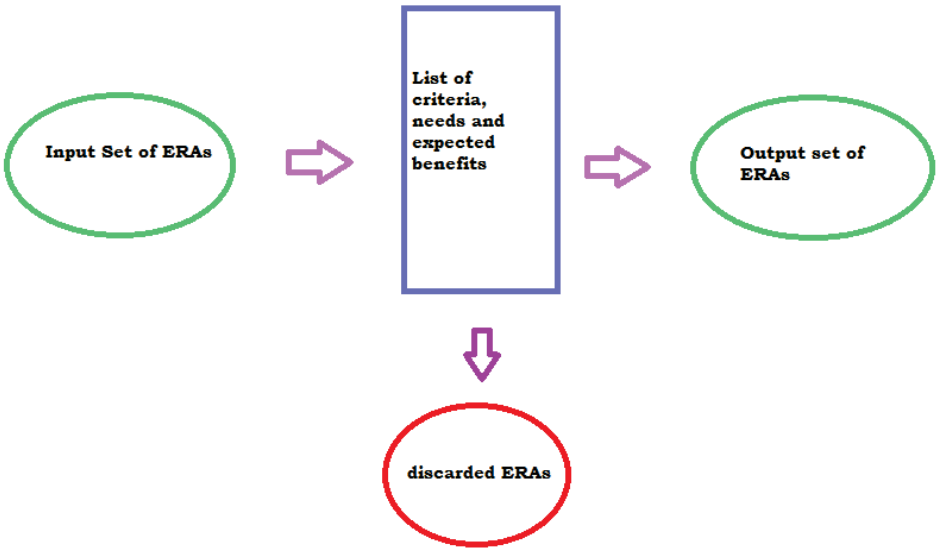


Figure 10-Conceptual model of the second tool

The processing part of the tool consists of a set of criteria, needs and expected benefits that have been defined by the architects that were interviewed during the exploration phase, (Interview : Enterprise Reference Architectures, 2012) some of which are considered to be more important as there was a lot of consensus about them. At the following table all of the criteria, needs and expected benefits are shown in order of importance as it was revealed by the interview results. (Kotzampasaki, Design of a process and toolkit for the selection of an Enterprise Reference Architecture, 2013)

	Criterion
1.	Relevance to the sector the organization belongs in
2.	Relevance to the project requirements
3.	Concreteness
4.	Good documentation
5.	Acceptance
6.	Provides a quick start/ Easy to use
7.	Use of best practices
8.	Simplicity

Table 4-Criteria/needs/benefits when selecting an ERA

The first two criteria that are presented in the above table, namely “relevance to the sector the organization belongs in” and “relevance to the project requirements” are the most important, as they were mentioned by all the interviewees either as a criterion for the selection of the ERA or as a need of the architect. These two criteria constitute the mandatory part of the tool. If an enterprise reference architecture does not meet one of these criteria cannot be considered as applicable for the case under consideration.
The rest of the criteria constitute the second part of the tool. These six criteria are split up in sub-criteria. It is not mandatory that all of the criteria and sub-criteria are met,

however the user has to indicate a grade to each one of them with respect to their appliance to the Enterprise Reference Architecture. Apart from indicating this grade though, the user has to set a parameter to control the level of the filtering. If the sum of the partial grades of these criteria is higher than this parameter, the enterprise reference architecture under examination is considered to be applicable. In the table below the criteria and sub-criteria are shown.

	Criterion	Sub-criterion
1.	Relevance to the sector the organization belongs in	-
2.	Relevance to the project requirements	-
3.	Concreteness	Concreteness of process models
		Concreteness of data models
		Concreteness of organization models
		Concreteness of business models
		Concreteness of information models
4.	Good documentation	Good documentation of the ERA specification (how it works)
		Good documentation of business rules
		Good documentation of standards
5.	Acceptance	Acceptance in the organization
		Acceptance in the domain
		Acceptance by the customer
		Acceptance by the project team
		Acceptance by the standardization comitee
6.	Quick start	-
7.	Use of best practices	Use of best practices in process models
		Use of best practices in data models
		Use of best practices in organization models
		Use of best practices in business models
		Use of best practices in information models
8.	Simplicity	Simple functions
		Simple processes
		Simple rules
		Easy to understand

Table 5-Criteria and sub-criteria

The tool is a software application. This application will be embedded in a website that will host all the three tools of this project, as well as the process specification. The application is able to decide whether an Enterprise Reference Architecture is applicable or not. The decision is based on the answers of the users of the application.

Requirements:

Functional Requirements:

Must-have:

1. The tool is a software application that decides whether an Enterprise Reference Architecture is applicable or not.
2. The tool gets as input a set of Enterprise Reference Architectures.
3. The output of the tool is a set of Enterprise Reference Architectures.
4. The application must consist of two parts.
5. The first part must be a multiple choice question where one or more answers are possible.
6. The second part must be a multiple answer question where the user indicates a grade for each possible answer.
7. The first part of the application must have two alternative answers and must allow the user to select more than one answer.
8. The second part of the application must have as many choices as the specified set of criteria (Table 2) and must allow the user to indicate a grade for each possible answer.
9. The grade indicated by the user must be a number within the scale 0 to 10.
10. The first part must require at least one answer.
11. The application should take the user to the second part only if the first question is answered and only if all the alternative choices have been selected.
12. The application must calculate the answers of each part.
13. The first part of the application is “passed” if #answers=2, otherwise the ERA is discarded.
14. If the first part is “passed” the user is automatically taken to the second part. If not, the user is automatically taken to the end.
15. The user shall set a parameter which indicates the minimum value of the sum of partial grades.
16. The second part of the application is “passed” if the overall grade that the user has provided (sum of the partial grades) is higher than the parameter set before, otherwise the ERA is discarded.
17. If the second part is “passed” the user gets an “applicable ERA” message. If not, the user gets a “discard ERA” message.

Nice -to-have:

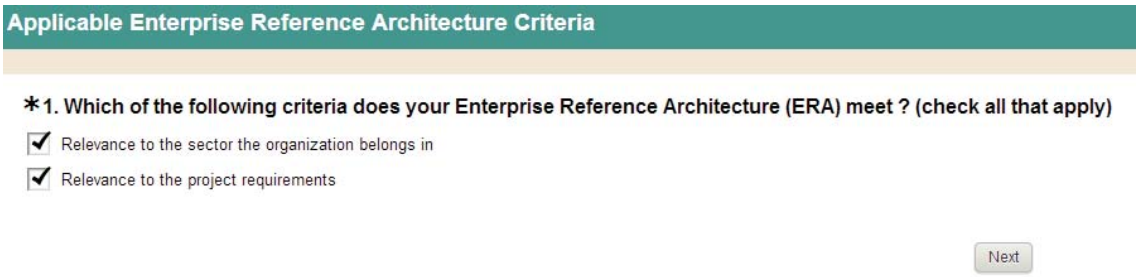
1. The user must be able to edit his answers.
2. The user must be able to see the last 30 interactions between him and the application (last 30 ERAs that he checked) in order to be able to re-evaluate and change his answers.
3. The user interface should be developed to be used by a non-expert.
4. The content of the application should be developed to be used by an expert.

5. If the user selects less than two answers, while he is in the first part, the application should reject the ERA automatically.

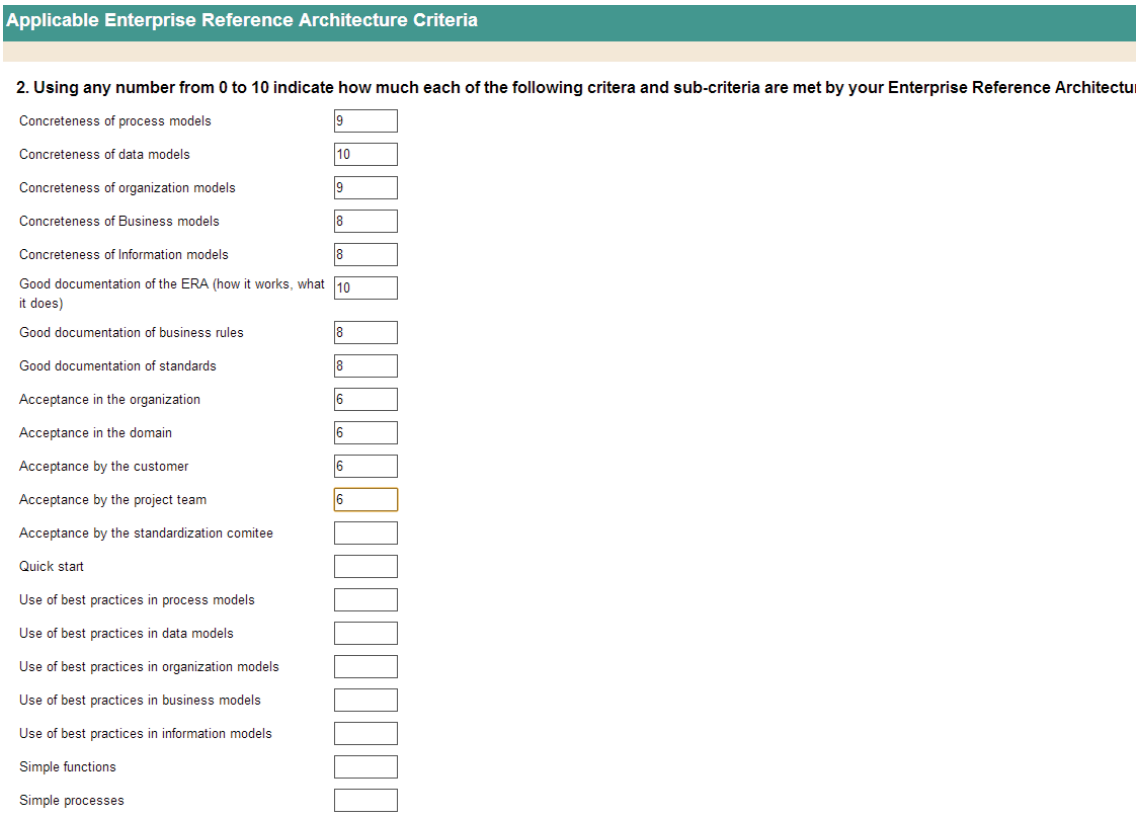
Behaviour

The tool behaves as follows:

- The user has already completed the first three steps of the process.
- An input set consisting of ERAs has been delivered.
- One by one, every Enterprise Reference Architecture within the input set is examined.
- The application provides the examination tool, and the user (architect) performs the checking. Thus the iteration is driven by the tool, whereas the checking is driven by the user.
- The first "mandatory " part uses a simple user interface that represents a checklist containing the first two criteria of the table.
- The architect checks if these criteria apply to the enterprise reference architecture under examination and ticks the respective boxes.
- The answers to these two criteria are binary, which means that the user can answer with a "yes" or "no". If his answer is "yes" he can tick the respective answer box. If his answer is "no" he does not tick the respective answer box.



- If both criteria have been selected then the application takes the user to the next part of the tool.
- The next part is a list of criteria which have been split up.
- The user sets a parameter which indicates the minimum value of the sum of the partial grades, in order for the ERA to be considered as applicable.
- The user has to provide a grade to these sub-criteria according to the level of appliance to the Enterprise Reference Architecture under examination.



Applicable Enterprise Reference Architecture Criteria

2. Using any number from 0 to 10 indicate how much each of the following critera and sub-criteria are met by your Enterprise Reference Architectu

Concreteness of process models	9
Concreteness of data models	10
Concreteness of organization models	9
Concreteness of Business models	8
Concreteness of Information models	8
Good documentation of the ERA (how it works, what it does)	10
Good documentation of business rules	8
Good documentation of standards	8
Acceptance in the organization	6
Acceptance in the domain	6
Acceptance by the customer	6
Acceptance by the project team	6
Acceptance by the standardization comitee	
Quick start	
Use of best practices in process models	
Use of best practices in data models	
Use of best practices in organization models	
Use of best practices in business models	
Use of best practices in information models	
Simple functions	
Simple processes	

- The overall grade of the Enterprise Reference Architecture is a sum of the partial grades that the user has given to each one of the sub- criteria.
- If the overall grade of the ERA is above the parameter he has already set then the user gets an “Applicable ERA” message, otherwise he gets a “Discard ERA” message.

Logical model

Description-Information Objects-Information Technology

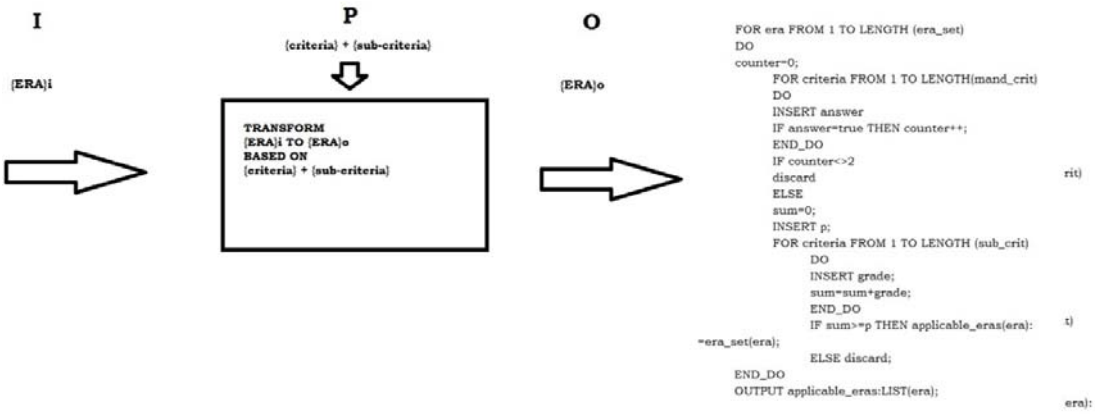


Figure 11-Logical Model of the second tool

The tool is an application that performs an applicability check of the enterprise reference architectures that the user provides as input. This input is a set of enterprise reference architectures that emerged after the first step of the process and it is processed when the architect makes use of the second tool. One by one, the ERAs are checked with regard to selection criteria and sub-criteria defined by the interviewed architects of the exploration phase. The output of the tool is a set of applicable enterprise reference architectures. Enterprise Reference Architectures that are not applicable are discarded. The pseudo-code as well as the functional and non-functional requirements can be found in Appendix E.

