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A Business Application Architecture Framework in Manufacturing Industry
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Abstract
In a contemporary business environment business processes are under constant change. Information systems and applications are becoming more complex so that they are able to support and react promptly to these complicated business requirements. An architecture framework is an instrument for managing a complex information systems environment. This study concentrates on issues related to comprehensive business application architectures in industrial manufacturing companies.

The objective of this study is to determine what common factors can be identified in business application architectures in the case companies and how the business application architectures have been developed in the case companies. In order to reach the objective of the study a framework with which the business application architectures and business application architecture development processes could be analyzed and enhanced was first developed.

The research approach used was qualitative multiple case research. Business application architectures and business application architecture development processes were studied in four case companies. As a research method mainly the action-oriented research approach was used. In addition, this study has features of constructive research and conceptual research approaches.

The results suggest that the business application architecture framework is a powerful instrument in analyzing and enhancing business application architectures and it has influenced the business practices in some companies. The framework consists of the business application classification model and the reference model for the business application architecture development process. The results suggest that it is preferable to aim towards an integrated business application architecture based on average applications rather than invest in best-in-class applications, which are not integrated. The case companies also aimed towards a higher level of integration within their supply chain. In all case companies the development and implementation of the business application architecture took several years. Consequently, the architecture has to be flexible so that it is able to adapt to emerging changes in requirements during the development and implementation of the architecture. Target business application architectures included less applications and less complexity but provided the same functionality as the initial architecture. On the other hand, typically the actual number of different applications typically didn’t decrease in the target architecture. This is because the target business application architecture had more functionality and more features to be supported than the initial architecture. As one result of this thesis it was concluded that case companies did not have an information architecture, but according to the IT management of the case companies it would be useful to have.
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1 INTRODUCTION

1.1 Background of the study

Today, practically all organizations in all sectors of industry, commerce and government are dependent on information systems. In this thesis the term information system is used as a general term and it is defined as a system that uses information technology to capture, transmit, store, retrieve, manipulate or display information used in one or more business processes (Alter 1996). In many industries information systems are becoming the expected way of conducting business. Consequently, organizations are looking towards information systems not just to improve efficiency of business, but also to create new opportunities and to obtain competitive advantage. The increasing role of information systems leads to the need of managing information systems as a strategic asset. This requires close interaction between the business strategy and the information systems strategy. In this study an information systems strategy is defined as the organization’s requirement or demand for information and systems to support the overall strategy of the business (Ward & Peppard 2002, p. 44). A related term, information technology strategy, is defined as outlining how the organization’s demand for information and systems will be supported by technology (Ward & Peppard 2002, p. 44).

Systems developed for an organization must be integrated with business processes, functions and sub-organizations. Organizations are becoming global and very complex systems as such. Also, in a contemporary business environment business processes are under constant change. Accordingly, information systems and applications are becoming more complex so that they can support and react promptly complicated business requirements. In this study an application is defined as a computer program designed to perform tasks. A more detailed definition is provided in Chapter 2. Complex information systems and applications require proper techniques and procedures to manage the entire setting.
The concept of classifying applications was introduced already in the 1960’s to meet the requirements described above and to help understand the field in a structured way. Over the years various application classification models have been published (e.g. Anthony 1965, Gorry & Scott Morton 1971, McFarlan 1984, Turban 2001, Ward & Peppard 2002). In this study an application classification model is defined as a model that classifies applications based on selected criteria. These criteria vary in different models from the number of users to the level of decision making. Anthony introduced the first hierarchical application classification model in 1965. He divided management activities into strategic planning, management control and operational control (Anthony 1965). Gibson and Nolan (Gibson and Nolan 1974, Nolan 1979) introduced the first model of the evolution of information systems in an organization. These models provided an initial framework for application classifications. All classifications listed above, in one way or another, classify applications based on the level of personnel that uses the application or the type of decisions the application supports. Classifications are not based on the applications themselves nor on the purpose of the application.

Later, in the 1980’s, strategic information systems were introduced. A strategic information system is a system that improves competitiveness by changing the nature or conduct of the business (Ward & Peppard 2002). Consequently, McFarlan (1984) published a classification model where applications where classified in four classes based on their current and expected future contribution to the company. The application categories in McFarlan’s model are turnaround, factory, strategic and support applications. McFarlan’s classification was based on the nature of the application itself rather than the types of users or organizational level.

Traditionally, information systems have been developed by using the functional approach. This means that a system is provided for an individual user or a vertical part in a company, such as the sales or manufacturing department. As a result, independent and non-integrated systems were created to support small parts of the whole business process. However, in contemporary enterprises a more comprehensive approach is required. This
is provided by enterprise architecture frameworks, which introduce the horizontal approach to information system development. The horizontal approach means that systems are looked at as larger entities, over functional departments. In this thesis an enterprise architecture is defined as a description of structures and processes within an enterprise. An enterprise architecture framework is defined as a logical instrument for assisting an organization in developing, analyzing and managing enterprise architectures. More detailed definitions are provided in Chapter 2. The first enterprise architecture framework was introduced by John Zachman (Zachman 1987). Enterprise architecture frameworks encourage integration and co-operation across the enterprise through all the functional departments. They provide a comprehensive view and try to achieve a common understanding of the enterprise and the business. The enterprise architecture is the overall framework or blueprint for how the enterprise uses information technology to achieve its business objectives (Van den Hoven 2003). It consists of four interrelated architectures: the business architecture, the application architecture, the information architecture and the technology architecture. In this thesis a business architecture is defined to cover the business strategy, governance, organization and key business processes. The application architecture is defined as a set of applications required for managing information and supporting business functions. An information architecture is defined as describing the structure of an organization's logical and physical information assets and their relationship to the business functions. In this study a technology architecture describes the information technology infrastructure and includes procedures and instructions on how to organise information technology resources. More detailed definitions are provided in Chapter 2.

Enterprise architecture provides instruments for management to build a comprehensive information technology (IT) and information systems strategy. Therefore, the capability of managing an enterprise architecture is an essential part of information technology and information systems strategy. This is supported by Feld and Stoddard (2004) who have stated that three main principles are needed to execute IT effectively: 1. A long term IT renewal plan linked to corporate strategy 2. A highly functional, performance oriented IT organization 3. A simplified, unifying corporate technology platform. By a unified
corporate technology platform they mean a horizontally oriented architecture (enterprise architecture) designed to serve the company as a whole.

Enterprise architectures and enterprise architecture development processes are rather complicated and thus difficult to manage. To support the enterprise architecture development process, several authors have introduced enterprise architecture frameworks (e.g. Zachman 1987, NCR Corporation 1996, Plachy & Hausler 1999, CIO Council 1999, Open Group 2002). The purpose of these frameworks is to assist in developing an adaptable enterprise architecture (Morganwalp & Sage 2003).

Some field research has been done in the area of enterprise architectures (e.g. Boar 1994, p. 314, Savoia 1996, p. 112, Periasamy & Feeny 1997). Also, some field studies exist in the area of application classifications (e.g. Wiseman 1985, Hirschheim et al. 1988, Ward & Peppard 2002, p. 299). Still, in both research areas there are not that many field studies made. Particularly in the area of enterprise architecture research the amount of research is limited, because the field is relatively new. As enterprise architectures are a vital part of IT management, and as it is well known that there is a lot to be done for improving practices in information systems management and implementation (e.g. Griffiths & Willcocks 1994, Turban et al. 2001), there is a clear need for further research. Because the field of research is fairly new, it seems obvious that it is not yet fully understood. Consequently, as an area of study, the phenomena of enterprise architectures appears to be an interesting research object and thus to seek better understanding of the phenomena and to increase knowledge on enterprise architectures is a sensible objective for a study. Increasing knowledge can be achieved by analyzing the architectures and architecture development processes in a real environment.

Most of the research made in the area of enterprise architectures is exploring the whole enterprise architecture, not any specific part of it. It can be argued that although covering the whole enterprise architecture has some advantages, it might be more efficient to select elements critical for business in an enterprise architecture and focus on them.
Accordingly, in this study the focus is on business application architectures, which are one business critical part of an enterprise architecture. In this study a business application architecture is defined to define the set of business specific applications required to manage information and support business functions. These applications include functions such as order processing, production planning and reporting. A business application architecture is part of the application architecture. In addition to business applications, an application architecture also includes general applications, such as applications for word processing. More detailed definitions are provided in Chapter 2.

In different business sectors there may be business sector specific features and differences in the kind of business application architectures they have and how they exploit them. The manufacturing industry is one of the business segments that has industry specific features and requirements and thus has been chosen as the business sector to be studied in this thesis. In a manufacturing company, in addition to general supply chain operations, such as logistics and inventory and support functions, such as finance and human resource management, there are characteristic functions like engineering and manufacturing. Engineering includes designing product geometry and product configurations, creating engineering drawings and a bill of materials. Based on these designs manufacturing then produces the products. Particularly the engineering uses applications that are meant only for their purposes. Typical engineering applications are Product Data Management (PDM) applications and Computer Aided Design (CAD) applications (Li & Li 2000). Carl & Judd (1994, p. 18) define a PDM as an application that manages and controls product information. Typically a PDM application also manages drawings made with a CAD application (Hoover 1999). A CAD handles information related to product design (Li & Li 2000). This means that product geometry is designed with a CAD application and product information such as bill of materials is stored in a PDM application. In manufacturing a characteristic application is Material Requirements Planning (MRP) application, but in practice such a function is included in ERP applications.
When taking under consideration the background described above, the motivation underlying this thesis is to obtain better understanding of the business application architecture development processes in the manufacturing industry.

1.2 Scope and objectives of the study

This study looks at issues related to comprehensive business application architectures in industrial manufacturing companies. The emphasis is on increasing knowledge of business application architectures and business application architecture development processes in real environments.

There is some research published on the practical use of application classification models, but not much on the practical use of enterprise architectures. The amount of published research material is even smaller if the research topic is limited to one industrial sector. There is only a limited number of studies dealing with manufacturing industry specific issues of enterprise architectures (e.g. Huber et al. 2001, Kutz 2001). In addition, a major part of the research dealing with enterprise architectures considers enterprise architectures as a whole, they do not focus on any specific part of the enterprise architecture, such as the application architecture, the information architecture or the technology architecture. If concentrating on one specific area of enterprise architecture, there is a clear need for further research to improve the understanding of the parts of enterprise architecture. In this study, the chosen area of an enterprise architecture is the business application architecture.

The main purpose for all application classification models is to help evaluate existing, planned and potential information systems and their contribution to business. The purpose of enterprise architecture frameworks is to provide a comprehensive view and understand the enterprise and the business. Several analyzing and development tools for applications and enterprise architectures have been presented in previous researches (e.g.

Both application classification models and enterprise architecture frameworks have valuable elements and features, which can be used as instruments in analyzing business application architectures. However, there are some deficiencies, which could be enhanced, considering that in this thesis the focus is on business application architectures instead of on entire enterprise architectures. This means that existing enterprise architecture frameworks are suitable for dealing with entire enterprise architectures, but it is argued that as such they are not suitable for analyzing one element of an enterprise architecture in detail. According to Hirvonen et al. (2003) enterprise architecture frameworks are suitable only for massive projects, where the whole enterprise architecture is designed anew and in practice development projects include only a few aspects of the enterprise architecture. The reasons for this will be discussed in more detail in Chapter 4. Additionally, the features of application classification models and the features of enterprise architecture frameworks have not been combined in previous research, although this would be a useful combination. In this thesis the selected features from application classification models and enterprise architecture frameworks are combined. An enhanced business application architecture framework is presented focusing on business applications and considering specific requirements of manufacturing industry. Accordingly, on a general level the aim of this study is to increase general knowledge of business application architectures and business application architecture development processes. Consequently, the objective of this study is to formulate answers to the following research questions:

**Research question 1:** What common factors can be identified in initial business application architectures in the case companies?

**Research question 2:** How have the business application architectures been developed in the case companies?
**Research question 3:** What common factors can be identified in target business application architectures in the case companies?

In order to reach the objective of the study a framework with which the business application architectures and business application architecture development processes can be analyzed and enhanced will first be developed.

In developing the framework the following sub-objectives can be identified:

- To develop an application classification model to investigate business application architectures
- To develop a reference model for the business application architecture development process

The business application classification model and the reference model for the business application architecture development process are essential structures of the business application architecture framework. In this thesis a *reference model for development process* is defined as a pattern of steps that describe by whom, in what order and in what way objectives of the development process can be reached. The reference model can be used as a measure in analyzing and enhancing the development process. A business application architecture development process is defined as a specific order of work activities across time and place, which begins from the initial business application architecture and has the target business application architecture as an output. An *initial business application architecture* is defined as the existing business application architecture before entering the business application architecture development process. A *target business application architecture* describes the configuration of a target business application architecture. Business application architecture development process has business requirements and critical constraints as inputs. Although a business application architecture development process has target business application architecture as an output, by nature the process is iterative. More detailed definitions are provided in Chapter 2.
The objectives in the empirical research of this thesis are to investigate business application architectures and business application architecture development processes in companies. This is done by applying the developed framework to the case studies of the thesis. The aim is also to show the functionality of the framework in practice.

There are several reasons, why it is important to obtain a better understanding of business application architectures and business application architecture development processes. First, the importance of information systems is a more inseparable part of business strategy than ever (e.g. Broadbent & Weill 1993, Ross & Weill 2002, Prahalad & Krishnan 2002). Second, in general, there have been a lot of problems in developing and implementing information systems in practice (e.g. Lyttinen & Hirschheim 1987, Turban et al. 2001). Problems occur especially when applications, or in the most complicated case a portfolio of applications, get more complex. For instance in the field of ERP (Enterprise Resource Planning) applications, there is a number of studies indicating the problems related to ERP applications and ERP implementation (e.g. Bancroft et al. 1997, Subramanian & Lacity 1997, Piszczalski 1997, Markus 2001, Legare 2002). Information system architecture and information technology architecture have been presented as increasingly important elements to ensure success in information system development and implementation (Morris & Ferguson 1993, Earl & Feeny 1994, Feeny & Willcocks 1998, Feld & Stoddard 2004). In this study an information system architecture is defined to compose of two elements: information architecture and application architecture. The reasons above support the relevance of this research work.

In analyzing business application architecture development in this study, an application driven approach has been chosen. The application driven approach means that a business application architecture is developed based on applications available on the market instead of developing the applications from scratch. This is because it is argued that in practice in many cases available enterprise applications set the constraints for business application architecture work. Several authors have described the benefits of using commercial applications available on the market instead of customized software development (e.g. Fox et al. 1997, Davenport 1998, Kara 1999, Wiers 2002). Davenport
even argues that enterprise wide systems, like ERP applications, push companies towards processes defined by the system, even when the customized processes may be a source of competitive advantage (Davenport 1998). The following reasons support the application driven approach:

- Currently most companies have enterprise wide systems, which set the practical boundaries for business application architecture development
- In companies not in the software industry, the mainstream appears to be to use off-the-shelf software packages instead of programming own software

The scope of this thesis is limited to cover only business applications. Thus, general applications, such as office automation applications have been excluded, as well as the information technology infrastructure issues. The main reason for the selected scope is that business applications are one critical part of an enterprise architecture. This is because business applications have a direct connection with the business strategy and therefore business applications can have a significant effect on the business strategy and the business performance of the company (e.g. Earl 1987, Ward & Peppard 2002, p. 41). In addition, as a consequence of selecting the application driven approach, technology infrastructure issues are handled mainly business application architecture driven. This means that because off-the-shelf applications are selected, they set the constraints and give guidelines for selecting the technology platform underneath.

In analyzing business application architecture development processes, the focus in the empirical part of the study is on target business application architecture development and thus the implementation of this target architecture is only briefly described. Kwon and Zmud (1987, p. 231) define implementation very widely “as an organizational effort to diffuse an appropriate information technology within a user community”. On the other hand according to Ginzberg (Ginzberg 1981 p. 461, adopted from Davis 1974) the system development stages are definition, physical design and implementation. Consequently, Ginzberg (1981) defines implementation as a stage that focuses on physical implementation of the application and in the implementation phase the application is
installed, operated and monitored. In this thesis implementation is defined according to Ginzberg (1981). The change management of a target business application architecture is also excluded from the scope of this thesis.

The manufacturing industry has been selected as a target business sector for the proposed business application architecture framework. The reason for selecting one target industry sector is to avoid too many generalisations. This might be the case, if the business application architecture framework were intended for all organizations in all industry sectors. The business application architecture framework is believed to be more applicable for target organizations when the unique requirements of the manufacturing industry have been considered.

Based on analysis of existing application classification models and enterprise architecture frameworks, it is claimed that none of the models or frameworks described in chapters 3.2 and 3.3 are optimal when developing or analyzing a business application architecture from an application driven point of view in manufacturing companies. Thus, a novel business application architecture framework is proposed to support the analysis of business application architecture development. The business application architecture framework proposed in this study consist of two elements:

1. A reference model for the business application architecture development process
2. A classification model for business applications

In this work, these instruments are developed to assist increasing knowledge on business application architectures and business application architecture development processes and to formulate answers to the research questions. However, the instruments created can be used to support in factual business application architecture development as well.
1.3 Research approach and research methods

Depending on the selected research problem, the available information, the level of available information and the final results the research aims at, several research approaches can be used. The selected research approach should provide instruments to achieve the research objective. The general aim of this study is to increase general knowledge of business application architectures and business application architecture development processes. The more specific objective of this study is to formulate answers to the research questions presented in Chapter 1.2. Business application architectures are rather complex structures and the research field is relatively new. In seeking better understanding of a real business environment phenomena, an empirical approach seems necessary. On the other hand, due to the complexity of the issue, a strong theoretical background provides tools for analyzing the phenomena. Therefore, it seems apparent that both theoretical and empirical research approaches are required.

In the very beginning of the work of this study, a quantitative research approach was considered in order to be able to gather empirical data of business application architectures. A quantitative method would help in generalizing the results and findings of the study. However, it appeared that due to the complexity of the phenomena in question, a quantitative approach would be difficult to use and there was a risk that the results would not be valuable. If using quantitative research methods, a survey regarding business application architecture development processes would have seemed a sensible research method. This is because a survey enables data collection from real environment and clearly data from real environments was required. According to Pinsonneault and Kraemer (1993, p. 78) surveys can be used for exploration, description and explanation purposes. If a survey is used for exploration, the aim is to become more familiar with the topic and to try out preliminary concepts about it. In using a survey for description, the objective is to find out what situations, events and attitudes occur in a population. In explanation, the purpose of a survey is to test causal relations.
In the research of business application architecture development processes, surveys would have been used for description or explanation purposes. In practice it seemed difficult to set the right measures and the correct questions in the form of a survey to be able to collect valuable data. This was mainly because of two reasons. First, business application architecture development is a complicated process and thus understanding the essence of it through a simple survey looks unlikely. Second, the whole concept and the terminology of a business application architecture or even an enterprise architecture is not well known among practitioners. Thus, if a survey would have been used there would have been a risk that persons answering the survey would have interpreted the questions incorrectly or alternatively a thorough explanation of what a business application architecture is would have been required.

Therefore, a qualitative research paradigm has been chosen for this study. A qualitative research approach is selected because of three main reasons, based on criteria proposed by Creswell (Creswell 1994). First, because business application architectures are comprehensive and complex, it is difficult to analyze them in a quantitative experiment. Second, a business application architecture framework as such is used in a limited number of cases, making quantitative evaluation less powerful. Third, business application architecture is a new concept and therefore a qualitative approach provides more insightful information about its characteristics. This is because business application architecture as a concept is not well established yet and thus qualitative methods provide valuable tools to define and structure the phenomenon. After the phenomenon has been structured it is easier and more beneficial to use quantitative methods to collect more relevant information of the phenomenon. If the phenomenon is not understood well enough before using quantitative methods, such as surveys, there is a risk that the collected data is not relevant.

Although collecting sensible data from a large number of companies was not seen reasonable, yet it seemed clear that purely theoretical approaches were not appropriate either. This is because business application architectures are utilized in real-life companies and without any empirical data they are difficult to analyze. Thus, the
conceptual approach with theoretical characteristics was not selected as the main research approach.

Since the quantitative research approach was rejected, consequently the nomothetical approach is not reasonable, because the nomothetical approach is typically used with large observation material and interpreted with statistical methods (Olkkonen 1993, p. 68). The decision oriented approach (management science oriented) typically uses the method of deduction (logical reasoning) and involves building mathematical models of complex business situations, using spreadsheets and/or other software programs to gain insight into the business situation, and communicating the resulting insights and recommendations (Kasanen et al. 1993, Lawrence & Pasternack 2002). In this study mathematical models were not seen as an appropriate way to analyze the phenomenon.

The constructive approach is defined as a goal-directed practical problem solving activity through the construction of models, diagrams or plans. The constructive approach always aims at an attempt to demonstrate explicitly the practical usability of the constructed solution. Constructive research is also normative and innovative by nature. (Kasanen et al. 1993)

An action-oriented research approach is aiming to increase understanding of the research problem. An action-oriented approach is seen to have similar characteristics as the constructive and decision oriented (management science oriented) approaches. Between the action-oriented and constructive approaches, the common features emerge mainly in the empirical phase of the studies. The action-oriented approach, however, does not aim at creating managerial constructions (Kasanen et al., 1993). Typical for the action-oriented approach is that the object and the researcher are tightly linked together. Also, normally there are only a few research objects to be studied and consequently quantitative methods are not possible. In the action-oriented approach the results can be either descriptive or normative. In the constructive approach results are always normative. The main aim of this study is not to build a construction and explicitly
demonstrate its practical usability, the aim is rather to increase understanding of the phenomenon.

Consequently, using the widely referred methodological classification of research approaches by Neilimo and Näsi (1980), this thesis can best be described as using primarily the action-oriented approach. Despite the descriptive and interpretative emphasis, this study also has normative features.

In Figure 1.1 the action-oriented research approach is presented in a framework (Kasanen et al., 1993) that classifies different research approaches on two axes according to their emphases, theoretical-empirical and descriptive-normative.

![Classification of Research Approaches](image)

*Figure 1.1. Positioning of the Action-oriented research approach (Kasanen et al., 1993).*

Typical options in the action-oriented approach are field research, action research and case study research. Field research tends to study phenomena over time or across several organizations. In this study only a few objects are studied and the phenomenon has not been studied over time. Thus, this study can not be classified as a field study. In action research, the researcher is not an independent observer but becomes a participant and the process of change becomes the subject of research. Thus, the researcher has two objectives: to take action to solve a problem and to contribute to a set of system
development concepts (Benbasat et al. 1987, p. 371). Therefore the researcher’s close and active involvement in the process that is being studied is typical for action research. The strength of action research is the in-depth and first hand understanding the researcher obtains. A weakness is the potential lack of objectivity stemming from the researcher’s stake in effecting a successful outcome for the client organization (Benbasat et al. 1987, p. 371). In this study the researcher had opportunities to participate in parts of the processes in two of the companies studied. However, this involvement is not considered deep enough to be pure action research, but some features exist.

This study concentrates on four empirical cases for a deeper understanding of the research object. According to Eisenhardt (1989, p. 534) “case study research is a research strategy which focuses on understanding the dynamics present within single setting”. Moreover, Gummesson (1991, p. 75) has stated that “Case research is a useful strategy for studying processes in companies”. According to Benbasat et al. (1987, p. 370) there are three reasons why case study research is a viable information systems research strategy. First, the researcher can study information systems in a natural setting, learn about the state of art and generate theories from practice. Second, the case method allows the researcher to answer “how” and “why” questions. Third, a case approach is an appropriate way to research an area in which few previous studies have been carried out. Benbasat (1987) continues by listing the key characteristics of case studies:

- The phenomenon is examined in a natural setting
- The data is collected by multiple means
- The complexity of the unit (one or only few) is studied intensively
- No experimental controls or manipulation are involved
- The investigator may not specify the set of independent and dependent variables in advance
- The derived results depend heavily on the integrative powers of the investigator
- Changes in site selection and data collection methods could take place as the researcher develops new hypotheses
Business application architecture development processes, which are dynamic development processes in a company, are the object of this study. A case study research appears to be a natural way of studying such a phenomenon. It is also useful to be able to study those processes in a natural setting. In addition, the complexity of this object supports the selection of the case study research approach. Therefore, the case study method has been chosen. When placed in a framework by Kasanen et al. (1993), shown in Figure 1.1, this study uses mainly the action-oriented research approach, although the study includes also some features of the constructive approach. Järvinen (2004) divides approaches for empirical studies in theory-testing approaches and theory-creating approaches. In Järvinen’s (2004) taxonomy of research methods a case study is included in the theory-creating research approach. In theory-creating research a new theory or method is developed grounded on gathered raw data (Järvinen 2004, p. 9). Therefore in Järvinen’s (2004) taxonomy of research this study is a theory-creating study.

Yin (1994, p. 13) defines a case study as follows: “A case study is an empirical enquiry that:

- investigates a contemporary phenomenon with its real-life context, especially when
- boundaries between phenomenon and context are not clearly evident; and in which
- multiple sources of evidence are used.”

Using multiple sources of evidence in data collection is one of the strengths of a case study. According to Yin (1994, p. 80) the following sources of evidence can be used: documentation, archival records, interviews, direct observations, participant observations and physical artefacts. The main sources of evidence in this thesis are interviews and documentation.

According to Yin (1994, pp 3-4) case studies can be used for exploratory, descriptive and explanatory purposes. In this study business application architecture development processes in case companies are described and reasons for choices made during the
process are explained. Therefore, this study is mainly used for descriptive purposes, but it has also explanatory features.

According to Yin (1994, pp 38-44) there are four types of case design:

1. Single-case, holistic (unitary unit of analysis)
2. Single-case, embedded (multiple units of analysis)
3. Multiple-case, holistic
4. Multiple-case, embedded

According to Benbasat et al. (1987, p. 373) multiple-case design is desirable when the intent of the research is description, theory building or theory testing. In this study a multiple-case design has been chosen.

This study has been executed with four cases in four companies. One of the case studies is holistic, because the company had only one site which was studied. The other three case studies are embedded meaning that the companies included several sites and only some of those sites were selected to be studied.

Although this study primarily uses the action-oriented approach, there are some features from other approaches. According to Olkkonen (Olkkonen 1993, p. 39) several research approaches can be used in one study. In the beginning of the research process it became apparent that terminology and definitions related to the research topic were very inconsistent. Therefore it was decided that a thorough analysis of the terminology is required and based on that a new taxonomy of definitions was to be built. For that purpose the conceptual research approach has been exploited.

To be able to analyze business application architectures, a classification model has been formulated. This classification model is a construction as such, but in this study it has been built for analyzing purposes and the main purpose is not to demonstrate its practical usability. Therefore, this study has some features similar to a pure constructive approach. The same applies to the reference model for a business application architecture
development process. The reference model is formulated for analyzing purposes, but if desired, it can be used for developing new business application architectures. In addition, especially in the conclusions, some recommendations are given related to business application architecture development processes and consequently features of normative research are used. Accordingly, in the framework presented by Kasanen et al. (1993) this study has conceptual, action oriented and constructive features.

1.4 Research process

This study has been executed during a long period of time. The reason for this is that the researcher did not have the opportunity of focusing on research full-time. The business application classification model and the reference model for the business application architecture development process described in the study are based on theoretical background and empirical experiences while working in the field of business and IT management.

Phases of the research process are mainly congruent with the logic of Eisenhardt’s (1989) eight step model for building theories from case study research. However, some of the steps were executed in parallel in this study and were not distinguished from each other as definite separate steps. The steps in Eisenhardt’s (1989, p. 533) model are:

1. *Getting started.* In this phase initial definition of the research question in broad terms is formulated.
2. *Selecting cases.* Cases are selected for theoretical, not statistical reasons. The cases may be chosen to replicate previous cases or extend emergent theory. Cases are not selected randomly.
3. *Crafting instruments and protocols.* Theory-creating research typically combine multiple data collection techniques.
4. *Entering the field.* A feature in creating a theory from case studies is the frequent overlap of data analysis and data collection.
5. **Analyzing data.** Analyzing data typically involves detailed case descriptions of each case site. A cross-case study pattern search is executed.

6. **Shaping hypotheses.** This step includes constantly comparing the theory and the data – iterating toward a theory which closely fits the data.

7. **Enfolding literature.** An essential feature of theory creating is comparison of the emergent concepts, theory or hypotheses with extant literature.

8. **Reaching closure.** Two issues are important in reaching closure: when to stop adding cases and when to stop iterating between theory and data. Researchers should stop adding cases when theoretical saturation is reached.

Background work for this research started by developing a preliminary version of the application classification model in the late 1990’s. The original reason for building the model was purely the purpose of using it as a management tool. After the very preliminary version of the model was launched, the theoretical background of the model became very fascinating. More research was therefore done in terms of theory. Based on exploring the theory and practical experiences in using the classification model as a management tool the preliminary classification model has been enhanced. Also, in exploring the theory business application architecture development as a development process started to be more and more interesting and it formed an essential part of the actual area of research. After getting better acquainted with the theory the area of research took a more precise form and the concrete objective for this study was formulated. Getting familiar with the research topic and formulating the objective of the study, as described above, are actions included in the first step of the model from Eisenhardt (1989) for building theories from case study research.

The second step in Eisenhardt’s (1989) model is selecting cases and the third step is crafting instruments and protocols. In this study these steps have been executed partly in parallel. After formulating the research questions it became evident that to be able to study the business application architecture development process in a structured manner a research instrument is required. A business application classification model could not assist in studying the actual business application architecture development process,
although it was valuable in analyzing the initial business application architecture and the
target business application architecture. Therefore, a more appropriate reference model
for analyzing the development of a business application architecture in practice was
required. More literature review was done to obtain a sound base for a reference model
for the business application architecture development process. Based on the literature
review the reference model for the business application architecture development process
has been strengthened and enhanced. The business application classification model and
the reference model for the business application architecture development process have
been used as instruments in structured data collection. The use of this data collection
instrument and the use of multiple data collection techniques follow the logic of the third
step of the theory building process by Eisenhardt (1989), crafting instruments and
protocols. The cases have been selected partly in parallel with crafting instruments and
protocols. As proposed by Eisenhardt (1989) the cases have not been selected randomly,
but to support replication.

As proposed by Eisenhardt (1989) data collection and analysis have partly overlapped in
this study. This has been to ensure flexible data collection. The fifth step of Eisenhardt’s
model is analyzing data. According to Eisenhardt (1989) analyzing data should include
detailed descriptions of each case and a cross case study comparison. In this study a
business application classification model is used as an instrument for analyzing business
application architectures in case companies. Consequently, the same analyzing logic has
been used in all case companies. Also in all case companies a reference model for
business application architecture development processes has been used for analyzing the
business application architecture development process. The analysis covers all the phases
of architecture development and their execution. As proposed by Eisenhardt (1989) each
of the cases is described in detail and a within-case analysis of each case is presented. In
addition, as proposed by Eisenhardt and Yin (Eisenhardt 1989, Yin 1994), a cross case
study comparison is executed.

During the research process theoretical background and practical solutions have been
linked together through an iterative process. A business application classification model
and a reference model for the business application architecture development process are essential structures of a business application architecture framework, which is developed in this study. The business application architecture framework is used in collecting the data, but it is also a construct itself. Thus, as proposed in Eisenhardt’s (1989) model’s step *shaping hypotheses* this construct has been enhanced during the case studies. The case studies have taken place during the year 2004 and during the first case studies the business application architecture framework has been enhanced based on data analysis. This has been a process where the business application architecture framework has been compared with data from case studies and then iterated towards a business application architecture framework which closely fits the data.

In Eisenhardt’s (1989) process of building a theory based on case study research, *enfolding literature* is a step where existing literature is compared with the results of the study. In this study this is done in the conclusions and discussion part of the study. The final step in Eisenhardt’s (1989) model is *reaching closure*. In this step two issues are important: when to stop adding cases and when to stop iterating between theory and data. In this study it has been assessed that replicating four cases have given results where a saturation point has been reached. According to Eisenhardt (1989, p. 545) practical constraints of available resources need also to be taken into account in this consideration. In terms of iterating between theory and data, the business application architecture framework has been iteratively enhanced during the case studies and as a result it has been assessed to fit the data closely. Progress of the research process is shown in Figure 1.2.
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**Figure 1.2. Progress of the research. In the figure the crosshatch pattern in arrow bars indicates the business application architecture development process and solid pattern indicates the implementation time.**

In Figure 1.2, in addition to progress of the research, duration and timing of business application architecture development processes in case companies are illustrated. In Figure 1.2 the crosshatch pattern in arrow bars indicates the business application architecture development process and the solid pattern indicates the implementation time. As shown in Figure 1.2, business application architecture development and implementation has been in different stages in different case companies at the time of the case studies.

### 1.5 Structure of the study

This first chapter presents the background, objectives and scope of the research, as well as explains the research methods used. The contents of the main chapters are presented in the paragraphs below. The structure of the thesis is illustrated in Figure 1.3.
Chapter 2 presents analysis of the terminology related to the research topic. Definitions for key concepts are shown and an architecture taxonomy is presented. In Chapter 2 the conceptual research approach is exploited.

Chapter 3 presents a summary of the literature survey conducted in application classification, enterprise architecture and related topics.

Chapters 4 and 5 describe the main constructs that have been created in this research. Chapter 4 presents the defined business application architecture framework. The business application architecture framework consists of a reference model for the business application architecture development process and a business application classification model. The business application architecture framework is an instrument to be used in analyzing business application architecture development based on the application driven approach. The business application classification model is to be used as part of the business application architecture framework in analyzing and enhancing business application architectures.

Chapter 5 contains the descriptions and the results of the empirical studies conducted in this thesis. The objectives, arrangements, methods and results are presented and discussed.
Figure 1.3. Structure of the thesis.
Chapter 6 contains the results of the study. Chapter 7 presents conclusions and discussion of this research. In conclusions the developed business application architecture framework is evaluated and implications for theory and practice are presented. In discussion validity of the study is evaluated and challenges for further research are discussed.
2 TERMINOLOGY, DEFINITIONS AND ARCHITECTURE TAXONOMY

This chapter deals with terminology and definitions related to this study. In addition taxonomy on different architectural concepts is presented. Generally accepted definitions for key terminology used in this thesis are examined. The aim of this chapter is to provide a solid foundation for the following chapters in terms of definitions and architectural structures.

It appears that terminology in the field of information technology and information systems research is very variable in different publications. Particularly in enterprise architecture research the terminology is inconsistent. Thus, special attention has been paid to clarify the terminology used in this thesis.

2.1 Terminology and definitions

Information technology
The Concise Oxford English Dictionary (2004) defines information technology as the study or use of systems (especially computers and telecommunications) for storing, retrieving and sending information. Ward and Peppard (Ward & Peppard 2002, p. 3) define that information technology includes both tangible (servers, routers, PCs) and intangible (software of all types) technology and telecommunications networks. According to Open Group (Open Group 2002) information technology is the technology included in hardware and the software used for information, regardless of the technology involved, whether computers, communications or others. Alter (1996) defines information technology as the hardware and software that make information systems possible. Devices and other physical things involved in processing information, such as computers, workstations, physical networks, data storage and transmission devices are considered hardware. The computer programs that interpret user inputs and tell the hardware what to do are software. Software includes operating systems, end-user
software such as word processors and application software related to specialized business tasks such as recording credit card transactions or designing automobiles. The definition by Ward and Peppard, *information technology* includes both tangible (servers, routers, PCs) and intangible (software of all types) technology and telecommunications networks is used in this study.

**Information system**

UKAIS (1999), UK Academy for Information Systems, has defined an information system as the means by which people and organizations utilizing technology, gather, process, store, use and disseminate information. The Dictionary of Computing (1996) defines an information system as a computer-based system with the defining characteristic that it provides information for users in one or more organizations. The Open Group (2002) defines an information system as the computer-based portion of a business system, where a business system includes the hardware, software, policy statements, procedures and people that together implement a business function. According to Alter (1996) an *information system* is a system that uses information technology to capture, transmit, store, retrieve, manipulate, or display information used in one or more business processes. Alter’s definition is used in this thesis.

**General application and Business application**

The Oxford English Dictionary (1989) defines an application (or an application program) as a program designed to carry out tasks or solve problems, which are specific to a given use. The Dictionary of Computing (1996) defines an application as a particular role or task to which a computer system can be applied, or, more usually, the software used for such a purpose.

Open Group (Open Group 2002) defines an application as a classification of computer programs designed to perform specific tasks, such as word processing, database management or graphics.
According to Gupta (Gupta 2000) application software is software designed to perform people related tasks such as inventory management, payroll and sales analysis. Gupta (Gupta 2000) divides application software in two groups: general-purpose software and dedicated software. Gupta defines general purpose software as software mass produced for a broad range of common business applications such as word processing, graphics, spreadsheets, payroll and accounting. According to Gupta’s definition dedicated software is specialized or customized software designed to meet the specific information needs of users.

In this study applications are classified in two groups: general applications and business specific applications. According to Ward and Peppard (Ward & Peppard 2002, p. 4) a general application is defined as a computer program designed to perform general tasks such as word processing, presentations, translations or other office tasks. A business application is defined as a computer program designed to perform specific business activities such as order processing, production planning, reporting, Enterprise Resource Planning, Product Data Management, Customer Relationship Management and data warehousing. A business application is related to a business process or a business support process. Main business processes are processes such as order fulfillment process (quotation, order entry, manufacturing, purchasing, delivery, invoicing and after sales) and R&D. Finance and human resources are support processes. Collaboration tools, such as e-mail, are also classified as business applications. Open Group (Open Group 2002) classifies applications as business applications and infrastructure applications. Open Group (Open Group 2002) defines as business applications applications that are specific to a particular enterprise or vertical industry while infrastructure applications include all other applications. NCR (NCR Corporation 1996) framework separates business applications and general applications.

**Enterprise**

According to Open Group (Open Group 2002) a good definition of "enterprise" in this context is any collection of organizations that has a common set of goals and/or a single bottom line. Parsons (1951, p. 72) defines an organization as a system based on
collaborative relations. In this sense, an enterprise can be a government agency, a whole corporation, a division of a corporation, a single department or a chain of geographically distant organizations linked together by common ownership. Parsons’ definition defines an organization almost as if it were a network. The term "enterprise" in the context of "enterprise architecture" can be used to denote both an entire enterprise, encompassing all its information systems, and a specific domain within the enterprise. In both cases, the architecture crosses multiple systems, and multiple functional groups within the enterprise.

CIO Council (CIO Council 2001) defines an enterprise as an organization (or cross-organizational entity) supporting a defined business scope and mission. An enterprise includes interdependent resources (people, organizations and technology) who must coordinate their functions and share information in support of a common mission (or set of related missions). The definition by CIO Council is used in this thesis.

Architecture
The Oxford English Dictionary (1989) defines an architecture in association with computing as the conceptual structure and overall logical organization of a computer or computer-based system from the point of view of its use or design; a particular realisation of this.

In ANSI/IEEE Std 1471-2000 the definition of an architecture is: “the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution”.

According to Open Group (Open Group 2002) architecture has two meanings depending on its contextual usage:

1. A formal description of a system, or a detailed plan of the system at component level to guide its implementation.
2. The structure of components, their interrelationships and the principles and
guidelines governing their design and evolution over time.

CIO Council (CIO Council 2001) defines an architecture as the structure of components,
their interrelationships, and the principles and guidelines governing their design and
evolution over time. In this study, the definition given by IEEE (IEEE, 1990) is used.
IEEE (IEEE, 1990) defines an *architecture* as the structure of components, their
relationships and the principles and guidelines governing their design and evolution over
time.

*Enterprise architecture*

According to CIO Council (CIO Council 2001) an “enterprise architecture is a strategic
information asset base, which defines the mission, the information necessary to perform
the mission and the technologies necessary to perform the mission, and the transitional
processes for implementing new technologies in response to the changing mission
needs.”

Zachman (1987) defines information systems architecture first as “creating a descriptive
framework from disciplines quite independent of information systems” and then specifies
that “information systems architecture is based upon a neutral objective framework”.

According to McGovern et al. (McGovern et al. 2003) an enterprise architecture consists
of the various structures and processes of an organization. An enterprise architecture
model is a representation of those structures and processes. A good enterprise
architecture model will depict the organization both as it is today and as it is envisioned
in the future, and will map the various views representing the architecture to one another.
These views include both business-oriented perspectives as well as technical
perspectives.
Vail (2002) defines an enterprise architecture as a set of aligned business and IT models of an enterprise, as well as the key aspects of the governing processes needed to keep these models applied and in a usable format.

According to Van den Hoven (2003) an enterprise architecture is the overall framework or blueprint of how the enterprise uses information technology to achieve its business objectives. An enterprise architecture consists of four interrelated architectures: the business architecture, the application architecture, the data architecture and the technology architecture.

King (1995) and Rockart and Hoffman (1993) have proposed a Strategic Capabilities Architecture, which as a concept is related to an enterprise architecture. The guiding dictum is that a single capability of the firm cannot provide sustainable competitive advantage. The firm cannot compete on the basis of ‘low cost’ or ‘best quality’ or ‘customer service.’ The sustainable competitive advantage of the firm derives from the “synergy” of its various capabilities. King’s (King 1995) strategic capabilities architecture consists of

- **Business architecture**
  Business strategy of the firm, long term goals, technological environment and external environment

- **Information architecture**
  Description of the information needs of the firm based on the business strategy

- **Data architecture**
  What data is available and in which systems

- **Systems architecture**

- **Technology architecture**

In this thesis the following definition is used: an enterprise architecture describes structures and processes within an enterprise. Four elements are included in an enterprise architecture:
1. Business (or business process) architecture
2. Applications architecture
3. Information architecture
4. Technology architecture

Three of these elements: business process, information architecture and technology architecture are included in all enterprise architecture models but the fourth elements, application architecture, is presented in most of them as separate element and in the rest of them it is included in the other perspectives (Zachman 1987, CIO Council 2001, Open Group 2002, Schekkerman 2003a). The enterprise architecture definition presented here differs from the definition by King (1995), since his Strategic capabilities architecture separates information and data.

**Business architecture**

According to CIO Council (1999) a business architecture is a component of current and target architectures and relates to the federal mission and goals. It includes the content of business models and focuses on federal business areas and processes responding to business drivers. A business architecture defines federal business processes, federal information flows and information needed to perform business functions. (CIO Council 1999)

According to Hasselbring (2000, p. 33) a business architecture consists of organizational structure and the workflows for business rules and processes. In this thesis *business architecture* is defined as in Open Group’s architecture framework (Open Group 2002): A business architecture defines the business strategy, governance, organization and key business processes.

**Application architecture**

According to Van den Hoven (2003) an application architecture provides a framework for building and implementing business applications to automate business processes and
support the business functions of the enterprise. An application architecture defines the core business applications that create and use data.

CIO Council (CIO Council 1999) defines an application architecture as a component of the design (systems) architecture that defines the major applications needed to manage data and support business functions.

According to Periasamy and Feeny (Periasamy & Feeny 1997) an application architecture is a graphical model showing the major applications which make up or will make up an organization’s integrated information system and how these applications relate to each other in terms of data flows between them.

In this thesis an application architecture is defined as a set of applications required for managing information and supporting business functions. An application architecture includes both general applications and business applications. This definition is very similar to the FEAF definition (CIO Council 1999), but different from the TOGAF definition, which defines an application architecture as a blueprint for the individual application (Open Group 2002).

**Business application architecture**

The term business application architecture is introduced in this thesis and has not been used in previous literature. The following definition is used: a business application architecture defines the set of business specific applications required to manage information and support business functions. These include functions such as order processing, production planning, reporting, Enterprise Resource Planning, Product Data Management, Customer Relationship Management and data warehousing. In this study also collaboration tools are classified as business applications. Open Group (Open Group 2002) divides applications to business applications and infrastructure applications, but their definition for a business application is different from the definition used in this study (see above).
**Systems architecture**

CIO Council (CIO Council 1999) defines a systems architecture, although they call it a design architecture, an architecture that focuses on the federal data, applications and technology required to support business needs. A current systems architecture defines the implemented design used to support the current business needs. A target systems architecture defines what will be used to support future business needs.

In this thesis three parts are included in a systems architecture: 1. information 2. information systems and 3. technology. This definition is similar to Axelsson (1998), CIO Council (1999) and Morganwalp (2003). CIO Council refers to a system architecture as design architecture (CIO Council 1999). A systems architecture should support business processes (Davenport 1993).

**Information System Architecture**

“An information systems architecture represents the sum total of all information related to flows, structures, functions and so on, both manual and automated, which are in place and/or required to support the relationships between the entities that make up the business. There are two aspects in this architecture: the functional aspect (application aspect) and the data aspect. The functional aspect of the architecture is the part one sees when one wants to use it. It is the means (automated or not) by which the data resource is made available to management in control of the other resources of business. The number of systems that may operate in the architecture are infinite in nature (and are limited only by one's imagination). The data aspect of the architecture is the informational representation of the relationships between the entities of the business. Looked at in the purest conceptual sense, the data has a tendency to be finite in nature. What is infinite is the use of data.” (Zachman 1978)

Also according to a study performed by Magoulas and Pessi (Magoulas and Pessi 1998) there are two aspects in information system research concerning information system architectures: the information aspect (information architecture) and the system aspect (application architecture).
Goldkuhl et al. (1993) define that "Information system architecture refers to how different computer-based information systems are structured and related to each other and surrounding activities."

Here information system architecture is defined to include two aspects: information architecture and application architecture. A similar definition is used by Zachman, Magoulas and Pessi and Axelsson (Zachman 1978, Magoulas & Pessi 1998, Axelsson 1998).

**Information architecture**

Van den Hoven (2003) defines an information architecture, although he uses the term data architecture, as the structure of data — the known facts or things used as a basis for inference or reckoning, its relationships, and the principles and guidelines governing the design and evolution of data over time.

According to CIO Council (CIO Council 1999) a data architecture is a component of a systems architecture and it consists of data entities, which have attributes and relationships with other data entities. These entities are related to business functions.

Brancheau et al. (1989) give the following definition for an information architecture: “An information architecture is a high-level map of the information requirements of an organization. It shows how major classes of information are related to major functions of the organization. In its pure form, the information mapping is independent of personal staffing, organization structures and technology platforms.” Kiewiet and Stegwee’s (Kiewiet & Stegwee 1992) definition is quite different: “An information architecture consists of groups of business processes and entity types.”

Periasamy and Feeny (1997) defines: “Information architecture is a set of high level models which complements the business plan in IT-related matters and serves as a tool for IS planning and a blueprint for IS plan implementation”. According to Periasamy and
Feeny (1997) an information architecture consists of an application architecture and a data architecture. This definition varies from most definitions of information architecture.

According to Periasamy (1993) “Information architecture is a high level set of models, plans and definitions, normally resulting from an IS planning process. It is a tool as well as a deliverable of IS planning. The architecture reflects the information requirements of the organization, and complements business models, application portfolio, IT architecture, information management strategy and other outputs from the planning process.”

In this thesis an information architecture is defined as describing the structure of an organization's logical and physical information assets and their relationships to the business functions. This is a synthesis of the definitions by TOGAF (The Open Group Architecture Framework) and CIO Council (Open Group 2002, CIO Council 1999). As in Brancheau et al. (1989) an information architecture is presented in this study as independent of organizational structures and technology platforms. Kiewiet and Stegwee (Kiewiet and Stegwee 1992) include business processes as part of the information architecture, but in this study it is defined as part of the business architecture. The definition in this study differs from King’s (King 1995), who defines an information architecture as a description of the information needs of the firm. King (King 1995) distinguishes a data architecture from an information architecture and defines it as data available in certain systems. In references used in this thesis the terms data and information, as well as the terms data architecture and information architecture, are used inconsistently and only some of the references distinguish data and information. Typically data is defined as unstructured facts and figures (Thierauf 2001, p. 7) and information is defined as structured data that is useful to the manager in analyzing and resolving problems (Thierauf 2001, p. 8). The terms data and information are distinguished in this thesis as defined by Thierauf (2001). For the sake of consistency the term information architecture and not the term data architecture is used in this study, except when citing references which are using the term data architecture in the same meaning. Another term closely related to information is knowledge. In this thesis
knowledge is defined following Thierauf’s definition (Thierauf 2001, p. 9): Knowledge can be obtained from experts based upon actual experience. Accordingly, an expert can transfer information to knowledge.

**Technology / Information technology infrastructure**

According to Earl (Earl, 1984, p. 210) information technology infrastructure consists of three elements:

1. Hardware infrastructure, which includes information technology hardware and telecommunications technology
2. Software infrastructure, which includes database management systems, modelling-, query- and programming tools, telecommunication protocols and system software
3. Information infrastructure includes organizing data, data availability and data security

Earl (1989) defines information technology infrastructure as “infrastructure, the technological foundation of computers, communications, data and basic systems.” Gunthon (1989) states that “We must think of information technology as an enabling mechanism, and build an infrastructure to support all of the information systems activity taking place right across the organization.” IT Infrastructure Library (ITIL 2004) defines that IT Infrastructure is the sum of an organization’s IT related hardware, software, data telecommunication facilities, procedures and documentation.

According to Weill et al. (Weill, Broadbent and St. Clair 1996) information technology infrastructure consists of three elements: 1. Equipment (hardware and telecommunications technology) 2. Network services (file services, EDI etc.) 3. Human factors (Knowledge, skills and experiences). The same classification is used by McKay and Brockaway (McKay and Brockaway 1989). Pressman (Pressman 1997) defines that technology infrastructure consists of hardware and software that support applications and information.
In this thesis information technology infrastructure is defined to consist of hardware and telecommunications technology, network services (file services, EDI etc.) and human factors (knowledge, skills and experiences) related to these technologies. This classification is used also by McKay and Brockaway (McKay and Brockaway 1989) and Weill, Broadbent and St. Clair (Weill, Broadbent and St. Clair 1996). Earl has replaced human factors with data and basic systems (Earl 1989), which are not included in this study.

*Technology / Information technology architecture*

According to CIO Council (CIO Council 1999) a technology architecture is the physical depiction of the technology environment for the enterprise showing actual hardware and systems software at the nodes and lines and their systems software, including operating systems and middleware.

In this study, an information technology architecture is defined according to Seger and Stoddard (1993). An information technology architecture describes information technology infrastructure and includes procedures and instructions on how to organize information technology resources.

*Framework*

The Oxford English Dictionary (2004) defines a framework as a structure composed of parts framed together, especially one designed for enclosing or supporting something.

*Architecture framework*

Alexander (Alexander et al. 1977) was one of the first ones to use patterns to facilitate the creation of systems architectures. According to him an architecture framework may be thought of as an advanced set of patterns.

Boar (1999) defines an architecture framework as an environment for developing architectures or implementations of systems.
According to Open Group (Open Group 2002) an architecture framework is a tool for assisting in the production of organization-specific architectures. An architecture framework consists of a technical reference model, a method for architecture development and a list of component standards, specifications, products and their interrelationships, which can be used to build architectures.

CIO Council (CIO Council 1999) defines a framework as a logical structure for classifying and organizing complex information. They continue defining Federal Enterprise Architecture Framework (FEAF) as an organizing mechanism for managing the development and maintenance of architecture descriptions. The Federal Enterprise Architecture Framework also provides a structure for organizing federal resources and describing and managing federal enterprise architecture activities.

In this thesis, the following definition is used: an architecture framework is a logical instrument for assisting an organization in developing, analyzing and managing business application architectures. An architecture framework consists of a reference model for the business application architecture development process and a classification model for classifying business applications.

**Business application architecture development process**
The Concise Oxford English Dictionary (2004) defines a process as a series of actions or steps towards achieving a particular end. Davenport (1993, p. 5) defines a process as a specific ordering of work activities across time and place, with a beginning, an end and clearly identified inputs and outputs. In this study Davenport’s (1993) definition of a process is used. Accordingly a business application architecture development process is defined as a specific ordering of work activities across time and place, which begins from the initial business application architecture and its output is the target business application architecture. As inputs business application architecture development process has for instance business requirements and critical constraints. Although a business application architecture development process has a target business application architecture as an output, the process is iterative by nature.
**Reference model for business application architecture development process**

Several authors have reported the use of reference models as an efficient way to analyze and enhance processes and phenomena (e.g. Pant et al. 1994, Stewart 1997, Little et al. 2001, El-Sayed 2002). In this thesis a *reference model for business application architecture development process* is defined as a pattern of steps that describe by whom, in what order, and in what way the target business application architecture can be reached. A reference model for the business application architecture development process can be used as a measure in analyzing and enhancing the business application architecture development process.

### 2.2 Architecture taxonomy of the study

An architecture taxonomy defines relationships between various architectures and sub-architectures. This study introduces an architecture taxonomy, which is a synthesis of Axelsson’s and Morganwalp’s (Axelsson 1998, Morganwalp 2003, p. 10) taxonomies with some additional elements. The architecture taxonomy by Morganwalp is illustrated in Figure 2.1.

According to Axelsson (Axelsson 1998) a systems architecture consists of different parts, and the relations between these parts. A systems architecture can be divided into:

1. An information systems architecture, which can be subdivided into an application (functional) and an information architecture;
2. A technical architecture
The information systems architecture consists of information, the concepts and the functionality of the applications. The applications together with the information are used to perform activities that provide services and products in business context. The applications are used for information processing and to communicate information between different systems, actors and business units. This implies that it is important that both the information systems architecture and the technical architecture support the business processes (Davenport 1993). The information systems architecture should support important business processes that contribute to added value for clients. This means that the information systems architecture must be in congruence with the business context, and that the systems architecture must support strategically important business goals and services. The technical part of the systems architecture is focused on the technologies that are or should be used to implement an information systems architecture. (Axelsson 1998)

Axelsson (1998) continues that although a technical architecture is an important part of a systems architecture, and that the technical architecture and the information systems architecture are interdependent of each other, in most cases the problems concerning systems architectures are business, organizational and political issues.
Architecture taxonomy by Axelsson (1998) is illustrated in Figure 2.2.

![Architecture taxonomy](image)

Figure 2.2. Architecture taxonomy (Axelsson 1998).

In this study an architecture taxonomy based on Axelsson’s and Morganwalp’s (Axelsson 1998, Morganwalp 2003, p. 10) taxonomies, is presented. These taxonomies have been combined and one more level has been added: the business application architecture. An enterprise architecture is seen as a comprehensive architecture and within that is business architecture. Axelsson does not have an enterprise architecture in his taxonomy, but Morganwalp has included it in her taxonomy. Both taxonomies have a systems architecture, which includes information, application and technical architectures. An information systems architecture consists of two main parts: an information architecture and an application architecture. The focus of this study is in the business application architecture, which is defined as part of the application architecture. The architecture taxonomy of this thesis is illustrated in Figure 2.3.
**Figure 2.3. Architecture taxonomy of this study.**

As shown in Figure 2.3 in this thesis an enterprise architecture is defined to consist of a business architecture and a systems architecture. A systems architecture consists of a information systems architecture and a technical architecture. A technical architecture is excluded from the scope of this study. An information systems architecture includes an information architecture and an application architecture. Although an information architecture is not part of the business application architecture it is closely connected and therefore included in the scope of this study. An application architecture is defined to include two sub-architectures: a general application architecture and a business application architecture. Here the focus is on the business application architecture.
3 ENTERPRISE APPLICATION MODELS AND ARCHITECTURES

The aim of this chapter is to present earlier research related to this study. This chapter presents previous research related to enterprise application classification models, enterprise architecture frameworks and other topics related to this thesis. The models presented in this chapter provide the theoretical background for the business application architecture framework shown in Chapter 4.

3.1 Enterprise application classification models

The concept of applications classification has been known since the first applications were launched and has been exploited by several authors (e.g. Anthony 1965, Gorry & Scott Morton 1971, Leek 1997, Ward & Peppard 2002). As other classification models, like the Boston matrix developed by Boston Consulting Group, application classifications help to understand the field in a structured way. Anthony introduced the first hierarchical application portfolio in 1965. He classified types of management activity (Anthony 1965). Gibson and Nolan (Gibson and Nolan 1974, Nolan 1979) introduced the first model of evolution of information systems in an organization. This was based on Anthony’s classification of management activity. These models provided the first framework for application classifications. The model by Anthony is illustrated in Figure 3.1.
In Anthony’s model, the classification is based on stratification of management activity in an organization. Anthony divided management activity into strategic planning, management control and operational control. He used the same logic in classifying applications, because they were built to support different levels of management activity.

Gorry and Scott Morton (1971) suggested that management information systems should be looked at from a decision-making point of view. The reason was that management information systems should exist only to support decisions. To help understand management information systems Gorry and Scott Morton created a Management Information Systems Framework. This framework was based on the work of Anthony and Simon (Anthony 1965, Simon 1960) on managerial activity. In their framework Gorry and Scott Morton have combined Anthony’s classification of managerial activity and Simon’s classification of the types of decision problems a manager has to deal with (structured, semi-structured and unstructured). Then they have classified management information systems in this matrix. The framework by Gorry and Scott Morton is illustrated in Figure 3.2.
Figure 3.2. Information Systems Framework (Gorry & Scott Morton 1971).

The classification matrix by Gorry and Scott Morton contains a class of decisions that are called semi-structured. They have defined semi-structured decisions as decisions where one or two of the three phases intelligence, design and choice, are unstructured. In the framework shown in Figure 3.2 decisions above the dotted line are largely structured and decisions below the line are mainly unstructured. Gorry and Scott Morton named decisions supporting information systems as “Decision Support Systems”. In Gorry and Scott Morton’s framework there are six cells, but they stress that these cells are not well-defined categories.

Information systems have changed considerably since the framework by Gorry and Scott Morton was published, but it can still be argued that the basic concept is valid. Utilisation of information systems has become a core of every company’s operative processes. Almost all activities that Gorry and Scott Morton called structured are now managed through information systems. In perspective to Gorry and Scott Morton’s framework, the future trend in utilising applications seems to be towards unstructured decisions and strategic planning.
During the first two decades of the time of information systems, the 1960’s and the 1970’s, they were mainly exploited for improving operational efficiency (data processing) and for improving management effectiveness by satisfying information requirements for decision making (management information systems). In the early 1980’s began the time of strategic information systems (Wiseman 1985, Galliers & Somogyi 1987, Friedman 1994). Ward and Peppard (Ward & Peppard 2002, p. 23) define a strategic information system as a system that improves competitiveness by changing the nature or conduct of the business.

Benjamin et al. (Benjamin et al. 1984) classify types of potential opportunity where strategic information systems can help, to those that focus on the market place and to those that focus on internal operations. In internal operations IS/IT can be used to improve traditional ways of business or to make ‘significant structural changes’ in the way a company does business. Notowidigdo (Notowidigdo 1984) divided strategic information systems into internal systems that benefit the company directly and external systems that benefit the company’s customers.

Venkatraman (1991) evaluates the strategic benefits that have been achieved by using information systems that changed the business. He identifies three types of use of information systems: 1. Business process redesign – using IS/IT to realign business activities and their relationships to achieve performance breakthroughs 2. Business network redesign – changing the way information is used by the organization and its trading partners, thereby changing how the industry overall carries out the value-adding processes. 3. Business scope redefinition – extending the market or product set based on information or changing the role of the organization in the industry.

The application architecture of a company needs to be planned and managed. According to McFarlan (1984) this should be based on current and expected future contribution of applications to the company. McFarlan (1984) has presented an application classification
model that classifies applications in four classes based on their business contribution. McFarlan’s grid is illustrated in Figure 3.3.

<table>
<thead>
<tr>
<th>Strategic</th>
<th>High Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications that are critical to sustaining future business strategy</td>
<td>Applications that may be important in achieving future success</td>
</tr>
<tr>
<td>Applications on which the organization currently depends for success</td>
<td>Applications that are valuable but not critical to success</td>
</tr>
</tbody>
</table>

**Figure 3.3. Applications portfolio (McFarlan 1984, modified by Ward & Peppard 2002).**

The model presented by McFarlan (1984) suggests analysis of current, planned and potential applications and to divide them into four categories based on the their current and future importance to the business. These categories are (category names are modified by Ward 1990, original names in brackets):

- **Strategic** (Strategic) applications are critical to future business success. They create or support change in how the organization conducts its business, with the aim of providing competitive advantage. If the technology used is ‘leading edge’ technology or not does not indicate if the application is strategic.

- **Key operational** (Factory) applications sustain existing business operations, helping to avoid any disadvantage. These kinds of applications are for example ERP or Point of Sale systems.

- **Support** (Support) applications improve business efficiency and management effectiveness but do not, in themselves, sustain business or provide any competitive advantage.
- High potential (Turnaround) innovative applications may create opportunities to gain future advantage, but this has not been proved yet.

Applications can move around the matrix during their lifetime. This may be for instance because innovative applications are not innovative anymore after a certain time period, but become key operational applications. Equally, as a general trend, it is typical that applications, which were for instance high potential in the 1980s, are not necessarily high potential anymore in the 21st century.

Originally this classification was intended to plot the overall expected contribution of information systems to business success in the company. In practise this is not useful in most cases, because most probably a company has applications in all the categories and there will be changes in the application portfolio overtime. These limitations of the original McFarlan grid have been described by Hirschheim et al. (Hirschheim et al. 1988), who found that it was an unhelpful way of categorising the whole set of information systems, since practically every company had systems in all four categories. Still the McFarlan grid is very useful when classifying applications within the company for the purpose of managing current and future application portfolios and setting priorities for investments (Ward & Peppard 2002).

Ward and Peppard (Ward & Peppard 2002) suggest an analysis to be performed with the following deliverables when evaluating a current applications portfolio:

- Categorisation in terms of application portfolio segments: strategic, high potential, key operational and support
- Assessment of coverage and contribution of systems to business needs and any major opportunities to increase business value
- The extent to which systems integrate or interoperate
- Assessment of the effectiveness and robustness and the unrealised potential in current systems and of the enhancement required to increase contribution
- Common elements and differences between current portfolio and required information and systems architecture
- Supporting information to allow prioritisation of enhancement and support work on current systems
- Opportunities that exist to improve information quality
- Strengths and weaknesses assessed against the business critical success factors
- Assessment of the risks of failure from the current portfolio

The information Technology Assessment and Adoption (ITAA) matrix developed by Munro and Huff (1985) is based on work by Benjamin et al. (1984) and considers how organizations have adopted IT/IS as a competitive weapon. Most companies, according to Munro and Huff, are technology driven and are looking for ways to deploy new technology to advantage or issue driven looking for new business opportunities within the known possibilities of existing technology.

Gallier (1987) also developed a matrix that considers factors affecting planning methods, but this time in relation to long-term and short-term thinking, strategy or issue driven and business issues versus technology driven planning. He separates the need for IS/IT to react to current business issues (key operational) from the need to react to changing future objectives (strategic) and compares them to the proactive IS/IT required for high potential opportunities. Like many others he recognizes the importance of managing support systems in an efficient way.

Turban et al. (2001) introduced a classification of information systems based on the number of users and the level of decision-making. They classified information systems in six groups. As a seventh category they introduced an information network infrastructure in their model. The Turban et al. model is illustrated in Figure 3.4.
Figure 3.4. Classification of information systems based on the number of users and the level of decision-making (Turban et al. 2001).

The system groups in the Turban et al. (2001) classification are:

*Office automation and communication systems* are used by all employees. Examples of these systems are word processing, spreadsheets and e-mail applications.

*Operational systems* support organizations in everyday actions such as registration of time used for different tasks, making of a purchasing order and the making of a travel expense report. The users are employees and line management. According to Turban et al. operational systems include also systems for
transaction processing, management information systems and support systems for decision-making.

*Managerial systems* are for planning, organizing and controlling in the short run. This group includes systems for statistical abstracts, reports of divergences, periodical and ad hoc -reports, comparative analysis, projections like trend analysis, sales in the future and cash flow. The users of managerial systems belong to the middle management.

*Management and expert support systems* provide support information and knowledge creation and their integration to business. Search engines in the Internet, computer aided design (CAD) and computer integrated manufacturing (CIM) are examples of this group. The users are experts like economists, lawyers and marketing experts.

*Strategic systems* support decisions that significantly change the way to do business. Strategic systems are both reactive and proactive. The users of strategic systems belong to the top management.

*Information network infrastructure* includes computers, networks, databases and other devices.

There are some issues that can be criticised in the model by Turban et al. (2001). First, it is difficult to see the connection between the level of organization and the systems as they present it. The most peculiar claim is to connect employees with office automation and communication systems. It seems obvious that every level of organization uses these systems and not just employees. Another interpretation of the model would be that in addition to employees all levels of organization shown above the employees in the model use office automation and communication systems and on the other hand all other levels except employees use operational systems. However, this logic is not valid, because for
instance operational systems are not used by top management. Altogether the model from Turban et al. does not seem logical.

Weill and Broadbent (1998) published their Information Technology Portfolio in 1998. Their classification model starts out with four different management objectives in assessing information technology investments. These four objectives are supported by four classes of information technology. It should be noted that the classification by Weill and Broadbent includes also technologies and not just applications. The four classes in the model are IT infrastructure, transactional IT, informational IT and strategic IT. The classification by Weil and Broadbent is illustrated in Figure 3.5.

![Diagram](image)

**Figure 3.5. IT classification model (Weil & Broadbent 1998).**
- *IT infrastructure* is the base for applications in an enterprise. The technical infrastructure is a shared facility across the company to run multiple applications.

- *Transactional IT* processes the basic transactional processes in the company aspiring at cost reduction. This category includes systems like payroll and order processing.

- *Informational IT* systems collect and refine information for enterprise management. Planning, communication, decision-making, accounting and knowledge management are typical areas of these systems. Information is typically collected from several transactional systems.

- *Strategic IT* is a category equivalent to the strategic category in McFarlan’s model, the aim is to gain competitive advantage or major innovation. The strategic potential of the technology is typically limited in time, and systems or technologies move from this category to another one during their life cycle.

Organizations are always influenced by the internal environment where they operate. This context is likely to be different in different companies and it has impact on information systems. Sullivan (Sullivan 1985) has proposed a simple matrix to analyze how forces outside the control of an individual part of the organization affect the IS/IT strategic environment. He has two axes in his matrix (Sullivan 1985):

- Infusion – the degree to which a company becomes dependent on IS/IT to carry out its core operations and manage the business

- Diffusion - the degree to which IT has become dispersed throughout the company and decisions concerning its use are devolved
These axes not only reflect the increasingly strategic nature of IS/IT, but also the changing economics of technology and the ability to use it without the need for skilled technical staff (Ward & Peppard 2002). Sullivan’s matrix is illustrated in Figure 3.6.

![Figure 3.6. Sullivan’s matrix of environments of IS/IT strategy.](image)

By marking high and low degrees of infusion and diffusion, four different environments are established. These are:

*Low diffusion / low infusion* - highly centralized control of IT resources while IS is not critical to the business. This is described as a ‘traditional’ environment, typical of companies using IT solely to improve efficiency in a system-to-system basis.

*Low diffusion / high infusion* - highly centralized control where IS is critical to business operations and control. The business could be seriously disadvantaged if systems fail. Therefore, high-quality systems with a high degree of integration are required.
High diffusion / low infusion - largely decentralized control, giving business managers the ability to satisfy their local priorities. Any integration of systems occurs due to user-user co-operation, not due to overall business or IT design. The management approach is ‘opportunistic’, driven by short-term priorities that may create business advantages in some areas.

High diffusion / high infusion - largely decentralized control, but the business depends on the systems for success, both in avoiding disadvantage and in achieving its overall business objectives. Sullivan describes this as a ‘complex’ environment that is difficult to manage. Too much central control to avoid poor investments will limit innovation, hence new strategic opportunities may be compromised; too little control and the core systems may disintegrate.

Kalakota and Robinson (2000) have introduced an e-business architecture, which is an integrated application framework. When comparing Kalakota and Robinson’s framework to other application classification models, the main difference is that their model covers external parties too. This is a consequence of their emphasis on e-business. In addition to e-business Kalakota and Robinson stress the importance of integrating all the parts of an application architecture. In their model applications are classified based on their purpose. According to Kalakota and Robinson (2000, p. 163) their framework can assist management to grasp the big picture and to set priorities in building the e-business enterprise. The classification model by Kalakota and Robinson is illustrated in Figure 3.7.
Figure 3.7. Information system architecture for e-business (Kalakota & Robinson 2000).

As shown in Figure 3.7, Kalakota and Robinson’s model has several application classes. They are ERP, Customer Relationship Management, Business Intelligence, Enterprise Application Integration Supply Chain Management, Selling Chain Management, management control and administrative control. Application classes are relatively small and quite different compared to other application models.