Figure 12 shows how the second tool behaves:

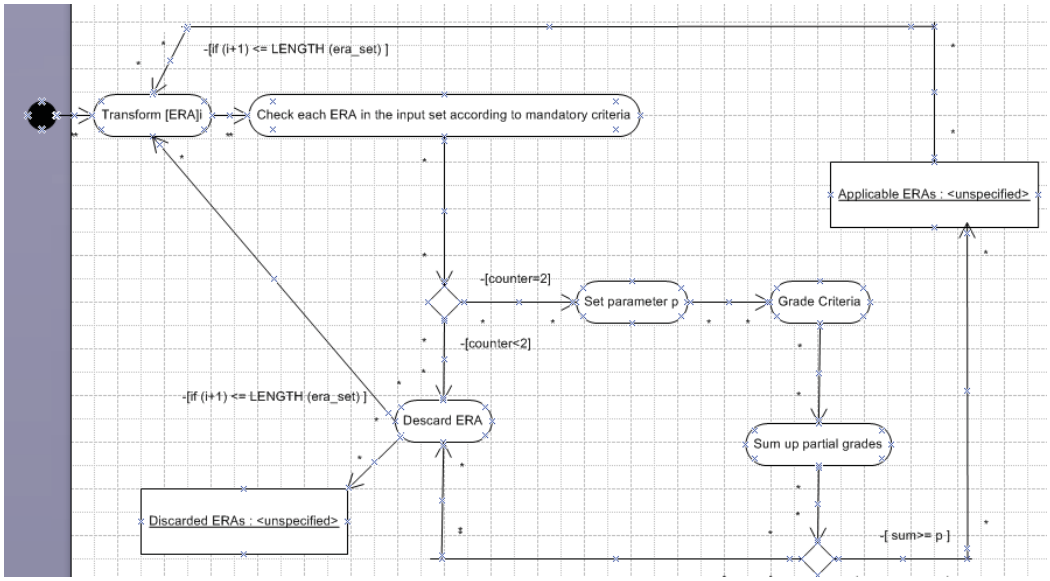


Figure 12-Behaviour of the second tool

3.3.3.Third Tool

The third tool is part of the fifth step of the process and helps the architect to make the final selection of the Enterprise Reference Architecture that he is going to use.

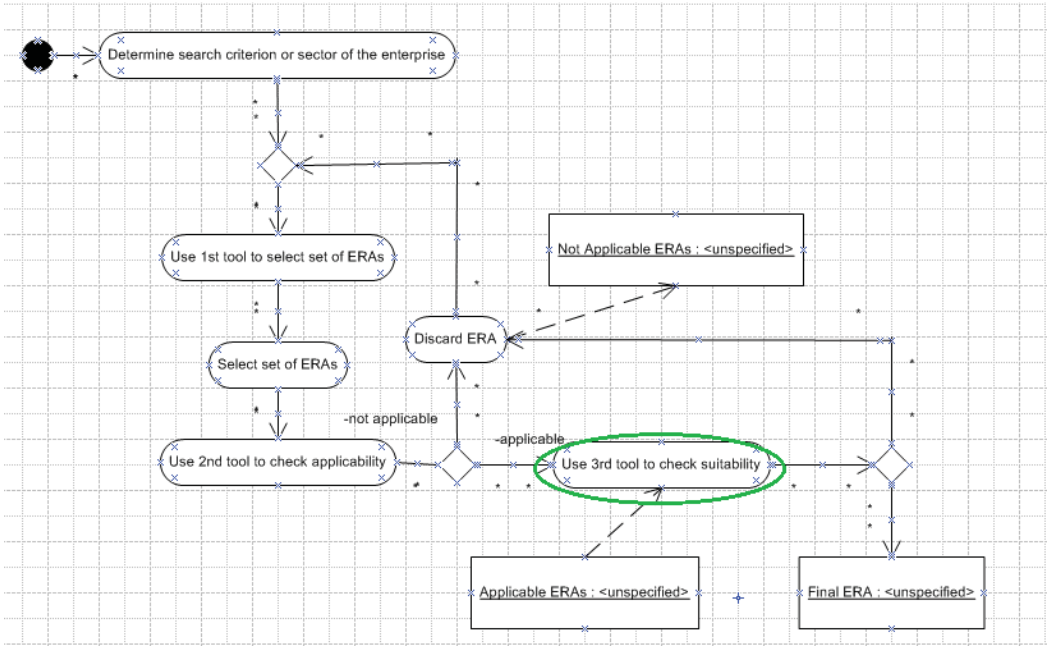


Figure 13-Mapping of the third tool in the process

During the interview execution in the exploration phase of the project, the interviewees were asked about the qualities (quality attributes) that an Enterprise Reference Architecture shall encompass. They were asked which of these qualities they consider to be the most important. The interview result analysis gave as a result a prioritization of these quality attributes, according to the architects answers. Although the answers varied as the qualities that each architect considers important are different, there was a lot of consensus in the main qualities of an ERA (e.g. applicability). This gave as a result an "order of importance".
Moreover, the literature study of the exploration phase added useful information with respect to the Enterprise Reference Architectures and their relation to the quality attributes. An Enterprise Reference Architecture has to address more architecture qualities than a concrete enterprise architecture due to its generic nature and its wider audience. (Angelov S., 2008) For example the applicability quality would be of high importance for an Enterprise Reference Architecture in terms of how much applicable the ERA would be to the different contexts in the domain. However for a concrete enterprise architecture, applicability would not be considered as important since a concrete architecture has been designed to be applicable for a certain context.
Quality attributes can be used in order to define if an ERA is going to be accepted or not. An ERA that will encompass these quality attributes will be of high quality and improve the organizations performance.
The quality attributes resulting from the exploration phase are shown in the following table:

	Quality Attributes
1.	Applicability
2.	Availability
3.	Alignment to goals
4.	Usability
5.	Integrity
6.	Security
7.	Efficiency
8.	Maintainability
9.	Flexibility
10.	Reliability
11.	Convergence
12.	Reusability

Table 6-Quality attributes

These quality attributes have been used in the design of the third tool which is used in the final step in the process of selecting an enterprise reference architecture.

Conceptual Model

Description- Information Models – Information Technology

The third tool is an application which helps the architect in making the final selection of the Enterprise Reference Architecture that he is going to use. The tool gets as input a set of enterprise reference architectures .These architectures have already been checked, in terms of applicability, by the use of the second tool. The architect now needs to check the enterprise reference architectures in terms of their quality, therefore he will use a list of quality attributes. The input set of enterprise reference architectures is processed when the architect uses the third tool. The output is the enterprise reference architecture that the architect is going to use. The rest of the ERAs are discarded.

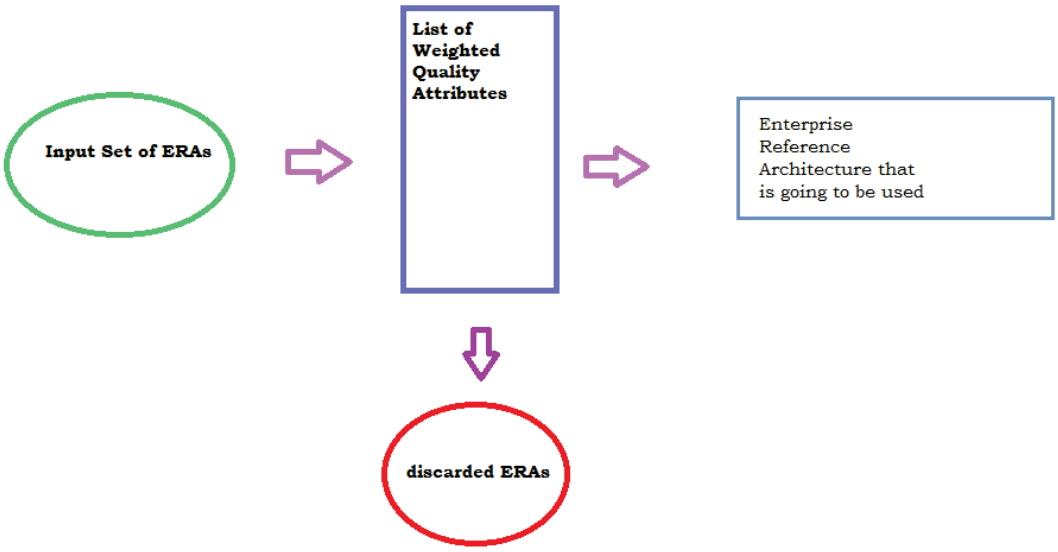


Figure 14-Conceptual Model of the third tool

The main part of the tool consists of a list of quality attributes that have been defined after the result analysis of the exploration phase (both interviews and literature research) (Kotzampasaki, Design of a process and toolkit for the selection of an Enterprise Reference Architecture, 2013). These quality attributes are weighted with a number, according to the "order of importance", as defined by the result analysis of the exploration phase and can be seen in Table 2. The weights of the attributes sum up to 1.

	Quality Attributes	Weight
1.	Applicability	0,35
2.	Availability	0,20
3.	Alignment to goals	0,10
4.	Usability	0,10
5.	Integrity	0,10
6.	Security	0,10
7.	Efficiency	0,05
8.	Maintainability	0,05
9.	Flexibility	0,05
10.	Reliability	0,05
11.	Convergence	0,05

Table 7-Weighted quality attributes

In Table 7 it can be seen that "Applicability" and "Availability" are weighted with a significantly higher value than the rest of the quality attributes. This is because these two were the quality attributes mentioned by all the interviewees, and also mostly referred to in the literature research.
In Table 8 the definitions of the quality attributes are provided. The architect needs to have a clear view of what each attribute means in order to apply the third tool.

Quality Attribute	Definition
Applicability	The ERA is relevant to the different contexts of the domain the organization belongs in.
Availability	The ERA is available. The architect is able to find it and use it.
Alignment to goals	The ERA aligns to the goals and functions of the organization and also to the project requirements.
Usability	The ERA is usable in terms of performing time, performing cost, concordance to the organization and concordant to IT trends.
Integrity	The ERA encompasses framework integrity, data integrity and application integrity.
Security	The ERA encompasses confidentiality, integrity of data and availability.
Efficiency	The ERA is efficient in terms of time and resources.
Maintainability	The ERA can be analyzed and changed.
Flexibility	The ERA is flexible. It is general enough to be used as a starting point but it also adds value to the business.
Reliability	The ERA encompasses fault tolerance and fast recovery.
Convergence	The ERA encompasses business process convergence to functions and to entities, as well as application systems convergence to business process and to entities.

Table 8-Quality attributes and their definition

The architect uses this list of weighted quality attributes to check the quality of each ERA in the input set. Each ERA in the input set, holds certain quality attributes at different levels. When checking the ERA under examination, the architect defines the level of each quality attribute in the ERA, by providing an index in a scale from 0 to 5. This index is multiplied with the respective weight. Hence for each quality attribute there is a number that reflects whether the ERA holds this quality attribute (and to what extent) or not. All of these numbers are summed and the final value reflects the quality of the ERA. The ERA with the highest value is the one that the architect gets as a result.

Requirements

Functional Requirements

Must – have :

1. The tool is a software application that makes the final selection of the ERA that is going to be used.
2. The tool gets as input a set of Enterprise Reference Architectures.
3. The output of the tool is the Enterprise Reference Architecture that the architect is going to use.
4. The application uses a list of weighted quality attributes.
5. The weights of the quality attributes sum up to 1.
6. The weights of the quality attributes must be visible to the users of the application.
7. The user of the application must indicate a number for each quality attribute showing the extent to which the ERA meets the respective quality.
8. The number that the user indicates is a number between 0 and 5.
9. If the ERA meets the respective quality attribute 100% the user shall “grade” the ERA with the highest number, i.e. 5.
10. If the ERA does not meet the respective quality attribute, the user shall “grade” the ERA with the lowest number, i.e. 0.
11. The number indicated by the user is multiplied by the weight of the quality attribute. The result is a partial value of the ERA under examination.
12. The sum of all the partial values of the ERA is the final value of the ERA.
13. The ERA with the highest value is the one that the application gives as output.
14. The ERAs that have lower final values than the one selected, are discarded.
15. The application requires that the user indicates a number for all the quality attributes.
16. If the user does not indicate a number for each quality attribute he gets an error message.

Nice – to – have:

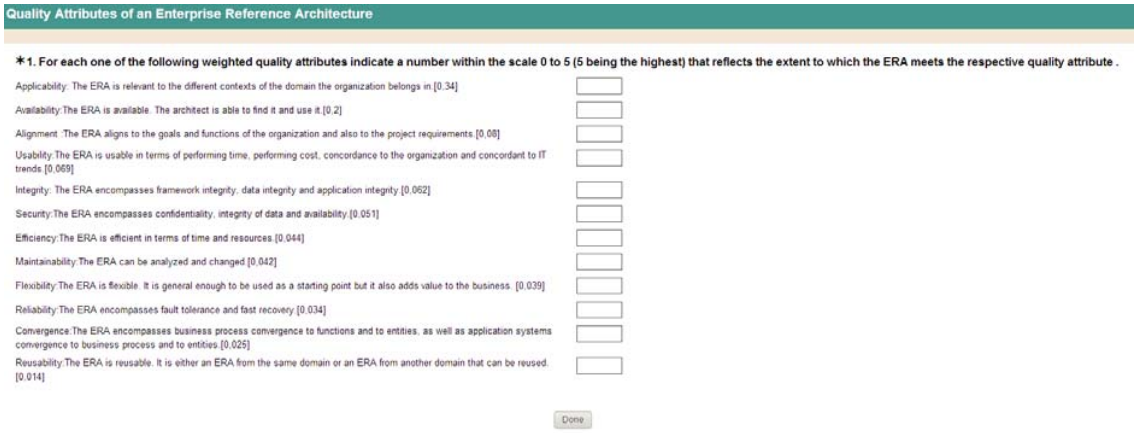
17. For each ERA that is being checked the application saves the final value into a database, so that it can be used again by a future user.
18. The user must be able to edit his answers.