As described above there are many ways of classifying applications and over the years several models have been introduced. Most of the classification models have good features and it’s a matter of one’s personal opinion which model is better than the next. Feasibility of different models depends on the purpose. Therefore, attention should be paid to choosing the right model before using any of them.
3.2 Application evolution models

One perspective in analyzing the development of information systems and their use in organizations is to look at them from the evolution point of view. Gibson and Nolan (Gibson & Nolan 1974) introduced the first evolution model in 1974. They developed an evolution model which illustrated four stages of growth (Gibson & Nolan 1974), and later Nolan (1979) added two further stages. Nolan and Gibson’s model is illustrated in Figure 3.8.

![Figure 3.8. Stages of evolution of IS/IT in relation to expenditure (Gibson & Nolan 1974).]
Stages in the model by Gibson and Nolan are as follows:

1. **Initiation**: Mainly batch processing to automate clerical operations. The focus is on operational systems and thus cost reduction.
2. **Contagion**: IS/IT expenses rise rapidly, because users demand more applications and have high expectations of benefits. There is not much control.
3. **Control**: Management is concerned about increased costs and takes IS/IT under control. As a result users are often dissatisfied, because the project delays and there is a high level of control.
4. **Integration**: There is considerable expenditure on integrating existing systems. Data processing provides service to users and not just solutions to problems.
5. **Data administration**: Information requirements rather than processing drive the applications portfolio and information is shared within the organization.
6. **Maturity**: Business development and planning and development of IS/IT in the organization are closely co-ordinated.

Nolan’s model was criticised by Benbasat (1984) and King and Kramer (1984), because they claim that empirical support for the model is generally weak. Drury (1983) noted that particularly in later stages of the model the real world is much more complex than what is reflected in the model. Despite of the criticism the model continues to be quite commonly used among practitioners (Ward & Peppard 2002). According to Friedman (1994) the introduction of strategic information systems fundamentally changed the concept of how IS/IT evolves to maturity in Nolan’s model.

According to Kalakota and Robinson (2000) evolution of business applications has been a process of three stages. The first stage, task-oriented applications, was when business applications were narrowly focused and task oriented, simplifying processes such as order entry. Although task specialization improved the productivity of a single task, the disadvantage was fragmentation of processes. In the second stage the aim was to build functional applications, when task oriented applications became more functionally integrated, for instance order entry was integrated with sales application. Kalakota and
Robinson (2000) call the third phase a stage of integrated cross-functional applications. In the third stage applications are integrated cross-functionally and they support seamless process flow across various functions. ERP and CRM applications are examples of integrated cross-functional applications. Porter (2001, p. 74) acknowledges very similar stages of evolution in business applications as Kalakota and Robinson. Furthermore, Porter defines a fourth and a fifth stage. According to Porter, a fourth stage enables the integration of the value chain and entire value system, that is, the set of value chains in an entire industry, encompassing those of tiers of suppliers, channels and customers. Porter continues that in a fifth stage information technology will be used not only to connect the various activities and players in the value system but to optimize its workings in real time. For instance choices will be made based on information from multiple activities and corporate entities.

Riihimaa and Ruohonen (2002) have studied the interaction between management problems and responses provided by information and telecommunication technology. They present several stages of development in management themes and emphasis on information systems development to correspond with those challenges. The stages presented by Riihimaa and Ruohonen are shown in Figure 3.9.
Riihimaa and Ruohon (2002) have studied development of information systems usage in Finnish industrial companies. They describe four different forces that drive evolution and change towards e-business. These are business development, technology development, organizational maturity and organizational potential to utilize e-business (Riihimaa & Ruohon 2002):

Business development – A rapidly changing business environment defines the possibilities for success for many companies. Consolidation and other changes in business sectors impact organizations. The change from a product oriented business to a more service oriented business guides the way to operate in a company.

Technology development – Depending on the company and industry sector technology may be the driving force in the development of the industry. This is the case in some areas of information technology, information systems and
telecommunication. For example in office automation Microsoft has established a strong market position for their products and the same applies to SAP in ERP systems.

*Organizational maturity* – Business environment set the frame, but the real change towards e-business is defined by the organization’s own ability to learn and adjust its processes to the demands set by customers and partners.

*Organizational potential to utilize e-business* – In some business sectors, such as banking and insurance, utilizing information and communication technology is a natural part of the business. For more traditional business sectors utilizing information technologies is not that obvious, but it is used there too. Good examples are supply chain management in the automotive industry or customer service and integration solutions in the engineering industry. A company’s potential to utilize new technologies is not limited to automating processes, it can also mean introducing a new service or product or process innovations.

Riihimaa and Ruohonen (2002) made a survey of the technology industry in Finland concerning development of information systems in organizations. They identified four stages of development of information systems in organizations. According to their survey these phases also apply on the order of development within a company. The development phases are:

- *ERP-phase*. Building and integrating basic systems within the company.
- *SCM-phase (Supply Chain Management)*. The focus is in aiming at a more efficient supply chain within the company or within the network of companies. Information systems play an important role and support this effort.
- *CRM-phase (Customer Relationship Management)*. The focus is to create value add services for customers. The ability to collect and manage customer related information is essential. The supply chain has to operate properly before customer information can be effectively utilized. Particularly sales and
order fulfillment processes need to be under control and systems need to be integrated.

- Knowledge management. The objective in the knowledge management phase is to create partnerships and share common knowledge within the company network. Characteristics for this phase are innovative ways to produce, distribute and develop products. In some cases services become an inseparable part of the products.

Application evolution models are useful instruments in analyzing the development of applications in an organization. Evolution models can be used for evaluating the general development level of applications in the organization. Equally application evolution models are practical in analyzing the order of implementation of different applications within an organization.

3.3 Enterprise architecture frameworks

Common understanding of the enterprise and the business are the cornerstones in developing any information system. Enterprise architecture models help create this common understanding. As defined earlier enterprise architecture describes structures and processes within an enterprise and consists of four elements. Those elements are the business (or business process) architecture, the applications architecture, the information architecture and the technology architecture. An enterprise architecture is a tool to help executives think about the organization as a whole (Harmon 2003).

The primary reason for developing an enterprise architecture is to support the business by providing the fundamental technology and process structure for an IT strategy (Open Group 2002). Enterprise architectures can be very complex and the integration of all the enterprise architecture components is essential for the organization to easily evolve and successfully adapt to the frequent technology and business changes that occur. An
enterprise architecture framework can aid development of an adaptable enterprise architecture (Morganwalp & Sage 2003).

Morganwalp (2003) has listed desired features for an enterprise architecture framework:

- *Encompasses enterprise-wide views* – Since an enterprise architecture affects the whole organization, different stakeholder views should be included.

- *Facilitates systems integration* – An organization has to integrate its business processes with internal as well as with external applications. Therefore it is essential that the enterprise architecture framework supports and facilitates this integration challenge.

- *Driven by or founded upon business requirements* – As any other information systems planning, an enterprise architecture framework has to be based on business requirements.

- *Flexible enough to support frequent changes in technology and/or business* – The business and technology environment is changing continuously. Therefore the enterprise architecture framework has to be flexible and agile to react to these changes.

Schekkerman (Schekkerman, 2003b) has listed similar critical success factors for an enterprise architecture framework:

- *Holistic in scope*: It must address all aspects of the extended enterprise and be directly associated with the business technology alignment: business structure, business activities, business processes, information flows, information-systems, infrastructure, standards and policies.

- *Collaboration based*: The effort must include representatives from all key stakeholders and value net members.

- *Alignment driven*: It must address the need to directly align extended business and technology drivers in a way that is comprehensible and transparent to all key stakeholders, with a continued process of tracing enterprise architecture initiatives to the business strategy.
- *Value driven:* It must provide mechanisms to define business cases that help ensure and demonstrate the business value of enterprise architecture solutions.

- *Dynamic environments:* It must include analytical methods that support the development of enterprise architectures that are flexible and dynamic to changing business drivers and new opportunities.

- *Normative results:* It must provide the ability to define solution sets that can be measured, validated and mapped to real world solutions.

- *Non-prescriptive:* It must not presume an implementation approach, because that would be out of the scope of the enterprise architecture program.

As Morganwalp (2003), also Whitman et al. (1998) stress the importance of multiple views in an enterprise architecture and particularly that these views need to be integrated with each other.

Presley, Huff et al. (1993) argue that multiple perspectives of an enterprise are required depending on the purpose of the examination. They describe a five-point approach when studying an enterprise:

- *Business Rule (or Information) View* defines the entities managed by the enterprise and the rules governing their relationships and interactions.

- *Activity View* defines the functions performed by the enterprise (what is done).

- *Business Process View* defines a time-sequenced set of processes (how is it done).

- *Resource View* defines the resources and capabilities managed by the enterprise.

- *Organization View* describes how the enterprise is organized. This includes the set of constraints and rules governing how it manages itself and its processes.

All the enterprise architecture frameworks support a principle of having at least four separate perspectives: business, information, information systems and technology (Open Group 2002, Zachman 1987, Schekkerman, 2003a, CIO Council 1999)
There are several enterprise architecture frameworks available. In this study some of them have been chosen to be described and reviewed in more detail. The selected enterprise architecture frameworks are the Zachman framework, the TOGAF, the FEAF and the NCR enterprise architecture framework. These frameworks have been selected because they are sited most often in enterprise architecture literature and are recognised among practitioners using enterprise architecture frameworks. The enterprise architecture frameworks excluded from this study include US DoD’s C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance) (C4ISR, 1997), IBM’s Enterprise Solutions Structure (ESS) (Plachy & Hausler 1999), Microsoft’s Enterprise Services Framework (Microsoft Corporation, 2003) and the Extended Enterprise Architecture (E2A) Framework (Schekkerman, 2003a). These frameworks have been excluded because there are not that much material available on them, at least not in scientific journals or similar sources. It has been evaluated that the enterprise architecture frameworks described in this study give a relatively comprehensive view of what enterprise architecture frameworks are and there is no added value in repeatedly describing all of them.


3.3.1 The Zachman enterprise architecture framework

Traditionally systems have been developed in steps such as requirement analysis, planning, system development and implementation. To substitute these methods John Zachman (Zachman 1987, Sowa & Zachman 1992, Zachman 1997) published an enterprise architecture framework in 1987. In this framework system development is based on different perspectives of various stakeholders. The Zachman framework is the most commonly used enterprise architecture framework (Evernden 1996, Cook 1996,
The Zachman framework for enterprise architecture is a “common context for understanding a complex structure by identifying the generic logic structure that organizes, or classifies, the descriptive representations of complex objects” (Zachman 1997). The Zachman framework establishes a set of perspectives and common tools to define and describe an enterprise. The Zachman framework and related approaches identify the need to separate data, process and technology (Zachman 1987, Finkelstein 1992). It should be noted that Zachman does not distinguish between the terms data and information, but uses the term data in the same meaning as the term information is used in this study. However, the Zachman framework is strictly structural and it does not include any elements to support the process of developing an enterprise architecture. This deficiency has faced some criticism among researchers (Cook 1996, Open group 2002, Ambler 2002, Morganwalp & Sage 2003).

The framework developed by John Zachman consists of a two-dimensional matrix. The columns represent various aspects of the enterprise that can be described, or modeled; and the rows represent various viewpoints from which the aspects can be described. Thus each cell formed by the intersection of a column and a row represents an aspect of the enterprise modeled from a particular viewpoint. The six rows of the matrix include perspectives of (Hay 2000):

1. **Scope (Planner's view, contextual):** Definition of the enterprise's direction and business purpose. This is necessary to establish the context for any system development effort.
2. **Enterprise model (Owner's view, conceptual):** This defines — in business terms — the nature of the business, including its structure, functions and organization.
3. **System model (Designer's view, logical):** This defines the business, but in more rigorous information terms. This perspective describes an application architecture.
4. **Technology model (Builder's view, physical):** This describes how technology may be used to address the information processing needs identified in the previous rows.

5. **Detailed representations (Sub-contractor's view, out of context):** Here a particular language is chosen, and the program listings, database specifications, networks etc.

6. **Functioning system:** A system is implemented and made part of an organization.

The six columns address the interrogatives what (data aspect), how (function aspect), where (network aspect), who (people aspect), when (time aspect) and why (motivation aspect). The Zachman enterprise architecture framework is illustrated in Figure 3.10.

<table>
<thead>
<tr>
<th>Scope (Planner)</th>
<th>What</th>
<th>How</th>
<th>Where</th>
<th>Who</th>
<th>When</th>
<th>Why</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>List of Things</td>
<td>List of Processes</td>
<td>List of Locations</td>
<td>List of Organizations</td>
<td>List of Business Events</td>
<td>List of Business Goals, Strategies</td>
</tr>
<tr>
<td>System Model (Designer)</td>
<td>Logical Data Models</td>
<td>Application Architecture</td>
<td>Distributed System Architecture</td>
<td>Human Interface Architecture</td>
<td>Processing Structure</td>
<td>Business Rule Model</td>
</tr>
<tr>
<td>Technology Model (Builder)</td>
<td>Physical Data Model</td>
<td>System Design</td>
<td>Technology Architecture</td>
<td>Presentation Architecture</td>
<td>Control Structure</td>
<td>Rule Design</td>
</tr>
<tr>
<td>Components (Subcontractor)</td>
<td>Data Definition</td>
<td>Program Architecture</td>
<td>Network Architecture</td>
<td>Security Architecture</td>
<td>Timing Definition</td>
<td>Rule Specification</td>
</tr>
<tr>
<td>Functioning System (Product)</td>
<td>Data</td>
<td>Function</td>
<td>Network</td>
<td>Organization</td>
<td>Schedule</td>
<td>Strategy</td>
</tr>
</tbody>
</table>

*Figure 3.10. The Zachman enterprise architecture framework (Vail 2002, p. 9).*

Clearly the strength of the framework is that it provides a structural way of thinking about an enterprise. The Zachman framework provides a comprehensive approach to enterprise architecture design with all the details within the enterprise. This level of details is an advantage of the framework, but it is simultaneously a disadvantage, because it makes the Zachman enterprise architecture framework quite complicated and heavy to use. The framework has the benefit of providing an overall picture of the enterprise
context during the process of getting down to details. Another weakness of the framework is that it does not include any tools or guidelines to support the enterprise architecture building process itself. This is the most criticized weakness of the framework (e.g. Ambler 2002, Vail 2002, Morganwalp 2003). This may cause sub-optimization and cost inefficiency, if individuals involved in enterprise architecture development are working on their part of the architecture too independently. In addition to the lack of a developing method, the Zachman framework doesn’t acknowledge the possibility of using an application driven approach.

Although the Zachman framework has been widely accepted and used there are some potential problems in it (Ambler 2002, Morganwalp 2003):

- The Zachman framework can lead to a documentation-heavy approach. There are 36 cells in the framework and each one needs to be supported by one or more artifacts.
- The Zachman framework can lead to a process-heavy approach to development. To fulfil all the cells in the framework the implementing process might be heavy.
- A major weakness of the framework is that it is strictly structural and it does not have any methods or reference models for development.

However, Ambler (2002) and de Villiers (2001), give some guidelines on how to exploit the Zachman enterprise architecture framework efficiently:

- Keep it simple
- Adopt the concept that your enterprise architecture efforts must reflect in a wide range of perspectives
- Adopt the augmented form of the Zachman framework to avoid methodology bias
- The Zachman Framework is useful as a high-level summary of relevant development artifacts and detailed descriptions of the relationships among artifacts, roles and activities.

3.3.2 TOGAF (The Open Group Architecture Framework)

TOGAF is a framework for developing an enterprise architecture. It is described in a set of documentation published by The Open Group (Open Group 2002).

The original development of TOGAF Version 1 in 1995 was based on the Technical Architecture Framework for Information Management (TAFIM), developed by the US Department of Defense (Open Group 2002). “The Open Group is an international vendor and technology-neutral consortium that is committed to delivering greater business efficiency by bringing together buyers and suppliers of information technology to lower the time, cost and risk associated with integrating new technology across the enterprise“ (Open Group 2004). TOGAF is not an architecture in and of itself, rather it provides the necessary tools with which an organization can produce an architecture for itself (Beveridge & Perks 2000). This is because TOGAF is an enterprise architecture framework and not an enterprise architecture. The major difference between the Zachman framework and TOGAF is that TOGAF includes guidelines and tools how to build an enterprise architecture. In TOGAF this is called the Architecture Development Method (ADM) and it is an essential part of the framework. The Zachman framework does not include a development method.

As the Zachman enterprise architecture framework, TOGAF also supports the concepts of stakeholder views. However, in TOGAF different stakeholder views do not have as important a role as in the Zachman framework. According to TOGAF (Open Group 2002) the following views should be considered:
- Users
- System and Software Engineers
- Operators, Administrators and Managers
- Acquirers

The architecture views to correspond with the above stakeholder views include (Open Group 2002):

- **Business Architecture Views**, which address the concerns of the users of the system and describe the flows of business information between people and business processes.

- **Data Architecture Views**, which address the concerns of database administrators and system engineers responsible for developing and integrating the various database components of the system.

- **Applications Architecture Views**, which address the concerns of system and software engineers responsible for developing and integrating the various application software components of the system.

- **Technology Architecture Views**, which address the concerns of acquirers (procurement personnel responsible for acquiring the commercial-off-the-shelf (COTS) software and hardware to be included in the system), operations staff, systems administrators and systems Managers.

It should be noted that as well as the Zachman framework, TOGAF does not distinguish data and information. TOGAF is designed to support four types of architecture. These are commonly accepted as subsets of an overall enterprise architecture (Open Group 2002):

- A business architecture - this defines the business strategy, governance, organization and key business processes.

- An applications architecture - this kind of architecture provides a blueprint for the individual application. Systems to be deployed, their interactions, and their relationships to the core business processes of the organization.

- A data architecture - this describes the structure of an organization's logical and physical data assets and data management resources.
- A technology architecture - this describes the software infrastructure intended to support the deployment of core, the mission-critical applications. This type of software is sometimes referred to as "middleware".

The Open Group updates TOGAF quite frequently and the current release of TOGAF includes three main components (Morganwalp 2003): the TOGAF Standards Information Base (SIB), the TOGAF Technical Reference Model (TRM) and the TOGAF Architecture Development Method (ADM). Together SIB and TRM form an Enterprise Continuum, which is a "virtual repository" of all the architecture assets - models, patterns and architecture descriptions - that exist both within the enterprise and in the IT industry at large, and which the enterprise considers to have available for the development of architectures (TOGAF 2002). In addition to SIB and TRM, the Enterprise Continuum includes the Integrated Information Infrastructure Reference Model (IIIRM), which is specifically aimed at helping the design of architectures that enable and support the information flow without boundaries.

The Standards Information Base (SIB) is a database of industry standards that can be used to define the particular services and other components of an enterprise-specific architecture. TOGAF Technical Reference Model (TRM) provides a model and taxonomy of generic platform services. The TRM also identifies system-wide capabilities such as security and network management (Morganwalp 2003).

TOGAF’s Architecture Development Method (ADM) is a cyclic and iterative method to support the enterprise architecture building process. ADM, as shown in Figure 3.11, consists of eight phases.
Figure 3.11. TOGAF Architecture Development Method (Open Group 2002).

At relevant places throughout the TOGAF ADM, there are reminders to consider which, if any, architectural assets from the Enterprise Continuum the architect should use (Open Group 2002). Characteristic for TOGAF is that architectures are driven top down from a business stand point, not bottom-up from a technical point of view (Beveridge & Perks 2000).

TOGAF Architecture Development Method (ADM) describes a step-by-step approach to develop an enterprise architecture. ADM is a generic model and each organization should
decide if they want to customize it for specific needs or exploit the generic model (Open Group 2002). Developing an enterprise architecture with the ADM is an iterative process, which consist of eight stages. The stages of the ADM are illustrated in Figure 3.11. In the first phase the strategic business requirements are defined and relevant stakeholders identified. Also an architecture vision to meet these requirements is determined.

In the second phase the current baseline business architecture is described and target business architecture developed. This phase is used to analyze the gaps between the baseline and the target business architectures. The objective of the third phase is to develop target architectures covering the Data and Application Systems domains (Open Group 2002). Depending on the scope of the project, data and application architectures can be created as sub-phases. Spewak (Spewak 2000) recommends a data-driven approach for the enterprise architecture building process. Regarding the data, the target is to define the major types and sources of data necessary to support the business, but this does not mean database design or the design of any logical or physical storage systems. Concerning the applications, the objective is to define what major applications are required to process the data and support the business. However, this excludes applications systems design itself and concentrates on the kinds of applications that are relevant to the enterprise (Open Group 2002).

The fourth phase in ADM is technology architecture development. This phase consists of eight sub-phases: create baseline, consider different views, create architectural model, select services portfolio, confirm business objectives are met by architecture model, determine criteria for specifications, define architecture completely and conduct gap-analysis (Morganwalp 2003). The fifth phase, opportunities and solutions, identifies the strategic change and the top-level projects to be undertaken in moving from the current environment to the target architecture (Open Group 2002). The migration planning phase is for developing the various project plans for projects, which have to be implemented. This phase is also for prioritizing these plans. The objective of the seventh phase, implementation governance, is to formulate recommendations and plans for each implementation project and then implement and deploy the systems (Morganwalp 2003).
The last phase of ADM, Architecture Change Management, includes creating a maintenance procedure for the new baseline that has been implemented in the previous phase.

3.3.3 **FEAF (Federal Enterprise Architecture Framework)**

The Federal Enterprise Architecture Framework (FEAF) was developed by the Council of Chief Information Officers of the US Government in the 1990s. FEAF provides direction and guidance to federal agencies for structuring an enterprise architecture. The FEAF is a strategic information asset base that defines the business, information necessary to operate the business, technologies necessary to support the business operations and transitional processes for implementing new technologies in response to the changing needs of the business. The target of FEAF is to promote shared development for common federal processes, interoperability and sharing of information among federal agencies and other governmental entities. The focus of the federal enterprise architecture is limited to common federal architecture issues, which benefit federal organizations and the public, if resolved at the federal level. (CIO Council 1999)

FEAF combines structure with the process overview in a transition process from the baseline enterprise architecture to the target enterprise architecture. FEAF is organized in eight components. However, it does not provide detailed steps on how to accomplish those components. Therefore it differs from TOGAF, which gives detailed guidance for the enterprise architecture development process. FEAF has four levels and each of them is progressively more detailed than the previous level. In FEAF the eight components of an enterprise architecture are (CIO Council 1999):

- *Architecture Drivers* - Represent two types of external stimuli or change agents for the enterprise architecture: business and design. The business drivers could be new legislation, new administration initiatives, budget enhancements for accelerated focus areas and market forces. Design drivers
include new and enhanced software and hardware and their combinations with a variety of deployment approaches.

- **Strategic Direction** - Guides the development of the target architecture and consists of a vision, principles, goals and objectives.

- **Current Architecture** - Defines the "as is" enterprise architecture and consists of two parts: current business and design architectures (i.e. data, applications and technology). This is a representation of current capabilities and technologies and is expanded as additional segments are defined.

- **Target Architecture** - Defines the "to-be-built" enterprise architecture and consists of two parts: target business and design architectures (i.e., data, applications and technology). This represents the future capabilities and technologies resulting from design enhancements to support changing business needs.

- **Transitional Processes** - Support the migration from the current to the target architecture. Critical transition processes for the federal enterprise include capital IT investment planning, migration planning, configuration management and engineering change control.

- **Architectural Segments** - Consist of focused architecture efforts on major cross-cutting business areas, such as common administrative systems; program areas, such as trade and grants; or small purchases via electronic commerce. They represent a portion (segment) of the overall enterprise architecture. A segment is considered to be an enterprise within the total federal enterprise.

- **Architectural Models** - Define the business and design models that comprise the segments of the enterprise description.

- **Standards** - Refer to all standards (some of which may be mandatory), guidelines and best practices.

In Figure 3.12 relationships between these components are shown (CIO Council 1999). Figure 3.12 describes level three of FEAF. As shown in Figure 3.12 the FEAF building process is divided in two parts; business drivers and design drivers.
Figure 3.12. Federal Enterprise Architectural Framework (Level 3) (CIO Council 1999).

As illustrated in Figure 3.12, the FEAR partitions a given architecture into business, data, applications and technology architectures. Enterprise architecture work starts from a current architecture and as a result of enterprise architecture development work is a target enterprise architecture. The FEAR does not distinguish between the terms data and information.

At level four the FEAR is quite similar to the Zachman framework. FEAR level four describes the stakeholder views (in rows) and interrogatives what, how and why as columns. The FEAR includes the first three columns of the Zachman framework. FEAR level four is illustrated in Figure 3.13.
<table>
<thead>
<tr>
<th>Planner Perspective</th>
<th>Data architecture (entities=what)</th>
<th>Application Architecture (activities=how)</th>
<th>Technology Architecture (locations=where)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner Perspective</td>
<td>List of Business Objects</td>
<td>List of Business Processes</td>
<td>List of Business Locations</td>
</tr>
<tr>
<td>Semantic Model</td>
<td>Business Process Model</td>
<td>Business Logistics System</td>
<td></td>
</tr>
<tr>
<td>Designer Perspective</td>
<td>Logical Data Model</td>
<td>Application Architecture</td>
<td>System Geographic Deployment Architecture</td>
</tr>
<tr>
<td>Builder Perspective</td>
<td>Physical Data Model</td>
<td>Systems Design</td>
<td>Technology Architecture</td>
</tr>
<tr>
<td>Subcontractor</td>
<td>Data Dictionary</td>
<td>Programs</td>
<td>Network Architecture</td>
</tr>
<tr>
<td>Perspective</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3.13.** FEAF Architecture matrix (adopted from CIO Council 1999). Cells which are in the focus of this study are highlighted.

The cells that this study primarily covers are highlighted in Figure 3.13.

3.3.4 **NCR enterprise architecture framework**

NCR, originally called U.S. National Cash Register, has developed an enterprise architecture framework of their own in the 1990's. The framework has similar elements as the TOGAF. The NCR enterprise architecture framework also has three main parts: model, method and standards information base.

NCR method is called Global Information Technology Planning (GITP), which is similar to TOGAF’s ADM (Architecture Development Method). GITP is illustrated in Figure 3.14 and it has five phases: 1. Scoping 2. IT & Business Alignment 3. Strategic Information & technology architecture 4. Transition strategy and planning and 5. Architecture management practices.

In the scoping phase the scope of an enterprise architecture developing exercise is defined. In the IT and Business Alignment section the business plans and goals of the company are documented. These business plans provide the basis for creating an IT strategy. During the Strategic Information & Technology Architecture phase the target architecture plan is created. This section has several sub-phases. Transition Strategy and Planning provides a logical way to move to the target architecture. This phase identifies the gaps between the current enterprise architecture and the target architecture. Based on the needs of the business, the gaps are addressed by a series of high level initiatives. Architecture Management Practices is the portion of the method that provides the company with tools for life-cycle management of the target architecture. (NCR Corporation 1996, www-document, accessed 24.2.2004)
In addition to the method, GITP, NCR’s enterprise architecture framework has a technical information base called OCCA (Open Co-operative Computing Architecture). OCCA was released originally in February 1990. NCR’s website claims that they pioneered the concept of open commercial systems at the time. OCCA is an architecture of functions that supports all the system and application level architectures. OCCA includes coverage of complete computing environment and it has the general building blocks on which more specific system or application architectures can be built. For example, OCCA contains supported open networking protocols and supported open networking components and it reflects with general computing requirements. OCCA is comparable to the Technical Reference Model (TRM) in TOGAF enterprise architecture framework. OCCA is shown in Figure 3.15.

![Diagram of OCCA Architecture Framework](image)

*Figure 3.15. NCR’s Open Co-operative Computing Architecture (OCCA).*

### 3.3.5 Summary of enterprise architecture frameworks

All enterprise architecture frameworks described in the previous section have different backgrounds and some significant differences can be identified. However, they also have some similarities:
1. They all cover all sub-architectures of an enterprise architecture. There are differences in the architecture taxonomies, but all the following elements are included in one way or another: business architecture, information architecture, application architecture and technology architecture.

2. All the described enterprise architecture frameworks support multiple views, in other words, several stakeholders have been taken into account. One major difference between enterprise architecture frameworks is that the TOGAF framework is the only one that includes a method to support enterprise architecture development or analyzing the architecture development. The other frameworks described do not have an enterprise architecture development method, a reference model for enterprise architecture development process or development analyzing method, except for some guidelines given in NCR’s framework. Indisputably the Zachman framework is the most common and most referred enterprise architecture framework and therefore it is a bit surprising that even it does not include a development method, a reference model for the enterprise architecture development process or a development analyzing method.

3. The structure of all the described enterprise architecture frameworks is relatively similar. Many elements in different enterprise architecture frameworks are comparable with each other. However, the type of organization behind each framework is different and the origins and the ultimate aim of the framework are therefore different from each other. The Zachman framework has been developed by one person and some years after publishing the framework John Zachman has established a consultancy practice, which uses the Zachman framework for commercial purposes. Whereas the origins of the FEAF and NCR’s framework are in US government and thus they are oriented for the purposes of heavy government organizations. TOGAF is developed by a large international consortium, although its origins are also in the US Department of Defense.
3.4 Information requirements and information architecture

Identifying information requirements is one of the key phases in planning and implementing an information system. Equally, it is important in planning the whole architecture of applications, in this case the business application architecture. Browne and Rogich (2001, p. 224) define requirements determination as the process of gathering and modeling information about required functionality of a proposed system by a systems analyst. Information requirements should be aligned with business requirements in the company. However, a number of authors have recognized that correct and complete information requirements are frequently difficult to obtain (e.g. Teng & Sethi 1990, Leifer et al. 1994, Guinan et al. 1998). Various methods, tools and techniques have been proposed to improve the information requirements determination process (e.g. Atkinson 2000, Cysneiros et al. 2001, Regnell et al. 2001). Information modeling is closely related to the information requirements determination process. Information modeling is the process of formally documenting the problem domain for the purpose of understanding and communication among stakeholders (Mylopoulos, 1992; Siau, 1998, 1999). Information models, which are mostly graphic, are used to represent both static phenomena (e.g., things and their properties) and dynamic phenomena (e.g., events and processes) in some domain (Wand & Weber, 2002). According to Kung and Solvberg (1986) information models have at least four purposes:

1. Supporting communication between developers and users
2. Helping analysts understand a domain
3. Providing input for the design process
4. Documenting the original requirements for future reference

Despite these efforts the information requirements determination process remains a challenging task. Davis (1982) suggest three main reasons for the difficulty of obtaining a correct and complete set of requirements:

- The constraints on humans as information processors and problem solvers
- The variety and complexity of information requirements
- The complex patterns of interaction among users and analysts in defining requirements

Consequently, if systems are developed based on information requirements, which are either wrong or incomplete, the systems themselves are likely to be unsuccessful. A complete and accurate collection of user requirements sets the stage for an efficient development process that increases the likelihood of a successful organizational system (Davis 1982). In addition to issues listed by Davis the constant change of business and business environments hamper the obtaining of information requirements. Although Davis aims at a complete set of requirements, in practice it seems impossible to achieve and there are always factors of uncertainty to be considered.

One outcome of the information requirements defining process is an information architecture (some authors use term data architecture instead). According to Brancheau et al. (1989) “An information architecture is a high-level map of the information requirements of an organization. It shows how major classes of information are related to major functions of the organization. In its pure form, information mapping is independent of personal staffing, organization structures and technology platforms”. Niederman et al. (1991) made a study among IT executives concerning the top 10 priorities for them at the time. In this survey, information architecture was ranked as number one. Although this survey was made more than ten years ago, it seems clear that information architecture would still be on the top ten list. Information architecture can be used to guide applications development and to facilitate the integration and sharing of information. According to Niederman et al. (1991, p. 479) several authors agree that information architecture offers the potential to serve as a basis for building a responsive and long lasting set of business applications, in other words a business application architecture (Scheer 1989, Martin 1989). However, Niederman et al. (1991) continue that information architecture is difficult to capture, use and maintain, due to both the breath of information requirements and the changing nature of the business environment. According to Van Den Hoven (2003), most enterprises do not have a well-integrated view of their data. As
a result, data is fragmented, inconsistent, redundant and generally inaccessible beyond the business function that it is directly supporting. Umar et al. (1999) stress the importance of ensuring the quality of data as part of the information architecture designing process.

According to Van Den Hoven (2003) an effective information architecture enables:

- Data to be used more efficiently and effectively within the enterprise
- Better integration of data to get an overall understanding of the enterprise and how well it is performing
- Better integration of the enterprise with its customers, suppliers and business partners

An information architecture establishes a base for the integrated business application architecture and basic rules for how and where, and which data entities should be maintained. A well-designed information architecture provides possibilities to build a high-quality business application architecture.

Gosling (1993) has listed some characteristics of a good information architecture:

- *Inclusiveness*. A good information architecture should be as comprehensive as possible, including as much of the information required to carry out its function as possible.
- *Balance*. An information architecture should provide a good balance between data consistency and flexibility. In other words, it should enforce some uniformity in the classification of information, while allowing flexibility to add new information that might be specific to one part of the organization. It must also be flexible enough to accommodate new information requirements that will certainly arise.
- *Multiple views*. The user should be able to look at the information in a variety of ways.
- *Business orientation*. An information architecture should reflect the organizational structure and orientation of the company, accommodating a line of business focus as well as traditional hierarchical relationships.

### 3.5 Information system investments

Application classification models and enterprise architecture development methods are linked inseparably link to information system investments, because when developing an enterprise or application architecture, investments are always required. There has been a number of studies on how IT investments should be assessed and justified, there is no common understanding how it should be done (Hochstrasser 1990, Peters 1990, Symons 1994, Davern & Kaufman 2000). Both the costs and benefits of information system investments are difficult to measure, because they are often intangible in nature and the benefits are realised during a long period of time (Powell 1992, Lederer & Mendelow 1993). Other analyses suggest that traditional financial analysis techniques are commonly in use, but that companies are finding it increasingly difficult to use them, because the types of benefit become more difficult to quantify adequately (Ballantine et al. 1994, Willcocks & Lester 1994). Also, the benefits from information system investments may be seen differently by different stakeholders or persons involved (Farbey et al. 1992). In addition, sometimes it is difficult to verify the causality between information system investments and benefits.