19. The user must be able to review all the input set of ERAs in order to be able to change his answers.
20. The user interface of the application shall be designed to be used by a non-expert.
21. The application itself shall be developed to be used by an expert.

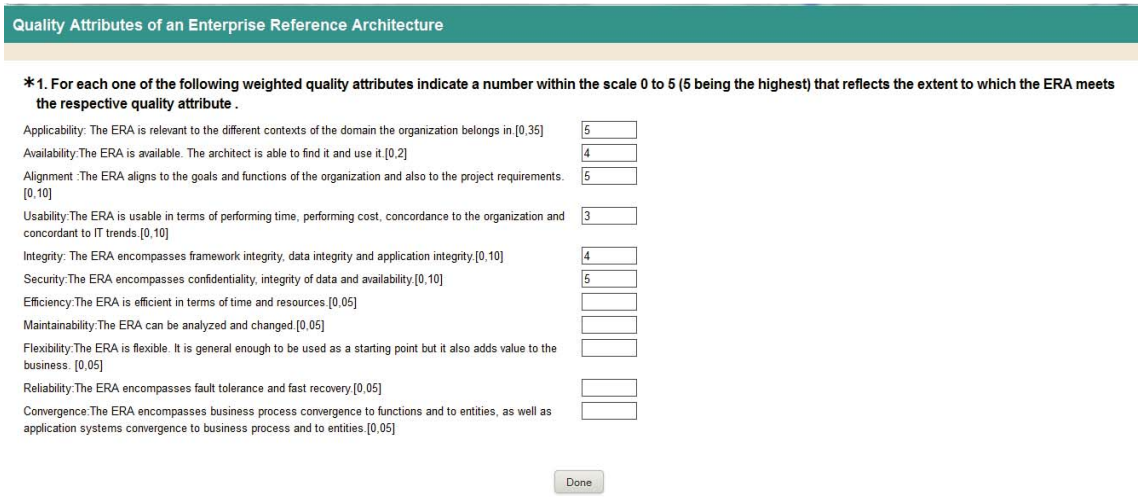
Behaviour

The tool behaves as follows:

- The user has already completed the four first steps of the selection process.
- An input set consisting of applicable ERAs has been delivered.
- One by one, the ERAs within the input set are checked in terms of quality.
- The application provides the checking tool and the user decides on the quality of each ERA with respect to the quality attributes given. Hence, the iteration is driven by the tool whereas the checking is driven by the user.
- The application uses a simple interface, consisting of a list of weighted quality attributes.



- For each one of the ERAs within the input set, the user decides to what extent the ERA meets each quality attribute.
- The user does that by indicating a grade within a scale from 0 to 5, for each quality attribute and each ERA.
- If the ERA meets the respective quality attribute 100% the user shall indicate 5 as an answer. If the ERA does not meet the respective quality attribute at all the user shall indicate 0 as an answer.



- The answers of the user reflect the extent to which the ERA meets each quality attribute.
- After the user completes the checking, the tool calculates the final value of the ERA.
- Each user-indicated number is multiplied by the respective weight of the quality attribute.
- All the products are summed, and the result represents the final quality value of the ERA.
- The ERA with the highest "quality value" is the ERA that the tool gives as an output.
- The rest of the ERAs are discarded.
- After an ERA has been checked, its final quality value is saved in a database in order to be reused by a future user of the tool.

Logical Model

Description – Information Objects Information Technology

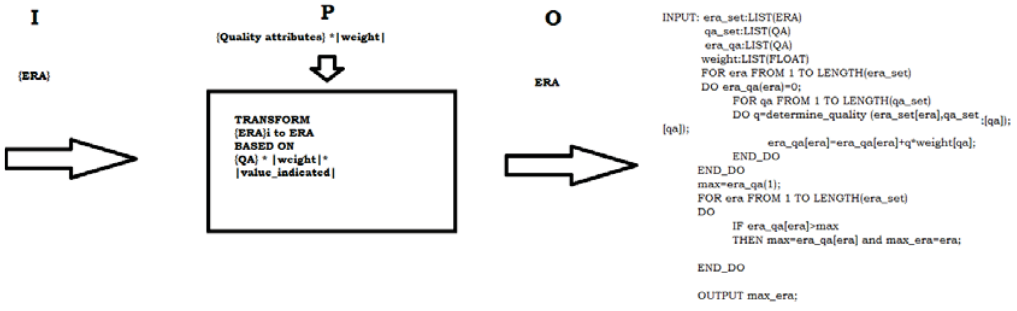


Figure 15-Logical Model of the third tool

The third tool is an application which helps the architect in making the final selection of the Enterprise Reference Architecture that he is going to use. The tool gets as input a set of enterprise reference architectures. The input set of enterprise reference architectures is processed when the architect uses the third tool. The output is the enterprise reference architecture that the architect is going to use. The rest of the ERAs are discarded. The pseudo-code that shows how the tool behaves, as well as the functional and non-functional requirements can be found in Appendix E.

Behaviour

Figure 16 shows how the tool behaves:

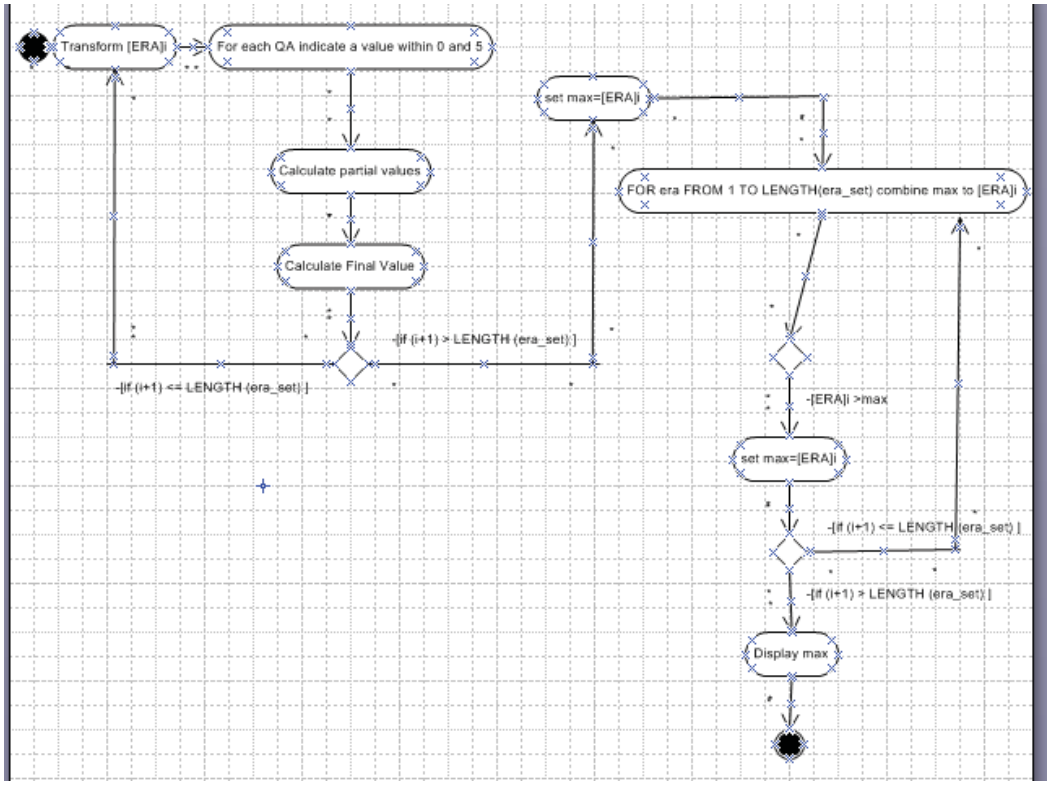


Figure 16-Behaviour of the third tool

4.Evaluation

The part of the evaluation is one of high importance for every design. In this chapter, the goal is a high-level quality evaluation of the overall design. Both the process and toolkit need to be evaluated by the main stakeholders in the ERA selection procedure, i.e. the group of architects.

4.1. Set Up

The first step for the evaluation procedure is the set up of the evaluation. In order to have a high-level quality evaluation of both the process and toolkit, the main stakeholders in the ERA selection procedure, the group of architects, was selected.
As mentioned earlier in this document, architects are the "key players" in the procedure of selecting an ERA since they are the specialists who are going to use the Enterprise Reference Architecture. They will be the main users of the process and toolkit and they are also experts in the domain of ERA. Hence, architects form the most appropriate group for the evaluation of this design.
After selecting the group that would evaluate the design, the evaluation process needed to be set up.
The input for the evaluation was the design of the process and toolkit.
The processing part was the examination of the overall design by the architects. The architects reviewed the design of the process and toolkit. The main points and design decisions were explained to them, so as to have a holistic view and to be able to make comments and suggestions. The architects had also the opportunity to look at the requirements of the design. After that they were asked five questions regarding the overall quality and requirements of the design. These questions came up after going through the overall requirements of the design and after determining the most important ones. This determination of the most important requirements had already been done during the design phase, and it was reused now.
The first two questions refer to the design presented in this report. The requirements stated have to be met in order for a design to be considered successful, so the architects were asked whether the design met the stated requirements. Apart from tha a design has to be realistic in order to be implemented. The architect's opinion was also asked.
The next three questions refer to the artefact itself (process and toolkit). Given the fact that such an artefact is implemented, the architects were asked if the problems faced would be solved, if the selection procedure would be facilitated and if the artefact would be efficient.
In table 9 the five questions can be seen.
The output of the evaluation was the architects' comments and the results.

	Questions
1.	**Do you think the design of the process and toolkit meets the requirements stated in this document?**
2.	**Do you think the design is realistic, in terms of cost and implementation?**
3.	**Would this process and toolkit solve the problems faced by the architects when trying to select an ERA?**

4.	**Would the process and toolkit facilitate at all the procedure of selecting an ERA?**
5.	**Is the process and toolkit efficient in terms of cost and time-saving?**

Table 9-Evaluation Questions

4.2. Execution

Three architects within Capgemini Nederland B.V. were chosen to evaluate the design. The design was shown and explained to them. After that they were contacted in order to proceed to the evaluation of the design.
The evaluation was done in 30 minute sessions, via phone or Skype conference.
Before initializing the evaluation process though, each architect had sent his/her general feedback via e-mail. This feedback was also used as input for the evaluation sessions.

During the evaluation procedure, the architects were initially asked to give their general comments as well as an overall perception of the design. After that they were asked the aforementioned five questions.
The issues that were mainly observed and discussed were maintenance and cost efficiency. These issues as well as the general comments of the architects are discussed in detail in the next section.

4.3. Results

The architects who evaluated the design were in general satisfied with the concept of the process and the potential use of the toolkit. All of them mentioned that "it can give a good view of what architectures are out there". Two of them also mentioned that the "question answering" nature of the second and third tool can be educational as the architect goes in depth to understand the architecture he examines. Moreover, the first tool gives a good overview of the architectures that exist. An example that was given on that topic was that an architect working in the government sector, only uses specific ERAs. If he moves to another sector though, he will not be aware of other reference architectures. The first tool could really take some worry away.
However, all of the participants were questioning the database. "The senior architect that updates the database shall have specific skills" they all said "and a lot of time available".
In detail :

- *Do you think the design of the process and toolkit meets the requirements stated in this document?*

In general, the participants stated that the requirements are met. A potential tool like the one designed would save time from the architects, and eventually money from the organization. Once an architect gets used to working with the tool he will eventually have more structure in his work. However, sometimes it seems that the tool makes all the decisions. An architect might need to have the first word on the final decision of an architecture.

- *Do you think the design is realistic, in terms of cost and implementation?*

The design was in general perceived as realistic, apart from the database maintenance part. Although having a senior architect updating the database is a right approach, it incorporates a lot of work and time. It can also be expensive and it is difficult to find an architect that would take the responsibility of such a task. The search engine would have to be smart as well, and the indexes would be necessary.

- *Would this process and toolkit solve the problems faced by the architects when trying to select an ERA?*

The use of the process and toolkit were considered to be able to solve the problems faced by the architects when selecting an ERA. These problems, that have already been discussed earlier in this document (Interview : Enterprise Reference Architectures, 2012) would more easily be solved after an architect started using the toolkit. New architects could gain knowledge and important insight on the domain of ERAs. Moreover experienced architects could gain structure in their work and in the overall selection procedure. The use of the first tool could also partly solve the bad documentation issue, as the architectures would be filtered.

- *Would the process and toolkit facilitate at all the procedure of selecting an ERA?*

There was not a lot of consensus regarding this topic. The general idea was that the use of the process could facilitate the procedure of selecting an ERA and give multiple solutions to the architects, but the maturity level of the organization would also play an important part. An organization with a high level of maturity could use the process and toolkit and benefit from it. On the other hand an organization of a low maturity level would not be benefited that much, as the architects tend to select generic ERAs and make the choices themselves.

- *Is the process and toolkit efficient in terms of cost and time-saving?*

The implementation of such a toolkit and process can be expensive, but once implemented and being used the gains in time would be important. Two out of the three participants agreed on the efficiency of the process and toolkit in terms of time and cost. However the third participant shared the worry that such kind of a toolkit can be way too expensive compared to the help it offers to the architects. An interesting opinion, coming from the same participant though, was that the second and third tool could be used as separate tools which would help each architect in different parts of the selection procedure.

4.4. Evaluation Outcome

The overall outcome of the evaluation procedure is that the potential use of the process and toolkit can be helpful and make the life of architects easier. It can be educational as well, especially for the young architects that have minor experience in selecting ERAs. The tools, once used, can give structure to the work of the architects and help them in their selection procedure.
However there are issues that need to be given thought. The toolkit and more specifically the maintenance of the database can be expensive and involves a lot of time and responsibility. Moreover companies of low maturity would not benefit by such a tool as they tend to work in different ways.
The answers of the architects pointed out important issues on the potential use of the process and toolkit. These issues will be taken into account and will be used in a refinement of the process and the toolkit component. This refinement can be proposed as a first step of future work.

5.Conclusion and Future Work

The study presented in this document is a master project that aimed at the design of a process and toolkit that would facilitate the architects in the procedure of selecting an Enterprise Reference Architecture for their organization.
Selecting an Enterprise Reference Architecture for a project is a difficult and time consuming job. Architects come across various issues such as scattered knowledge, large documents and acceptance by the customer. However, since there is room for improvement, this selection procedure can be facilitated if structure is added and better knowledge management is achieved. The process described in this document as well as the design of the toolkit that is embedded within the process, supports this kind of structure and aims at eventually adding significant value to the difficult procedure of selecting an Enterprise Reference Architecture.
This document started with the background study that was made for this project. The theoretical and practical exploration were presented and the main findings were also shown. Next the design approach was discussed and the design of the process and the three tools, composing the toolkit, was presented. The design process, proposes a number of steps that the architect can follow during the procedure of selecting an Enterprise Reference Architecture for his organization. A simple and user friendly toolkit is also embedded in this process. The architect can make use of the three toolkit components in each step of the process in order to facilitate the procedure even more. The first component of the toolkit is an application that incorporates a database including information that will help the architect find his initial ERA set. The second component is an application that provides the architect with a set of criteria that are graded by him in order to help him check the applicability of the initial set of ERAs that he already has in hand, after the use of the first component. The third component of the toolkit helps the architect check the suitability of the ERAs that he has in hand. This check is being done by an application that uses weighted quality attributes for which the architect has to determine a value. The design of the process and toolkit was followed by its evaluation. Three architects within Capgemini Nederland B.V. evaluated the design and offered their comments as an input for improvement and future work. The evaluation procedure led to the conclusion that the potential use of the process and toolkit designed can help the architects in their decisions and also give an educational hand to the younger architects. The three tools can add structure to the architects' work. However, issues were also raised regarding the maintenance of the database and the cost of implantation, as well as the maturity of the company using the toolkit.

A refinement of the process and the three components of the toolkit can be recommended as a first step for future work. After the evaluation it was clear that there is room for improvement in this design. The answers of the architects pointed out important issues regarding the potential use of the process and toolkit. These issues can be taken as input for the refinement of this design.
It should also be pointed out, that the group of architects selected for this research contained architects that are usually hired by different IT companies. A research group containing architects working for a specific IT company as internal staff could possibly give different results. This can also be a future research suggestion.

An essential future step could also be the creation of a prototype for the design presented. Finally the design presented in this study can be the basis of the actual implementation of the process and toolkit for the selection of an Enterprise Reference Architecture.

6.Bibliography

Aalst, W. v. (2004). Business Process Management Demystified: A Tutorial on Models,. *Lectures on Concurrency and Petri Nets* , pp. 1-65.

Angelov S., T. J. (2008). Towards a method for the evaluation of reference architectures: Experiences from a case. *ECSA* , 225-240.

Bernus P., N. L. (1996). A framework to define a generic enterprise reference architecture and methodology. *Computer Integrated Manufacturing Systems* , 179-191.

Danny Greefhorst, H. K. (2006). The many faces of architectural descriptions. *Inf Syst Front* , 103-113.

Davoudi M.R., A. F. (2009). Characterization of enterprise architecture quality attributes. 131-137.

Eeles, P. (2008). Understanding Architectural Assets. *Seventh Working IEEE/IFIP Conference on Software Architecture*, (pp. 267-270).

Gammelgård Magnus, S. M. (2007). An IT management assessment framework: evaluating enterprise architecture scenarios. 415-435.

Goel A., S. H. (2010). Formal models of virtual enterprise architecture: Motivations and approaches. 1207-1217.

Goethals Frank, S. M. (2006). Management and enterprise architecture click: The FAD(E)E framework. *Inf Syst Front* , 67-79.

(2012). Interview : Enterprise Reference Architectures. (M. K. Wijke ten Harmsen van der Beek, Interviewer)

Johnson P., J. E. (2007). A tool for enterprise architecture analysis. *11th IEEE International Enterprise Distributed Object Computing Conference* (pp. 142-153). IEEE computer society.

Kalpic B., B. P. (2002). Business process modelling in industry - The powerful tool in enterprise management. *Computers in Industry* , 299-318.

Kotzampasaki, M. (2013). *Design of a process and toolkit for the selection of an Enterprise Reference Architecture.* Eindhoven.

Kotzampasaki, M. (2012). *First filtering results.* Eindhoven.

Kotzampasaki, M. (2012). *Second filtering results.* Eindhoven.

Lim N., L. T.-G.-G. (2009). A comparative analysis of enterprise architecture frameworks based on EA quality attributes. *10th ACIS International Conference on Software Engineering,Artificial Intelligences,Networking and Parallel/Distributed Computing* (pp. 283-288). IEEE computer society.

Marlies van Steeenbergen, M. v. (2007). *An Instrument for the Development of the Enterprise Architecture Practice.*

Martin Haft, B. H. (2005). The Architect's Dilemma-Will Reference Architectures Help. *QoSa-SOQUA* , 106-122.

OGC. (2007). *Managing Success Programmes.* London: TSO.

Raouf, K. (2011). Qualitative characteristics of enterprise architecture. *Procedia Computer Science* , 1277-1282.

Reithofer W., N. G. (1997). Bottom-up planning approaches in enterprise modelling - The need and the state of the art. *Computers in Industry* , 223-235.

Sari B., S. T. (2007). Formation of dynamic virtual enterprises and enterprise networks. 1246-1262.

Ten Harmsen Van Der Beek W., T. J. (2012). The application of enterprise reference architecture in the financial industry. 93-110.

Van Der Raadt B., V. V. (2008). Designing the enterprise architecture function. *QoSA* , 103-118.

W.M.P. van der Aalst, A. t. (2003). Business Process Management:A Survey. *International Conference of Business Process Management (BPM 2003)* (pp. 1-12). Berlin: Springer-Verlag.

Zandi F., T. M. (2012). A fuzzy group multi-criteria enterprise architecture framework selection model. *Expert Systems with Applications* , 1165-1173.

8.APPENDICES

Appendix A- Literature Research Protocol

- RESEARCH PROTOCOL
    - Scope is limited to literature written in the English Language
    - Scope is limited to literature published between January 1996 and September 2012. Reason for choosing 1996 is that is the year of commencement of the Clinger-Cohen Act legislation in the USA that each federal Department and Agency has the responsibility to establish and maintain Enterprise Architecture (EA) programs. This is seen as the moment that it was widely recognized that organizations need to practice EA. September 2012 is chosen as end zone of the time scope because the timing of the literature search will be start in third quarter of 2012.
    - It is limited to literature that that has been gone through a full review process and was published in articles
    - Main source of the research is Science Direct, Scopus, and Google Scholar

- SEARCH TERMS
    1. ["Reference Architecture" OR "Enterprise Reference Architecture"] AND ["Definition of" OR "Specification of"]
    2. "Reference Model" AND ["Definition of "OR "Specification of"]
    3. ["Enterprise Reference Architecture" OR "Reference Architecture"] AND [" Characteristics" OR "Attributes"]
    4. ["Enterprise Reference Architecture" OR "Reference Architecture"] AND "requirements"
    5. ["Enterprise Reference Architecture" OR "Reference Architecture"] AND " qualities"
    6. ["Enterprise Reference Architecture" OR "Enterprise Architecture"] AND "qualities"
    7. "Reference Model" AND "requirements" AND "qualities"
    8. ["Enterprise Architecture" OR "Enterprise Reference Architecture"] AND ["framework" OR "selection framework"]

Appendix B-Summaries of Literature Papers

- **SUMMARIES OF PAPERS**

1) UNDERSTANDING ARCHITECTURAL ASSETS

The use of reusable assets can be of great value for an architect. As there are many different types of assets to consider, and it is not always clear what is meant by each of them, this paper discusses the different types of reusable assets that are available to the architect as well as their characteristics and usage.
There are three main sources of architecture:

1. Theft, which is actually the use of existing assets
2. Method or process, which defines a systematic way that the architecture is derived based on system requirements
3. Intuition, which reflects the experience of the architect who recognizes a pattern or finds inspiration for an architectural element.

It is well understood that the use of reusable assets within a project can be of great value. The most common types of reusable assets are presented (based on the author's experience) and brief definitions are given. According to the author the most common types of reusable assets are patterns, architectural styles, reference architectures, application frameworks, architectural mechanisms, packaged applications, components and component libraries, and finally legacy applications. It might seem that all of these asset types are independent but there are clear relationships between them (e.g patterns are applied in reference architectures, application frameworks and legacy applications and a reference architecture makes use of application frameworks). There are also different ways to characterize the above mentioned assets, for example with regard to their granularity (coarse-grained/fine-grained) or their level of implementation. Apart from that, there are more factors that need to be taken into account when reusing assets, such as the existing standards, the method to be used as well as the tools. To sum up, reusable assets can bring dramatic improvement to the project performance as long as they are applied correctly.

The above summary and analysis makes clear that this paper is closely related to the interviews as it reflects the differences between architectural assets, the relations between them and the benefits that can bring to a project. It is also shown that for each single project, the use of a different (or more) architectural

asset is possible and always depended on the field of interest, standards, tools and methods.

2) THE MANY FACES OF ARCHITECTURAL DECISIONS

It is difficult to describe architecture, and in order for this problem to be addressed, architecture frameworks have been defined. This paper makes a comparison of existing frameworks and also defines nine fundamental dimensions that underlie architectural thinking .
In simple words, architecture is the high-level structure of a system, describing fundamental aspects of it and guiding people that design and build the system. Therefore, it needs to be described, and this description also needs to be structured. Architecture frameworks can guide this procedure, as they offer a standard approach to the architecture, but there are a lot of them and even though there might be agreement on the use of a specific framework, each system can be different and deviations from the framework would be necessary. Architecture frameworks are divided into two categories : Enterprise-class frameworks and application-class frameworks. The first category includes frameworks with multiple dimensions that lead to a large number of architectural models. Such frameworks are Zachman, IFW, TOGAF, IAF and more. The second category comprises a small number of architectural models, as it mostly describes architectures of specific applications. This paper also includes a table containing all the existing frameworks, their dimension and their values , which can be of great help for the analysis of my interview results. Moreover this analysis leads to some observations regarding the confusion that might arise (different terms for similar aspects, informal definition of terms, absence of distinction of clear values within the dimensions, thus no effective communication etc) as well as the essential ideas. Architectural dimension is also defined. It is a criterion to partition an architectural description into a set of segments where each segment is identified by a unique value within a list of values associated with this dimension. All of this results in nine base dimensions that according to the author can be used as a means of communication check list or even basis for an architectural description . The nine base dimensions proposed are: Type of information, scope, detail level, stakeholder, transformation, quality attribute, meta level, nature, representation. To sum up, since there are many differences between architectural frameworks ,clearly these base dimensions can help in better understanding and comparing the existing frameworks as well as understanding architectural descriptions.

3) THE ARCHITECTS DILLEMA – WILL REFERENCE ARCHITECTURES HELP?

This paper states the dilemma the architects come across. Although effective standard architectures would have a great impact on quality and efficiency there is hardly any standard architecture established. This is because standard architectures are either too specific or too general. This is the part where reference architectures are introduced. Reference architectures are a weaker form of standard architectures, but still a form of high value. They bring proven benefits in practice and although they do not solve the above mentioned dilemma, they present a valuable compromise. At the end of this paper, Quasar, a reference architecture for Business Information Systems is presented.
A standard architecture for a specific domain (e.g. business information systems) is a set of specified abstract components, their interactions and their interfaces. There is specified syntax and semantics and concrete components implement the standard interfaces directly . Moreover application programmers program against the standard interfaces only and never see the concrete product APIs. Standard architectures are not being established though. They are either too specific or too general, and the challenge of providing architectures with a less binding character arises. These are the reference architectures. A reference architecture for a specific domain is again a set of specified abstract components, their interactions and their interfaces, however concrete components do not have to implement the reference interfaces directly. They can differ in naming, specialization, special features or convenience. The main benefit of reference architectures is that avoidable dependencies can actually be eliminated.
The reference architecture that is presented in this paper is Quasar, which stands for quality software architecture. Its principles are simplicity, separation of concerns, concrete components and interfaces. The most important characteristics are that this reference architecture is component-based, application and technology separated (components that implement application logic are separated from components that provide technical services) ,minimal and acyclic. The analysis of the complete reference architecture that is presented in this paper gives a good insight of the above mentioned principles and characteristics.
To sum up, although standard architectures would bring great benefits , they are not established. Reference architectures on the other hand, being a weaker form of standard architectures and being more widely applicable, serve as a way to move closer to standardization.

4) AN INSTRUMENT FOR THE DEVELOPMENT OF THE ENTERPRISE ARCHITECTURE PRACTICE

This paper presents an architecture maturity model for the domain of enterprise architecture. At first the three basic types of architecture maturity models are distinguished, i.e. the staged 5-level models, the continuous 5-level models and the Focus Area oriented models where the overall maturity of the organization is expresses as a combination of the maturity levels of the focus areas. After that the architecture maturity matrix is presented in terms of its structure and use. Finally two case studies are presented and the matrix is adjusted according to the results.
The development of the above mentioned maturity matrix is based upon the principles of DYA (Dynamic Architecture) which relate closely to our research, as they state fundamental needs of an architecture (e.g. development of architecture must be driven by business needs). Moreover ,the architecture maturity matrix and its use can give us a good insight on certain qualities that an architecture must serve in order to be sufficient and mature. It also underlines the key areas one should pay attention to, during the development of an architectural practice. In addition to that it can also be used as an instrument for the evaluation of the current state of an architecture.
All in all the matrix presented in this paper provides insight and support to improve the architectural practice of an organization and facilitates the architectural practices to run smoothly and being accepted.