Parker et al. (1992) assess in detail the ways in which information and systems benefits accrue and how they can be quantified to help in justifying investments. They consider three main types of application investments:

- *Substitutive* – technology replacing people with economics being the main driving force, improves efficiency
– **Complementary** – improving organizational productivity and employee effectiveness by enabling work to be performed in new ways
– **Innovative** – achieving competitive edge by changing trading practice, creating new markets etc.

They continue by suggesting five different techniques for evaluating information system investment benefits:

1. **Traditional cost–benefit analysis** focuses on efficiency improvements in company processes resulting from automation.
2. **Value linking** estimates the improvement in business performance, not just in the savings made, by improving the linkages between processes or activities (e.g. automatic reconciliation of orders).
3. **Value acceleration** considers time dependence of benefits and costs in other departments of system improvements (e.g. giving sales data to buyers on daily bases and improving their ability to respond to changes in demand).
4. **Value restructuring** considers the productivity resulting from process and organizational change and change of job roles.
5. **Innovation evaluation** attempts to estimate the value of new business or new business practices levered from IT/IS (e.g. launch of on-line banking service)

Mooney et al. (1995) propose a business process oriented approach in the evaluation of the potential value of IT in business. They divide business processes into operational and managerial processes. In their framework IT business value can be automational, informational or transformational. Automational refers to efficiency of processes and informational means better sharing or better quality of information. Transformational refers to the value created by facilitating process innovation. The framework by Mooney et al. (1995) is illustrated in Figure 3.16.


<table>
<thead>
<tr>
<th>Business Processes</th>
<th>Automational</th>
<th>Informational</th>
<th>Transformational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Management</td>
<td></td>
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</tbody>
</table>

*Figure 3.16. A Framework for identifying business value created through the impact of IT on business processes dimensions of IT Business Value (Mooney et al. 1995)*

Equally important as the evaluation of information system investments as such, is the capability to prioritise them. This is because it is unlikely possible to execute all application investments in parallel. Ward and Peppard (2002) suggest three factors to be included when assessing the priorities for information system investments. First, what is the most important to do, based on identified benefits. Second, what can be done based on resources available, and third, what is likely a success based on the risks of failure of each investment. According to the research of Farrell (2003) three practices distinguish the companies that were most successful in their IT investments. First, they targeted their investments at the productivity levels that mattered most to them and their industries. Second, they carefully thought through the timing and sequence of their investments. Third, they didn’t pursue IT in isolation but rather developed managerial innovations in parallel with technology innovations.

Prioritising information system investments depends also on the company’s overall value position and choice of pursuing competitive advantage (e.g. cost leadership, customer intimacy or product leadership). Ward and Ward and Peppard (Ward 1990, Ward & Peppard 2002, p. 242) suggest applying McFarlan’s (1984) application classification model logic also in this respect:
- Strategic applications should relate to the dimension in which the company seeks to excel in one to three years (e.g. operational excellence or product leadership), with the objective of gaining advantage in the market place.
- Key operational application investments are essential in any dimension if the systems are causing performance level problems.
- Investments on high-potential applications would normally be prototypes related to specific strategic developments or evaluations of ideas relevant to the other dimensions.

However, even if some good prioritising techniques would exist Lederer and Mendelow (1993) argue that the reasons for establishing and setting priorities for information system investments can be divided into two groups: rational and political. Clemons (1991) emphasizes that the increasing competitive impact of information systems makes evaluation and prioritizing even more problematic. It is difficult to evaluate the value of building strategic information systems, because the environment of contemporary companies is characterised by turbulence and constant change.

As a part of the appraisal of information system investment viability, it is critical to assess the potential risk. The risk may be realised as failing to deliver anything at all, failing to deliver the expected benefits or exceeding the schedule or budget significantly. Study on information system investments by Lyytinen and Hirschheim (1987) suggest that failure can occur in four domains:

1. Technical failure – this is a domain of the IT department that is responsible for the technical quality of the system and the technology it uses.
2. Data failure – this is a shared responsibility between the IT department and the users who input the data.
3. User failure – this may be caused by the users who can not use the system or partly caused by information system professionals, because of
insufficient training or documentation. A major weakness in many projects is inadequate training.

4. Organizational failure – systems may be satisfactory for particular functional needs, but fail to satisfy the organization overall. This happens, because of inadequate understanding of how the system relates to other processes and activities.

Although literature concerning IT investments deals mainly with information system investments and not specifically business application investments, all that has been suggested applies also to business application investments. This is because business applications are defined as part of information systems. It can even be argued that business applications are the most complex part of information systems and thus the management of business application investments is the most difficult part of information system investments. Therefore, the difficulties to assess information system investments apply also to business application investments. Also, it can be argued that the most significant benefits of information system investments can be achieved with business application investments, because they have the closest link to the business. Thus, in terms of potential benefits, business application investments are probably the most interesting part of information system investments.

3.6 Enterprise application integration

Organizations use a diversity of information systems such as ERP, CRM and e-business applications to support their business processes. This diversity of heterogeneous and in many cases incompatible systems are causing problems in terms of integrating applications. Integrating business applications efficiently is a vital part of building a business application architecture. Typically business processes go through several applications and without integration the possibility to automate those business processes is limited. Enterprise Application Integration (EAI) is attempting to overcome such challenges. Linthicum (1999, p.354) defines enterprise application integration as:
“Unrestricted sharing of information between two or more enterprise applications. A set of technologies that allow the movement and exchange of information between different applications and business processes within and between organizations”.

Application integration is achieved through the incorporation of functionality from disparate systems using a variety of integration technologies such as adapters and message brokers (Themistocleous & Irani, 2002). According to Inmon (1999) there was a clear demand for EAI particularly as ERP applications became more prevalent in the 1990’s and there was a need to be able to integrate already existing applications and data within the ERP system. Although legacy systems have problems with maintainability and inflexibility, they provide reliable solutions and therefore the amount of legacy systems in use remains high (Lloyd et al. 1999). This implies that the importance of enterprise application integration between legacy systems and recently implemented applications will continue. Themistocleous & Irani (2001) report that a significant business benefit of application integration is the reduction of overall integration cost, because it provides a flexible, manageable and maintainable enterprise infrastructure that supports changing business and technical requirements. According to Ruh et al. (2000) based on an integrated enterprise architecture, companies can increase their productivity and provide better services for their customers and improve their relationships with their clients. Also Gable (2002) emphasizes the cost savings attained with enterprise application integration. The savings come through lower cost per transaction, decreased error correction cost and decreased need to write and maintain customized interfaces between individual applications.

In building effective business application architectures enterprise application integration has a valuable role to ensure seamless integration of various applications in the architecture. If an enterprise application integration really works as it is planned, it allows flexibility in choosing applications for the business application architecture, because integration can be achieved without using the same enterprise wide application, such as all inclusive ERP, for all functions.
4 BUSINESS APPLICATION ARCHITECTURE FRAMEWORK

The aim of this chapter is to present the business application architecture framework. The framework is based on models described in previous chapter. The business application architecture framework consists of two main parts, the reference model for business application architecture development process and the business application classification model. These components are presented in chapters 4.1 and 4.2.

In the preceding literature review three main issues have been covered:

1. Various methods and models to classify information systems and applications have been described
2. Information system evolution models have been presented
3. Some enterprise architecture frameworks have been described

The main purpose of all classification models presented in this study is to help evaluate existing, planned and potential information systems and their contribution to business. Based on this exercise, management can formulate IS/IT strategy and allocate investments. Information system evolution models focus mainly on describing and analyzing how information systems have developed over time.

An enterprise architecture presents structures and processes within an enterprise and helps to understand different relations within the organization. The primary purpose for developing an enterprise architecture is to support the business by providing the fundamental technology and process structure for an IT strategy (Open Group 2002).

An enterprise architecture provides a strategic context for the evolution of information systems in a constantly changing business environment. An enterprise architecture framework simplifies architecture development process and ensures more complete coverage of the designed solution. An architecture development process is a complex
process, which involves several stakeholders in the organization. An enterprise architecture framework enables a systematic development process, which is easier to repeat in different parts of the organization.

As stated earlier, both application classification models and enterprise architecture frameworks have valuable elements and features, which can be used as instruments to increase knowledge on business application architectures. However, based on analyzes of application classification models and enterprise architecture frameworks, it appears that some features may be enhanced. This is valid particularly from the perspective of this study, because the emphasis is on business application architectures and in manufacturing industry instead of whole enterprise architectures in general. Additionally, in previous research, the features of application classification models and the features of enterprise architecture frameworks have not been combined, although this would be a useful combination. In this study features from application classification models and from enterprise architecture frameworks are combined and an enhanced business application architecture framework is presented.

In terms of application classification models the main deficiency is that in most of the previous classification models the type of management activity, the organizational level of management using the application or the decision types are the classification criteria. Models do not classify applications based on the features in the applications themselves, or based on the purpose of the application. In addition, existing application classification models do not take into account any manufacturing industry specific requirements, such as engineering function.

Despite effort put in the development of existing enterprise architecture frameworks, there are some common deficiencies, that can be identified:

1. They cover all aspects of the enterprise, including the technology infrastructure
2. None of the enterprise architecture frameworks are application driven
3. Most of them do not include a method or a reference model to support an enterprise architecture development process or the analysis of the development process. Only the enterprise architecture framework by Open Group (Open Group 2002) includes a real enterprise architecture development method, and the NCR framework (NCR Corporation 1996) has some elements of a development process. According to survey by Hirvonen (2005) these suggested approaches are applicable only for massive projects, where the entire enterprise architecture is planned and designed as anew. Hirvonen (2005) continues that such a projects are rare and in most cases the projects are targeted to one or few aspects of enterprise architecture. One of those aspects can be business application architecture.

The existing enterprise architecture frameworks provide a comprehensive view of all the aspects of the enterprise, which is their benefit, but it may also be a deficiency in some cases. A few points support this argument. First, when seeking operational efficiency or competitive advantage with information systems, it can most likely be achieved with some key business applications, not with information technology lying underneath these applications. It is argued that information technology infrastructure has to be reliable and efficient, but that’s all. Thus, the technology aspect of an enterprise architecture is not vital in strategic development of information systems. Second, enterprise architecture development may be a heavy and resource demanding process with low productivity if all technology and detailed features are included. Therefore, strategic management efforts should be directed to key business applications instead of dividing resources to all aspects of information systems and information technology in the organization. In this study this part of an enterprise architecture is defined as business application architecture (see more in Chapter 2).

The third deficiency of enterprise architecture frameworks is the lack of support for an application driven approach. The perspective of this approach is to develop an enterprise architecture based on an application driven approach instead of building the architecture
from detailed small elements. Only in Open Group’s TOGAF framework (Open Group 2002) the possibility of an application driven approach is briefly mentioned:

“Oh the other hand, major applications systems such as those for Enterprise Resource Planning, Customer Relationship Management, etc., often provide a combination of technology infrastructure and business application logic, and some organizations take an application-driven approach, whereby they recognize certain key applications as forming the core underpinning of the mission-critical business processes, and take the implementation and integration of those core applications as the primary focus of architecture effort (the integration issues often constituting a major challenge)” (Open Group 2002, p. 41).

Excluding this statement none of the other enterprise architecture frameworks mention this application driven approach option. Traditionally system development projects follow a basic logic: requirements analysis and determination, planning and development of the system and system implementation. There are quite a few software development methods like the stagewise model (Benington 1956), the water fall model (Royce 1970) and the spiral model (Boehm 1988) to support this development. When developing an enterprise architecture in practice, it is often not a question of developing the software, it is rather a question of choosing the correct elements from commercially available packages and integrating them with legacy systems. Even if the plan is not to develop the application, but to exploit commercial packages, the general logic of software development methods is still valid. This means that requirement analysis is done first and then application is configured based on these requirements. However, this is not always possible in practice. This may be because the application does not necessarily comply with requirements and the process has to be refined instead. Enterprise wide systems, like an ERP application push the company towards processes defined by the system, even when the customized processes may be a source of competitive advantage (Davenport 1998). It is, however, important to ensure a good organizational fit with the application, because there is apparent correlation between a good fit with organizational requirements and successful implementations (Kyung-Kwon and Young-Gul 2002). Advantages
gained when using commercial off-the-shelf (COTS) software packages instead of customized software development are widely accepted among practitioners and in the research community (e.g. Fox et al. 1997, Davenport 1998, Kara 1999, Wiers 2002). According to Wiers (2002) research in the field of production planning and control also implicitly assume that information systems’ functionality follows the requirements specified in models, but this is valid only in cases where the software is custom built for a specific situation with unlimited funds. He continues that in practice companies implement commercially available standard software packages.

The application driven approach allows the possibility of exploiting the logic of application classification in business application architecture development. Although existing application classification models do not necessarily have the best possible fit with a reference model for business application architecture development process, the logic as such is valid.

The fourth potential enhancement issue in enterprise architecture frameworks is the missing enterprise architecture development method, a reference model for architecture development process or development analyzing method. Only the enterprise architecture framework by Open Group (Open Group 2002) encompasses a real enterprise architecture development method or development analyzing method. The other frameworks either exclude it completely or include only some vague guidelines. For example, unexpectedly, the best known Zachman enterprise architecture framework (Zachman 1987) does not have an enterprise architecture development method, reference model or development analyzing method. In addition, because the focus of this thesis is in business application architecture and not in the whole enterprise architecture, this affects also the reference model for business application architecture development process. Therefore none of the existing enterprise architecture development methods or development analyzing methods are applicable and consequently a novel reference model for business application architecture development process is presented in Chapter 4.1.
The business application architecture framework proposed in this study is limited to business applications only. Therefore, general applications and information technology infrastructure issues have been excluded. There are several reasons for the selected scope. First, business applications are one of the most critical parts of an enterprise architecture. Second, a business application architecture is closely linked with business drivers and business requirements, thus a business application architecture has a major impact on how business is run. Third, as a consequence of selecting the application driven approach, technology infrastructure issues are handled mainly business application architecture driven. This means that because off-the-shelf applications are selected, they set the constraints and give guidelines for selecting the technology platform underneath.

According to Periasamy and Feeny (Periasamy & Feeny 1997) an application architecture should have two levels. A more general higher level for management, for the base for decision making and for communicating the basic principles of the application architecture. The second level is more detailed and is used for project implementation. In this study the focus is on the higher level of business application architectures.

The framework suggested in this study results from a study of various approaches discussed in the literature (Anthony 1965, Gorry and Scott Morton 1971, McFarlan 1984, Ward 1990, Zachman 1987, Open Group 2002, CIO Council 1999, NCR Corporation 1996). The proposed business application architecture framework has two main components: a reference model for business application architecture development process and a classification model for business applications. The business application architecture framework is presented in following sub-chapters. Although a business application architecture framework is used to find answers to research questions presented in Chapter 5.2 and consequently to increase general knowledge of business application architectures and business application architecture development processes in this study, it can equally well be used to support business application architecture development.
4.1 Reference model for business application architecture development process – application driven approach

The reference model for business application architecture development process is an essential part of the business application architecture framework. The reference model for business application architecture development process is used in this study in investigating the characteristics of business application architecture development processes. However, it can help also in the actual development of business application architectures.

The business application architecture development process is a process where a target business application architecture is defined. The development process should be based on the company strategy. The scope of the process can vary from all the business applications to just few key applications. The duration of the business application architecture development process varies substantially in different companies. Typically the development of a target business application architecture is realized in a short time period, for instance within a couple of months, but then the implementation of the target architecture may take several years. However, because of this long implementation period some elements of target business application architecture will change during the process and as a result the business application architecture development process is partly iterative. Normally the management of the company is involved in the development process. The development of a target architecture may be guided by external consultants or it may be headed by personnel. A business application architecture development process may be executed on a business unit level or on a company level. In large companies there may be several development processes ongoing in parallel.

According to Curtis et al. (1992, p. 76) a process model is an abstract description of an actual or proposed process that represents selected process elements that are considered important to the purpose of the model and can be enacted by a human or machine.

Curtis et al. (1992) present five basic uses for process models:
- **Facilitate human understanding and communication** requires that a group be able to share a common representational format
- **Support process improvement** requires a basis for defining and analyzing processes
- **Support process management** requires a defined process against which actual project behaviors can be compared
- **Automate process guidance** requires automated tools for manipulating process descriptions
- **Automate execution support** requires a computational basis for controlling behavior within an automated environment

The reference model for business application architecture development process is a process model in that respect that it presents a proposed process, which can be used in developing target business application architecture. The reference model can be used in analyzing, comparing and enhancing actual business application architecture development processes. In this thesis reference model for business application architecture development process is used for analyzing development processes. According to the goals for process models by Curtis et al. (1992) the reference model for business application architecture development process can be used to facilitate human understanding and communication, to support process improvement and to support process management.

In the reference model for business application architecture development process the application driven approach has been chosen. This means that commercial off-the-shelf software is utilized instead of developing software based on requirements. The application driven approach has been chosen, because it is argued that in practice available enterprise applications set the constraints for business application architecture work. Also, in this study the strategy of exploiting off-the-shelf packages instead of developing own applications has been chosen. This is supported by several authors (e.g. Davenport 1998, Kara 1999, Wiers 2002). Fox et al. (1997) identified the following benefits in using COTS (commercial off-the-shelf software):
- Using COTS products would reduce development costs and overall schedule
- As a corollary, the development cycle would be accelerated
- Feasibility demonstrations could be put together quickly
- End-product quality would be higher as measured by a richer feature set and increased system robustness (assuming the selected COTS product is mature)
- COTS vendors would provide maintenance for their COTS products

Maintenance on identified problem solutions is provided by the COTS software vendor, but problem investigation and identification by the software vendor are the most costly parts of COTS software maintenance.

Although the proposed business application architecture framework is meant for analyzing and enhancing business application architecture development based on commercial off-the-shelf software, it is also valid if customized applications are used. However, even though also business application architecture development processes where customized applications have been be used as components can be analyzed with business application architecture framework, but the framework does not support the analyzing or enhancing of software development as such.

The proposed reference model for business application architecture development process has seven consecutive phases. These phases are 1. IT and business alignment 2. Information requirement analysis and information architecture 3. Analysis of initial business application architecture 4. Development of target business application architecture 5. Planning and prioritizing 6. Business application architecture implementation and deployment 7. Business application architecture change management. The phases of business application architecture development are illustrated in Figure 4.1. Each phase is described and justified in more detail in the following section.
Figure 4.1. Reference model for business application architecture development process.
Table 4.1 presents a summary of output of different phases of a reference model for business application architecture development process.

**Table 4.1. Output of different phases of a reference model for business application architecture development process.**

<table>
<thead>
<tr>
<th>Phase in the reference model</th>
<th>Tools to support the phase</th>
<th>Output of the phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. IT and Business alignment</td>
<td>- e.g. Alignment model from Broadbent &amp; Weill (1993)</td>
<td>- Description of business vision and business strategy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Identified key business processes and critical success factors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Identified business requirements for business application architecture development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Identified relevant stakeholders</td>
</tr>
<tr>
<td>2. Information requirements and information architecture</td>
<td>- e.g. Entity Relationship Model by Chen (1976) or simple information architecture description as shown in Table 5.4</td>
<td>- Description of initial information architecture and description of target information architecture</td>
</tr>
<tr>
<td>3. Analysis of initial business application architecture</td>
<td>- Business application classification model</td>
<td>- Classified description of initial business applications</td>
</tr>
<tr>
<td></td>
<td>- Reference model for business application architecture development process, steps in phase 3</td>
<td>- Identified effective applications in initial business application architecture</td>
</tr>
<tr>
<td>4. Development of target business application architecture</td>
<td>- Business application classification model</td>
<td>- Classified description of target business application architecture</td>
</tr>
<tr>
<td></td>
<td>- Reference model for business application architecture development process, steps in phase 4</td>
<td></td>
</tr>
<tr>
<td>5. Planning and prioritizing</td>
<td>- IT project and IT investment evaluation methods as listed by Hochstrasser (1990)</td>
<td>- Identified top level projects to be undertaken</td>
</tr>
<tr>
<td>6. Business application architecture implementation and deployment</td>
<td>- Implementation methods and methodologies for different applications provided by the system integrator (e.g. Accelerated SAP)</td>
<td>- Implemented target business application architecture</td>
</tr>
<tr>
<td>7. Business application architecture change management</td>
<td>- e.g. ITIL Service Management procedures</td>
<td>- Controlled changes in target business application architecture</td>
</tr>
</tbody>
</table>
Phase 1: IT and business alignment

One critical challenge for information systems is alignment with the business vision and strategy. Several authors have stated this over the years (e.g. Ives et al. 1993, Feeny & Willcocks 1998, Feld & Stoddard 2004, D’Souza & Mukherjee 2004). To ensure that information systems and information technology are aligned with the business strategy is the natural first step when developing a business application architecture. The objective of this phase is to get an understanding of the business environment and business strategy and the requirements and constraints they set for the business application architecture. In this phase an initial business architecture is described and a target business architecture defined. Management support for business application architecture work is essential, as for any other IT/IS strategy work, and this should be ensured before getting started. According to a number of surveys, management support for IT/IS strategy development is a prerequisite for success (e.g. Luftman & Brier 1999, Peppard & Ward 1999, Teo & Ang 2001).

The first step should be the description or definition of the business vision and business strategy. Here it is assumed that a business strategy exists in the organization in some form and the exercise is rather to collect information by gathering material and interviewing people in the organization. After a common understanding of the business strategy and goals is achieved, business processes and critical success factors (CSF) should be defined and described. Here the focus ought to be in key business processes, which are linked with business applications. Rockart (1979) defines a critical success factor as being “the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization”. The important area for determining CSFs, as a part of business application architecture development, is the business unit, since this is the practical level to determine strategy (Ward & Peppard 2002). However, CSFs (or business drivers) that are common for the whole company, should be identified to ensure ground for a global business application architecture (Ives et al. 1993).
In addition to the business strategy and business processes, a complete business architecture includes description of functional, organizational and geographical aspects of the business environment. All these would be useful to complete for an initial business architecture and more importantly, for the target business architecture. However, it is wise to be practical and in each case it should be considered how comprehensive the business architecture description and analysis must be.

A typical feature in all enterprise architecture frameworks is that they take into account the perspective of different stakeholders. As default three stakeholder groups are included in proposed framework. These are management, users and IT management. These are quite similar stakeholders as in TOGAF and in other literature (Barlow 1990, Open Group 2002), but much simpler than in the Zachman and the FEAF frameworks (Zachman 1987, CIO Council 1999). Particularly the involvement of business management is emphasized, because the role of business managers in the process of developing IS strategy (or business application architecture) is vital (e.g. Dutta 1995, Armstrong & Sambamurthy 1999, Ross & Weill 2002). These views have been selected, because they present different types of groups of stakeholders in the organization, but are still a limited number and keep the framework simple enough. This is because according to several authors (e.g. Whitman et al. 1998) it is difficult to relate the views to each other and to maintain consistency.

Enterprises operate in an external environment and many aspects of it need to be analyzed in the business strategy process. According to Porter (2001) we are entering a new stage of development, where new technologies enable integration of value chains in different companies and thus form a set of value chains in the entire industry. Consequently, external parts of this set of value chains will effect each company in the setting. As well as the internal environment in the company affects the business application architecture work (Sullivan 1985), similarly the influence from external context needs to be considered in business application architecture development. Competition, partners, technology innovations and economical or social environments may set requirements for the business application architecture. In different industry
sectors this influence varies a lot and not much can be said on what would apply in all cases. However, the effect of the external environment needs to be covered in the IT and business alignment phase.

**Phase 2: Information requirements and information architecture**

In the information requirements and information architecture phases information requirements are collected, an initial baseline information architecture is described and a target information architecture developed. Determining information requirements is an essential part of all information system development models (e.g. Royce 1970, Boehm 1988) and according to several authors a critical part of any information system project (Hevner & Harlan 1995, Browne & Rogich 2001). Consequently, it is a natural part to be included also in the reference model for business application architecture development process. Equally, because information architecture is one of the main outcomes of the information requirements determination process, information architecture too must be included in the reference model for business application architecture development process. The target information architecture must support the target business architecture and critical success factors. The main reason for building an information architecture is to eliminate redundancy in data and business processes. An information architecture is a technology-independent model of an enterprise’s data requirements consisting of diagrams and descriptions of the data (Van Den Hoven 2003). A well-developed information architecture reveals overlap in data entities that exist in various business applications. Typical multiple data entities are customer, supplier and product data.

When describing an initial information architecture and developing a target information architecture, any of the well-known data modeling techniques, such as Entity Relationship Model by Chen (1976), can be used. Davis (1982) defines two levels of information requirements. First, the organizational information requirements to define an overall information system structure and to specify a portfolio of applications and databases are presented. Second, the detailed information requirements for an application
are discussed. In the proposed framework the focus is on organizational level information architecture modeling and detailed data modeling and database design have been excluded. As a consequence of application driven approach the business applications will in most cases set the limits for data modeling and database structure. There is still a clear need for high level information architecture to manage which business application is the master source for each data entity, such as customer data, and to avoid overlap of the same information in various applications.

In describing an initial information architecture and a target information architecture on an enterprise wide level and a business unit level (or in any other dimension, which is not enterprise wide) information entities should be distinguished. This has to be defined in each case, because for example in some companies basic product information may be a common data entity and in some organizations it may vary between different business units.

**Phase 3: Analysis of initial business application architecture**

Understanding the initial situation is a prerequisite for being able to develop a business application architecture for future needs. Analyzing the initial situation is vital, because the initial status represents the starting point from which any possibly required change begins. The importance of understanding the current situation and processes in any change process is stressed by many authors (e.g. Davenport & Short 1990, Hammer 1990, Ward & Peppard 2002). In analyzing an initial business application architecture the following steps are proposed:

1. Identification of key business applications that are relevant applications for the organization
2. Classification of these key business applications based on the purpose of the application. The classification model based on the purpose of the business application is proposed in Chapter 4.2 of this thesis.
3. Assessment of coverage of business applications compared to business processes and information architecture and how well business applications meet current business needs.
4. Assessment of how business applications match with requirements set by defined stakeholders (management, IT management and users).
5. Evaluation of the effectiveness of the initial key business applications.
6. Recognition of possible unrealised potential or non used features in initial applications.
7. Evaluation of the level of integration.
8. Assessment of risks and robustness of initial key business applications (e.g. small supplier or obsolete technology).

In identifying key applications it is important to interview key people in the organization to get different views on which applications are seen as crucial. Additionally documentation and internal records are useful in identifying most important business applications. Assessing the coverage of business applications compared to business processes and information architecture means that there may be uncovered areas. This may be as a result of changes in the way the to operate, technology innovations or changes in the scope of the business (e.g. acquisition). These need to be taken into account when developing target business application architectures. Step four, checking stakeholder requirements is worth doing, because some of the key stakeholder groups may have been forgotten in developing the initial business application architecture. As described before, in this model three stakeholder groups are included: management, IT management and users.

Evaluation of effectiveness is for identifying effective business applications in the initial architecture. There may be some elements that are very effective for the organization even though they are not obvious when looking only at the big picture. For instance if there is a unique part of business process, which is managed with a small, customized application e.g. to meet legal requirements in a certain country.
In quite many cases there are business applications where all the features are not utilized comprehensively. This may be because during the implementation phase the priority might have been to stay in budget and in schedule, not to exploit all possible features in a particular application. Especially in ERP implementations this is typical (e.g. Ross 1998, Markus & Tanis 1999, Parr & Shanks 2000), because of the complexity of the application. Later on, after the actual implementation, it is worth checking if there are useful features available, before rushing into new investments. Also, it is likely that during the implementation the way that the application operates is not completely understood. This is supported by findings by Bresnahan and Greestein (1996) and Brynjolfsson and Hitt (1998), who found that it takes time for employees to understand and experiment with new technology before they can use it efficiently. Some sources (IMPACT 1998, Ward & Peppard 2002, p. 546) propose a ‘shakedown’ phase after the first implementation. In the ‘shakedown’ phase further changes to the business practices or further configuration of the software are made. To avoid customization, it is better to focus on basic implementation first and after the application has been used for some time to re-evaluate the need for customizations users have requested.

Steps seven in the analysis of the initial business application architecture is for analyzing which business applications are integrated, how tight these integration interfaces are and what information is transferred between applications. This has an impact on the target business application architecture, if some current applications will be replaced and some will remain as they are. For example: the current CRM application is integrated with the current ERP application and basic customer information is transferred from CRM to ERP. In a target business application architecture the current CRM is to be replaced, because it is obsolete. Then a new interface has to be built and data field mapping exercise performed to see that all data fields required by ERP exist in the new CRM. This step can be combined with identifying and classifying initial business applications (Step 1).

Risk assessment of initial key applications is to validate their vitality for the target business application architecture. Some of the applications may have good compatibility
also with future business requirements, but for example if the technology is obsolete, the vendor’s survival is uncertain or the application’s support from the vendor is uncertain, choices should be made carefully. On the other hand, some applications may have an acceptable risk level and compatibility with future business requirements, but do not fit in the whole target business application architecture. For instance, if one key driver in a target business application architecture is to harmonize database structures and to achieve tight integration between applications, and a particular application can not be integrated to other required applications.

**Phase 4: Development of target business application architecture**

In the development of a business application architecture, the application driven approach has been chosen. This means that software packages available on the market are exploited instead of developing applications or building an enterprise architecture from small detailed components. Enterprise architecture frameworks have often taken an approach to describe all details with small components.

In the development of a target business application architecture a step-by-step approach is suggested. The steps of business application architecture development are formulated based on the basic logic of information system development methodologies, which have been described and evaluated by several authors (e.g. Vickers 1999, Livari et al. 2000, Grenci & Hull 2004) and influenced by logic of information requirement determination methods (e.g. Sau-ling Lai 2000, Havelka 2003). Additionally practical experiences in the industry are exploited. Existing enterprise architecture frameworks could not be utilized because excluding TOGAF (Open Group 2002), they do not have any development method, a reference model for architecture development or development analyzing methods. As a result the following steps are suggested:

1. Identification of the key business applications that are relevant applications for the target organization and for the target business requirements.
2. Description of the target business application architecture draft for key business applications. This business application architecture draft should be based on the results of IT and business alignment, information architecture and analysis of initial business application architecture phases. In this work it is proposed that the business application classification model described in Chapter 4.2 be used. In case of multiple business units, common elements of business application architecture need to be identified.

3. Ensuring the integrity of the information architecture and the target business application architecture. Follow the principle that each data entity (e.g. product information or customer information) should have one master application, where data is maintained and copied from there to other applications if needed.

4. Evaluation of how well the target business application architecture matches requirements set by defined stakeholders (management, IT management and users).

5. Analysis of the required level of integration between different business applications within the enterprise and external party applications.

6. Analysis of the gaps between the initial business application architecture and the target business application architecture.

7. Identification of potential development areas based on the gaps between the initial business application architecture and the target business application architecture.

8. Finalization of the target business application architecture paying attention to the possible practical constraints set by the initial business application architecture.

9. In case of multiple business application architectures in different business units the above steps need to be repeated.

It is important to note that there are differences in key applications of the initial business application architecture and the target business application architecture. For instance, the application to support project management is a key application in the initial architecture, but as a consequence of selling project business that application is not needed in the target business application architecture. In describing the business application architecture draft for key applications, the business application classification model helps to do it in a systematic way. Information architecture need to be developed to avoid
overlap of information entities in different applications. An application independent information architecture also improves the flexibility of the business application architecture, because possible changes in information requirements can be identified and responded to without ripping apart the whole business application architecture.

One aspect in a business application architecture is the flexibility and the level of integration of different applications. Several authors (Sprott 2000, Light et al. 2001, Morganwalp & Sage 2003) have noted the importance of flexibility in enterprise architectures. There are several reasons to support the aim towards a flexible architecture. First, possible rapid changes in business environment, which need a response from the business application architecture. Second, changes in the company structure because of acquisitions or mergers. Third, the agile response, if some applications become obsolete. Due to inevitable changes in business environments the flexibility of the business application architecture is one of the most critical factors in business application architecture development. To ensure this flexibility open interfaces and standard integration protocols should be applied whenever possible. Hence it is easier to change a particular part of the business application architecture without causing impassable problems for other applications. Integration is required between internal applications and towards external applications, such as customer applications.

Business application integration is required to ensure fluent business processes through the enterprise and to avoid overlap in information architecture entities. The principle in developing a business application architecture is that the more comprehensive applications are used as components of the architecture, the more inflexible the business application architecture will be. On the other hand, if the target is a more flexible business application architecture, then more independent applications should be used, but this leads to additional integration and interfaces. This may cause problems in data integrity and additional costs. There is no one correct approach, but in each case different perspectives should be considered when deciding on the level of integration in the business application architecture.
The requirement for business application integration is not limited to the company boundaries, but it concerns the entire supply chain. The key issue, in the integration of whole supply chain, is to improve co-ordination between supply chain members (Chandra & Kumar 2001). However, despite years of process breakthroughs and elegant technology solutions, an agile and adaptive supply chain is still an unattainable goal (Bromberger & Hoover 2003). For obvious reasons the complexity of the integration exercise increases, if external parties also get involved.

If a company has several business units with different requirements and different business application architectures, a multiple level business application architecture needs to be developed. This can be done by first identifying common elements in the business application architecture and then repeating the development steps of a business application architecture on a business unit level. The integrity of these two levels of a business application architecture needs to be ensured. Common versus local issues in the architecture varies in each company and they can be a source of competitive advantage (Broadbent & Weill 1997).

**Phase 5: Planning and prioritizing**

The main issues in the planning and prioritizing phase are to identify the top-level projects to be undertaken in moving from the initial environment to the target business application architecture, evaluate the implementation options and prioritize these implementation projects based on dependencies, resources, costs and benefits. It is inevitable that investments are required in this phase. Thus, the ability to manage application investments and other related investments is essential competence when planning and prioritizing business application implementations.

The application driven approach described in previous sections is followed when identifying major projects and evaluating implementation options. Therefore, the proposed business application classification model is suggested also for this purpose.
ERP application is probably one of the most critical applications in a company’s business application architecture. Therefore, particular attention and effort should be addressed to ensure that the ERP part of the business application architecture is managed properly. In addition ERP implementations seem to cause considerable problems for companies (Davenport 1998, Stedman 1998, Parr & Shanks 2000). Thus, there has been some criticism towards ERP applications and proposals to use best of breed applications instead (Light et al. 2001).