5) CHARACTERIZATION OF ENTERPRISE ARCHITECTURE QUALITY ATTRIBUTES

Enterprise Architectures can support decision making on enterprise-wide issues. Enterprises are complex, highly integrated systems comprised of processes , organizations, information and supporting technologies, with multifaceted interdependencies and interrelationships across their boundaries. When architecting our first consideration is the transition from the “as is “ to the “to be” state, but we also look at the underlying decision analysis related, considering this way the various “Could be “states of the new transforming enterprise. In this paper it is shown how various properties and behaviours of systems relate to enterprises, and how decisions on ‘’ could be “ alternatives can be made based on optimization around a given quality. Also a structure to define quality attributes is provided. Clearly, as far as the “architecture qualities” part of our interviews is concerned, this paper can prove of great help.
Quality attributes can be defined from different points of view (business, data, application, technology). An Enterprise Architecture quality attribute is a non-functional property that has meaning in all aspects of an enterprise. To

characterize quality attributes we use general scenarios. These general scenarios are enterprise independent and can adapt to any enterprise. The attribute characterizations are presented as a collection of general scenarios. The elements of an EA general scenario are the following:
The stimulus that requires the architecture to respond, the source of the stimulus, the context within the stimulus occurs, the view (business, data, application, technology), the artefact, the possible responses and the measures used to characterize the architecture's response.
At the last part of this paper maintainability is presented as a sample of an EA quality attribute and its general and concrete scenario are being structured. This approach help us see in practice how all of the above work.

6) A COMPARATIVE ANALYSIS OF ENTERPRISE ARCHITECTURE FRAMEWORKS BASED ON EA ATTRIBUTES

As already mentioned EA provides a knowledge base and support for decision making within the enterprise . An EA Framework describes the fundamental elements of an EA and the relationship between them. It defines suggested architecture artefacts and generic definition for developing architectures and a logical structure for classifying and organising enterprise system. It also provides the guidance about the EA artefacts. In this paper characteristics of EAF are provided with the help of EA quality attributes. First EA quality is defined as well as the quality attributes that were collected such as interoperability, flexibility, reusability, scalability, portability, standardization, alignment, integration, communication, information sharing and quality etc. These QA definitions serve as the base for the analysis that follows. After that the QA are related to each one of the 4 dimensional concepts (view, perspective, scope, time) . Finally, with regard to those quality attributes , dimensions , and certain criteria, five EA frameworks (3 descriptive, 2 Combined) are compared.
This paper can be helpful in showing how to select the most suitable EAF that meets the quality requirements .

7) QUALITATIVE CHARACTERISTICS OF ENTERPRISE ARCHITECTURE

In this paper enterprise architecture is characterized in terms of quality. Enterprise architecture gives a holistic specification about the strategy , key activities , information and organizational technologies and functions and their effects on business processes. Apart from that the domain of EA also affects

organizational external relations. Therefore, selecting an unsuitable architecture can cause disorder, many expenses and deviation from the organizational goal.
The author defines the qualitative characteristics of Software Architecture. After that he gives six definitions for enterprise architecture, and based on these he defines the properties that must be included in any enterprise architecture. These properties include alignment, convergence, maintainability, integrity, reliability, efficiency, security, usability and implementability. These qualitative characteristics are also sub-characterised and a quality model of Enterprise Architecture is being given.
All in all, a model for defining a good enterprise architecture is given that can be used in evaluating an Enterprise Architecture, in analysis of weak and strong points of an enterprise architecture design and to provide a strong tool for using suggested enterprise architectures.

8) A FUZZY GROUP MULTI-CRITERIA ENTERPRISE ARCHITECTURE FRAMEWORK SELECTION MODEL

Enterprise architecture frameworks can ensure interoperability of information systems and improve the effectiveness and efficiency. However, the selection of the appropriate framework has become a difficult task. There is the need to consider and evaluate the alternative frameworks and then select the appropriate one through collaborative effort.
Traditional assessment techniques though, emphasize quantitative and economic analysis and often forget about qualitative analysis, and the up to now research in EA framework selection does not include both quantitative and qualitative criteria. In this paper a model for EA framework evaluation and selection is proposed. The model contributes in 4 ways:

a) It takes into consideration the qualitative and quantitative criteria and their respective value judgements
b) It considers verbal expressions and linguistic variables for qualitative judgements which lead to ambiguity in the decision process.
c) It handles imprecise or vague judgements
d) It uses meaningful and robust multi-criteria model to aggregate both qualitative and quantitative data.

9) A TOOL FOR ENTERPRISE ARCHITECTURE ANALYSIS

In this paper , a tool for the analysis of enterprise architecture scenarios is presented. This tool can guide the development of enterprise architecture models and also derive a measure of the quality of this modelled architecture. Although in this paper only the “availability” quality is presented, the tool is designed to support the analysis of various quality attributes. Interoperability, security and maintainability can be some of them.
This tool can add value to our research as it can be a guide in the generation of an enterprise architecture model. In addition to that , since the authors have provided both the architecture and usage of this tool , a good insight and understanding is given.

10) THE APPLICATION OF ENTERPRISE REFERENCE ARCHITECTURE IN THE FINANCIAL INDUSTRY

Enterprise Architecture is the key in addressing the challenges in business / IT alignment that the financial institutions are facing, but there are still major issues in EA design and realization to be solved. These solutions are the goal of the research which is being executed in joint collaboration between the TU/e and business partners. In this paper, ERA is positioned as a conceptual model which will also be (partially) validated in practice.
First , the need for ERA in the Financial Industry is presented. In the past years, the architecture profession has matured and there are now plenty of available methods. In spite of this fact though, financial companies still experience a gap between the practical issues they are facing and the available architectural methods. Reference architectures are needed in order to improve the quality of architectural work.
The following section in the paper gives the definitions of the concepts of architecture, enterprise architecture, Reference Architecture and Enterprise Reference Architecture. After that a working definition of Enterprise Reference Architecture is being given and what follows is the presentation of the research that will be conducted. The research approach is presented As well as the conceptual model for this research. The next section describes the results of the first research project.

11) TOWARDS A METHOD FOR THE EVALUATION OF REFERENCE ARCHITECTURES: EXPERIENCES FROM A CASE

Because of the fundamental role that reference architectures have in the structure of information systems , they have to be of high quality. Thus, an evaluation process is essential. There exist numerous methods of evaluation, concerning software architectures though. In this paper concrete and reference architectures are presented. They are also compared and the differences between them are reflected. These differences are:

1. Reference architectures are of generic nature. This is a fundamental difference.
2. There is not a clear group of stakeholders of a reference architecture.
3. Reference architectures are defined on a high level of abstraction
4. A reference architecture has to address more architectural qualities than a concrete architecture.

After presenting the above differences between concrete and reference architectures , their evaluation is discussed. A number of methods exist for the evaluation of concrete architectures. These methods have different goals as well as techniques. Most of them provide techniques for the evaluation of system qualities and the definition and evaluation of business and architectural qualities has not received much of attention. When it comes to evaluating reference architectures though there are a number of problems that we are facing. We cannot use the same evaluation methods with the concrete architectures and this arises from the fact that the differences mentioned above exist. First of all the lack of a clearly defined group of stakeholders does not help, since most of the methods rely on the participation of stakeholders. Moreover, most evaluation methods make use of scenarios but the generic nature of RA and their high level of abstraction makes the generation of scenarios difficult.
In the next part a vision of a method for the evaluation of RA is presented, for the case of E-contracting RA. To sum up, the differences that exist between RA and Concrete architectures, make it hard to use the existing evaluation methods.

12) AN IT MANAGEMENT ASSESSMENT FRAMEWORK: EVALUATING ENTERPRISE ARCHITECTURE SCENARIOS

As already mentioned, Enterprise Architecture is an approach for the management of IT. Its wide scope though leads to the creation of detailed models. In this paper an assessment framework is proposed. This framework can be used to identify

relevant questions of EA and EA scenarios. The framework works with three dimensions namely IT organization, IT systems and Business organization.
Systems tend to interact by means of equally diverse and confusing connectors and the applications are deployed on a wide variety of platforms while utilizing many different technologies.
The need for management of IT in contemporary organizations is driven by frequent changes in the general business environment such as mergers, acquisitions, strategic alliances , global partnerships, or dramatic economy changes and pressures.
IT-management function consists of one or more roles with overarching responsibility for decisions related to the enterprise IT. IT-management responsibility includes areas such as IT-business alignment, IT investment and IT systems assessment and improvement.
In order to facilitate this decision making Enterprise Architecture appears, as it is based on the architectural models of the enterprise information system and its context. To do this , this paper proposes a framework that will help in the determination of questions for IT-management decision making. The proposed framework consists of the three dimensions mentioned above(the areas that are controllable by IT management) .It makes a distinction separating IT into the IT systems themselves, and the organization managing and maintaining the systems. These top domains are named IT systems and IT organization respectively. The IT organization generates business value to the business organization by ensuring that the IT systems operate correctly and is responsible for long-term planning of the evolution of all IT within the enterprise. The IT organization can also generate business value direct to the business organization by training of users , support, helpdesk , providing documentation etc. The IT systems generate business value when the systems are used in the Business Organization.
The framework is used to :

1. To measure on the enterprise architecture as such
2. To evaluate EA scenarios
3. To demonstrate business value.

As far as the three dimensions are concerned , IT organization's main purpose is to ensure the quality of services delivered to the business , either directly or through the IT systems that the IT organization manages. IT systems refer to infrastructure, applications and information within the enterprise. They need to have some quality attributes such as availability and reliability, data quality, functional fit, information security, interoperability, modifiability, performance, safety, usability and user productivity. Business Organization is the interface to the rest of the business organization for IT management. It has three sub-dimensions, namely inputs and outputs of the organization, organizational resources and organizational structure.

Finally a case study is used to reflect how the framework works and how it has been broken down in order to assess EA scenarios.

13) BOTTOM-UP PLANNING APPROACHES IN ENTERPRISE MODELING- THE NEED AND THE STATE OF THE ART

In this paper there is a description of a bottom-up design methodology and the need for it is explained. There is also a review of existing reference models (or reference architectures) which can be helpful for us. It is closely related to our interview's first question , and can also give us an insight on the needs an enterprise (or future enterprise) has.

14) BUSINESS PROCESS MODELING IN INDUSTRY –THE POWERFUL TOOL IN ENTERPRISE MANAGEMENT

This paper was not as much related as expected to our interview questions. In few words, it shows the power that enterprise modelling had in a project that had as a main goal to improve the process of new product development.
Despite this fact though, it gave a good insight on enterprise modelling and knowledge management and how these two are related.

15) A FRAMEWORK TO DEFINE A GENERIC ENTERPRISE REFERENCE ARCHITECTURE AND METHODOLOGY

As enterprises keep changing all the time and in all of their parts, so do their models and descriptions. And in order to still be effective and efficient they must keep up with those changes. There is the need for a generic enterprise reference architecture and methodology. The generic enterprise reference architecture and methodology is about those models, tools and methods which are needed to build the integrated enterprise. The architecture applies to the most types of enterprises, that's why it is generic. In this paper GERAM (the Generic Enterprise Reference Architecture and Methodology) is presented, by defining a toolbox of concepts for designing and maintaining enterprises for their entire life-cycle.
The requirements that any enterprise reference architecture and methodology should satisfy are shown in the following list:

1. The best treatment of the enterprise scope from the system theoretic point of view
2. The provision of consistent modelling environment leading to executable code

3. The existence of a detailed methodology which enterprises can follow
4. The adoption of good engineering practice for building reusable, tested and standard models
5. The provision of a unifying perspective for products, processes, management, enterprise development and strategic management.

The paper proposes design decision in order for the above requirements to be satisfied. The life-cycle matrix is presented with the definition of some necessary technical details and next four matrices are proposed. These are "the enterprise life-cycle matrix #3", "The methodology life-cycle matrix #2", "The strategic enterprise management life-cycle matrix #1 ", and "the product life-cycle matrix #4" . Finally , the components of GERAM are presented.
GERAM shows how reference architectures can be applied to various subclasses of the enterprise and allows better communication in the enterprise integration process.

16) MANAGEMENT AND ENTERPRISE ARCHITECTURE CLICK: THE FAD(E) E FRAMEWORK

In this paper it is shown that Enterprise Architecture is something that organizations must have. Without Enterprise Architecture it is impossible for the organizations to fulfil the basic requirements for an enterprise such as alignment, integration and flexibility. The need for fast implementation of the organization's systems lead to focusing on the short term. However this causes employees to ignore architecture , mortgaging the long term. A balance between the long and the short term needs to be found. Apart from that, enterprise architecture should not be seen as an ICT people job, but it must include business people too. This is also fundamental as the advantage that comes out from enterprise architecture is beneficial to business.
The framework that is proposed in this paper, is called Framework for the Architectural Development of the (Extended) Enterprise (FAD(E)E) and shows how the enterprise architecture process is meant to look like (in theoretical terms). The contribution of this paper to our research is major as it reflects the importance of several parts of the enterprise architecture process such as requirements, tools, people involved etc.

17) FORMAL MODELS OF VIRTUAL ENTERPRISE ARCHITECTURE: MOTIVATIONS AND APPROACHES

This paper looks into the concepts of Enterprise Architecture, and Virtual Enterprise. It also defines Enterprise Architecture and Virtual Enterprise

Architecture while providing results from different approaches for formal models of Virtual Enterprise Architecture. A good insight in Enterprise Architecture and Virtual Enterprise Architecture is given. Moreover , the modelling approaches that are presented as well as their comparison is also interesting.

18) FORMATION OF DYNAMIC VIRTUAL ENTERPRISES AND ENTERPRISE NETWORKS

This paper addresses the set up of virtual enterprises and enterprise networks. The research that is presented here has as a main goal to clarify and define the concept of virtual enterprises and enterprise networks, to develop a framework and reference architecture for virtual enterprises and finally to develop a methodology for virtual enterprises. The part of the development of the framework and the reference architecture can be interesting for our research in the essence that it is presented.