In prioritizing there are several perspectives, which need to be taken into consideration. Ward and Peppard (2002) suggest three factors to be included when assessing the priorities for information system investments. First, what is the most important thing to do, based on identified benefits. Second, what can be done, based on available resources and third, what is likely to be a success, based on the failure risks of each investment. It is proposed here that the aspect of rational implementation order in terms of functionality of the whole business application architecture should be added. This means that for example an ERP application is required before it is sensible to implement a CRM application or an e-business application. This is because ERP has the basic information and functionality to support CRM and e-business applications, without ERP application orders entered to the e-business application cannot be delivered. This approach is in line with findings in the study of Riihimaa and Ruohon (2002) (in more detail in Chapter 3.2 – Application evolution models) and follows the principle logic of application evolution models presented by Kalakota and Robinson (2000) and Porter (2001).

**Phase 6: Business application architecture implementation and deployment**

The objective of the implementation and deployment phase is to implement applications included in the business application architecture. Implementation should follow the order defined in the previous phase. In this phase common guidelines and recommendations for implementation projects can be given. However, the implementation projects are an
interesting field of research of its own and detailed analysis has been excluded from this thesis.

**Phase 7: Business application architecture change management**

In the business application architecture change management phase maintenance procedures needed to keep the business application architecture up to date are determined. This process will continually monitor such things as new developments in technology and changes in the business environment and determine whether to formally initiate a new architecture evolution cycle (Open Group 2002). There are various valid approaches to change management, and several management techniques and methodologies that can be used to manage change, such as service management methods by ITIL (2004). It needs to be carefully considered if a new architecture development cycle is required or is adjustment of the existing business application architecture enough. Open Group (2002) suggest to classify required architectural changes into three categories:

- **Simplification change.** A simplification change can normally be handled via change management techniques.
- **Incremental change.** An incremental change may be capable of being handled via change management techniques, or it may require partial re-architecting, depending on the nature of the change.
- **Re-architecting change.** A re-architecting change requires putting the whole architecture through the architecture development cycle again.

However, the change management of the architecture is an interesting field of research of its own and detailed analysis has been excluded from this thesis.
4.2 Proposed classification model for business application architecture analyzing and development

Classifying applications helps to understand the contribution expected from current and future applications in the enterprise. Application classification models provide instruments for balancing the application portfolio and the life cycle of applications. Classifying applications is an effective way of managing applications’ portfolio (Ward & Peppard 2002).

As described in Chapter 3.1 there are several classification models (Anthony 1965, Gorry & Scott Morton 1971, McFarlan 1984, Turban et al. 2001) available. All these application classification models have taken a different perspective to classify applications, in one way or another. In Anthony’s (1965) model the basis for classification was stratification of management activity in an organization. He divided management activity into strategic planning, management control and operational control. Therefore he classified applications using the same logic. Gorry & Scott Morton (1971) classified management information systems and in addition to Anthony’s management activity, they also used the decision-making perspective as classification criteria. However, their perspective was based on different types of decisions (structured, semi-structured and unstructured) rather than on the level of management that was making the decisions. Turban et al. (2001) used the number of users and the level of decision-making as classification criteria. The classification result is very similar to Anthony’s model because of the nature of organization structure: the number of users (people) diminishes as the management level raises.

A common factor for all the classifications described above is, that in one way or another, the applications are classified based either on the level of organization using the application or the type of decisions the application supports. Classifications are not based on the applications themselves. McFarlan (1984) introduced a classification that was based on the nature of the application itself rather than the type of users or organizational level. He divided applications to strategic, key operational, high potential and support.
The difference is that an application may be, for example, strategic regardless whether management or employees use it. The CRM application is a good example, because in some companies it may provide a strategic competitive advantage, but only employees and middle management are using it. Classification models by Weill and Broadbent (1998) and by Kalakota and Robinson (2000) are similar to McFarlan’s model in the respect that also in those models application classification is based on the purpose of the application. However, Weill and Broadbent have included also technologies and not just applications in their model. On the other hand, Kalakota and Robinson’s model differentiates from other models, because it has considered also the external parties involved.

A summary of key features in different application classification models is shown in Table 4.2.

Different classification criteria and categories in each classification model are shown in Table 4.2. The fundamentals in various models are fairly similar, but the classification criteria and categories are different. Because of this diversity the model that fits best in each situation depends on the circumstances.
Table 4.2. Summary of different application classification models.

<table>
<thead>
<tr>
<th>Model</th>
<th>Classification criteria</th>
<th>Categories in the model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthony</td>
<td>Stratification of management activity</td>
<td>-Planning systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Control systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Operational systems</td>
</tr>
<tr>
<td>Gorry &amp; Scott Morton</td>
<td>Stratification of management activity</td>
<td>Columns:</td>
</tr>
<tr>
<td></td>
<td>-Decision types</td>
<td>-Planning systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Control systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Operational systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rows:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Structured decisions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Semi-structured decisions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Unstructured decisions</td>
</tr>
<tr>
<td>McFarlan</td>
<td>-Current and expected future contribution to the company</td>
<td>-Key operational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Strategic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-High potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Support</td>
</tr>
<tr>
<td>Weill &amp; Broadbent</td>
<td>-Purpose of use of the information technology</td>
<td>-IT infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Transactional IT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Informational IT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Strategic IT</td>
</tr>
<tr>
<td>Kalakota &amp; Robinson</td>
<td>-Purpose of use of the application</td>
<td>ERP, EAI, BI, Administrative control, Management control, CRM, SCM, Selling Chain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Management</td>
</tr>
<tr>
<td>Turban</td>
<td>-Management level of users</td>
<td>-Strategic</td>
</tr>
<tr>
<td></td>
<td>-Number of users</td>
<td>-Management support systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Managerial systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Operational systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Office automation and communication</td>
</tr>
<tr>
<td>Proposed model</td>
<td>-Purpose of use of the application</td>
<td>-Back end applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Front end applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Engineering applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Management tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Communication applications</td>
</tr>
</tbody>
</table>

Based on the analysis of existing application classification it seems that models described in Chapter 3.1 could be enhanced, when analyzing development of a business application architecture from the application driven point of view for manufacturing companies. There are several reasons why existing application classification models were rejected and a new application classification model is proposed:

1. In most of the previous classification models the type of management activity or the types of decisions were the classification criteria. These were not seen as
suitable classification criteria in a building business application architecture or analyzing the development process of business application architecture.

2. Models by Anthony (1965) and Gorry and Scott Morton (1971) were too generic and thus they didn’t provide categories for contemporary business applications.

3. The model by Weil and Broadbent (1998) included also information technology infrastructure, which is left out of the scope of this study. Thus, their model is not suitable for the purpose of this thesis.

4. Except for Kalakota and Robinson’s (2001) model, new application classes for e-business, CRM or Supply Chain Management were not included.

5. Kalakota and Robinson’s (2001) model was rejected, because it has so many categories that it would have been difficult to use.

6. Reasons for the rejection of the model by Turban et al. (2001) have been given in previous chapters.

7. The business application architecture framework in this thesis is aimed to the manufacturing industry and features to support manufacturing industry specific requirements, such as support for engineering function, are not included in previous classification models. McFarlan’s (1984) model would have been logical to be used as such in this study, but it doesn’t support the industry specific features either.

4.2.1 Classification principle in proposed classification model

The following classification model is proposed to support analyzing of business application architecture development in manufacturing companies. As described in Chapter 1 typical function in a manufacturing company is the engineering function. Equally, as for analyzing, business application classification model can be used in developing business application architecture. In the proposed model classification is based on the purpose of the application itself and it is independent of organizational levels. Applications are classified as Back end applications, Front end applications, Management tools, Engineering applications and Communication applications. This
classification is illustrated in Figure 4.2. The actual applications shown in Figure 4.2 are just examples to clarify the logic of the classification model.

**Figure 4.2. Proposed application classification model for manufacturing industry.**

**Back end applications**

Back end applications are transactional applications that perform transactions and operations, which are not directly in the customer interface. Such transactions are for instance order processing, inventory management and accounting. Back end applications form the backbone of an organization’s business applications. Back end applications include for instance ERP, finance, human resource management and payroll. If the company does not have a comprehensive ERP system, these functions can be covered by several independent applications. Although ERP systems have clear advantages and an ERP package is the dominant strategy in enterprises to gain business process integration,
it is not always obvious that a company should implement a comprehensive ERP package. An alternative strategy would be to use best of breed packages for specific purposes (Light et al. 2001). The main reason for this alternative strategy is to achieve flexibility in the business application architecture. In several cases this maybe a better option, because case studies in literature highlight the unresolved inflexibility of ERP applications (e.g. Davenport 1998, Kumar & Van Hillegersberg 2000, Hagel & Brown 2001).

In earlier developmental phases of information systems Back end applications provided a competitive advantage. Yet, in 1990’s companies were pursuing competitive advantage with large ERP implementations. Currently every contemporary company is dependent on Back end applications which do not provide a competitive advantage anymore, but are a vital engine in running the business. Presently Back end applications enable the use of Front end applications, which provide the competitive advantage. Information systems evolution models (Kalakota & Robinson 2001, Riihimaa & Ruohonen 2002) clearly prove that without proper Back end applications this would not be possible. Often the lifetime of Back end applications is relatively long. This is due to the nature of Back end applications: there is no need to upgrade the latest features every year, if the basic operations are running on an acceptable efficiency level without the upgrades. Lloyd et al. (1999) made similar findings as they state that the amount of legacy systems in use remains high and their lifetime is long, because they provide reliable solutions for running the basic operations. In major ERP implementations obviously the effort required also limits the possibility to upgrade too often.

When comparing with earlier classification models it is clear that, Back end applications cover most of the application classes in Anthony’s (1965) model, except for some applications that can be placed in the Management tools category. This is due to the age of Anthony’s model. At that time applications were used to generate reports or for routine operations typically in the back office. Comparing with Turban’s (2001) model Back end applications equal partly with operational systems. Comparison with Gorry and Scott Morton’s (1971) classification is not applicable, because of the logical difference. Back
end applications can be identified in Kalakota and Robinson’s (2001) model, although the
classification is different. In McFarlan’s classification key operational and support
applications have similar features as Back end applications. In Weill and Broadbent’s
model (1998) Back end applications cover transactional applications and part of the
informational applications.

**Front end applications**

Front end applications are used in customer interface. Front end applications are
classified applications, which are used in customer interface or are utilized to create or
distribute value-added services for customers. Front end applications include for example
Customer Relationship Management (CRM), e-business and extranet applications. Value-
added services created and distributed with Front end applications are for instance
electronic user manuals, customer drawings and product service history information
databases. In companies dealing directly with consumers or end-users Front end
applications may include Point-of-Sale or shop management applications. As ERP
applications get more and more comprehensive in some cases they have features of Front
end applications, although ERP applications are classified as Back end applications in
this classification model.

Front end applications can not be found in Anthony’s or Gorry and Scott Morton’s (1971)
classifications, but similar elements can be identified in Kalakota and Robinson’s (2001)
classification. Turban’s (2001) classification does not include Front end applications as
such. In McFarlan’s (1984) and in Weill and Broadbent’s models there is a category for
strategic applications. Some of the Front end applications may be strategic, but as such
these application classes are not comparable.
**Engineering applications**

Engineering applications are used for engineering and R&D. These include for example Product Data Management (PDM) and CAD. Traditionally PDM and CAD applications are linked tightly together and currently also PDM and ERP are often linked (Soliman et al. 2001), but this creates problems relating to data overlap (Miller 1999). Engineering applications are characteristic for manufacturing companies. Especially these are used in manufacturing companies with engineering function, although Engineering applications can also be used for design. Engineering applications are often used in companies that deal with complex product data. This does not mean that the product itself would need to be complex, but it may include a lot of product related information. Another type of use is companies producing drawings. These drawings may concern for example products, product assemblies, product designs, lay-outs, system planning etc.

Engineering applications can not be found in any of the described classification models except Turban’s (2001) classification. In Turban’s model engineering applications can be included, but they classify under ‘Management and expert support systems’ just as any other management support system and their unique features have not been taken into account.

**Management tools**

Management tools are applications used to support management activities in all levels of the organization. Management tools are typically applications that do not make transactions, but collect, refine and distribute information to support management activities. Management tools include applications such as supply chain management, data warehouse, business intelligence applications, budgeting and reporting. These applications are often integrated with Back end, Front end and Engineering applications and they collect data from these applications and refine it as useful information. A typical Management tool is a data warehouse application, which collects data from various ERP applications in the enterprise, refines it and then distributes information throughout the enterprise. This information can be for example financial figures from various business units. Another useful way to exploit data warehouse is to use it to distribute information.
in the supply chain. This means quotations, orders, stock count and Work In Progress. With data warehouse it is possible to achieve visibility through the supply chain without heavy ERP implementation. However, the difference is that data warehouse is not a transaction system, so it only distributes information, but does not automate transactions in order fulfillment process as an ERP system would do. This is why data warehouse is classified as a Management tool, not as a Back end application. As Inmon (1999) states “Data warehousing solves the problem of integration, except it solves the problem only for informational processing. As appealing and as powerful as data warehousing technology is, it is not a solution for operational transaction integration.” The difference between utilizing data warehouse or an ERP application to support information flow or information flow and transactions is illustrated in Figure 4.3.

![Figure 4.3](image)

**Figure 4.3. Principle of data warehouse and ERP application in supporting information flow.**

In Figure 4.3 it’s shown that an ERP application manages transactions and information and data warehouse can manage only information flow. However, this may be sufficient in many cases, particularly considering the low investment cost of data warehouse implementation compared to ERP implementation.
Management tools can be found in some form in most of the described application classification models (Anthony, 1965, Gorry & Scott Morton, 1971, Weill & Broadbent 1998, Kalakota & Robinson 2001, Turban 2001). In McFarlan’s classification the logic is different and thus difficult to compare.

**Communication**

Communication applications are used for collaboration and communication within the company and with external parties. Communication applications include applications such as e-mail and groupware.

Communication is included only in Turban’s (2001) classification model where it is combined with office automation and in Weill & Broadbent’s (1998) classification, where it is included in informational IT. All other described application classification models exclude communication as an application category.

**4.2.2 Features of the proposed business application classification model**

The business application classification model can be used as a tool in analyzing and enhancing the business application architecture development process. The purpose of the proposed classification model is to use it in analyzing initial business application architectures and in developing and describing target business application architecture. The classification model enables structured and comparable presentation of different business application architectures. The model is focused on illustrating business application architectures on a relatively high level. Therefore, it is not meant for detailed analysis of a particular business application.

In multinational companies it is likely that there are several business units with different types of business requirements. For example some units might be service business oriented dealing directly with end-users and others’ core competence might be mass
production and they deal only with distributors. In such cases the business application architecture can not be exactly the same for all business units. An other typical situation requiring several business application architecture elements simultaneously, is a company which has been built by acquiring businesses. The business application classification model can be used for defining which applications should be local and which applications should be common for the entire company. Although Ives et al. (1993) stress the importance of global business drivers, they recognize that the key business drivers are rarely exactly the same in each business unit. However, there are some common components and some elements that can vary in different units. As described in a study by Ives et al. (Ives et al. 1993) common critical success factors (they call a similar factor a global business driver) are the key to defining common elements in business application architectures. An other factor is the diversity of businesses, processes or functions. Even if the businesses are diverse, the application requirements are likely to be similar in certain functions, such as human resource and accounting or in activities such as communication. Yet, in accounting there might be differences in legal requirements in different countries and that may require at least local configuration in the finance application.

It is important to identify which applications or application areas in a business application architecture should be common and which applications can be different in various business units. The company should not aim at having as much common applications as possible or as much local applications as possible, it’s rather a question of finding the right balance suitable for each circumstance. According to Ives et al. (1993) global applications and databases must be readily accessible throughout the company, whereas local IT/IS solutions ensure the flexibility required in dealing with problems and opportunities unique to local environments. According to Allen et al. (1991, p. 436) the two most important criteria in choosing an information system architecture are flexibility and efficiency. The proposed application classification model can be exploited in defining common and local level applications to ensure flexibility. This principle is illustrated in Figure 4.4.
Figure 4.4. Principle of defining common and local business applications. Applications marked in the figure as LOCAL or COMMON are just examples to show the logic of classification model.

In Figure 4.4 common business applications are marked with the text COMMON and local level applications are marked with the text LOCAL. A business application architecture should ensure integrity between local applications and common applications. Local business applications may be very different in each business. Consequently, complicated interface structures are formed, because the interface between each local application and the common application has to be built separately.

An organization may have local business application architectures for business units in areas where they have local applications. However, common business applications should be descend from the corporate level business application architecture. When developing a business application architecture for a multinational company, attention should be paid to
local level business application architectures, the different applications in local units are not necessarily needed in each local business unit. There might be sites that are so small that it is not practical to develop a specific business application architecture for them. The principle of a multilevel business application architecture is illustrated in Figure 4.5.

![Diagram of multilevel business application architecture principle](image)

**Figure 4.5. Multilevel business application architecture principle.**

Figure 4.5 shows for instance that a corporation has common PDM and Management tools applications, but the ERP and payroll applications are local. This allows flexibility in business units, but on the other hand, results in integration issues between applications in various business units.

As a business application architecture has to ensure the integrity between local and common applications, the integrity of information is an issue to be taken into account. It is likely that information in different applications is inconsistent and therefore not comparable. The more common applications there are in the business application architecture the more likely it is to have consistent information in the applications.
The business application architecture framework presented in this chapter is used for analyzing business application architectures and business application architecture development processes in case companies. The analysis is presented in the following chapter. The selected case companies are leading manufacturing companies in their own field of business in Finland.
5 CASE STUDIES OF BUSINESS APPLICATION ARCHITECTURE

This chapter describes the empirical part of this research and consists of four case studies, in which the business application architecture development processes are described and analyzed. In Chapter 5.9 a cross case study comparison of four case studies is presented. The objective of the empirical part of this study is to increase knowledge of business application architectures and business application architecture development processes in the manufacturing industry. This is executed by exploiting the business application architecture framework developed in Chapter 4 in order to find answers to research questions presented Chapter 1.2, and in more detail in Chapter 5.2. The aim of the empirical part of this thesis is not to test the framework as such, but rather to use it as a tool to investigate business application architectures and their development processes and thus to prove the framework’s functionality in practice. The main tasks of this chapter are:

1. To find out what common factors can be identified in initial business application architectures in the four case companies
2. To find out how business application architecture development is performed in practice
3. To find out what common factors can be identified in target business application architectures in the four case companies

5.1 Obtaining case companies

According to Eisenhardt (1989, p. 536) the selection of the company to be investigated is one of the critical aspects in case research. The basic criterion is that the case company must be a typical representative of the theoretical category in question. In practice it can be argued that it is difficult to define what is a typical manufacturing company. Thus, a
multiple case study design was chosen to increase robustness and to improve external validity of this study. In a multiple case study case companies are chosen based on a prediction that they would provide similar results. In other words case design is a literal replication. Four case companies were selected to be studied. Case companies were selected based on practical reasons, such as the previous experiences the researcher had on two of the case companies, which helped in data collection. The researcher had been involved with the first company for some years before the actual research took place. Thus, the researcher was purely in an observing role at the time of the research. However, because the researcher had been involved with the company before, special attention was paid to ensure that interviews were objective. Additionally the, case report was reviewed by the management of the company in question. In the second company, the risk of loosing objectivity was higher, because the researcher was involved with the company still at the time of the research. In this case objectivity was pursued by interviewing several people in different positions in the company, including top management. This was done to avoid influence of individual opinions. Additionally, several other sources of evidence, such as archival records and documentation, were used. Despite all these efforts, the influence of the researcher’s involvement with two of the case companies could not be completely eliminated. However, when choosing the case companies it was evaluated that the possible influence of previous involvement was a minor concern compared to the advantage of getting valuable background information of the development processes in the case companies.

The companies that were approached, were leading companies in their own fields of business. Although these companies were all manufacturing companies, their products and fields of business were very different. Key features of each case company are illustrated in Table 5.1.
Table 5.1. Summary of case companies.

<table>
<thead>
<tr>
<th>Company size</th>
<th>Company 1</th>
<th>Company 2</th>
<th>Company 3</th>
<th>Company 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of the business</td>
<td>-SME company</td>
<td>-Large company</td>
<td>-Large company</td>
<td>-Large company</td>
</tr>
<tr>
<td>-Own manufacturing</td>
<td>-Own manufacturing</td>
<td>-Mainly mass production of consumer products</td>
<td>-Own manufacturing</td>
<td>-Made to order and assembled to order manufacturing</td>
</tr>
<tr>
<td>-Large projects</td>
<td>-Projects</td>
<td>-Several sites in several countries</td>
<td>-After sales business</td>
<td>-After sales business</td>
</tr>
<tr>
<td>-Single product sales</td>
<td>-Trading products</td>
<td>-Several sites in several countries</td>
<td>-Several sites in several countries</td>
<td>-Several sites in several countries</td>
</tr>
<tr>
<td>-One site</td>
<td>-Single product sales</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core competence</td>
<td>-Superior delivery performance</td>
<td>-Complete solutions</td>
<td>-Brand management</td>
<td>-Customer driven tailor-made production model</td>
</tr>
<tr>
<td>-Premium specialized products</td>
<td>-Wide assortment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customers</td>
<td>-Large corporations</td>
<td>-Wide variety from large to small businesses</td>
<td>-Consumers (distribution via retail chains)</td>
<td>-Several sales channels</td>
</tr>
<tr>
<td>-Some small businesses</td>
<td></td>
<td></td>
<td>-Entrepreneurs</td>
<td></td>
</tr>
<tr>
<td>Products</td>
<td>-Customised premium products</td>
<td>-Mainly mass products</td>
<td>-Some premium products</td>
<td>-Customized engineered products</td>
</tr>
<tr>
<td>-Wide variety of products from standard to customized</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case study design</td>
<td>Holistic case study</td>
<td>Embedded case study</td>
<td>Embedded case study</td>
<td>Embedded case study</td>
</tr>
</tbody>
</table>

5.2 Research questions of the study

The objectives in the empirical research of this study were to formulate answers to research questions presented. This was executed by investigating development processes in case companies by using the developed framework. The detailed empirical research questions are formulated based on the developed framework. The detailed research questions of this thesis are as follows:

Research question 1: What common factors can be identified in initial business application architectures in the case companies?
-How have initial business application architectures been analyzed?
-What are the main reasons to drive the change of initial business application architecture?
-What are the main elements and their level of integration in the initial business application architecture?
- What are the effectiveness, unrealized potential and risk factors in initial business application architectures?

**Research question 2**: How have business application architectures been developed in the case companies?

- Has there been any particular method in developing business application architectures?
- How are business requirements and business application architectures aligned?
- What different stakeholders are involved in business application architecture development?
- How has the external environment influenced business application architecture development?
- How have information architectures been used in business application architecture development?
- What practical constraints have been considered in business application architecture development?
- How are business application architecture implementation activities prioritized?

**Research question 3**: What common factors can be identified in target business application architectures in the case companies?

- What are the main elements and their level of integration in target business application architectures?
- What are the centralized and local elements in target business application architectures?

The case report of each case company is structured following the reference model for business application architecture development process as it is presented in Figure 4.1. The main topics in each case report are 1. IT and business alignment 2. information architecture 3. analysis of the initial business application architecture 4. development of the target business application architecture 5. planning, prioritising and implementation of the target business application architecture. Each of these main topics are then divided
into more detailed sub-topics, which are written in italic. These sub-topics follow the reference model for business application architecture development process presented in Figure 4.1 as well.

5.3 Data collection from the case companies

In order to meet the challenge of the research problem an intensive collection of data was required. Several sources of evidence were used in collecting, but interviews were used as the main source of data. To gain deeper understanding of the case companies and business application architecture development processes in the companies, background information was collected by interviewing people. The purpose was to interview people who had an important role in business application architecture development in the case company. Some of the persons were interviewed individually and some of them in small groups. The interviews were semi-structured, covering topics defined beforehand. In total, approximately 20 interviews were carried out. The interviews took place between May 2004 and November 2004 mainly in the premises of the case companies. Some additional information was gathered by interviews on the phone. The interviewed individuals represented a wide range of status from executives to users in case companies.

The questionnaire used in the interviews was loosely structured. This was because the phenomenon in question was relatively complex and different companies had planned and implemented their business application architectures using various procedures. Therefore, also the questionnaire had to be flexible to gain versatile information. The detailed questionnaire is presented in Appendix A.

In addition to interviewing, data has been gathered from documentation, such as internal reports, unofficial memorandums and company presentations. In case Company 1 and in case Company 2 data was collected also from archival records such as organizational charts and personal records. In case Company 3 the researcher had an opportunity to
make several site visits and therefore direct observation was used as one source of data. Direct observations meant observations during the site visits concerning how the users used different applications and how they felt about the coverage of applications’ features compared to the their requirements. In case Companies 1 and 2 participant observations were done. The researcher had the opportunity of participating in the business application architecture development processes in Company 1 and in Company 2. However, these processes took place before the actual case studies were executed and therefore interviews were also done in Companies 1 and Company 2 as well as in Company 3 and Company 4. Data collection methods in different case companies are illustrated in Table 5.2.

<table>
<thead>
<tr>
<th>Source of evidence used</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Archival records</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interviews</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Direct observations</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Participant observations</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In selecting the initial business application architecture that was to be studied there were two main perspectives to be considered. First, the moment of time that should be set as a starting point for the business application architecture development process and therefore for the initial business application architecture. Second, the scope and number of the business units to be studied in more detail in each case company. In terms of time different periods were selected for different case companies. The aim was to find a natural starting point to be set as the initial business application architecture. It could be change in strategy, major change in the business application architecture or change in business environment, for instance. The point of time chosen as the starting point for the business application architecture development process is described in each case company. Initial business application architectures are also described to correspond with that point of time. In selecting the units of analysis within the case company the objective was to choose a few typical units that could represent other units. In practice these
representatives were different business units in the company. The selected business units are described in more detail in each case.

5.4 Description of case companies

Case Company 1
Company 1 is a leading manufacturer of engineered solutions in one chosen customer industry segment. It operates in a business to business environment. Company 1 is a subsidiary of a large corporation. This corporation is the world's largest manufacturer of engineered products and solutions in its own field of business. In the corporation worldwide Company 1 is the global Center of Excellence for the industry segment in which it operates. Company 1 has one site that is located in Finland. The company has its own manufacturing operation and it has customers and distributors globally. The sales of Company 1 are less than 100 MEUR and it has a few hundred employees.

Case Company 2
Company 2 is one of the leading providers of products in its own field of business in Europe and a market leader in the Nordic countries. It manufactures and delivers complete solutions of engineered products and systems to its customers. The company operates in a business to business environment. It has separate operations in several countries around Europe. Company 2 has performed extensive and profitable growth for several years through acquisitions and organic growth. The sales of Company 2 are less than 500 MEUR and it has a few thousand employees.

Case Company 3
Company 3 is a leading brand company in its own field of business. It is a market leader in the Nordic countries. The company manufactures and delivers high branded consumer products. However, although products are consumer products, Company 3 operates mainly through a distribution chain. It has separate operations in several countries in
Europe. The sales of the Company 3 are less than 500 MEUR and it has over a thousand employees.

**Case Company 4**

Company 4 is currently one of the leading manufacturers in its own field of business. It manufactures and delivers tailor-made engineered products for its customers. The company operates in a business to business environment. Presently it is a subsidiary of a large corporation. This corporation operates in the same field of business as Company 4, but it also has other fields of businesses. The company has several sales sites and a few separate manufacturing sites. It has customers and distributors globally. The sales of Company 4 are more than 100 MEUR and it has a few thousand employees.

5.5 **Case Company 1**

5.5.1 **IT and business alignment**

An entrepreneur established Company 1 in the early 1970’s. After two other owners the company was sold to it’s current owner, a multinational corporation, in 1998. The change from a privately owned entrepreneur company to a part of a multinational publicly listed corporation naturally required a change in the strategy of the company. The major change in the company strategy also affected its information systems strategy. Therefore, this point in time was selected as a starting point for the initial business application architecture in this thesis.

*Critical success factors and critical business requirements*

The affect of owner change in Company 1 required re-thinking of business and IT alignment. The core of the strategy remained the same, but there were some additional elements as a consequence of the new global setting and environment. The following
success factors and business requirements were identified as critical in developing a business application architecture in the changed business environment:

- Superior delivery performance
- Customised high quality products for specific market sector
- Large system projects and comprehensive solutions for customers
- Long-term partnership co-operation with customers
- Center of excellence for specific market sector in a large corporation
- Continuous profitability with low operating working capital

In this Company “Superior delivery performance” meant supply chain responsiveness and reliable deliveries. “Customised high quality products for specific market sector” requires flexibility from the supply chain to be able to produce and deliver small lot sizes with high quality. This requires efficient production and engineering functions and flexible applications to support them. Due to the long lifetime of products sufficient after sales services were essential. On the other hand, characteristic for the company was that it also delivered comprehensive solution projects. This required a very different competence set (e.g. project management skills) than customised products operations. “Long-term partnerships with customers” required a good understanding and knowledge of the customer’s business. Being a “Center of excellence for specific market sector in a large corporation” was a new role for Company 1. A prerequisite for that was the ability to share knowledge within the corporation.

The key business processes and functions to be covered in the business application architecture are illustrated in Table 5.3.
Table 5.3. Key business functions in Company 1.

<table>
<thead>
<tr>
<th>ORDER FULFILMENT</th>
<th>ENGINEERING</th>
<th>SUPPORT FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quotations</td>
<td>R&amp;D</td>
<td>Management reporting</td>
</tr>
<tr>
<td>Sales</td>
<td>Product design</td>
<td>Accounting</td>
</tr>
<tr>
<td>Logistics</td>
<td>Systems planning</td>
<td>Payroll</td>
</tr>
<tr>
<td>Purchasing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliveries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make to order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembly to order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After sales</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Different stakeholders involved in business application architecture development

In Company 1 the business strategy development process was rather a process of reforming the strategy because of owner change, than developing a business strategy. Creating an information systems strategy based on business requirements was headed by the Operations Director and supported by IT management. The management team had a steering role when the information systems strategy was in the implementation phase, but not in developing the information systems strategy as such. Middle management of Company 1 was intensively involved in developing and implementing the information systems strategy and the business application architecture. Users were also intensively involved in developing and implementing the business application architecture. Users were very actively participating with IT management in the requirements definition phase. However, this detailed level of the business application architecture is excluded from this study.

Influence of business environment and external parties (partners, customers, suppliers and competitors) to business application architecture

In Company 1 the business environment had a major influence on the business application architecture and that was taken into account in the business application architecture development process. There were two main issues influencing the business application architecture. First, internal, which means that the company had joined it’s parent company. The parent company was a multinational global market leader in its own field of business. This affected business operations as well as information systems and
information technology. In terms of business operations Company 1 was totally independent and it had one site before joining the corporation. After joining the corporation Company 1 had to learn how to operate as a part of a large group. Although the company continued as an independent business unit there were issues such as logistics and distribution channels where the parent company was involved. Also, the company was selected as the global Center of Excellence of its field in the corporation. Consequently, this increased the importance of Company 1 within the parent company significantly as well as the international connections required. In addition, the parent company had certain policies concerning information systems that need to be taken into account in the business application architecture. This was a new approach in the company, because decisions regarding IT, and accordingly the business application architecture, could not be made purely by the management of Company 1 anymore.

The second issue influencing the business application architecture were the external parties, in this case, the customers. Company 1 was an inseparable part of the supply chain of its customers. Although the company itself was relatively small, its customers included large corporations, which expected integrated solutions from their suppliers. Therefore Company 1 had to build a business application architecture that enabled integration with their customers. Because these customers were large companies, they had high expectations and this required substantial effort from the company.

5.5.2 Information architecture

Case Company 1 did not have a separate information architecture. However, the main information requirements for different business applications had been identified in a information requirements determination process. Information requirements had been determined separately for each business application. The determination of requirements took place as part of implementation project of each business application. Requirements were determined by users and IT management and the determination process varied depending on the application in question. The most detailed process was executed with
the ERP application. Although requirements were determined, the company had not formed an information architecture based on this process.

Due to the low level of integration between applications there was quite a lot of overlap in data elements. Particularly product and account data was maintained in several business applications. This caused double data entry and therefore manual work and risk of error. Also, quotation/order data did not have a clear flow between sales and ERP applications, but had to be re-entered manually. A rough description of information architecture was generated for the purposes of this study. The initial information architecture of Company 1 is illustrated in Table 5.4. In Table 5.4 the primary information source is marked as Master. This means that a particular information entity is maintained in the Master business application and copied to other business applications, which are marked with X.

As shown in Table 5.4, product data is located in several business applications and therefore highlights a potential problem area. In terms of customer information the initial business application architecture was relatively good, because customer information was copied from a Master application (ERP A) to other applications. Just as product information, quotation and order data was maintained in several applications. Consequently, the initial business application architecture did not support fluent information flow in the quotation – order – invoicing process. This was clearly an area for potential enhancement of information flow.
Table 5.4. Key information entities in different business applications in Company 1.

<table>
<thead>
<tr>
<th></th>
<th>Customer data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Quotation/Order data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BACK END</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERP A</td>
<td>Master</td>
<td>Master</td>
<td>Master</td>
<td>Master</td>
<td>Master</td>
</tr>
<tr>
<td>FINANCIALS A</td>
<td>x</td>
<td>x</td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FINANCIALS A (payroll)</td>
<td></td>
<td></td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FRONT END</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYSTEM SALES CONFIGURATOR 1</td>
<td>x</td>
<td>x</td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRODUCT SALES CONFIGURATOR 1</td>
<td></td>
<td></td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOCUMENT A</td>
<td>x</td>
<td></td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRODUCT CATALOG 1</td>
<td></td>
<td>Master</td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFTER SALES 1</td>
<td>x</td>
<td>Master</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENGINEERING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDM 1</td>
<td></td>
<td>Master</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD A Systems planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAD 3-D 1 product design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MANAGEMENT TOOLS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REPORTING A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOGISTICS A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMUNICATION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COLLABORATION 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Company 1 the quality of Master data was relatively good. The main problem in the company was the non-integrated business application architecture. This lead to double entering data and therefore people simply forgot to maintain the same data entity in several applications or else there was the risk of entering errors.

5.5.3 Analysis of initial business application architecture

The initial business application architecture analysis follows the steps proposed in Chapter 4.1. The exact order of the steps has not been analyzed, because it may vary in
different organizations and the steps may be executed in parallel. Analysis of all the steps and their execution is, however, included whether or not they were in the process.