19) DESIGNING THE ENTERPRISE ARCHITECTURE FUNCTION

In this paper it is reflected how the Enterprise Architecture Function includes not only the delivery of Enterprise Architecture but also the stakeholders, structures, and processes involved with Enterprise Architecture decision making and Enterprise Architecture conformance. The authors do this by giving a holistic description of the Enterprise Architecture function. The structure and products of the EA function are described and the EA delivery function follows. After that the EA process model is presented together with the bodies and roles that interact while pursuing different objectives and goals. Finally, a case study of the EA function in a large company is shown as well as the lessons learned.

Appendix C – Interview Questions

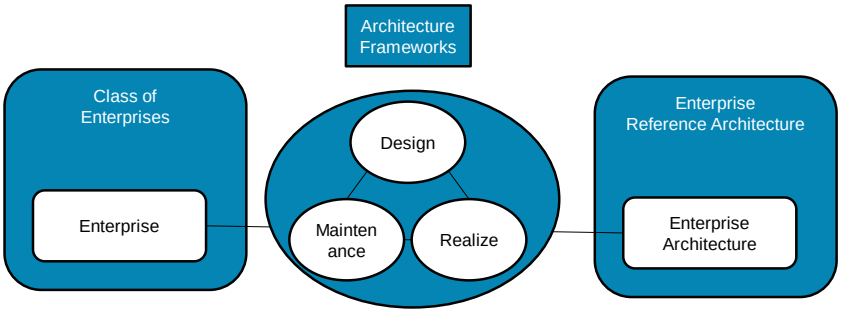
INTERVIEW QUESTIONS

-CURRENT ROLE, RESPONSIBILITIES AND TASKS

Can you give a short description about your current role, responsibilities and tasks in your daily architecture work?

-INTRODUCTION TO ENTERPRISE REFERENCE ARCHITECTURE

Interviewer presents this model on a separate sheet and asks the interviewee whether this model is recognized. Also the definition of ERA is explained. The sheer with picture will be put on the table during the complete interview.



-OPEN QUESTIONS:

1. Which enterprise reference architectures do you use in the existing architecture practice?
2. Who do you consider (potential) users of enterprise reference architectures?
3. What are their needs regarding enterprise reference architectures?
4. How are enterprise reference architectures used (or can be used) by you in your work to design and realization of concrete enterprise architectures?
5. Which criteria do you use when selecting an enterprise reference architecture?
6. What quality of an ERA do you consider to be of most importance?
7. When are enterprise reference architectures used (or can be used) during the architecting process?
8. Why are enterprise reference architectures used or should be used? In other words, what are the benefits that ERA can bring to enterprise architecture design, realization and maintenance?

9. What is the impact enterprise reference architecture can have on decision making regarding investments? In other words, what are the benefits that ERA can bring to decision making about the project portfolio?
10. Below you will see a list of some of the benefits that are brought to an organization by the use of an ERA. Please prioritize them with a scale from 1-6 (1 being what you believe is the most important benefit that can be brought and 6 being the least important one).
11. Which are the main problems you are facing when attempting to select an ERA? Are these problems related to the possible challenges you are facing when you actually use an ERA?
12. When selecting an ERA for your organization, do you prefer to use an ERA focused on a specific domain or a more generalized one?

Appendix D – Interview Summaries and Interview Statistics

Interview Summaries

Interview 1

During the first interview the simplified model of ERA was shown to the interviewee. The interviewee recognized the model , and brought up the question "what does "class of enterprises" mean?". As far as the definition of ERA is concerned, the interviewee stated that it is a true statement, in the sense that Enterprise Reference Architecture indeed provides a design principle, methods and models that are needed to create the concrete architecture. The interviewee also commented that ERA is a combination of a set of principles and a set of models at most times, and sometimes of methods as well. That is not always the case , but this is how it is done in practice.
The interviewee works in the public sector so the enterprise reference architectures he currently uses are NORA (Nederlandse Overheid Referentie Architectuur) and MARE which is a subset of NORA, more detailed and used in the public services organizations (e.g. the tax authority). These are open standards for the government but not organisation specific. Sometimes organisation specific architectures are also used.
Architects are the actual users of enterprise reference architectures. Managers can also have responsibility on it but no other people can use it. Enterprise Reference Architecture is the toolkit for making the concrete architecture, and can help in speeding up thinking by showing what is already there. So it can be interesting for other stakeholders too but they will not be working with it. As far as the needs regarding the ERA are concerned, a good set of documentation consisting of explanation and guidelines on how to use and apply it, is of high importance. Principles are also very important and they should be documented very well indicating what is the principle, what is the reasoning behind the principles, the consequences. An ERA must always be up to date and the user must be able to find the most up to date version of it. Last but not least an ERA has to be comprehensible. Users must be able to understand what it means, either by the establishment of a common language or by a glossary. It is also important for a reference architecture to be concrete and unambiguous.
Enterprise Reference Architectures can be used in many ways, depending on how detailed they are. It can be used as a starting point to speed up design work, and then make it organisation specific according to the requirements and qualities. The reuse of building blocks is also possible and the same stands for the principles. What is important though is that the same standards are used and that there is alignment with the models.
When selecting an ERA the first thing to look for is the relevance to what the architect has to do. Especially in the public sector there is not actual choice. People know what there is out there, and they just look for something relevant to each project.
Relevance is also important as a quality attribute of an ERA. Other important qualities that an ERA shall support are: its unambiguity, how concrete and clear it is and also its availability.

ERAs are mainly used at the beginning of the process. They can be used during the modelling work too, but in practice the architect starts with selecting the most relevant RA and the building blocks that can be reused, and refines the architecture later in the process.
The benefits that ERAs can bring to enterprise architecture design, realization and maintenance are numerous. Speed, better quality and completeness are the most important. The use of standards can help in increasing then interoperability and the proper implementation of solutions. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Reusability
2. Establishment of a common Architecture strategy in the organization
3. Interoperability
4. Speeding up design work
5. Use of best practices
6. Structured work

Problems that can be faced when selecting an ERA arise too. First of all knowledge is scattered and it is hard to find information on RA. It would be really helpful if that kind of knowledge was available. Apart from that , ERAs can be extremely large documents, so it is hard for the architect to find the things he can use. A clearer structure would help in that problem. Last but not least, the lists of principles are really long too. The architect can use a couple of them and leave the rest outside, but this is not effective. The principles of a RA should be those with the highest priority.

Interview 2

During the second interview the simplified model of ERA was shown to the interviewee. The question of "what does class of enterprises mean?" was brought up again. Questions were also brought up after the interviewee read the definition of ERA. The interview asked whether there is a distinction between information and data , and what do the lines in the picture mean and how they are connected to the definition.
The interviewee currently works as an architecture trainer within Capgemini. He uses a TOGAF reference models. As an architect , during the past years, and after discussions that he had with customers, reference architectures that are used are NORA, ETAM and CORA (Common Reference Architecture). He also mentioned that there is also another CORA for house incorporations and that this one is a totally different one for the Common RA.
Architects of all kinds are the actual users of enterprise reference architectures. Enterprise architects, domain architects, business architects, application architects, data architects and technology architects. As far as their needs are concerned, an ERA should be able to be used as a frame of reference and a basis for discussion. In that way it can actually help in speeding up the work. The users also need the reference architecture to be flexible.
Enterprise Reference Architectures can be used as a basis and be adopted according to the business needs. First of all see if the RA is applicable and relevant and then try to use it within the organization. As mentioned above, the RA should be flexible enough to deviate because every organization is different.

When selecting an ERA the first thing to look for is the relevance to the industry. He mentioned that he is hesitant about the use of more general RA like CORA and that he would more often use an architecture relevant to the industry as it would be more applicable and recognized by the customer.
Relevance to the industry was also mentioned as an important quality of an ERA. Apart from that, flexibility is considered to be important too. There should be general enough but also able to add value to the business. It also has to be recognized by the organization. At this point the interviewee mentioned that the maturity of the organization is closely related to the reference architecture. The more immature an organization is , the more general the RA that is selected will be. If the organization is mature enough the RA can be more specific.
The interviewee talked in TOGAF terminology and stated that ERA can be used in phases A, B, C and D of the project. After these phases you usually start working on solutions and on implementing solutions.
Speeding up work, and making the decision making process and maintenance more simple were according to the interviewee, the most important benefits an ERA can bring. He also mentioned that because of its impact in decision making it can reduce cost and lead to more conscious decisions that will also have a positive impact on investments. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Speeding up design work
2. Establishment of a common Architecture strategy in the organization
3. Use of best practices
4. Structured work
5. Interoperability
6. Reusability

A common problem that is faced when attempting to select an ERA is the acceptance of the ERA by the customer. Customers usually need to have an architecture of a more general acceptance and they don't mind if it is less usable as long as it is accepted. Another issue is how much depended on the technology the RA is.

Interview 3

During the third interview the simplified model of ERA was shown to the interviewee. The interviewee asked if this picture showed a complete architecture or a part of it. He also asked what would this Reference Architecture be used for. After reading the definition of ERA, the interviewee commented that the main problem is that people usually do not understand what reference architecture means. He also said that the last part of the definition is too IT centric and that he hasn't seen until now a good definition about what business architecture is.
The interviewee uses parts of all kinds of models that he has come across in the past. He uses those models as well as the general reference models that there are within Capgemini, in order to get ideas and then create his architecture. All in all the reference models that he uses are mainly models that he has reused in the past, but still he uses them as a starting point, to get part of the information needed and to base on them the new architecture.

Architects are the only users of enterprise reference architectures. ERAs and Reference models are tools for specialists, thus people that are not used to think as architects cannot use them. As far as their needs are concerned, a reference model should be so common that it is really tested. The interviewee mentioned that the structure organizations is the same at 80%. The 20% that is left is what makes it different from others and it is something that you cannot find in the RA, but in the concrete architecture of the organization.
Enterprise Reference Architectures can be used as a starting point at the parts that the organization needs to be different from the other organizations.
When selecting an ERA the first thing to look for is the relevance to the sector the organization belongs in. Also, a similar environment or same kind of situation under consideration can be used as criteria for the selection of an ERA.
Reusability was mentioned as the most important quality together with how understandable the architecture is. Architectures that are really tested are always preferred too. The interviewee mentioned that is really important when using a RA to be able to find the one that created it, so that you know exactly what it is about. Also an important quality is the use of a common language (like Archimate) so that misinterpretations are eliminated.
The interviewee said that ERA can be used at the beginning of the project, to speed up design, to give ideas and to have examples of what can go wrong or work properly. It can also be used when someone reviews that architecture.
Speeding up work is according to the interviewee, the most important benefit an ERA can bring. ERA supports decision making and actually asks people to get a line of thinking. They need to follow certain steps which they cannot skip. This leads to conscious decisions. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Establishment of a common Architecture strategy in the organization
2. Use of best practices
3. Speeding up design work
4. Structured work
5. Reusability
6. Interoperability

The problem that the interview mentioned as the most important one is that it is difficult to find the line of thinking related to the reference architecture. Scope and area of interest can be completely different and this can make you end up with the wrong conclusions.

Interview 4

During the fourth interview the simplified model of ERA was shown to the interviewee. The interviewee what does the "class of enterprises" mean. After reading the definition of ERA, the interviewee commented that he misses the "Why?" question. Why is the ERA implemented.
The interviewee said he does not uses ERAs in his daily architecture work. He sometimes uses reference models.
Architects are the actual users of enterprise reference architectures according to the interviewee but he also mentioned that the use of ERA by customers and other stakeholders can add value to the business, in the sense that discussion can start. He also said that if the ERA could be presented to the customers and stakeholders upfront it would make the life of enterprise architects easier as they would be able to take the customers and stakeholders along in the process. Users needs regarding ERAs vary. ERA can be a way to know what went wrong and what went well before. It also helps in having a good understanding of the concepts. Another need of ERA users is the availability of example role maps, showing how the ERA was implemented within the organization. Governance rules are also needed.
Enterprise Reference Architectures can be used as a starting point and by reusing building blocks. It can also be used to detect and solve pitfalls.
When selecting an ERA the first thing to look for is the relevance to the sector the organization belongs in and also that the threshold is really low. The ERA has to be easy to use, and help in the quick start.
Reusability was mentioned as an important quality of an ERA. The interviewee said that if the building blocks are not only reusable but also loosely coupled the quality of the ERA increases. Finally he mentioned that his personal favourite quality attributes are flexibility and future-proofness of the ERA.
The interviewee said that a good ERA can be used during the total process, and even before starting the process.
The prevention of same mistakes, the creation of a common language, reusability and easy maintenance are the most important benefits that an ERA can bring according to the interviewee. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Reusability
2. Establishment of a common Architecture strategy in the organization
3. Use of best practices
4. Structured work
5. Interoperability
6. Speeding up design work

The problem that the interview mentioned as the most important one is finding the proper ERA and then accessing it.

Interview 5

During the fifth interview the simplified model of ERA was shown to the interviewee. The interviewee commented that the model was really simplified and that he could understand it after reading the definition. He also mentioned that he could totally relate to the definition.
The interviewee said that he uses domain depended RAs that exist within Capgemini. Capgemini has a RAs for almost every segment so these are that he uses.
Enterprise architects and consultants are the main users of ERAs. They can be used though by anyone who is interested in seeing the quality of the company's architecture. An important user need regarding ERA is the use of the best applications, practices, processes, and also best breed of solutions.
Enterprise Reference Architectures can be used as a starting point, and it can really help when the architect needs to come up with a new idea. When there's a green field assignment, the architect can map the existing reference architecture in the landscape. If it's too complex he can simplify it, if it is too expensive he can make a new one.
When selecting an ERA the first thing to look for is the relevance to the sector the organization belongs in and also the level of detail that is needed. In addition to that , the more accepted an ERA is , the more likely it is going to be selected.
Acceptance, relevance to the sector the organization belongs in or reusability of an ERA from another sector were mentioned as the most important qualities of an ERA. Apart from that he mentioned that ERAs help in "thinking outside the box".
The interviewee said that an ERA can be used at the point zero of the process, after talking to the customer and coming to an understanding.
Delivery speed, reduction of cost and complexity and standardization were mentioned as benefits an ERA can bring. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Structured work
2. Use of best practices
3. Speeding up design work
4. Reusability
5. Interoperability
6. Establishment of a common Architecture strategy in the organization

The interviewee said that a common problem when selecting an ERA is seeking into knowledge management and try to find a relevant architecture.