Identification and classification of key business applications and level of integration

In case Company 1 some key applications in the initial business application architecture had already been in place for quite some time. Because the company is a relatively small company, there had been no strategic intent or resources directed to business application architecture development. In developing the initial business application architecture Company 1 had not used any enterprise architecture framework or similar method. The initial business application architecture was a consequence of actions taken to meet fundamental business requirements and the influence of the business environment. Key business applications in the initial business application architecture are shown in Figure 5.1.

The backbone of Back end applications in Company 1 was the ERP application. The ERP application’s functionality included sales, production, purchasing, logistics and invoicing functions. In addition reporting was executed also with the ERP application. Financials were integrated with the ERP system, but through a different application. The financials application covered also payroll functionality, but in a different module.
Figure 5.1. Company 1 initial business application architecture.

Front end applications included a product catalogue, system sales configurator, product sales configurator and electronic manuals application. The product catalogue and electronic manuals application were distributed on a CD-ROM and they were not integrated with any other application. The Product sales configurator and the System sales configurator were not integrated with other applications. There was also an after sales application and document management application, which were not integrated with the other applications.

The company had a 3-D CAD application, which was integrated with PDM for product design as an Engineering application. Company 1 had a separate CAD application for
system design, which was integrated with the PDM application. The PDM application was integrated with the ERP application.

As a Management tool the company had a logistics application. The logistics application was used for generating reports for managing logistics. The logistics application was integrated with the ERP application. Reporting was done from ERP application and there were no additional reporting tools. In collaboration only a simple e-mail application was used and it did not include a shared calendar or any other collaboration functions.

Based on classification of the initial business application architecture some observations were made. First, the level of integration between applications was fairly low. Especially, the Front end applications were not integrated with any other applications. However, the Engineering applications were integrated. Second, the Management tools seemed weak because there were no reporting applications, only one application for supply chain management.

*Business applications coverage compared to initial business processes*
In principle the main part of core business processes and critical success factors was covered with functionality provided by the initial business application architecture. In Company 1 the issue was rather how efficient and robust the business applications were than if the required functionality was covered or not. This was noted particularly by IT management during the business application architecture development process. Business applications coverage was not analyzed systematically, but analyzing was done based on general observations. However, some remarks regarding business application coverage can be made. First, as stated in critical success factors, an important part of the company’s business were projects and after sales. These areas were not supported by the initial business application architecture. Second, “Long-term partnership with customers” required the capability of managing customer information, which was weakly covered in the initial business application architecture. Third, to achieve “Continuous profitability” the management reporting application should support control, although Company 1
already had a business application for logistics reporting. The logistics reporting application was useful when aiming at “Superior delivery performance”.

*Information architecture from different stakeholders’ perspective*

As stated before the company did not have an independent information architecture, so it could not be analyzed. From the perspective of the users, the initial business application architecture covered their requirements quite well with the exception of lack of support for project management and after sales services. From the management perspective a weak support for reporting was the main difficulty. From the point of view of IT management applications were relatively old and therefore demanding to maintain.

*Effectiveness of initial key business applications*

In the company effectiveness analysis was not performed in a structured way, but effectiveness evaluation was based rather on extensive experience of using the applications than on actual analysis. In the initial business application architecture some applications were identified as effective. An after sales application was customised for the company and it had special features supporting their field of business. As such the System sales configurator was a standard off-the-shelf package, but the company had put major effort in building configuration rules and logic into the application. Therefore, the application was effective and particularly the content had high business value.

*Recognition of possible unrealised potential in initial business applications*

The main business applications in Company 1 had been in use for a relatively long period of time. Consequently, users had learned to use available features in those applications quite efficiently. However, applications that had been implemented more recently, such as the logistics application and the sales configurators, had potential features to be utilised. In the ERP application material requirement planning (MRP) was available, but it was not used. This was identified as a potential area of enhancement. One clear issue of unrealised potential in the initial business application architecture was the low level of integration. By continuing to use the initial business applications, but integrating them tighter, additional efficiency would be provided.
Risk assessment and robustness of initial key business applications

Risk assessment of the initial business application architecture was executed in a very strict way. This was because the parent company had rigorous procedure to ensure Y2K compliance of all key business applications. The main issue in terms of business risk was the ERP application. The ERP application was not Y2K compliant or at least the vendor did not guarantee it. There was a possibility to upgrade, but it seemed likely of the vendor to stop development and support of the company’s ERP application. However, the ERP application was provided by one of the leading system integrators in Finland.

Another leading supplier provided the financials application, but it also included a potential risk of becoming non-supported in the future. Business applications in Engineering were seen as robust and vendors were leading providers and therefore they were assumed reliable. In Front end business applications the system sales configurator was robust and developed by a midsize company. However, due to change of ownership there was a risk that prices would increase significantly. The product sales configurator, after sales and electronic documentation applications were customised for Company 1. Vendors of these applications were evaluated as potential risks, because of their small size.

5.5.4 Development of target business application architecture

Development of target business application architecture analysis follows the steps proposed in Chapter 4.1. As in analysis of the initial business application architecture, the exact order of the steps has not been analyzed, because it may vary in different organizations, but whether these steps were included in the process or not is not analyzed and how they were executed is described.

In the company the business application architecture development process took a fairly long time and some requirements appeared later during the development process. In
developing the target business application architecture this company had not used an enterprise architecture framework or similar method. However, the company had used the application classification model proposed in this thesis in analyzing the initial business application architecture and in developing the target architecture.

In Company 1 the main drivers for changing the initial business application architecture were the risks related to the Y2K issue, the weakness of Front end applications and the low level of integration between applications.

*Identification of key business applications and description of target business application architecture draft*

Grounds for business application architecture development were the critical success factors and business requirements found in the “IT and business alignment” and in the initial business application architecture analysis. Identification and selection of key business applications for target business application architecture was executed in a rather organized matter.

Critical success factors and key business requirements conducted the following business application requirements. “Superior delivery performance” and “Customised high quality products” required efficient and flexible Back end applications and obviously a reliable data content in those applications. Customised products also required efficient engineering applications and a short response time for the whole supply chain. Therefore, tighter integration of applications than in the initial business application architecture throughout the supply chain was required. Because of “Large system projects and comprehensive solutions” applications to support project business and after sales were required. A prerequisite to manage “Long-term partnerships with customers” was an application for customer relationship management. Being part of a large corporation required an application for efficient knowledge and information sharing, which was not available in the initial business application architecture.
Some application areas from the initial business application architecture were selected as key business applications in the target business application architecture. These were ERP, financials, logistics application, collaboration, PDM, CAD for product design and CAD for systems planning. In addition Front end application areas such as document management, product catalogue and sales configurator were included in the target business application architecture.

In terms of applications themselves the most demanding change was the replacement of the initial ERP application (ERP 1). There were two reasons for this change. The first inevitable cause was that ERP 1 was not a Y2K compliant application. Therefore the only options were to upgrade it or to change it. Upgrading was possible, but it was not seen as a viable option in long term. Another reason for changing ERP 1 was that the parent company had plans to replace their obsolete business application in Europe. The parent company had already implemented ERP A application in two other continents and it seemed likely that ERP A would also be implemented in Europe. Because of these reasons Company 1 decided to choose ERP A as their new ERP application. However, key information requirements were determined and functional compliance with ERP A was checked before the decision. As a result ERP A was qualified for the target business application architecture. ERP A was one of the leading ERP packages, but it was not very strong in Finnish financials. Therefore it was decided that the company should continue with the initial financials application (FINANCIALS A) and this was chosen to be in the target business application architecture.

The logistics application was evaluated efficient and it had an important role in supporting the critical success factor “Superior delivery performance”. Therefore it was selected in the target business application architecture as application LOGISTICS A. The collaboration application COLLABORATION 1 was a simple e-mail application and therefore it was not sufficient for the target business application architecture, particularly because the importance of knowledge and information sharing had increased due to being part of a large corporation. Consequently, a new collaboration application COLLABORATION A was selected for the target business application architecture.
Another reason for changing the collaboration application was that COLLABORATION A application was a corporate standard in the parent company.

In the Engineering PDM application, PDM 1, was from a local vendor and was integrated with the CAD applications and with ERP 1 application. Because ERP 1 had to be changed in this integration, the interface was to be re-written. The required functionality in the PDM application was analyzed and based on that it was evident that the PDM functionality that was needed was relatively simple. Therefore, a change from the PDM application to PDM A, which was a add-on module to ERP A application, was decided. In addition to simplicity another reason for this choice was the seamless integration with the ERP A application. The CAD application for systems design was seen as efficient and robust and there was no reason to change it, thus the CAD application from the initial architecture was selected for the target business application architecture as CAD A.

The CAD application for product design, CAD 3-D 1, was evaluated as robust when the initial business application architecture was analyzed. However, during the development of the target business application architecture it turned out that the vendor of CAD 3-D 1 was not planning to provide support for CAD 3-D 1 anymore. Consequently CAD 3-D 1 had to be changed. In choosing a new 3-D CAD the major influence was that the parent company had chosen a corporation wide 3-D CAD application from a leading vendor. This application was evaluated and the available features were assessed as acceptable. Therefore, the 3-D CAD application used by the parent company was chosen for the target business application architecture as CAD 3-D A.

In Front end the document management application was customised for the company and despite the evaluated risk it (DOCUMENT A) was chosen in the target business application architecture, because its features increased value. A product catalogue (PRODUCT CATALOGUE A) was also kept in the business application architecture.

Company 1 was eager to keep the SYSTEM SALES CONFIGURATOR 1 application, but the risk of price increase was realised and they had no choice than to drop it from the
target business application architecture. This was unfortunate especially because of major
effort that had been put into creating all the configuration rules in the application. Most of
this data content could however be transferred to another application. To replace
SYSTEM SALES CONFIGURATOR 1 the company decided to develop a small,
customised system sales configurator (SYSTEM SALES CONFIGURATOR A).

Based on critical success factors and key business requirements, some new business
applications, which did not exist in the initial business application architecture, were
introduced in the target business application architecture. These applications were
customer relationship management (CRM), extranet portal, order transfer management,
reporting and archiving. The need for a CRM application was conducted from a key
business requirement “Long-term partnerships with customers”. Therefore CRM became
an application in the target business application architecture. An extranet portal was seen
as a good way to provide valuable services for customers. The required services were
mainly related to large projects. EXTRANET PORTAL A was chosen as a platform for
the portal solution.

Company 1 was integrated with some of its customers’ supply chains. These customers
were large corporations and they required capability to receive electronic purchasing
orders and capability to send electronic invoices to them. Therefore, an application for
managing these functions must be included in the target business application architecture.
The company selected ORDER TRANSFER A application for that purpose. One benefit
of choosing the ORDER TRANSFER A application was that at the same time this
application could be utilized with Company 1’s own suppliers.

In the initial business application architecture reporting was based on direct reports from
ERP 1 application, which was clearly not sufficient in long term. Thus, REPORTING A
was selected for management reporting in the target business application architecture.
Archiving was not a business critical function, but because of the implementation of the
ORDER TRANSFER A application increasing amount of invoices and orders became
electronic, which resulted in managing the whole order-invoice chain electronically.
ARCHIVING A was thus chosen as an application for managing electronic purchasing invoices approval process and archiving.

As a result of the business application architecture development process a target business application architecture draft was drawn. This target business application architecture draft is illustrated in Figure 5.2.

*Figure 5.2. Company 1 target business application architecture draft.*
**Integrity of information architecture and target business application architecture**

The company did not have an actual information architecture. Therefore, it was difficult to evaluate the integrity of the information architecture and the target business application architecture. The main conclusion that could be made from the initial information architecture (Table 5.4) was that especially product information was created in many applications (five in total). This was a clear improvement issue in the target business application architecture.

**Target business application architecture from defined stakeholders’ perspective**

The defined stakeholders were management, IT management and users. From the management perspective there was a clear improvement from the initial business application architecture to the target business application architecture. The main difference was improved reporting capabilities. IT management felt that some obsolete applications in the initial architecture were replaced in the target business application architecture. This helped in terms of required maintenance, but on the other hand increased the number of applications and required more maintenance effort as a whole. From the users perspective an apparent enhancement was the higher level of integration, which reduced the amount of manual work. The new applications, such as ERP, also had improved features to assist in several tasks.

**Required level of integration**

The integration requirements were based on static information entities, such as product information and customer information, and transactions, such as quotations, orders and invoices related to process flow. In Company 1 the same information entities existed in several business applications and some transactional information needed to be integrated to enable fluent process flow. In the target architecture information entities were very similar to those drafted in the initial information architecture. Information entities for the target architecture are illustrated in Table 5.5. Simultaneously Table 5.5 illustrates the high-level target information architecture of the company. In Table 5.5 the primary information source is marked as Master. This means that a particular information entity is
maintained in the Master business application and copied to other business applications, which are marked with X.

**Table 5.5. Information entities and high-level target information architecture in Company 1.**

<table>
<thead>
<tr>
<th>Back end</th>
<th>Customer data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Quotation/Order data</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP A</td>
<td>Master</td>
<td>Master</td>
<td>Master</td>
<td>Master</td>
<td>Master</td>
</tr>
<tr>
<td>Financials A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Archiving A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payroll I</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Front end</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Extranet Portal A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>-Order Transfer A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Document A</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Product Catalog A</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crm A</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>System sales</td>
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<td></td>
</tr>
<tr>
<td>Conspiritator A</td>
<td></td>
<td></td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Engineering</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDM A</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cad A System planning</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cad 3-D A Product Design</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Management tools</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporting A</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Logistics A</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The main difference between the target information architecture and the initial information architecture is that in the target architecture there is only one application where Master data is maintained. Consequently, tighter integration between applications than in the initial business application architecture was required.

In addition to static information entities, fluent processes, such as quotation and order flows, require integration of business applications. The integration interfaces in Company 1 are shown in Figure 5.3. In Figure 5.3 order data is marked with OD, quotation data (QuD), Product data (PD), customer data (CD), supplier data (SD) and book-keeping accounts (AC). The arrows illustrate the direction of data transfer. A bi-directional arrow indicates that information is transferred in both directions. For instance in Company 1 the
target was that the product data master was the ERP application. From ERP A product data is copied to PDM A application.

Figure 5.3. Integration interfaces in Company 1.

Analyzing gaps between initial business application architecture and target business application architecture

In Company 1 there were quite a few differences between the initial and target business application architectures. In the whole process, changing the ERP application demanded the largest effort. The other business applications that were changed were system sales
configurator, collaboration, PDM and CAD for product design. Additional applications were CRM A, EXTRANET PORTAL A, ORDER TRANSFER A, REPORTING A and ARCHIVING A.

*Finalizing target business application architecture considering practical constraints*

In Company 1 finalizing of the business application architecture was not consciously executed as a separate phase. In finalizing the target business application architecture it was decided that PRODUCT CATALOGUE A, DOCUMENT A and ORDER TRANSFER A should be integrated to EXTRANET PORTAL A. Practical constraints were also considered. The main practical constraint was the change of the system sales configurator. Ideally the company would have liked to keep SYSTEM SALES CONFIGURATOR 1, but due to high costs it was more or less forced to replace it with another solution. Due to limited resources and a relatively large gap between initial and target business application architectures, prioritizing the importance of applications was essential. The finalized target business application architecture is shown in Figure 5.4.
Figure 5.4. Finalized target business application architecture in Company 1.

The importance of EXTRANET PORTAL A increased during business application architecture finalizing, because several new features were integrated to it. The principle and content of EXTRANET PORTAL A is illustrated in Figure 5.5.
Figure 5.5. Principle and content of Company 1 extranet.

EXTRANET PORTAL A included primarily services for customers including mostly different types of electronic documentation, such as quality documents, user manuals or contracts. Other features included delivery performance reports and ORDER TRANSFER A application for integrating order and invoicing flow with customers and suppliers.

5.5.5 Planning, prioritising and implementation of target business application architecture

Some major tasks were identified in planning and prioritizing business application architecture implementation. The change from ERP 1 to ERP A demanded the largest amount of effort. Y2K compliance in ERP implementation was automatically first priority. Other challenging tasks were replacement of the system sales configurator and
development of an extranet portal. In addition an issue requiring resources was the relatively low level of integration in the initial business application architecture. To move from the initial to the target business application architecture the following top-level projects were identified:

- Implementation of the parent company’s ERP application
- Selection and implementation of a new CRM application
- Development and implementation of an extranet portal
- Implementation of a new reporting application
- 3-D CAD replacement implementation
- Replacement implementation of a system sales configurator
- Implementation of the parent company’s collaboration application

Later on during the process the following additional tasks were identified:
- Implementation of a small scale PDM application
- Implementation of a new archiving application
- Selection and implementation of a new order transfer application

In prioritizing the ERP A implementation had to be dealt with first, because of the Y2K problem and it being the backbone of the business application architecture. In Company 1 practicalities guided the prioritizing process. The company was relatively small and therefore resources were limited. Thus, they had to concentrate on one or two projects at the time. The order of implementation in Company 1 followed the logic described by Riihima and Ruohonen (2002) in their survey among Finnish industry. Implementation in the company was started with Back end applications and then followed by Front end and Engineering applications. After ERP A implementation the other projects did not have precise planned implementation priorities, instead the implementation order was defined by available resources for certain project. Rough timing and priorities during business application architecture development in Company 1 are illustrated in Figure 5.6.
| Business application architecture planning | Year 1 Q1-Q2 | Year 1 Q3-Q4 | Year 2 Q1-Q2 | Year 2 Q3-Q4 | Year 3 Q1-Q2 | Year 3 Q3-Q4 | Year 4 Q1-Q2 | Year 4 Q3-Q4 | Year 5 Q1-Q2 | Year 5 Q3-Q4 | Year 6 Q1-Q2 | Year 6 Q3-Q4 | Year 7 Q1-Q2 | Year 7 Q3-Q4 |
| ERP A implementation | | | | | | | | | | | | | |
| CRM A selection and implementation | | | | | | | | | | | | | |
| EXTRANET A development and implementation | | | | | | | | | | | | | |
| REPORTING A implementation | | | | | | | | | | | | | |
| PIM A selection and implementation | | | | | | | | | | | | | |
| CAD 3-D A implementation | | | | | | | | | | | | | |
| ARCHIVING A implementation | | | | | | | | | | | | | |
| ORDER TRANSFER A implementation | | | | | | | | | | | | | |
| SYSTEM SALES CONFIGURATOR A implementation | | | | | | | | | | | | | |
| COLLABORATION A implementation | | | | | | | | | | | | | |
| Other projects | | | | | | | | | | | | | |

Figure 5.6. Business application architecture development timing in Company 1.

As shown in Figure 5.6 the company focused in one or two projects at a time. This was due to limited resources. In prioritizing ERP A was implemented first, mainly because of the Y2K issue, but also because ERP formed the base for other applications. Front end applications like EXTRANET A, SYSTEM SALES CONFIGURATOR A and ORDER TRANSFER A were all implemented after ERP A. CRM A had to be postponed because of other projects.

Because the business application architecture development process is a continuous process, the current status of the business application architecture was briefly analyzed at the time of writing this thesis. The current status of the business application architecture in the company is illustrated in Figure 5.7.
**Figure 5.7. Current status of business application architecture in Company 1.**

As shown in Figure 5.7, there are still issues under development. The main differences compared to the target business application architecture are:

- CRM A application has been selected but not implemented
- The after sales module in ERP A is not in place
- COLLABORATION 1 is in use instead of COLLABORATION A
- DOCUMENT A is not integrated with EXTRANET PORTAL A
- SYSTEM SALES CONFIGURATOR A is not integrated with ERP A
Phase one of ERP A implementation was executed without the project and after sales modules. The project module is in place, but the after sales module is not in use yet. CRM A implementation has been delayed because of other more urgent priorities. It is not business critical whether Company 1 is using COLLABORATION 1 or COLLABORATION A as a collaboration tool and therefore implementation is waiting for available resources. DOCUMENT A and SYSTEM SALES CONFIGURATOR A are already in use but they are not yet integrated with other business applications.

5.6 Case Company 2

5.6.1 IT and business alignment

Late in the year 2000 management of the company decided to put effort into IT/IS strategy work. As part of that process also a new IT Director was recruited to formulate and implement the IT/IS strategy. Thus, the point in time when this IT strategy work was started was a natural moment to set as the initial business application architecture point for this thesis.

Critical success factors and critical business requirements

In Company 2 management did put some effort into ensuring IT and business alignment. When formulating the target business application architecture critical business requirements were identified. In identifying business requirements emphasis was on critical success factors that influenced business applications. The following business application architecture related critical success factors and requirements were identified and picked up from the company strategy:

- Business application architecture has to enable the execution of the business strategy
- A customer oriented way to operate
- Long-term total service and commitment
- Operational excellence and efficiency
- Innovative products and services
- Leadership in the European market by acquisitions and organic growth

“Customer oriented way to operate” in the company meant products that were high quality and designed based on the customer’s requirements. It also meant value added services for customers and flexible and accurate deliveries. For case company 2 value added services for customers meant electronic manuals, installed base and service history information of customer installations. “Long-term total service and commitment” required comprehensive service offering which again had to cover e.g. electronic manuals, installed base, service history information and spare part offering. “Operational excellence and efficiency” required capable logistics and information sharing through the supply chain. “Leadership in European market by acquisitions and organic growth” required a flexible structure, which was capable of supporting rapid growth. Innovative products required extensive use of applications probably also in the products or to support the products.

The key business processes and functions that needed to be covered varied in different sites. Total support for a whole range of processes and functions was required. These are shown in Table 5.6.
Table 5.6. Key business functions in Company 2.

<table>
<thead>
<tr>
<th>ORDER FULFILMENT</th>
<th>ENGINEERING</th>
<th>SUPPORT FUNCTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quotations</td>
<td>R&amp;D</td>
<td>Management reporting</td>
</tr>
<tr>
<td>Sales</td>
<td>Product design</td>
<td>Accounting</td>
</tr>
<tr>
<td>Logistics</td>
<td>Lay-out planning</td>
<td>Payroll</td>
</tr>
<tr>
<td>Purchasing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliveries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make to order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembly to order</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make to stock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shop floor control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After sales</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Different stakeholders involved in business application architecture development

The business strategy development process was a significant effort from the executive team of the company. Strategy development had an essential role in the meetings of the executive team. Therefore, the critical success factors were clearly stated by the business management. However, business management was not intensively involved when transforming critical success factors into business application architecture requirements. This transformation process was headed by IT management while business management had only a few meetings where business critical requirements and their implications to the business application architecture were confirmed. Middle management got involved in the process when business requirements were identified in more detail. The users were not involved in forming the requirements for the actual business application architecture, but they were involved in the process when requirements were defined for each business application. As stated in Chapter 4.1, this detailed level is excluded from the scope of the business application architecture proposed in this study. This definition is similar definition to the two application architecture levels used by Periasamy and Feeny (1997).
Influence of business environment and external parties (partners, customers, suppliers and competitors) to business application architecture

In analysing the business environment of Company 2, logistics flows appeared to have an essential effect when designing the target business application architecture. This was taken into account in the designing process. Business units in the company were relatively independent. This setting was mainly a consequence of several acquisitions. Due to this business logic a major portion of the deliveries from different business units were directly to customers or to their own distribution channels. The logistical flows of the company are illustrated in Figure 5.8.

![Figure 5.8. Logistical flows of Company 2. Numbers in arrows illustrate delivered products. Actual numbers have been changed to avoid revealing of confidential business information.](image)

As shown in Figure 5.8 a major part of material and information flows from various business units were with external suppliers and customers, and not with other business units. Only a minor part of deliveries was through a central warehouse, which was located in Business unit 1. This loose logistics chain between business units did not
necessarily require a common application for transactions and warehouse management. Obviously a common application for transactions would be useful, but not vital nor necessary and worth the investments and effort required for the implementation. Particularly considering that Company 2’s strategy has been to continue aggressive growth through acquisitions in the future, which would lead to an even larger number of business units in similar setting as illustrated in Figure 5.8. This observation had a major effect on designing of the target business application architecture.

5.6.2 Information architecture

Case Company 2 did not have a separate information architecture. The main information requirements had been identified, but there had been no actual mapping of information elements in different applications and the amount of overlap. Clearly there was some overlap especially in product and customer data. The primary principle had been to keep the ERP application as a master and maintain data there, but the principle had not been very strict. Although an information architecture had not been made, a rough description of it was generated for the purposes of this study. The initial information architecture of Business unit 1 is illustrated in Table 5.7.

As shown in Table 5.7 customer data and product data were located in several business applications and therefore potential problems were likely to relate to these areas.

In the company the quality of data has been very variable. Particularly in smaller business units the quality of data was poor. Even though the quality in some business units was on an acceptable level, the main problem was still the extensive variation of data content from the perspective of the whole company. This meant that in one unit product data might include a double amount of data fields and follow a different logic than in some other unit. Consequently, transforming product information into a consistent form was a major challenge.
Table 5.7. Key information entities in different business applications in Business unit I.

<table>
<thead>
<tr>
<th></th>
<th>Customer data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Quotation/Order data</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACK END</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>ERP A</td>
<td></td>
<td>Master</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>FINANCIALS I</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>PAYROLL I</td>
<td></td>
<td>X</td>
<td>Master</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ERP A ADD ON invoicing</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRONT END</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>AFTER SALES I</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QUOTATION A</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>DOCUMENT A</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTERNET SITE I</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>web catalog</td>
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<tr>
<td>ENGINEERING</td>
<td></td>
<td>Master</td>
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<tr>
<td>PDM 1</td>
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<tr>
<td>CAD A lay outs</td>
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<td>X</td>
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<tr>
<td>CAD A product design</td>
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<tr>
<td>MANAGEMENT TOOLS</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>REPORTING I</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>BUDGETING A</td>
<td></td>
<td>X</td>
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<tr>
<td>COMMUNICATION COLLABORATION A</td>
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</tbody>
</table>

During the business application architecture development process management and maintenance of some information entities like product data was centralized. This improved the quality of data significantly, because of the unified procedures and controlled content maintenance.

5.6.3 Analysis of initial business application architecture

Identification and classification of key business applications and level of integration

In case Company 2 the initial business application architecture was rather a consequence of various separate actions than a strategic goal. Consequently no enterprise architecture
framework or similar method had been used. In the company business applications were identified and classified using the classification model proposed in this thesis. The key business applications in the initial business application architecture are shown in Table 5.8.

**Table 5.8. Initial business applications in case Company 2**

<table>
<thead>
<tr>
<th></th>
<th>Business Unit 1</th>
<th>Business Unit 2</th>
<th>Business Unit 3</th>
<th>Business Unit 4</th>
<th>Business Unit 5</th>
<th>N/A Business Unit 6</th>
<th>N/A Business Unit 7</th>
<th>N/A Business Unit 8</th>
<th>N/A Business Unit 9</th>
<th>N/A Business Unit 10</th>
<th>N/A Business Unit 11</th>
<th>N/A Business Unit 12</th>
<th>N/A Business Unit 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACK END</td>
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<tr>
<td>ERP</td>
<td>ERP A</td>
<td>ERP 2</td>
<td>ERP 3</td>
<td>ERP 4</td>
<td>ERP A</td>
<td>ERP 6</td>
<td>ERP 7</td>
<td>ERP 8</td>
<td>ERP 9</td>
<td>ERP 10</td>
<td>ERP 11</td>
<td>ERP 12</td>
<td>ERP 13</td>
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<tr>
<td>Finance</td>
<td>ERP A</td>
<td>Finance 2</td>
<td>Finance 3</td>
<td>ERP 4</td>
<td>ERP A</td>
<td>Finance 5</td>
<td>ERP 7</td>
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<td>CRM</td>
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<td>Technical</td>
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<td>documentation</td>
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<tr>
<td>PDM</td>
<td>PDM 1</td>
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<td>TOOLS</td>
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<td>Reporting</td>
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<td>COMMUNICATION</td>
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<tr>
<td>Collaboration</td>
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<td>Collaboration A</td>
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</table>

At the time only Business units 1 to 6 were part of Company 2, but also applications from Business units 7 to 13 are shown in Table 5.8 to make the initial business application architecture easier to compare with the target business application architecture explained in Chapter 5.6.4. In Table 5.8 business applications are classified as proposed in the classification model in Chapter 4.2. Some conclusions concerning the initial business application architecture could be made. First, Back end applications were very heterogeneous. All business units, except Business unit 1 and Business unit 5, had different ERP applications and different finance applications. In Business units 1, 4 and 5 ERP applications covered also finance and in Business units 2, 3 and 6 finance was run by a completely different application than ERP. Therefore, one main objective when developing the target business application architecture was to unify this diversity of applications. The mixed assortment of applications was believed to cause a lot of hidden additional costs.
A second conclusion was that Front end applications were a weak part of the initial business application architecture, because except for Business unit 1 there were practically no Front end business applications. In Engineering all business units had the same CAD application, which, in principle, enabled exchange of drawings between business units. However, only Business units 1 and 2 had a Product Data Management (PDM) application and although Business units 1 and 2 had PDM, they were both different applications. As Front end also Management tools were a weak component of the initial business application architecture and only Business unit 1 had a separate reporting application. In Communication the collaboration application was already harmonised in the initial business application architecture phase. However, it was not implemented to Business units 2 and 3 yet, which had no collaboration or e-mail application at the time.

Business units 1 and 6 were selected for more detailed analysis. Business unit 1 included the company headquarters and was the largest business unit and covered all the following functions: sales, production, logistics, purchasing, invoicing, finance and after sales. In analysis the proposed business application classification model was used on a business unit level. The detailed initial business application architecture in Business unit 1 is illustrated in Figure 5.10.

The core of Back end applications in Business unit 1 was the ERP application. The ERP application included sales, production, purchasing, logistics and after sales functions. As an ERP application add-on Business unit 1 had an invoicing application. Financials was integrated with the ERP application, but was not in the same system. Payroll was integrated with the financials application.
Figure 5.10. Company 2 initial business application architecture in Business unit 1.

In Engineering Business unit 1 had a CAD application integrated with the PDM for product design. Business unit 1 had a separate CAD installation for lay-out design which was not integrated with the PDM application. The PDM application was not integrated with the ERP application. This caused double data entry and the possibility of errors in Bill of Materials, because that needed to be entered manually in both applications. Front end applications included web-catalogue, quotation application, document management application and small application for after sales information management. The after sales application and the quotation application were integrated with the ERP application. The web-catalogue and the document management application were not integrated with any
other application. The document management application was mainly for managing electronic user manuals and it was not integrated with any other application.

As a Management tool Business unit 1 had a budgeting application and a reporting application. The budgeting application was not integrated with any other application. The reporting application was quite advanced and allowed multidimensional reporting, but it took information only from the ERP application and was not integrated with Financials, budgeting or PDM.

Business unit 6 was a medium sized sales company. It had sales, purchasing, logistics and finance functions, but no production. The detailed initial business application architecture of Business unit 6 is illustrated in Figure 5.11.

*Figure 5.11. Company 2 initial business application architecture in Business unit 6.*
In Back end applications of Business unit 6 there was a customized small-scale business application (ERP 6), which was not really an ERP application. ERP 6 covered sales, purchasing, logistics and invoicing functions. Financials was integrated with an ERP application, but the application was different. Payroll was integrated with Financials.

In Engineering Business unit 6 had a CAD application for lay-out design. Business unit 6 did not have a PDM application. The CAD application was not integrated with any other application. Front end applications included a static internet site, a documentation application for technical documentation and a simple quotation application. The internet site and quotation application were not integrated with any other application. The quotation application was integrated with the ERP application.

As a Management tool Business unit 6 had a budgeting application and a reporting application. The budgeting application was not integrated with any other application. The reporting application used the data uploaded from the ERP application.

*Business applications coverage compared to initial business processes*

There were some shortcomings of business application coverage. First, based on analysis of critical success factors and initial business application architecture was the exiguity of applications provided for the Front end. This was not in line with the critical success factors “Customer oriented way to operate” and “Long-term total service and commitment”. Clearly there was need for business applications to support customer orientation and better customer service. A second deficiency was in management tools, because that was believed to have more importance in the future that management could cope with the aggressive growth plan. Especially, because part of the growth was to be executed by acquisitions, which meant even more challenging management task. A third potential lack of coverage was the capability to support “Innovative products and services”.
Information architecture from different stakeholders’ perspective

As stated before Company 2 did not have an independent information architecture, and thus it could not be analyzed. Also, it was difficult to evaluate the initial business application architecture from the perspective of different stakeholders, because different stakeholders were not that involved in the development process.

Effectiveness of initial key business applications

Effectiveness of business applications was evaluated and some business applications were pointed out as particularly effective. These were the quotation application, after sales application, lay-out design application and invoicing add-on application in Business unit 1. Quotation and after sales applications were custom built for the company. Lay-out design and invoicing applications were not custom built, but they had unique features suitable for Company 2. In Business unit 6 no applications were identified with special effectiveness.

Recognition of possible unrealised potential in initial business applications

In Business unit 1 there were unused features in the ERP application. The reason for this was quite typical, other priorities in the implementation project. Although ERP implementation was ready in 1995, the organization had not had resources or energy to re-evaluate possible useful features. In addition to ERP, also the reporting application had many potential features to be used.

In Business unit 6 the main application, the ERP application, was customized for Business unit 6 and thus there were no features, which were not used. In addition, most applications in Business unit 6 were relatively old and therefore all possible features were exploited efficiently.

Risk assessment and robustness of initial key business applications

Risk assessment was not executed in an organised manner, but based on general observations. Most of the key business applications were seen as robust. In Business unit
1 ERP and financial applications were provided by a leading supplier and the applications themselves were robust, only a version upgrade was inevitable at some point. The business applications that had possible risks were quotation, lay-out design and invoicing add-on applications. In the quotation and systems planning applications the risk was related to a small supplier and in the invoicing application to ended support from the supplier. In Business unit 6 the ERP application had a high risk level because of a small supplier and obsolete technology.

5.6.4 Development of target business application architecture

Development of the target business application architecture analysis followed the steps proposed in Chapter 4.1. As in the initial business application architecture analysis, the exact order of the steps has not been analyzed, because it may vary in different organizations, but whether these steps were included in the process or not was analyzed and their execution is described. In the company the initial business application architecture was analyzed and the target business application architecture was created in a relatively short period of time. On the other hand, the implementation of the target business application architecture has taken a long time and is still under way. Company 2 did not use any enterprise architecture framework or similar tool in developing the target business application architecture. However, the company used the application classification model proposed in this thesis in analyzing the initial business application architecture and in developing the target business application architecture.

In Company 2 the main driver for changing the initial business application architecture was the objective of unifying the applications in various sites. Additional drivers were the lack of sufficient business applications in Front end and in Management tools.
Identification of key business applications and description of target business application architecture draft

Key applications were identified by IT management based on critical success factors and business requirements found in ‘IT and business alignment’ and based on results of ‘initial business application architecture analysis’.

Critical success factors from the IT and business alignment lead to the following key application requirements. First, “Customer oriented way to operate” required applications to support value added services for customers, customer relationship management and flexible and accurate deliveries for customers. For the company value added services for customers meant electronic manuals, installed base and service history information of customer installations. All these needed to be included in the target business application architecture. Customer relationship management was divided to two areas: contact management and analytical customer relationship management. “Long-term total service and commitment” required comprehensive service offering, which in terms of business applications had to cover e.g. electronic manuals, installed base and service history information distributed to customers and a possibility for easy access to spare parts. “Operational excellence and efficiency” requires efficient back end applications and information sharing throughout the supply chain. A prerequisite for “Leadership in European market by acquisitions and organic growth” was a business application architecture, which was flexible enough to manage acquisitions and capable of managing significant growth of scope in the business. Also it meant that the business application architecture had to be designed to serve the whole of Europe, not just one or two countries. Communication and European wide application services support required particular attention.

The key business applications identified from the initial business application architecture for the target business application architecture were ERP, financials, PDM, CAD for product design and CAD for lay-out planning, document management and quotation application. From the existing business applications ERP in Business unit 1 (ERP 1) was
selected as the ERP application (ERP A) in the target business application architecture. It was decided that the financials application would be replaced with ERP A. In the target business application architecture the ERP application was set to be “common whenever an ERP implementation was required”. This meant that none of the business units were forced to change from their existing ERP to ERP A, but if they had a business reason to change the application then ERP A had to be considered. The main reason for this quite flexible policy were the material and information flows shown in Chapter 5.6.1 in Figure 5.8. Because there was not that much material or information flows between business units, automating these transaction flows with a common ERP application was not seen as a critical goal worth the effort of ERP implementation. However, visibility and information sharing in the supply chain were set as a goal for the target business application architecture.

To enable sharing of product information PDM was selected as an area where the objective was to have a common application (PDM A). However, any of the existing PDM applications in different business units were not seen as possible option as common PDM. The only potential option, PDM application in Business unit 1 (PDM 1), was from a local vendor and it was not qualified in the target architecture. Thus, the company decided to look for a new PDM application for the target business application architecture. All business units were already using the same CAD application (CAD A). Users were satisfied with it and CAD A was from the leading supplier and therefore it was chosen also for the target business application architecture. A document management application was used only in Business unit 1 in the initial business application architecture. Business unit 1 used the document management application for technical documentation. This document management application (DOCUMENT A) was evaluated as appropriate and it was qualified for the target business application architecture.

A quotation application (QUOTATION A) was used only in Business unit 1. In effectiveness analysis of the initial business applications QUOTATION A was identified as particularly effective with unique features. However, it had a risk, because it was from a small supplier. Despite this risk Company 2 decided to keep QUOTATION A in the
target business application architecture for two reasons. First, because of the unique features customized for the company and second because it was closely integrated with ERP A, which was selected as the main ERP application in the target business application architecture. Those two applications were seen as a powerful combination. To unify customer interface QUOTATION A was set as a common business application in the target business application architecture.

In addition, based on critical success factors CRM, extranet services and data warehouse were identified as business application areas, which did not exist in the initial business application architecture, but which were essential for the target business application architecture. A CRM application was required, because a “Customer oriented way to operate” was identified as a critical success factor. The CRM was divided in two areas: contact management and analytical customer relationship management. Contact management included support for direct actions with the customer and analytical customer relationship management covered actions to analyse information to act more customer oriented. To support multinational customer account management, the CRM (CRM A) was decided to be a common application in target business application architecture.

Extranet services (EXTRANET A) were seen as a vital way to provide value added services for customers. These services included electronic manuals, installed base, service history information of customer installations and sales of commodity products and spare parts via extranet.

Data warehouse was selected as a tool for information sharing between different Business units. Although data warehouse did not automate transactions it was seen cost effective for information sharing. Data warehouse was set as common business application (DATA WAREHOUSE A).

Based on critical success factors Communication was required to cover Europe. Therefore it was an obvious common business application (COLLABORATION A).
COLLABORATION A was already in use in some of the business units and it included e-mail, a group calendar and a possibility for small scale application development. Archiving and electronic purchasing invoice management were not classified as critical business application areas, but as efficient. Therefore they were also included in the target business application architecture (ARCHIVING A).

As a result of the process described above a target business application architecture draft was developed. This target business application architecture draft is illustrated in Figure 5.12.

**Figure 5.12. General Company 2 target business application architecture draft.**
Integrity of information architecture and target business application architecture
As stated earlier Company 2 did not have an actual information architecture. Thus, it was
difficult to compare the integrity of the information architecture and the target business
application architecture. This was an obvious development area for the company.

Target business application architecture from defined stakeholders’ perspective
From the users perspective the main enhancement were the stronger Front end
applications. These new Front end applications had several improved features to assist in
customer related tasks particularly. In addition, a higher level of integration reduced the
amount of manual work that was required. From the management’s perspective the data
warehouse in the target business application architecture was a clear improvement
compared to the initial business application architecture.

From the IT management’s point of view the main difference between the initial business
application architecture and the target business application architecture was the more
harmonized environment of applications. In the initial business application architecture
various sites had a wide range of different applications and in the target business
application architecture many of those were replaced with common applications. This
helped significantly in terms of required maintenance.

Required level of integration
Integration requirements were based on information architecture and process flow related
transactions, such as quotations or orders. In Company 2 there were information entities,
which existed in several business applications and transactional information that needed
to be integrated with other applications. Information entities, which required to be
integrated, are shown in Table 5.9. In fact Table 5.9 simultaneously illustrates the high-
level target information architecture of the company. In Table 5.9 the primary
information source is marked as Master. This means that a particular information entity is
maintained in the Master business application and copied to other business applications.
Table 5.9. Information entities and high-level target information architecture of Company 2 in Business unit 1.

<table>
<thead>
<tr>
<th></th>
<th>Customer data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Quotation/Order data</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACK END</td>
<td></td>
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<tr>
<td>ERP A</td>
<td>Master</td>
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<td>Master</td>
<td>Master</td>
<td>X</td>
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<tr>
<td>ARCHIVING A</td>
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<td>PAYROLL 1</td>
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<td>FRONT END</td>
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<td>CRM A</td>
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<td>Master</td>
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<td>-AFTER SALES 1</td>
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<td>-QUOTATION A</td>
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<td>DOCUMENT A</td>
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<td>WWW-SERVICES</td>
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<td>-EXTRANET A</td>
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<td>-INTERNET SITE 1</td>
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<td>web catalog</td>
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<td>PDM A</td>
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<td>CAD A lay outs</td>
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<td>CAD A product design</td>
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<td>MANAGEMENT TOOLS</td>
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<td>DATA WAREHOUSE A</td>
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<tr>
<td>BUDGETING A</td>
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<td>COMMUNICATION</td>
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<tr>
<td>COLLABORATION A</td>
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In addition to static information entities, fluent processes, such as quotation and order flows, require integration of business applications. The integration interfaces in Business unit 1 are shown in Figure 5.13.
Figure 5.13. Integration interfaces in Business unit 1.

In Figure 5.13 interfaces are illustrated with arrows. The arrows show the direction of information flow. A bi-directional arrow indicates that information is transferred in both directions. For instance product data master was a PDM application. From PDM product data was copied to the ERP A application. Quotations and orders came to ERP A via QUOTATION A application or EXTRANET A application.
Analyzing gaps between initial business application architecture and target business application architecture

The main differences between the initial and the target business application architecture in Business unit 1 were CRM, extranet and data warehouse applications. In ERP merger with add-on applications was required. Some of the applications from the initial business application architecture were selected to continue in the target business application architecture, but some needed to be changed, like the PDM application. In other business units there were more changes required, because one major objective in the target business application architecture was to harmonize business applications in various business units.

Finalizing target business application architecture considering practical constraints

Finalizing of the target business application architecture was not executed as a separate phase in the company. During the development process of the target business application architecture, the majority remained as described in Figure 5.12. However, it was decided to merge AFTER SALES and QUOTATION A applications with CRM A application. The final high-level target business application architecture is shown in Figure 5.14.
Figure 5.14. Company 2 target business application architecture.

One new major element in the target business application architecture compared to the initial business application architecture was the EXTRANET A application. Therefore it is illustrated in Figure 5.15.
Figure 5.15. Principle of EXTRANET A application.

Company 2 had thirteen different Business units. This required a business application architecture for each of them. One of the goals of the business application architecture development process was to unify business application architectures as much as possible, and to utilize common business applications whenever possible. However, due to limited resources, practical limitations needed to be considered. Therefore, the target business application architecture components were applied when it was reasonable considering requirements and costs. The target business application architecture applications for each business unit are illustrated in Table 5.10.
### Table 5.10. Target business application architecture in all business units. Business units 1-6 were a part of Company 2 at the time of initial business application architecture. Business units 7-13 have been acquired during past three years.

<table>
<thead>
<tr>
<th>BACK END</th>
<th>Business Unit 1</th>
<th>Business Unit 2</th>
<th>Business Unit 3</th>
<th>Business Unit 4</th>
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| MANAGEMENT TOOLS  | DATA             | DATABASE        | DATABASE        | DATABASE        | DATABASE        | DATABASE        |
|                   | REPORTING        | REPORTING       | REPORTING       | REPORTING       | REPORTING       | REPORTING       |
|                   | BUDGETING A      | BUDGETING A     | BUDGETING A     | BUDGETING A     | BUDGETING A     | BUDGETING A     |

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<tr>
<td>FINANCIALS</td>
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| MANAGEMENT TOOLS  | DATA             | DATABASE        | DATABASE        | DATABASE        | DATABASE        | DATABASE        | DATABASE        |
|                   | REPORTING        | REPORTING       | REPORTING       | REPORTING       | REPORTING       | REPORTING       | REPORTING       |
|                   | BUDGETING A      | BUDGETING A     | BUDGETING A     | BUDGETING A     | BUDGETING A     | BUDGETING A     | BUDGETING A     |

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</thead>
</table>

186
In this study Business units 1 and 6 were chosen for more detailed analysis. Thus, a detailed target business application architecture for Business unit 1 is shown in Figure 5.16 and a detailed target business application architecture for Business unit 6 in Figure 5.17.

**Figure 5.16.** Company 2 detailed target business application architecture in Business unit 1.
Figure 5.17. Company 2 detailed target business application architecture in Business unit 6.

As shown in Figure 5.17 the target business application architecture in Business unit 6 was much simpler than the target business application architecture in Business unit 1. This was because Business unit 6 was smaller and did not have all the same functions as Business unit 1 (e.g. manufacturing).
5.6.5 Planning, prioritising and implementation of target business application architecture

In planning and prioritizing resources, both human and financial were limitations. In practice prioritizing was executed by IT management. A few major tasks were identified in business application architecture implementation. The most significant gap between the initial business application architecture and the target business application architecture was in Front end applications. From the Front end applications the extranet portal and the CRM were identified as required individual applications. Other identified deficiencies were data warehouse development and implementation and harmonization of ERP applications. Based on internal material flows, shown in Figure 5.8, a common ERP application was not set as a necessity. Still, a common ERP application in major sites was said to be a long-term target. In terms of the required investment and effort versus the achieved contribution, the common ERP target was formulated thus “Business units have to seriously consider the common ERP whenever there is a business reason to change the ERP application. If there is no business reason to change the ERP application, then the particular business unit will not be forced to implement the common ERP application”. As a result the following top-level projects were identified:

- ERP harmonization in larger business units, considering there was a business reason to change the application
- Data warehouse implementation for all business units
- CRM application development or selection and implementation
- Extranet portal development and implementation
- Selection and implementation of a new common PDM
- Minor projects associated with simplifying the business application architecture by merging various applications into fewer applications
As in many other companies the ERP application was the backbone of the business application architecture, also in Company 2. Particular attention and effort was therefore addressed to ensure that the ERP part of the business application architecture was managed properly. In prioritizing top-level projects, similarities with the logic proposed by Ward and Peppard (2002) could be found: First, what was the most important thing to do, based on the identified benefits. Second, could be done, based on available resources.

In addition, the aspect of a rational implementation order was taken into account. The order of implementation in the company was in line with findings by Riihimaa and Ruohonen (2002). Front end applications and Management tools were seen as the most important development area. However, following findings by Riihimaa and Ruohonen (2002) it was clear that Back end applications should be at an acceptable level first. Therefore, the priorities displayed a compromise between these two targets. Priorities in business application architecture development in Company 2 are shown in Figure 5.18.

<table>
<thead>
<tr>
<th>Business application architecture planning</th>
<th>Year 1</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP A roll-out</td>
<td>Q1-Q2</td>
<td>Q3-Q4</td>
<td>Q1-Q2</td>
<td>Q3-Q4</td>
<td>Q1-Q2</td>
<td>Q3-Q4</td>
<td>Q1-Q2</td>
<td>Q3-Q4</td>
</tr>
<tr>
<td>CRM A development and roll-out</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>EXTRANET A development and implementation</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Data warehouse</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>PDM A selection and roll-out</td>
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<td></td>
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<tr>
<td>ARCHIVING A implementation</td>
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<td></td>
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<tr>
<td>Other projects</td>
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</tr>
</tbody>
</table>

**Figure 5.18. Business application architecture development priorities in Company 2.**

As illustrated in Figure 5.18, most of the projects were on-going in parallel. In prioritizing there were two main challenges. First, to synchronize projects in a logical way. For example, ERP A was implemented in Business unit 1 before EXTRANET A or CRM A was implemented. Second, to manage the available resources and to be able to cope with all on-going projects. Most of the resources were required in many projects at the same time and therefore some of the lower priority projects were postponed because of lack of resources.
The current status of the business application architecture at the time of writing this thesis was briefly analyzed. The current status of the business application architecture in Company 2 is illustrated in Figure 5.19.

![Diagram showing current status of business application architecture](image)

**Figure 5.19.** Current status of business application architecture in Business unit 1.

As shown in Figure 5.19, the company has not yet achieved the target business application architecture. Business unit 1 is closest to the target business application architecture. Still, major differences in Business unit 1 compared to the target business application architecture are:

- ERP 1 FINANCIALS instead of integrated finance in ERP A
- ERP A add-on for invoicing instead of invoicing directly from ERP A
Projects module of ERP A not yet implemented
- PDM 1 instead of PDM A
- BUDGETING A not integrated with DATA WAREHOUSE A

ERP 1 FINANCIALS has not been merged with ERP A. This merger is a significant effort and that is why it has been delayed several times. Company 2 is still using the ERP A ADD-ON for invoicing. This is because the ERP A ADD-ON is very effective, but on the other hand executing invoicing in a separate application is causing some problems. At the moment ERP A does not include a project module, but it is planned to be implemented in the target business application architecture. In addition PDM 1 should be replaced with PDM A and an interface to be built between BUDGETING A and DATA WAREHOUSE A applications. Currently the company is using DATA WAREHOUSE A, but only to a limited extent.

5.7 Case Company 3

5.7.1 IT and business alignment

By the mid 1990’s architecture of different business applications in Company 3 had evolved during a long period of time. Business units were independent and they had made decisions concerning IT autonomously. As a result the business application architecture was heterogeneous and non-integrated. In the year 1998 management of the company decided to allocate resources on taking more control and to co-ordinate IT issues in various business units centrally. Thus, year 1998 was selected as a starting point for the initial business application architecture.

In Company 3 Business unit 1 was selected for more detailed analysis. Business unit 1 was one of the largest business units, and it had all the relevant functions: sales,
production, logistics, purchasing, invoicing, finance and a sales shop to be a good representative of all the business units.

**Critical success factors and critical business requirements**

As part of taking more control of business units critical success factors were also identified. The following critical success factors were identified:

- The most attractive branded assortment in the field of business of Company 3
- Designed premium products
- The most effective retail concept
- Demand visibility
- Innovative thinking
- Continuous development

Brand management and assortment management were the most critical success factors for the company. These were combined as critical success factor “The most attractive branded assortment”. The company mainly provided designed premium products, thus management of product design was a critical success factor. Because the products were segmented in the premium segment, the prices of the products were naturally higher than average in the same field of business. Consequently, Company 3 had set the objective to have “the most effective retail concept”, which meant generated sales per used space in a retail shop. Due to the nature of the products the demand varied significantly and it was difficult to forecast. Thus, the “visibility of demand” was important to be able to react agile to changes in demand. “Innovative thinking” and “continuous development” were seen critical to ensure long term success.

Key business processes and functions that are required to be covered in the target business application architecture are illustrated in Table 5.11.
Table 5.11. Key business processes and functions in Company 3.

<table>
<thead>
<tr>
<th>Key business processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand and novelties management</td>
</tr>
<tr>
<td>Assortment management</td>
</tr>
<tr>
<td>Sales forecasting and production planning</td>
</tr>
<tr>
<td>Innovation</td>
</tr>
<tr>
<td>Retail concept</td>
</tr>
<tr>
<td>Management process</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key business requirements and functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORDER FULFILMENT</td>
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<td>Point-of-Sale</td>
</tr>
<tr>
<td>Sales</td>
</tr>
<tr>
<td>Logistics</td>
</tr>
<tr>
<td>Purchasing</td>
</tr>
<tr>
<td>Deliveries</td>
</tr>
<tr>
<td>Manufacturing</td>
</tr>
<tr>
<td>Sales channel management</td>
</tr>
</tbody>
</table>

Key drivers to change the business application architecture were conducted from the critical success factors. The essential driver was a consequence of the critical success factors “Most effective retail concept” and “Most attractive branded assortment”. This driver was demand visibility. Demand visibility meant visibility through the whole supply chain and the capability to forecast and react effectively to changes in demand. A prerequisite for visibility through the supply chain was also transparency between different business units. Additionally, the improvement of consistency and accuracy of information was driving the change of business application architecture.

Different stakeholders involved in business application architecture development
In the company the critical success factors were identified and described by the business management. However, business management was not very involved in determining business application architecture requirements, was headed by IT management. Particularly in the beginning of the target business application architecture development process more intensive contribution from business management would have been valuable. Later on business management got more engaged in the determination process and this gave IT management the needed guidance and support. Company 3 and Business
unit 1 had several business process development projects where detailed requirements were defined. Middle management and users were involved in these projects.

**Influence of business environment and external parties (partners, customers, suppliers and competitors) to business application architecture**

In this company external parties influenced the business application architecture which was taken into account in developing the business application architecture. The main customers of Company 3 were large retail chains and the company was an integrated part of their supply chain. Retail chains had relatively high demands on how their suppliers should be able to receive orders and how suppliers should send invoices to them. Thus the company had to build a business application architecture that enabled integration with its customers. Due to the nature of business in Company 3 they had a large number of sales orders per year and also because of that the integration with their customers was essential.

On the other hand, on the suppliers’ side the company had only a few main suppliers and more importantly, the number of interactions with them was fairly low. Therefore, there was no reason to integrate the business application architecture with suppliers. However, in terms of suppliers there was a requirement to be able to manage outsourcing operations. The production of some of the company’s products were outsourced and that way to operate was increasing. This required the capability of managing outsourcing.

**5.7.2 Information architecture**

As well as Company 1 and Company 2, Company 3 did not have a separate information architecture. The company put a lot of effort in describing business processes and thus major information requirements had also been identified. However, there was no actual mapping of which information entities were in which applications and how much overlap there was. An ERP application was used as master for most of the information entities. Despite the lack of an actual information architecture, a ballpark description of an
information architecture was generated for the purposes of this study. The initial information architecture of Business unit 1 is illustrated in Table 5.12.

**Table 5.12. Key information entities in initial business application architecture in Business unit 1.**

<table>
<thead>
<tr>
<th>BACK END</th>
<th>Customer data</th>
<th>End user data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Order data</th>
</tr>
</thead>
<tbody>
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<td>FINANCIALS A</td>
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<td>Master</td>
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</tr>
<tr>
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<td>X</td>
<td>Master</td>
<td>Master</td>
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</tbody>
</table>

In general the quality of data in Company 3 was not very good. This was mainly because of problems with consistency and accuracy due to decentralised database structure.

### 5.7.3 Analysis of initial business application architecture

*Identification and classification of key business applications and level of integration*

In the company particularly IT management put a reasonable effort in analyzing the initial business application architecture. Characteristic for the initial business application architecture was that in different business units the initial business application
architecture was heterogeneous and there was lack of integration between various business units. This heterogeneous environment was a consequence of diverse ways to operate in different business units. Furthermore, there had been no enterprise architecture framework or any similar method to support development of the initial business application architecture. Key business applications in the initial business application architecture are shown in Table 5.13.

Table 5.13. Initial business applications in main business units in case Company 3.

<table>
<thead>
<tr>
<th>BACK END</th>
<th>Business Unit 1</th>
<th>Business Unit 2</th>
<th>Business Unit 3</th>
<th>Business Unit 4</th>
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<td>ERP 1</td>
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<tr>
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<td>ERP 1</td>
<td>ERP 1</td>
<td>PRODUCTION PLANNING 5</td>
<td>PRODUCTION PLANNING 6</td>
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<td>PAYROLL 1</td>
<td>PAYROLL 4</td>
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<td>PDM</td>
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</tr>
<tr>
<td>3-D CAD</td>
<td>3-D CAD A</td>
<td>3-D CAD B</td>
<td>3-D CAD 4</td>
<td>3-D CAD 5</td>
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</tr>
<tr>
<td>MANAGEMENT TOOLS</td>
<td>REPORTING A</td>
<td>REPORTING A</td>
<td>REPORTING A</td>
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<td>REPORTING A</td>
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</tr>
<tr>
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<td>COLLABORATION 1</td>
<td>COLLABORATION 1</td>
<td>COLLABORATION 1</td>
<td>COLLABORATION 1</td>
<td>COLLABORATION 1</td>
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</tbody>
</table>

Some observations on the initial business application architecture can be made. First, although ERP 1 application in Back end applications seems very homogeneous, the problem was that in practice ERP 1 was a different installation in each business unit. In principle the ERP 1 application was the same, but there were differences in the applications and particularly in the way the application was used. Also, ERP 1 applications in all units were integrated with each other, but this integration required batch processing.

The second observation is that Management tools were a weak part of the initial business application architecture and clearly an area for enhancement. Furthermore, Engineering looks like a weak section in the initial business application architecture. However, the requirements concerning Engineering applications in Company 3 were very simple and
Therefore, with a few exceptions, there was no need for further development in Engineering applications.

Because Business unit 1 was chosen for more detailed analysis, the detailed initial business application architecture in Business unit 1 is shown in Figure 5.20.

**Figure 5.20.** Company 3 initial business application architecture in Business unit 1.

In Company 3 the ERP application had an even more essential role than in Company 1 and Company 2. This was because the ERP application was customized for Company 3 and therefore had several vital and unique functions to meet business requirements. The ERP application included basic data registers, sales forecasts, order fulfillment process, production, purchasing and logistics. Financials was a separate application, but it was integrated with the ERP application. In production Business unit 1 had an application for
collecting data of manufacturing times and costs. This production data collection application was integrated with the payroll application. The payroll application was different from the financials application.

In Engineering Business unit 1 had a 3-D CAD application for product design. Business unit 1 did not have a PDM application. The company products are simple in terms of product structure and thus the PDM application was not that relevant. On the other hand, product design is very important.

Front end applications included web-catalogue, mail-order support application, Point-of-Sale application and order transfer application. Part of the company’s orders were received via mail and an application to support the management of these mail-orders was needed. Also, Company 3 owned some shops where the products were sold to consumers. In those shops a Point-of-Sale application was required. Point-of-Sale and order transfer applications were integrated with the ERP application. The web-catalogue was not integrated with any other applications. The mail-order support application was integrated with financials and the ERP application.

As a Management tool Business unit 1 had a reporting application. The reporting application included detailed reporting information, but was not integrated with other applications. In Communication Business unit 1 used a simple e-mail application.

*Business applications coverage compared to initial business processes*

Development of the target business application architecture was a long process. Business application coverage was evaluated as an on-going process rather than as a separate phase. But, a thorough analysis was executed in terms of the ERP application. According to this feasibility study most core business processes and critical success factors were covered with the functionality provided by the initial business application architecture. Clearly the issue for improvement was in demand visibility. This was because a lot of batch processing was required between different components of the ERP application and between different business units. Equally, more efficient tools to support the supply chain

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were requested. Additionally, more centralized management for customer information was required.

*Information architecture from different stakeholders’ perspective*

Company 3 didn’t have an independent information architecture, so it could not be analyzed.

*Effectiveness of initial key business applications*

In the company application effectiveness was evaluated thoroughly. Company 3 had several development projects for improving business processes and supply chain efficiency and as a part of these effectiveness analysis of initial business applications was performed. In this analysis of applications some applications were identified as effective in Business unit 1. These were a Point-of-Sale application and an order transfer application. The Point-of-Sale application had a good fit with business requirements and it was cost efficient. The order transfer application was an interface application between ERP and customers’ applications. It included several customized interfaces, which had high business value. The ERP application also had some features, which were effective as such, because they were customized for the company. On the other hand, the ERP application had several weaknesses such as batch processing within the application.

*Recognition of possible unrealised potential in initial business applications*

Recognition of possible unrealised potential was done in Company 3 and it was executed mainly by IT management, but several people from business management were also involved. Recognition of possible unrealised potential was done in the company and it was executed by IT management. Although the ERP application was customized for the company there were still unused features in the application. This was because business units were not adequately controlled by the headquarters and were using the ERP application differently in different business units. As a result, and despite the clear shortcomings in the ERP application, there were several features, which were available in the ERP application, but were not used efficiently. The problem was especially that
different business units were not using the application in the same way. In addition to the ERP application, also the financials application had potential features to be used.

Risk assessment and robustness of initial key business applications
Risk assessment was executed in a fairly organised manner and the risks were assessed by IT management. In Business unit 1, as well as in Company 3 in general, most key business applications were seen as robust. The ERP application was customized and therefore included a risk related to knowledge and capable resources available outside the company. Other potential risks in Business unit 1 were in Point-of-Sale and mail order support applications. The Point-of-Sale application had a potential risk related to the supplier, but on the other hand the application was reliable and very cost efficient. The mail order support application had a risk related to obsolete technology platform.

The financials application in Business unit 1 was provided by a leading supplier and the application itself was robust. The payroll application was relatively old and at least a version upgrade would be required at some point.

5.7.4 Development of target business application architecture

The initial business application architecture was analyzed and the target business application architecture has been created in phases during a long period of time. Equally, the implementation of the target business application architecture has taken a fairly long time and is still under way. Company 3 did not use any enterprise architecture framework or any comparable methods in developing the target business application architecture.

Identification of key business applications and description of target business application architecture draft
Key business applications were identified by business management together with IT management, although identification was not performed as a particular phase but rather as a process.

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Critical success factors and business requirements set the following needs for the target business application architecture. First, brand and assortment management required applications for sharing product and customer information company wide. Second, “the most effective retail concept” and “demand visibility” required visibility throughout the supply chain and efficient tools for managing logistics. The driving forces in developing the target business application architecture were the improved capabilities for sharing information and better support for managing the supply chain.

The identified key business applications in the initial business application architecture for the target business application architecture were ERP, financials, production data collection, mail order support, Point-of-Sale, order transfer, reporting and product catalogue.

In designing the target business application architecture the most critical issue in Company 3 was clearly the decision concerning ERP. According to IT Manager, the company had two relevant options: choose and implement a major commercial ERP package or put significant effort into further development of the ERP application existing in Business unit 1 (ERP 1). To evaluate these options a comprehensive feasibility study was organized. As a result of the feasibility exercise the company decided to further develop the ERP 1 application. This enhanced version of ERP 1 (named here as ERP 1A) was chosen for the target business application architecture and a major internal development project was started to develop the ERP 1A application.

The main benefits of ERP 1 were that it was customized for the company and therefore had industry specific features and was cost efficient to run because there were no maintenance fees. The main shortcomings were that although ERP 1 was in one database, this database was decentralized, there were no unified parameters and it did not have a graphical user interface. As a consequence of the multi-database set up ERP 1 could not provide visibility between business units and batch processing was required. In addition, ERP 1 was originally developed to suit other business sectors, which were part of
Company 3 at the time. As inheritance ERP 1 had some features which were not suitable for the company anymore. These features were additional attributes designed for other business sectors and Company 3 did not continue to use those features. In developing the ERP 1A application the main issues, conducted from the critical success factors, were to provide transparency between business units by creating a common database for all sites and to establish common procedures and unified parameters for all business units. In the target business application architecture it was decided to implement ERP 1A application in all business units. Visibility and information sharing in the supply chain were the main goals for the target business application architecture.

The financials application from Business unit 1 (FINANCIALS A) was selected for the target business application architecture and set as a common application for all business units. FINANCIALS A was already in use in all business units, except for Business unit 4.

The company had several different types of manufacturing. Therefore two production data collection applications were selected for the target business application architecture. These were PRODUCTION DATA COLLECTION A and PRODUCTION DATA COLLECTION B. Both of these applications were already in use in the initial business application architecture. In the target business application architecture PRODUCTION DATA COLLECTION A was chosen in Business unit 1.

In terms of an initial Point-of-Sale application business units in Finland were using an application from a local vendor. On the other hand, this application was evaluated as efficient in the initial business application architecture. This Point-of-Sale application (POINT-OF-SALE A) used in Finnish business units (Business units 1, 2 and 3) was not qualified as a common application in the target business application architecture. However, because it was evaluated as efficient there was no reason to replace POINT-OF-SALE A and thus it was decided to choose two Point-of-Sale applications for the target business application architecture, namely POINT-OF-SALE A for Finnish business units and POINT-OF-SALE B for business units outside Finland.
The mail order support application used in the initial business application architecture was accepted for the target business application architecture as MAIL ORDER SUPPORT A. It was decided to be used in all business units which needed mail order support functionality. Also, the order transfer application used in the initial business application architecture was chosen for the target business application architecture. However, there was a requirement to enhance this application with several new features. Thus, in the target business application architecture the application is called ORDER/INVOICE TRANSFER A.

The product catalogue from the initial business application architecture was used in the internet and it covered basic catalogue functions. It was qualified in the target business application architecture as PRODUCT CATALOGUE A application. Equally, REPORTING A was accepted for the target architecture as a reporting application.

The collaboration application in the initial business application architecture was a simple e-mail application and was not sufficient for the target business application architecture. Consequently, some leading collaboration applications were assessed and COLLABORATION A was chosen for the target business application architecture. A common collaboration application in all business units was seen critical and thus COLLABORATION A was set as a common application.

In Business units 1, 2 and 3 the same payroll application was used in the initial business application architecture. However, the application was old and needed to be upgraded or replaced. Company 3 decided to replace it with PAYROLL A in the target business application architecture, but PAYROLL A was not set as common application, because of differences in legal requirements in different countries. The payroll application was to be decided by each business unit.

In Engineering product design was important for the company. For product design the 3-D CAD application from the initial business application architecture was selected for the
target business application architecture as 3-D CAD A. However, 3-D CAD A could not be set as a common application, because different business units had diverse requirements for their CAD application. Although product design was essential, products were simple and thus product data management was not a critical requirement. Anyhow, COLLABORATION A provided a possibility for small-scale application development and included some data management features. Thus, a plain PDM application (PDM A) with COLLABORATION A was decided to be built.

In addition to the application areas that existed already in the initial business application architecture, new application areas were introduced in the target business application architecture. These applications were based on critical success factors and other business requirements. CRM, data warehouse and supply chain management were identified as new business application areas, which were necessary for the target business application architecture. A CRM application was required for better management of customer related information. Thus, CRM A was chosen for managing business-to-business customer relationships. CRM A was decided to be a common application in the target business application architecture.

One of the most important identified critical success factors was the “Demand visibility”. In addition to development of the ERP 1A application this required comprehensive reporting capabilities throughout the company. Clearly the reporting application used in the initial business application architecture was not sufficient to meet these expectations. Accordingly DATA WAREHOUSE A was selected for improved and company wide reporting. The objective of DATA WAREHOUSE A was additionally to support information sharing. DATA WAREHOUSE A was set as a common business application.

Later, during implementation of the target business application architecture more emphasis was put on management of company wide logistics. For that purpose different options were evaluated and REPORTING B was chosen for supply chain management.
As a result of the processes described above a target business application architecture draft was developed. This target business application architecture draft is shown in Figure 5.21.

Figure 5.21. General Company 3 target business application architecture draft.

Integrity of information architecture and target business application architecture

Company 3 did not have a true information architecture. Therefore, it was difficult to evaluate the integrity of the information architecture and the target business application architecture. According to the IT Manager of the company, an information architecture would be a useful tool for the company and accordingly this was a clear development issue for Company 3.
**Target business application architecture from defined stakeholders’ perspective**

From the users’ perspective the obvious enhancement was better integration, which significantly reduced the amount of manual work. Other improvements from the users’ point of view were the better collaboration tool, COLLABORATION A and additional features in ORDER/INVOICE TRANSFER A.

From management’s perspective DATA WAREHOUSE A and REPORTING B in the target business application architecture improved the transparency of the supply chain and provided better information to support management decisions.

For IT management the target business application architecture offered a noticeably easier environment to maintain. Several batch processes within ERP 1 and interfaces between ERP 1 installations were required in different business units.

**Required level of integration**

Integration requirements were based mainly on transactions related to order fulfillment processes and relatively complex application architecture. The same information entities were in several business applications. The high-level target information architecture, and concurrently information entities with integration requirements are illustrated in Table 5.14.

<table>
<thead>
<tr>
<th></th>
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<th>End user data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Order data</th>
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<td>CAD 3-D A Product design</td>
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<td><strong>MANAGEMENT TOOLS</strong></td>
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<td>X</td>
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</tr>
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<td>COLLABORATION A</td>
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</table>

Interpenetrating information entities required integration of business applications. The integration interfaces in Business unit 1 are illustrated in Figure 5.22.
**Figure 5.22. Integration interfaces in Company 3, Business unit 1.**

In Figure 5.22 interfaces are shown with arrows. The arrows show the direction of information flows. A bi-directional arrow indicates that information is transferred in both directions.
Analyzing gaps between initial business application architecture and target business application architecture

In Company 3 some new applications were introduced in the target business application architecture. These were PDM A, REPORTING B and DATA WAREHOUSE A. Furthermore some applications from the initial business application architecture were replaced in the target business application architecture. The replacement applications were ERP 1A, PAYROLL A and COLLABORATION A.