Interview 6

During the sixth interview the simplified model of ERA was shown to the interviewee. The interviewee didn't recognize the model directly and he commented that it was not self explanatory. After reading the definition he could connect it to the picture. He mentioned that design principles are context sensitive and are normally chosen during the definition of the ERA. Questions were brought up too. "What is the structure intended to provide?" , "How is ERA used?"
The interviewee said that he hardly ever uses existing enterprise reference architectures. Sometimes he can use them at the beginning as a starting point or as a completeness check, but rarely. What he makes use of is technical patterns, service oriented patterns, technical applications, data applications.
Enterprise architects are the only users of the ERA. Other groups of stakeholders, like Business executives, CEOs or project managers, can also use it , but it can be dangerous. Only enterprise architects know the proper way to use an ERA, so they must be the only users. However, other groups can use the ERA together with the architects. Architects' needs regarding ERAs is a long list. Technology patterns are one thing. Functionalities also need to be known, and apart from that translation of what are the possible applications underneath is needed. He also mentioned that architects prefer already made packets that are available in the market, as long as there is space for improvement.
Enterprise Reference Architectures can be used as a toolbox that is going to help in several ways the process of the project.
When selecting an ERA the first thing to look for is the relevance to the sector the organization belongs in and the functional capabilities. You have to check if there are any relevant architectures available. Another important criterion is if the architecture is client specific. It needs to match the customer's requirements.
According to the interviewee the most important quality attribute of an ERA is the wide choice between different patterns in order to implement it.
An ERA can be used at the beginning of the project but if you use the pick and play approach it can also be taken to the next step.
The most important benefit according to the interviewee is the speeding up of the work.In addition to that comes the quality improvement, the standardization , the exchangeability and all of this sum up to the cost reduction. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Speeding up design work
2. Establishment of a common Architecture strategy in the organization
3. Use of best practices
4. Interoperability
5. Structured work
6. Reusability

The most common problem that the interviewee recognizes is that there are always different levels of abstraction and detail. It is always a challenge to select the right one for your context. Another issue is the scope of the enterprise. How big it is and how much time is available.

Interview 7

During the seventh interview the simplified model of ERA was shown to the interviewee. He could recognize the picture but the question about the "class of enterprises" was brought up again. After reading the definition, the interviewee commented that he missed the data side and the information architecture.
The interviewee works for IBN so he uses BIAN as well as an IBN data model.
Enterprise architects are the only users of the ERA. However they can explain the architecture to the decision makers. They are the only ones though that can recognize if something is missing or if something needs to be changed, and also implement this change. Architects' need an ERA that is not too generic. They are looking for focus in the sector the organization belongs in. They also need to know why the ERA is needed.
Enterprise Reference Architectures can be used as a starting point, to help you save time from creating your own architecture. They can also be used as maps of past mistakes that need to be prevented.
When selecting an ERA the first thing to look for is to be open to the public domain and to be proven, tested and accepted.
According to the interviewee the most important quality attribute of an ERA is its applicability. Apart from that lessons learned were also mentioned as an important quality.
An ERA can be used at the beginning of the project and also in the security check.
The most important benefit according to the interviewee is that ERA can bring an architecture of a better quality that can also be of lower cost. This is because less work needs to be done in the design and development phase. When asked to prioritize the benefits given in the table of question 10 the priority was:

1. Use of best practices
2. Speeding up design work
3. Interoperability
4. Establishment of a common Architecture strategy in the organization
5. Structured work
6. Reusability

A common problem that the interviewee has come across is the issue of whether the ERA helps the business. Is it of actual value? There is always the risk of it being a theoretical exercise.

Statistics Table

Interviewee	Nationality	Profession	Years of Working Experience	Years of Archit. Experience	Arch. Training	Experience in Financial Ind.
#1	Dutch	Architecture Trainer, Architect	25	20	Yes	yes
#2	Dutch	Architecture Trainer	20	15	Yes	yes
#3	Dutch	Enterprise Architect	40	16	Yes	Yes (since 1985)
#4	Dutch	Business Solution Architect/ Developer	17	3	Yes	no
#5	Dutch	Architect, Financial Controller	37	20	yes	Yes (35 years)
#6	Dutch	Enterprise Architect	20	12	Yes	Yes (15-20 years)
#7	Dutch	IT Architect	25	10	yes	Yes (10-15 years)

Appendix E – Tool Requirements

First Tool Requirements:

Functional Requirements

ID_ FR1_v1	
Description	The tool shall consist of a search engine and a database.
Rationale	The tool is consisted of a search engine, in order to search for the query entered by the user and a database containing

	information fetched by the sources already defined.
Reason this requirement is included in this shortlist	The tool needs to be consisted of these modules in order to make a proper and complete search.
Fit criterion	Two modules have to be developed. A search engine and a database.
Dependencies	

ID_ FR2_v1	
Description	The tool gets as input information entered by the user and gives as output a set of ERAs relevant to the user search.
Rationale	The objective of the tool is to help the user get an initial set of ERAs that he will filter in the next steps of the process.
Reason this requirement is included in this shortlist	The tool shall get as input the query the user wishes for and return a set of results (ERAs) that will be his initial set of ERAs.
Fit criterion	The search engine must have this functionality.
Dependencies	ID_FR1_v1

ID_ FR3_v1	
Description	The search engine is connected to the database where all the data collected from a senior architect is stored. This is where the clustering of the data takes place.
Rationale	The data shall be stored in a database, where there can be a proper categorization as well as regular updates.
Reason this requirement is included in this shortlist	The data used for the results of the user search shall be up-to-date as well as categorized, and this can be achieved with the use of a database.

Fit criterion	A database shall be developed.
Dependencies	

ID_ FR4_v1	
Description	The sources indicated from the exploration phase shall be categorized with at least three different ways.
Rationale	The categorization of the sources shall be done in at least three ways. According to their nature (forums, websites etc), existing knowledge and knowledge to be explored, and according to the organization's maturity level.
Reason this requirement is included in this shortlist	The user has to be able to browse through the sources according to the category of his choice.
Fit criterion	The categorization shall be done in at least three ways.
Dependencies	

ID_ FR5_v1	
Description	The application returns the results in a way that the user can make a selection.
Rationale	The user must be able to make a selection within the returned results, e.g. "select all", "select none" or by ticking the respective boxes of the results he wishes to keep.
Reason this requirement is included in this shortlist	Not all of the results returned will be suitable for the user, at least on a first glance. The user has to be able to keep as many ERAs as he wants in his initial set.
Fit criterion	The results of the search query shall be returned in a proper way.
Dependencies	

ID_ FR6_v1	

Description	The user can save his selection of ERAs and submit it later.
Rationale	The user must be able to save his selection of ERAs and review it or submit it later.
Reason this requirement is included in this shortlist	The user might not be sure about the query he had used or the domain of the organization. Thus he must be able to save his selection and review it later.
Fit criterion	The selection of the user has to be saved.
Dependencies	ID_FR5_v1

ID_ FR7_v1	
Description	The user shall be able to repeat his search or a different search and save the returned results in a new input set or in his previews one
Rationale	The use must be able to execute as many searches as he wants and save his results in as many sets as he wants.
Reason this requirement is included in this shortlist	The user must be able to combine searches and results or save his results in order to review them later.
Fit criterion	The user must be able to save as many result sets as he wants.
Dependencies	ID_FR5_v1, ID_FR6_v1

ID_ FR8_v1	
Description	The application shall provide the user with the possibility to review his last 30 searches.
Rationale	The user shall have the opportunity to check his last searches so that he does not repeat them.
Reason this requirement is included in this shortlist	The user might need to make a search that he has already made before. Some of the results might be saved or he might not need to search again. This functionality will save time.

Fit criterion	The user can review his last 30 searches.
Dependencies	

Non-Functional Requirements

1.Look and Feel Requirements:

ID_ NFR1_v1	
Description	The application shall have an interface that is consistent with the general design of the website that will host the three tools and the process specification.
Rationale	The application shall not disrupt the general design of the hosting website.
Reason this requirement is included in this shortlist	A website is considered as a whole when it comes to each design. Thus the application shall be in harmony with the general appearance of the whole website.
Fit criterion	Required forms and colours should comply with the website appearance.
Dependencies	

2.Usability Requirements

ID_ NFR2_v1	
Description	The application shall have an interface that can be used by someone with no previous experience.
Rationale	The application is going to be used by experienced architects and new architects as well thus it should be simple enough.
Reason this requirement is	The application should be usable for the newcomers and the

included in this shortlist	experienced users as well.
Fit criterion	The application shall be self-explanatory while not annoying for the experienced users.
Dependencies	

ID_ NFR3_v1	
Description	The application shall be developed in multiple languages.
Rationale	All the users of the application shall be able to use the application in their language of preference.
Reason this requirement is included in this shortlist	The tool can be used by multinational companies with employees of different nationalities. The application should be developed in multiple languages so that the architects can use it in their language of preference.
Fit criterion	The terms used in the application should by translatable.
Dependencies	

3.Speed requirements

ID_ NFR4_v1	
Description	The final result of the search shall be given in 1 second at most.
Rationale	The search engine must be quick and return the results as quickly as possible.
Reason this requirement is included in this shortlist	The application shall satisfy the users as much as possible in terms of speed in the returning results.
Fit criterion	During the testing of the application it has to be shown that the calculation of the result will not take more than 1 second.
Dependencies	

4.Availability requirements

ID_ NFR5_v1	
Description	The application shall be available 24 hours per day.
Rationale	Since the application will be hosted in an online website it has to be available 24 hours per day.
Reason this requirement is included in this shortlist	It is important for the user to be able to use the application anytime he wants (working remotely, time difference etc.).
Fit criterion	The testing of the application must show that the application is available 24 hours per day.
Dependencies	

5.Capacity Requirements

ID_ NFR6_v1	
Description	The application can be used by 100 users at the same time.
Rationale	Many architects might want to use the application on the same time.
Reason this requirement is included in this shortlist	The tool might be used by multinational companies with many employees. It is important that all of the architects can use the application at the same time and the service quality to remain high. It might also be used by architects in different time zones, thus it shall support a high capacity.
Fit criterion	The testing shall show that the application can be used by 100 users at the same time.
Dependencies	

6.Operational requirements

ID_ NFR7_v1	
Description	The senior architect shall collect the information he stores in the database from the Dutch Government website, the internal knowledge base of Capgemini, Capgemini Community, the Global Architecture Forum, the Open Group Website, the Enterprise Architecture Center of Excellence, EA Links-Institute for EA Developments.
Rationale	The senior architect that will manually update the database must fetch data from relevant to the Enterprise Reference Architecture domain websites.
Reason this requirement is included in this shortlist	The application must be able to return results that are relevant.
Fit criterion	The testing of the application shall demonstrate that the information stored in the database comes from these websites.
Dependencies	

ID_ NFR8_v1	
Description	The application has to be compatible with many web browsers (Mozilla Firefox, Internet Explorer 6 (or higher),Google Chrome, Safari, Opera , Avant, Maxthon)
Rationale	The application will be hosted in a website and many users with different web browsers will have access to it.
Reason this requirement is included in this shortlist	The application has to be accessible by all the users without any dependence on the web browser they are using.
Fit criterion	The testing of the application shall demonstrate that it is compatible with many web browsers such as Mozilla Firefox, Internet Explorer 6 (or higher),Google Chrome, Safari, Opera , Avant and Maxthon.

Dependencies	

Second Tool Requirements and Pseudo-code:

Functional Requirements

ID_FR1_v1		
Description	The application shall decide whether an ERA is applicable or not, based on the user's answers.	
Rationale	In each part of the application the user indicates his answers.	
Reason this requirement is included in this shortlist	This application is a tool which is a part of a process that helps an architect in the selection of an ERA. The use of this tool is driven by the user.	
Fit criterion	The user shall answer all the questions that require an answer regarding the ERA under examination.	
Dependencies		

ID_FR2_v1		
Description	The first part of the application is a multiple choice question that multiple answers can be given but at least one is required.	
Rationale	The first part requires at least one answer but the user can select both answers too.	
Reason this requirement is included in this shortlist	The first part of the application consists of two mandatory criteria in order for an ERA to be considered applicable. Thus, it is mandatory to be answered.	
Fit criterion	The user shall give at least one answer in order for the application to continue.	
Dependencies		

ID_FR3_v1		
Description	The second part of the application shall calculate the grades that the user gives and provide a total sum.	

Rationale	For each criterion the user indicates a grade within a scale from 0 to 10.
Reason this requirement is included in this shortlist	The tool calculates the total sum of the grades in order to decide later if the ERA is applicable.
Fit criterion	The user indicates a grade for each criterion and the application calculates the total sum.
Dependencies	

ID_FR4_v1		
Description	The user sets a parameter p which indicates the minimum value the partial grade sum shall have.	
Rationale	The user indicates a value for the parameter p.	
Reason this requirement is included in this shortlist	The level of the filtering is controlled by the user, thus p is set by him.	
Fit criterion	The user indicates a value for p that has to be met.	
Dependencies		

ID_FR5_v1		
Description	The application shall decide whether an ERA is applicable or not, based on the total sum of the grades provided by the user.	
Rationale	The application calculates the grades and provides a sum.	
Reason this requirement is included in this shortlist	The application shall automatically decide whether an ERA is applicable or not, based on the total sum of the grades provided by the user.	
Fit criterion	If the total sum is equal or higher than the parameter p (also set by the user) the ERA is considered to be applicable,	

	otherwise it is discarded.
Dependencies	**ID_FR3_v1**

ID_FR6_v1		
Description	The application shall display an error message if the user has not provided an answer for the first part.	
Rationale	The first part of the application requires an answer so if the user has not selected one, he has to be informed.	
Reason this requirement is included in this shortlist	The error message confirms that something is going wrong, so the user has the opportunity to use the application properly.	
Fit criterion	The first part of the screen has got at least one answer.	
Dependencies	**ID_FR2_v1**	

ID_FR7_v1		
Description	The application shall provide the appropriate message after the second part of the application has been completed.	
Rationale	The application automatically decides whether the ERA is applicable or not and the user shall be informed.	
Reason this requirement is included in this shortlist	After the user has completed the second part of the application he wants to know if the ERA under examination is applicable or not.	
Fit criterion	If the total sum is equal or higher than the parameter set by the user,the application displays an “Applicable ERA” message, otherwise the application displays a “Discard ERA” message.	
Dependencies	**ID_FR4_v1**	

ID_FR8_v1		

Description	The application shall provide the user with the possibility to review and change his answers.
Rationale	The user can enter wrong data by mistake and this will lead to a wrong decision concerning the ERA under examination.
Reason this requirement is included in this shortlist	If the user can review his answers he can correct any mistakes he had made and the final decision of the application will be correct.
Fit criterion	The answers entered by the user should be displayable.
Dependencies	

ID_FR9_v1		
Description	The application shall update the input and output sets of ERAs after a full transaction has been completed.	
Rationale	When an ERA has been examined, it should be removed from the input set of ERAs. Moreover if the ERA is applicable it should be put into the output set.	
Reason this requirement is included in this shortlist	The input set should be updated, otherwise the application will never stop and will examine the same ERAs over and over.	
Fit criterion	The examination of an ERA shall be completed.	
Dependencies		

Non-Functional Requirements

1.Look and Feel Requirements:

ID_ NFR1_v1	
Description	The application shall have an interface that is consistent with the general design of the website that will host the three tools and the process specification.
Rationale	The application shall not disrupt the general design of the hosting website.
Reason this requirement is included in this shortlist	A website is considered as a whole when it comes to each design. Thus the application shall be in harmony with the general appearance of the whole website.
Fit criterion	Required forms and colours should comply with the website appearance.
Dependencies	

2.Usability Requirements

ID_ NFR2_v1	
Description	The application shall have an interface that can be used by someone with no previous experience.
Rationale	The application is going to be used by experienced architects and new architects as well thus it should be simple enough.
Reason this requirement is included in this shortlist	The application should be usable for the newcomers and the experienced users as well.
Fit criterion	The application shall be self-explanatory while not annoying for the experienced users.
Dependencies	

ID_ NFR3_v1	
Description	The application shall be developed in multiple languages.
Rationale	All the users of the application shall be able to use the application in their language of preference.
Reason this requirement is included in this shortlist	The tool can be used by multinational companies with employees of different nationalities. The application should be developed in multiple languages so that the architects can use it in their language of preference.
Fit criterion	The terms used in the application should by translatable.
Dependencies	

3.Speed requirements

ID_ NFR4_v1	
Description	The final result of the application shall be given in 15 seconds.
Rationale	The user might be short in time and the input set might be big. Since the application requires interaction with the user the final answer has to be given quickly.
Reason this requirement is included in this shortlist	The automated decision of this application shall satisfy the users as much as possible.
Fit criterion	During the testing of the application it has to be shown that the calculation of the result will not take more than 15 seconds.
Dependencies	

4.Availability requirements

ID_ NFR5_v1	
Description	The application shall be available 24 hours per day.
Rationale	Since the application will be hosted in an online website it has to be available 24 hours per day.
Reason this requirement is included in this shortlist	It is important for the user to be able to use the application anytime he wants (working remotely, time difference etc.).
Fit criterion	The testing of the application must show that the application is available 24 hours per day.
Dependencies	

5.Capacity Requirements

ID_ NFR6_v1	
Description	The application can be used by 100 users at the same time.
Rationale	Many architects might want to use the application on the same time.
Reason this requirement is included in this shortlist	The tool can be used by multinational companies with many employees. It is important that all of the architects can use the application at the same time and the service quality to remain high. It can also be used by architects in different time zones.
Fit criterion	The testing shall show that the application can be used by 100 users at the same time.
Dependencies	

6.Operational requirements

ID_ NFR7_v1	
Description	The application has to be compatible with many web browsers (Mozilla Firefox, Internet Explorer 6 (or higher),Google

	Chrome, Safari, Opera , Avant, Maxthon)
Rationale	The application will be hosted in a website and many users with different web browsers will have access to it.
Reason this requirement is included in this shortlist	The application has to be accessible by all the users without any dependence on the web browser they are using.
Fit criterion	The testing of the application shall demonstrate that it is compatible with many web browsers such as Mozilla Firefox, Internet Explorer 6 (or higher),Google Chrome, Safari, Opera , Avant and Maxthon.
Dependencies	

Pseudo-Code for the second tool:

```
INPUT  era_set: LIST(ERA)
        mand_crit:LIST(criteria)
        sub_crit:LIST(criteria)
        BOOLEAN answer;
        INT grade, p;

        FOR era FROM 1 TO LENGTH (era_set)
        DO
        counter=0;
                FOR criteria FROM 1 TO LENGTH(mand_crit)
                DO
                INSERT answer
                IF answer=true THEN counter++;
                END_DO
                IF counter<>2
                discard
                ELSE
                sum=0;
                INSERT p;
                FOR criteria FROM 1 TO LENGTH (sub_crit)
                        DO
                        INSERT grade;
                        sum=sum+grade;
                        END_DO
                        IF sum>=p THEN applicable_eras(era):=era_set(era);
                        ELSE discard;
        END_DO
        OUTPUT applicable_eras:LIST(era);
```

Third tool requirements and pseudo-code:

Functional Requirements

Requirement:ID_FR1_v1		
Description	The application shall define the quality of an ERA based on the user's answers and the respective weights.	
Rationale	For each quality attribute of the application the user indicates a value.	
Reason this requirement is included in this shortlist	This application is a tool that is part of a process that helps the user select an Enterprise Reference Architecture. The use of this tool is driven by the user.	
Fit criterion	The user must provide an answer (value) for all the quality attributes of the application.	
Dependencies		

Requirement:ID_FR2_v1		
Description	The application consists of a list of weighted quality attributes. The weights sum up to 1.	
Rationale	The quality attributes that are used within the application are weighted according to the result analysis of the exploration phase.	
Reason this requirement is included in this shortlist	According to the architects, there are different levels of importance for each quality attribute. The weights indicate this level.	
Fit criterion	Each quality attribute is weighted with a number between 0 and 1.	
Dependencies		

Requirement:ID_FR3_v1		

Description	The weights of the quality attributes must be visible to the user of the application.
Rationale	The weights of the quality attributes indicate how important a quality attribute is. The user of the application has to be aware of the importance of the quality attributes.
Reason this requirement is included in this shortlist	If the user is aware of the importance of the quality attributes, he can indicate an accurate number that fits the quality attribute.
Fit criterion	The weights for each quality attribute are displayed next to the quality attribute.
Dependencies	ID_FR2_V1

Requirement:ID_FR4_v1	
Description	The definition of each quality attribute must be visible to the user of the application.
Rationale	The user has to be aware what a quality attribute exactly means.
Reason this requirement is included in this shortlist	If the user knows the meaning of each quality attribute he will be able to indicate a proper value for the respective quality attribute.
Fit criterion	The definition of each quality attribute is displayed next to the respective quality attribute
Dependencies	ID_FR2_v1

Requirement:ID_FR5_v1	
Description	The application must calculate for each ERA the partial values of each Quality Attribute
Rationale	For each quality attribute the user shall indicate a number between 0 and 5 according to the extent the ERA meets the respective quality attribute. The application multiplies the number with the respective weight of the quality attribute.
Reason this requirement is included	The application shall automatically calculate the partial values for each ERA in order to sum them up in the next step.

in this shortlist	
Fit criterion	The user indicates a number from 0 to 5 for each quality attribute and the application multiplies it with the respective weight.
Dependencies	

Requirement:ID_FR6_v1	
Description	The application must calculate the final quality value for each ERA in the input set.
Rationale	Since the final selection of the ERA that is going to be used is based on the final quality values of the ERAs, these should be calculated. In order to achieve that the partial valuesof each ERA are added.
Reason this requirement is included in this shortlist	The application shall automatically calculate the final quality value of each ERA by summing up the partial values.
Fit criterion	The partial values for each ERA are summed and the result represents the final quality value.
Dependencies	ID_FR2_v1

Requirement:ID_FR7_v1	
Description	The application shall provide an error message if the user has not indicate a number for one or more quality attributes.
Rationale	The application requires an answer for all the quality attributes, so if the user has not provided one he shall be informed.
Reason this requirement is included in this shortlist	The error message confirms that something is going wrong so the user has the opportunity to correct the mistake and use the application properly.
Fit criterion	All the boxes of the application require an answer.
Dependencies	ID_FR2_v1

Requirement:ID_FR8_v1	
Description	The application shall update a database after each transaction has been completed.
Rationale	After a final value of an ERA has been calculated, a database shall be updated so that the value can be reused in the future.
Reason this requirement is included in this shortlist	A future user of the application will save time if some values of ERAs have already been saved, since there will not be the need to recalculate them.
Fit criterion	Necessary data fields are generated after the calculation of the final values is completed and the data is made compatible with the database.
Dependencies	ID_FR3_v1

Requirement:ID_FR9_v1	
Description	The application shall provide the user with the possibility to review and change his answers.
Rationale	The user might enter a wrong value by mistake and this will lead to a wrong calculation of the ERA's quality value.
Reason this requirement is included in this shortlist	If the user can review his answers he can correct his mistakes and the final calculation of the quality value will be correct.
Fit criterion	The answers entered by the user should be displayable.
Dependencies	

Requirement:ID_FR10_v1	
Description	The application shall update the input set of ERAs after a quality check of an ERA has been completed.
Rationale	When an ERA has been checked, it must be removed from the input set of ERAs.
Reason this requirement	The input set of the ERAs shall be updated so that there will

is included in this shortlist	not be iterations and checking of the same ERAs.
Fit criterion	The checking of an ERA shall be completed.
Dependencies	

Non-Functional Requirements

1.Look and feel requirements

ID_ NFR1_v1	
Description	The application shall have an interface that is consistent with the general design of the website that will host the three tools and the process specification.
Rationale	The application shall not disrupt the general design of the hosting website.
Reason this requirement is included in this shortlist	A website is considered as a whole when it comes to each design. Thus the application shall be in harmony with the general appearance of the whole website.
Fit criterion	Required forms and colours should comply with the website appearance.
Dependencies	

2.Usability Requirements

ID_ NFR2_v1	
Description	The application shall have an interface that can be used by someone with no previous experience.
Rationale	The application is going to be used by experienced architects and new architects as well thus it should be simple enough.
Reason this	The application should be usable for the newcomers and the

requirement is included in this shortlist	experienced users as well.
Fit criterion	The application shall be self-explanatory while not annoying for the experienced users.
Dependencies	

ID_ NFR3_v1	
Description	The application shall be developed in multiple languages.
Rationale	All the users of the application shall be able to use the application in their language of preference.
Reason this requirement is included in this shortlist	Capgemini is a multinational company with employees of different nationalities. The application should be developed in multiple languages so that the architects can use it in their language of preference.
Fit criterion	The terms used in the application should by translatable.
Dependencies	

3.Speed Requirements

ID_ NFR4_v1	
Description	The partial and final calculations of the application shall be given in 2 to 5 seconds.
Rationale	The user might be short in time and the input set might be big. Since the application requires interaction with the user the final answer has to be given quickly.
Reason this requirement is included in this shortlist	The automated decision of this application shall satisfy the users as much as possible.
Fit criterion	During the testing of the application it has to be shown that the calculation of the result will not take more than 5 seconds.

Dependencies	

4.Availability Requirements

ID_ NFR5_v1	
Description	The application shall be available 24 hours per day.
Rationale	Since the application will be hosted in an online website it has to be available 24 hours per day.
Reason this requirement is included in this shortlist	It is important for the user to be able to use the application anytime he wants (working remotely, time difference etc.).
Fit criterion	The testing of the application must show that the application is available 24 hours per day.
Dependencies	

5.Capacity Requirements

ID_ NFR6_v1	
Description	The application can be used by 100 users at the same time.
Rationale	Many architects might want to use the application on the same time.
Reason this requirement is included in this shortlist	The tool can be used by multinational companies with many employees. It is important that all of the architects can use the application at the same time and the service quality to remain high.
Fit criterion	The testing shall show that the application can be used by 100 users at the same time.
Dependencies	

6.Operational Requirements

ID_ NFR7_v1	
Description	The application has to be compatible with many web browsers (Mozilla Firefox, Internet Explorer 6 (or higher),Google Chrome, Safari, Opera , Avant, Maxthon)
Rationale	The application will be hosted in a website and many users with different web browsers will have access to it.
Reason this requirement is included in this shortlist	The application has to be accessible by all the users without any dependence on the web browser they are using.
Fit criterion	The testing of the application shall demonstrate that it is compatible with many web browsers such as Mozilla Firefox, Internet Explorer 6 (or higher),Google Chrome, Safari, Opera , Avant and Maxthon.
Dependencies	

Pseudo-code for the third tool:

```
INPUT: era_set:LIST(ERA)
        qa_set:LIST(QA)
        era_qa:LIST(QA)
       weight:LIST(FLOAT)
       FOR era FROM 1 TO LENGTH(era_set)
       DO era_qa(era)=0;
              FOR qa FROM 1 TO LENGTH(qa_set)
              DO q=determine_quality (era_set[era],qa_set[qa]);
                     era_qa[era]=era_qa[era]+q*weight[qa];
              END_DO
       END_DO
       max=era_qa(1);
       FOR era FROM 1 TO LENGTH(era_set)
       DO
              IF era_qa[era]>max
              THEN max=era_qa[era] and max_era=era;

       END_DO

       OUTPUT max_era;
```

Appendix F-List of Tables and Figures

TABLES

FIGURES