Key drivers to change the initial business application architecture were creating demand visibility and improving the integrity of applications. The integrity of applications increased information consistency and accuracy. Implementation of REPORTING B and DATA WAREHOUSE A were clearly aiming at these objectives. The most challenging task in the business application architecture was the development of ERP 1A. Although ERP 1A was based on ERP 1, developing it required a lot of planning and programming.

Finalizing target business application architecture considering practical constraints

Finalizing of the target business application architecture was not done as a separate phase. Finalizing of the target business application architecture was rather a consequence of a long development time of the target architecture than a planned step.

During finalizing the application architecture CRM B, ARCHIVING A and WEB ORDER ENTRY A were added to the target business application architecture. In the target architecture draft CRM A application was for managing Business-to-Business customer relationships. Additionally, the company had a requirement to provide tools for their own sales personnel who acted as field sales persons. Thus, CRM B was added to the target business application architecture for this purpose. As in Company 2 also in Company 3 electronic archiving and purchasing invoice management was not a critical requirement, but it was seen as an area for potential cost savings. Consequently ARCHIVING A was included in the target architecture.
In Company 3 sales orders were generally received through ORDER/INVOICE TRANSFER A. However, an additional requirement to be able to receive orders also via internet appeared. This was for sales agents and smaller customers who could not integrate their own applications with ORDER/INVOICE TRANSFER A. Therefore WEB ORDER ENTRY A was added to the target business application architecture. The final high-level business application architecture indicating which applications were set as common or local is shown in Figure 5.23. Some applications were set as common for selected business units (marked with “For selected BUs” in Figure 5.23) that had similar business requirements, but whose requirements differed from other business units.

**Figure 5.23.** Common and local applications Company 3’s target business application architecture.
The company had six major business units and a few smaller business units. Smaller business units were excluded from the study, because the business application architecture was very simple. The target business application architecture applications in different business units are illustrated in Table 5.15.

**Table 5.15. Target business application architecture in all business units.**

<table>
<thead>
<tr>
<th>BACK END</th>
<th>Business Unit 1</th>
<th>Business Unit 2</th>
<th>Business Unit 3</th>
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</tbody>
</table>

Finalized detailed target business application architecture in Business unit 1 is illustrated in Figure 5.24.
**Figure 5.24.** Company 3 detailed target business application architecture in Business unit 1.

### 5.7.5 Planning, prioritising and implementation of target business application architecture

Planning and prioritizing was executed in collaboration between business and IT management. Some main tasks were identified for business application architecture implementation. The most challenging issue was the development and implementation of ERP 1A application. Other development and implementation tasks were in Management tools and in CRM applications in Front end. Improvements were especially required in
Management tools and those enhancements were set as high priority. The following top-level projects were identified:

- ERP IA development and implementation in all business units
- Data warehouse implementation in all business units
- Implementation of CRM applications in selected business units
- Replacement implementation of Collaboration application in all business units
- Replacement implementation of payroll application in selected business units

Later on the following additional projects were identified:

- Logistics application implementation in selected business units
- Implementation of archiving application in selected business units
- Web order entry application implementation in selected business units

In Company 3 the ERP application had an even more important role than in Company 1 and in Company 2. This was also taken into account when prioritizing target business application architecture development. On the other hand, there were business requirements, which were increasing the priority of other implementations. The IT management of the company had to balance between these partly contradictory objectives. The implementation order of business applications in Company 3 are illustrated in Figure 5.25.
Figure 5.25. Business application architecture development priorities in Company 3.

As in other case companies, implementation took several years also in Company 3. In addition to projects illustrated in Figure 5.25 there were several smaller development projects. For instance, because ERP 1 was a customized application, there were development projects related to that continuously on-going.

The status of the business application architecture at the time of writing this thesis is described below in a few words. The current status of business application architecture in Business unit 1 in Company 3 is shown in Figure 5.26.

As shown in Figure 5.26 the company has currently implemented most of the applications in the target business application architecture in Business unit 1. The main issues still missing from the target business application architecture in Business unit 1 are:

- ERP 1 is still in use and ERP 1A is not implemented yet
- CRM B is not implemented yet
- WEB ORDER ENTRY A is not implemented yet
Figure 5.26. Current status of business application architecture in Business unit 1 in Company 3.

In Business unit 1 the main difference is that Company 3 is still using ERP 1 and ERP 1A has not been implemented yet, although the development of ERP 1A is under way. Apparently development and implementation of ERP 1A is the main challenge for the company. Other projects, CRM B implementation and WEB ORDER ENTRY A implementation, are relatively minor issues compared to that. However, instead of implementing the missing applications in Business unit 1, the main challenge in Company 3 as a whole is to expand the use of common applications to all other business units.
5.8 Case Company 4

5.8.1 IT and business alignment

Company 4 was established in the 1950’s as a small manufacturer of engineered products. Since the beginning the company has focused purely on these selected engineered products and the product range is still focused on the same products. During the past decades Company 4 has grown significantly and it is currently one of the leading manufacturers in its own field of business in the world. As the company has grown, it has had several different owners, and after a number of owners Company 4 was sold to it’s current owner, a multinational corporation, in 2003. The current parent company is a world leader in the same field of business as where Company 4 operates. Just as the current owner, also the previous owners of Company 4 had been large corporations. However, the current owner is the first to act in the same field of business as Company 4. This change had an effect in the strategy of the company. Logically this change of ownership influenced also the IT/IS strategy. The main difference was that the company had to take into account the requirements and corporate policies set by the parent company in designing the IT/IS environment. Consequently, the change of ownership was chosen as a starting point for the initial business application architecture in this study.

In terms of information systems different business units in Company 4 were independent and there weren’t many common applications. Because of this high independence of business units in information systems only one business unit was selected to be in the scope of this study. Business unit 1 was chosen for analysis.
Critical success factors and critical business requirements

After the change of ownership re-evaluation of IT and business alignment was required. There were no major changes in strategy as such, but a few issues needed to be considered. First, because the parent company operated in the same field of business as Company 4, product segments and sales channels had to be evaluated. The second issue was the group policies in the parent company, which influenced particularly IT. The following critical success factors and business requirements were recognised as essential in developing the business application architecture in the changed business environment:

- Customer driven tailor-made production
- High quality expertise services
- Customer care
- Sales channel management
- Operating as a part of large corporation

The foundation of the company’s operations is the principle to manufacture-to-order. This “Customer driven tailor-made production” requires responsiveness, flexibility and transparency from the whole supply chain. In addition to the manufacture-to-order model an other characteristic feature in Company 4 is that it is specialized purely on one product type, unlike its competitors, who typically manufacture several types of engineered products. As a result the company can provide “High quality expertise services” in this product type to its customers. In Company 4 critical success factor “Customer care” means that in addition to meeting individual requirements by each customer the life cycle of each product is long and customer relationships normally last long. This requires for instance management of spare parts and management of customer related information. “Sales channel management” is a critical success factor, because the products of the company are sold through several sales channels and thus their management is important. “Operating as part of a large corporation” was added as a business requirement, because it affected the operating environment and IT.
Different business processes needed to be covered in the target business application architecture. Key business processes of Business unit 1 in the company are shown in Table 5.16.

**Table 5.16. Key business functions in Business unit 1 in Company 4.**

<table>
<thead>
<tr>
<th>ORDER FULFILMENT</th>
<th>ENGINEERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quotations</td>
<td>R&amp;D</td>
</tr>
<tr>
<td>Product configuration</td>
<td>Product design</td>
</tr>
<tr>
<td>Sales</td>
<td></td>
</tr>
<tr>
<td>Logistics</td>
<td></td>
</tr>
<tr>
<td>Purchasing</td>
<td></td>
</tr>
<tr>
<td>Deliveries</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Make to order</td>
<td>SUPPORT FUNCTIONS</td>
</tr>
<tr>
<td>Assembly to order</td>
<td>Management reporting</td>
</tr>
<tr>
<td>Mass customization</td>
<td>Forecasting</td>
</tr>
<tr>
<td>After sales</td>
<td>Accounting</td>
</tr>
<tr>
<td>Spare parts management</td>
<td>Payroll</td>
</tr>
</tbody>
</table>

**Different stakeholders involved in business application architecture development**

The trigger of the business application architecture development process in the company was mainly the change of ownership. To ensure structured and comprehensive business application architecture development, a leading consulting firm was assigned to the process. Their task was to analyze the initial business application architecture and to give recommendations regarding the target business application architecture. The implementation of the target business application architecture was excluded from consultancy assignment.

In Company 4 business management was intensively involved in analyzing the initial business application architecture and developing the target business application architecture. Analysis of the initial business application architecture and development of the target business application architecture was headed by the IT Director of the company in co-operation with the consultants. Analysis and the target architecture development process were performed in the form of workshops and interviews. In addition to business management also users and middle management participated actively in analysis of the
initial business application architecture and the development of the target business application architecture.

*Influence of business environment and external parties (partners, customers, suppliers and competitors) to business application architecture*

The business environment and external parties had some influence on the business application architecture. A lot of effort was put into taking this influence into account in the business application architecture development process. The main external driver influencing the business application architecture was the need for a highly integrated supply chain. Accordingly, there was a need to increase speed, automation and transparency of customer order flow to production and even to key suppliers. Additionally, integration of information and material flow was required with after sales operations, particularly with spare parts sales and management. This was because after sales and spare parts were an essential part of Company 4’s business.

Another business environment aspect effecting the business application architecture of Company 4 was affiliation to the parent company. The company had been a part of large corporations before, but the current parent company was the first owner that operated in the same field of business as the company itself. This had an effect on the supply chain of Company 4. Consequently, the parent company became a potential sales channel for the products of Company 4 and there were potential synergies in procurement and in shared production capacity. This required integration with the supply chain of the parent company.

In addition to supply chain integration with the parent company, as can be expected, the owner had also certain policies concerning information systems that needed to be taken into account in designing the business application architecture. Equally, there were requirements concerning reporting which needed to be considered in the business application architecture.
5.8.2 Information architecture

Company 4 didn’t have an actual information architecture. However, the main information requirements had been identified. Although an information architecture had not been made, a draft description of the information architecture was generated for the purposes of this thesis. There was not much overlap in Master data, only supplier Master data was maintained in several applications. Product data was copied from a Master business application to several other applications. The initial information architecture of Business unit 1 is illustrated in Table 5.17.
Table 5.17. Key information entities in different business applications in Business unit 1.

<table>
<thead>
<tr>
<th>Application</th>
<th>Customer data</th>
<th>End user data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Quotation/Order data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BACK END</strong></td>
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<tr>
<td>SCHEDULING 1</td>
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<tr>
<td>MRP A</td>
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</tr>
<tr>
<td>INVENTORY MANAGEMENT 1</td>
<td>x</td>
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<tr>
<td>FINANCIALS 1</td>
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<td>x</td>
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<tr>
<td>INVOICING 1</td>
<td>Master</td>
<td>x</td>
<td>x</td>
<td>Master</td>
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<tr>
<td>PURCHASING 1</td>
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<tr>
<td>MATERIAL PURCHASING 1</td>
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<tr>
<td>SUPPLIER MANAGEMENT 1</td>
<td></td>
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<td>Master</td>
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<td>QUALITY A</td>
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<td>QUALITY 2</td>
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<td>PAYROLL 1</td>
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<td><strong>FRONT END</strong></td>
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<tr>
<td>SALES CONFIGURATOR A</td>
<td>Master</td>
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<td>QUOTATION A</td>
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<tr>
<td>PRICING A</td>
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<tr>
<td>ORDER/INVOICE MANAGEMENT 1</td>
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<td>Master</td>
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<td>Master</td>
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<tr>
<td>SPARE PARTS A</td>
<td>x</td>
<td>x</td>
<td>Master</td>
<td>Master</td>
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<tr>
<td>WEB SPARE PARTS A</td>
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<td>Master</td>
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<tr>
<td>PRODUCT CATALOG A</td>
<td></td>
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<tr>
<td><strong>ENGINEERING</strong></td>
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<tr>
<td>PDM 1</td>
<td>Master</td>
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<tr>
<td>3-D CAD 1</td>
<td></td>
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<tr>
<td><strong>MANAGEMENT TOOLS</strong></td>
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<tr>
<td>DATA WAREHOUSE 1</td>
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<tr>
<td><strong>COMMUNICATION</strong></td>
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<tr>
<td>COLLABORATION 1</td>
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</table>
5.8.3 Analysis of initial business application architecture

Identification and classification of key business applications and level of integration
The initial business application architecture was analyzed in a very structured way. External consultants were also involved in this analysis project. Characteristic for the initial business application architecture was that already within one business unit the architecture consisted of a large number of different applications. Between these applications there was a high number of interfaces.

In developing the initial business application architecture the company had not used any enterprise architecture framework or similar method. The initial business application architecture was very different in different business units. In this study Business unit 1 was chosen for the analysis. Business unit 1 included the main manufacturing unit and a sales unit. Business unit 1 covered all relevant functions sales, production, R&D, logistics, purchasing, invoicing, finance and after sales. The detailed initial business application architecture in Business unit 1 is shown in Figure 5.27.

Unlike other case companies Company 4 did not have an ERP application as a backbone in Back end applications. Instead, the company had several smaller applications, which were integrated with each other. In Back end applications all the main functions, such as inventory management, material requirements planning (MRP), order management and purchasing were in different applications. This best of breed strategy was partly chosen consciously and partly as a consequence of development in the past. The main reason for the chosen best of breed strategy was to pursue flexibility in the business application architecture. This strategy has also some benefits compared to the comprehensive ERP application, as described in a case study by Light et al. (2001).
Figure 5.27. Company 4 initial business application architecture in Business unit 1.

In Business unit 1 most of the Back end applications were integrated in a way which enabled information flow between applications. However, a high number of separate applications created complexity, which was difficult to manage and maintain.

In Engineering Business unit 1 had a PDM application and a 3-D CAD application for product engineering and design. The PDM and the 3-D CAD application were integrated with each other. As a Management tool Business unit 1 had a data warehouse application. The data warehouse application also included a forecasting application. However, in practice most of the management reports were generated directly by operational applications.
The core of the Front end applications was the sales configurator. The sales configurator got input from quotation and pricing applications. In addition, in Front end applications there was an application for managing spare parts and a web-site including product catalogue and web spare part sales applications.

In Collaboration the company used an application, which included e-mail and shared calendars.

*Business applications coverage compared to initial business processes*

Business application coverage was evaluated as part of the analysis of the initial business application architecture. According to this analysis the core business processes and critical success factors were covered with the functionality provided by the initial business application architecture. The main critical success factor, customer driven flexible production management model, was well supported by the initial business application architecture.

In the analysis of the initial business application architecture user satisfaction was also evaluated. In general users were quite highly satisfied with application support for business tasks and they trusted that applications in the initial business application architecture could support them in the future. From the management’s perspective support for reporting could have been better. From IT management’s point of view the main problem was the high number of applications and consequently the interfaces between these applications. Also the applications were provided by quite a few vendors and that increased the complexity of the setting.

Despite the high user satisfaction level there were some basic functionality issues in the initial business application architecture. The most essential deficiency was the lack of a centralized database for customer information and order management. Although different applications including customer and order information were integrated, there was still a lot of double data entry and overlap of information. Other shortcomings in the initial
business application architecture were in the automation and transparency of the order fulfilment process, low level of integration with suppliers, inadequate support for spare parts logistics and management of product and configuration data.

Information architecture from different stakeholders’ perspective
Company 4 did not have an independent information architecture, so it could not be analyzed.

Effectiveness of initial key business applications
Effectiveness of the initial applications was assessed as part of the analysis of the initial business application architecture. Most of the applications in Business unit 1 were developed from scratch or heavily customized. Therefore, individual applications were effective as such. Also, users were satisfied with the applications in general. However, the problem in the company was the complexity of the initial architecture and high number of separate business applications in the initial business application architecture. This decreased the effectiveness of the whole business application architecture significantly because of several interfaces, a possibility for errors and double data entry.

Recognition of possible unrealised potential in initial business applications
As a consequence of most applications being developed for the company or being greatly customized, nearly all features in the main applications were in use. Additionally, the main applications had been in use for a long time and therefore users had learned to use the available features efficiently.

Risk assessment and robustness of initial key business applications
Risk assessment was performed in a very organised manner. Risk assessment was part of the analysis of the initial business application architecture and external consultants headed it. In Business unit 1 the risk level was evaluated as low. There were only a few critical technologies with potential risks or urgent replacement needs.
According to risk assessment the complex environment caused the main risk. Particularly the high number of separate applications and interfaces led to the risk of instability of the initial business application architecture. The high number of different technology platforms also created complexity. In addition, most applications were developed from scratch or heavily customized, which was a risk as such. The large amount of vendors was evaluated as a risk, on the other hand, it lowered the risk of being depended on one or a few vendors.

From all the individual applications only the MRP application was seen as a risk, because the vendor had not quarantined support for very long.

5.8.4 Development of target business application architecture

In Company 4 the initial business application architecture was analyzed and the target business application architecture developed in a short period of time. However, the target business application architecture was proposed in a few phases. The company did not use any enterprise architecture framework in developing the target business application architecture, although analysis of the initial architecture and development of the target business application architecture was executed in an organized manner.

In Company 4 the main drivers to change the business application architecture were the complexity of the initial business application architecture and the need to build better integration and transparency through the company.

Identification of key business applications and description of target business application architecture draft

Key business applications were identified by the team of external consultants and IT management. Identification was based on critical success factors and business requirements. The process of identification was performed in an organized way.
Critical success factors and business requirements formed the base for business application architecture development. According to analysis of the initial business application architecture, the initial architecture supported the critical success factor “Customer driven tailor-made production” well. However, there were shortcomings in the transparency of the supply chain. Critical success factors “High quality expertise services” and “Customer care” required the ability to manage customer information properly. A prerequisite for that was integrated and efficient management of customer information throughout the company. As a consequence of an operating model, where products were either made to order or assembled to order, the ability for sales configuration was critical. Additionally, Company 4 provided visibility of specific customer order to each customer. This too required transparency of the whole supply chain.

The business requirement “Sales channel management” required capability and flexibility to manage several different sales channels. As a new sales channel the company had its parent company. The business requirement “Operating as part of a large corporation” affected in the form of common policies and compatibility issues. The target business application architecture had to be compatible with the business application architecture of the parent company.

In planning the target business application architecture in Company 4 the main issue was the complexity of the initial business application architecture. The target business application architecture was developed by first creating a few potential options and then choosing the most preferable one from them. Roughly, the options were to follow the choices made by the owner, continue mainly with the existing business applications and reduce complexity or to move to an enterprise application integration solution. After consideration a combination of these options was chosen.

In the company the target business application architecture was planned already from the beginning to be developed and implemented in phases. Several applications from the initial architecture were selected to be in development phase 1 of the target business
application architecture. Those applications included all Front end applications, PDM (PDM 1) and 3-D CAD (CAD 3-D 1) application from Engineering and data warehouse (DATA WAREHOUSE 1) in Management tools. In Front end applications particularly sales configuration (SALES CONFIGURATOR A) was essential according to the critical success factors. Pricing (PRICING A) and quotation (QUOTATION A) applications were related to sales configuration and therefore accepted in the target business application architecture. In Front end a new application compared to the initial architecture was the CRM A application. CRM application was required for efficient management of customer information. Also the collaboration application, COLLABORATION 1, was accepted for the target architecture.

The main differences compared to the initial business application architecture were in Back end applications. This was natural, because most of the complexity was in Back end applications. In addition, based on critical success factors “Customer driven tailor-made production” and “Customer care” improved transparency and centralized management of key information entities was clearly one objective in the target business application architecture. In phase 1 basic data registers of product, customer and supplier data were replaced with an ERP application (ERP A /Phase 1). In addition the functionality of financials (FINANCIALS 1) and order and invoicing (ORDER/INVOICE MANAGEMENT 1) were included in ERP A /Phase 1. Scheduling (SCHEDULING 1), material requirements planning (MRP 1), inventory management (INVENTORY MANAGEMENT 1) and material purchasing (MATERIAL PURCHASING 1) were excluded from the scope of ERP A /Phase 1. Both quality management (QUALITY A) and quality reports (QUALITY 2) applications from the initial architecture were accepted in phase 1 of the target business application architecture. Equally, payroll application (PAYROLL 1) was covered in phase 1 of the target business application architecture. The target business application architecture in phase 1 in Business unit 1 is illustrated in Figure 5.28. Figure 5.28 describes also the integration interfaces on a ballpark level. This phase 1 target business application architecture in Company 4 is comparable with the business application architecture drafts from the other case companies.
Figure 5.28. Phase 1 of target business application architecture in Business unit 1 in Company 4.

Integrity of information architecture and target business application architecture

Company 4 did not have an actual information architecture. Consequently, integrity of the information architecture and the target business application architecture could not be assessed. However, according to the IT Director, the company was planning to build an information architecture in the near future.

Target business application architecture from defined stakeholders’ perspective

For the users a reduced number of different applications meant less manual work and much better transparency in order fulfillment process, although there was still potential
for enhancements. Also, the CRM A application provided better support for handling customer related information.

From management’s perspective the main improvement was the better transparency in the supply chain. In addition, centralized management of customer and order information provided more reliable information to support management decisions.

For IT management the reduced amount of applications in the target business application architecture offered a clearly easier and more stable environment to maintain. Also, the decreased number of interfaces helped in the maintaining task.

Required level of integration
Integration requirements were based on the scattered application architecture, although in the target business application architecture the number of different applications decreased significantly. In addition the seamless flow of transactions and transparency through the supply chain needed a higher level of integration. As in the other case companies, also in Company 4 the same information entities existed in several applications. Information entities and information architecture for the target business application architecture is shown in Table 5.18.

The main difference between the target information architecture and the initial information architecture was that, except for product data, there is only one application where Master data is maintained in the target architecture. Consequently, this required tighter integration between applications than what there was in the initial business application architecture.
Table 5.18. Information entities and high-level target information architecture in Business unit 1 in Company 4.

<table>
<thead>
<tr>
<th></th>
<th>Customer data</th>
<th>Product data</th>
<th>Supplier data</th>
<th>Accounts</th>
<th>Quotation/Order data</th>
</tr>
</thead>
<tbody>
<tr>
<td>BACK END</td>
<td></td>
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<tr>
<td>ERP A</td>
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<td>Master</td>
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<tr>
<td>PURCHASING A</td>
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<td>QUALITY A</td>
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<td>FRONT END</td>
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<tr>
<td>SALES CONFIGURATOR A</td>
<td>X</td>
<td>X</td>
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<tr>
<td>QUOTATION A</td>
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<td>PRICING A</td>
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<tr>
<td>SPARE PARTS A</td>
<td>X</td>
<td>Master</td>
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<tr>
<td>WEB SPARE PARTS A</td>
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<td>PRODUCT CATALOG A</td>
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<tr>
<td>CRM A</td>
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<td>Master</td>
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<tr>
<td>ENGINEERING</td>
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<td>PDM A</td>
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<tr>
<td>3-D CAD A</td>
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<td>MANAGEMENT TOOLS</td>
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<tr>
<td>DATA WAREHOUSE 1</td>
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<td>COMMUNICATION</td>
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<tr>
<td>COLLABORATION 1</td>
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</table>

Analyzing gaps between initial business application architecture and target business application architecture

In Business unit 1 the main difference between the initial and the target business application architecture was the change from a best of breed architecture to an ERP application. Other diversities were a new CRM application and in phase two of the target business application architecture the replacement of PDM and CAD 3-D applications.

Finalizing target business application architecture considering practical constraints

In Company 4 in Business unit 1 the target business application architecture was designed in two phases. Phase 1 is comparable with the target business application architecture draft and therefore it is reported here as such. Phase 2 is reported here as a finalized target business application architecture.
There were several additional components in the finalized target architecture compared to the target business application architecture draft. In Back end the following further applications were included in the ERP application (ERP A / Phase 2) MRP 1, SCHEDULING 1, MATERIAL PURCHASING 1 and INVENTORY MANAGEMENT 1. As a result Business unit 1 had a full scale ERP application in the finalized target business application architecture. Other Back end applications in development phase 2 included merging the quality reports application (QUALITY 2) to the quality management application (QUALITY A) and replacing the payroll application (PAYROLL 1). In payroll two options were identified either to use ERP A / Phase 2 or outsource the payroll application as ASP (ASP A). The decision had not yet been made during the development of the finalized business application architecture.

In Engineering applications the objective of phase two was to follow the owner’s policy in both PDM and CAD 3-D applications. Thus, the same applications as in the parent company, PDM A and CAD 3-D A, were chosen for the final target business application architecture. In Management tools the forecasting application was abandoned and efforts were planned to focus in DATA WAREHOUSE 1, although also the future of DATA WAREHOUSE 1 was under review. The finalized target business application architecture of phase 2 in Business unit 1 is illustrated in Figure 5.29.
Figure 5.29. Company 4 detailed target business application architecture in Business unit 1.

5.8.5 Planning, prioritising and implementation of target business application architecture

Company 4 is in the beginning of the business application architecture development process. At the time of writing this thesis the company had analyzed the initial business application architecture and developed the target business application architecture, but they had not yet taken any implementation steps towards the target architecture.
The recommended order of priorities was set by IT management and external consultants. Company 4 divided business application architecture priorities in three categories: short term, medium term and long term. In planning and prioritizing the main issue in the company was the complexity of applications in Back end. Accordingly, choosing and implementing ERP A was the first priority. ERP A implementation was planned to be executed in phases. In addition to ERP A implementation the following top-level projects were identified:

- ERP selection and implementation in phases
- CRM application development or selection and implementation
- Data warehouse enhancement
- Replacement implementation of PDM and 3-D CAD application
- Merger of two quality applications

Priorities in business application architecture development in Company 4 are shown in Figure 5.30.

<table>
<thead>
<tr>
<th>Analysis of initial architecture</th>
<th>BACK END</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business application architecture planning</td>
<td>ERP A / Phase 1</td>
</tr>
<tr>
<td>ERP A / Phase 2</td>
<td>SUPPLIER MANAGEMENT</td>
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<td></td>
<td>FINANCIALS</td>
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<td></td>
<td>ORDER/INVOICE MANAGEMENT</td>
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<td>ERP A / Phase 2</td>
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<td></td>
<td>SCHEDULING</td>
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<td>MRP</td>
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<td></td>
<td>INVENTORY MANAGEMENT</td>
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<tr>
<td></td>
<td>PURCHASING</td>
</tr>
<tr>
<td>Merger of QUALITY MANAGEMENT and QUALITY REPORTS</td>
<td>PAYROLL A or ASP A</td>
</tr>
<tr>
<td>FRONT END</td>
<td>CRM A implementation</td>
</tr>
<tr>
<td>ENGINEERING</td>
<td>PDM A</td>
</tr>
<tr>
<td>MANAGEMENT TOOLS</td>
<td>CAD 3-D A</td>
</tr>
<tr>
<td>DATA WAREHOUSE A enhancement</td>
<td>COMMUNICATION</td>
</tr>
<tr>
<td>COLLABORATION A implementation</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5.30. Business application architecture development priorities in Business unit 1 in Company 4.**
In Company 4 analyzing and describing the current status of business application architecture is not applicable, because the company is in the beginning of the process and thus the current status is identical with the initial business application architecture.

5.9 Cross case study comparison

5.9.1 Comparison of business application architectures

Information architecture
Clearly information architecture was a weak element in all the case companies. None of the case companies had an actual information architecture. In two companies a very high-level of information architecture was drafted. High-level information architectures were very similar in different companies. Key static data entities were customer information, product information and supplier information. In addition information entities related to key process flow were quotation, order and invoice information.

Initial business application architecture
In all case companies the initial business application architecture had similar features. In three case companies an ERP application was the backbone of the business applications already in the initial business application architecture. Only Company 4 did not have an ERP application in initial business application architecture. In Company 1 and Company 2 a commercial ERP package was used. In Company 3 a customized application was used to cover same functionality. Company 4 used a number of customized and developed applications to cover the same functionality as the ERP application. In Engineering applications the setting of applications was very similar: all case companies had PDM applications and CAD applications. Clearly larger companies, Company 2, Company 3 and Company 4, had invested more in Management tools than Company 1 already in their initial business application architectures. This is understandable, because in larger
companies the complexity of the business structure increases and therefore it requires
heavier tools to manage it.

When looking at Front end applications in the initial business application architecture, a
combining aspect is the exiguity of these applications. In the initial business application
architectures all the case companies have put more effort in developing Back end and
Engineering applications than Front end applications. Only Company 4 had strong Front
dend applications in the initial business application architecture. In Communication all
case companies had basic e-mail application. In addition, Company 2, Company 3 and
Company 4 had some collaboration tools such as shared calendars.

In business applications coverage there were some shortcomings compared to initial
business processes, again primarily related to Front end applications and Management
tools. However, in general these shortcomings were not seen as a major problem.

In all case companies there were several applications in the initial business application
architecture, which were identified as very effective. In all cases these were small
applications customized for a specific task. This finding is against the principle of
favouring COTS packages. However, these effective customized applications were used
for very definite tasks, such as printing invoices in a certain market area. Therefore, the
conclusion should be to favour COTS in major business applications but not to be too
strict and allow specific customized applications when applicable.

In Company 1 and Company 2, which were using commercial software packages as key
business applications, there clearly was unrealised potential in the initial business
applications. In both cases the main reasons were the affluence of features in major
applications and due to prioritising in implementation some features were never used. In
Company 3 and Company 4 more customized applications were used and thus there were
not that many spare features available.
Clearly the level of integration in the initial business application architecture affected the effectiveness of the architecture in the case companies. Particularly in Company 1 the low level of integration caused problems. Based on this finding it seems that the outcome as a total business application architecture is better if applications are integrated, even in a case where the individual applications do not necessarily have the best possible fit with specific requirements. Consequently, if one has to choose between an integrated architecture with acceptable fit of individual applications or a non-integrated architecture with excellent fit of individual applications, the better result seems to occur with the integrated architecture.

In all case companies there were some business applications which were evaluated to have risks. In addition to bypassing the Y2K risk the other risks were mainly related to small or unreliable vendors or obsolete technology.Obsolete technology was a risk in itself, but another risk related to it was the possible unavailability of support services.

**Target business application architecture**

As in the initial business application architecture all case companies had similar features also in their target business application architectures. In three case companies an ERP application remained as the backbone for business applications in the target architecture and in Company 4, which didn’t have an ERP in the initial architecture, an ERP application became a vital part of the target business application architecture. Company 1 and Company 2 had a commercial ERP package already in their initial business application architecture. Also Company 4 was planning to move from customized applications in their initial architecture to commercial ERP package in their target business application architecture.

Apparent general changes in transferring from the initial business application architecture to the target business application architecture were the strengthening of Front end applications and Management tools.
In all case companies integration requirements were based on static information entities, such as product information, customer information and process flow related transactions like quotations and orders. Concerning the static information entities the integration issue in all case companies was that the same information entities existed in several applications and if they were to be maintained manually the amount of manual work increased and there was a risk for errors. On the other hand, there was a cost issue related to each integration interface. In choosing from these options all case companies were aiming at more extensive integration between key business applications. Therefore the target business application architecture differed from the initial business application architecture in terms of higher level of integration.

In case companies 2 and 3 more than one business unit was included in the study. Based on these cases, only careful generalisations can be made. Management tools and Communication applications were set as common applications in the target business application architecture for the whole company and payroll applications were set as local applications in both case companies. In addition all companies which had more than one site, Company 2, Company 3 and Company 4, were aiming towards a common ERP application.

If there had been no practical constraints, the target business application architecture would have been different in each case company than what it is now. However, it seems that practical limitations affected the actual end result of the target business application architecture, less than the implementation time.

5.9.2 Comparison of business application architecture development processes

IT and business alignment

In all case companies critical business requirements were identified in the beginning of the business application architecture development process. However, the extent of this exercise varied reasonably much. Understandably in large case companies this process
was more thorough than in smaller case companies. Key issues in driving the change in business application architecture deviated a lot. The reasons ranged from harmonising the business application architecture to improving the quality of information. In all case companies several stakeholder groups were involved in business application architecture development. In each case business management, IT management and users were involved in the process. Development was driven either by business management or by IT management. In each case company the business environment had significant influence on the business application architecture. In case companies 1 and 3, which were part of the supply chain in their field of industry, also external parties had major influence on the business application architecture.

**Information architecture and information requirements**

Information architecture was the weak element of business application architecture development in all case companies. None of the case companies had an actual information architecture. Consequently, none of the case companies used an information architecture as basis when developing the target business application architecture. However, information requirements were determined as part of the business application architecture development process in all case companies.

**Analysis of initial business application architecture**

In all case companies the business application architecture development process was based on analysis of the initial business application architecture. In case companies 1 and 2 business applications in the initial business application architecture were identified and classified using a similar classification model as proposed in this thesis. In case companies 3 and 4 business applications in the initial business application architecture were identified, but not classified. None of the case companies had used an enterprise architecture framework or any other similar tools in developing the initial business application architecture.

In the business application architecture development process business applications coverage compared to the initial business processes was analyzed only in half of the case
companies as a separate phase in the process. In Company 3 and Company 4 a thorough analysis was performed, but in Company 1 and Company 2 this was done more instinctively.

In all case companies there were some applications in the initial business application architecture, which were identified as exceptionally effective. This identification was performed in all case companies and taken into account in the target business application architecture design.

The way to execute risk and robustness assessment varied in case companies. In Company 1 risk assessment was performed in a very strict way, but that was because the Y2K issue was concrete at the time of analyzing the initial business application architecture. Also in Company 4 analysis of risk was performed in an organized way. In Company 2 and Company 3 risk and robustness assessment was based more on general observations.

**Development of target business application architecture**

The business application architecture development process was based on analysis of the initial business application architecture and of the determined business requirements in all case companies. In general, development of target business application architectures in case companies was a rather organized process. In Company 1, Company 2 and Company 4 development of the target business application architecture draft was done in a relatively short time, although the first draft changed during the implementation process. In Company 3 development of the target business application architecture took a relatively long time.

In terms of integration between business applications very similar issues were considered in all case companies. As part of target business application architecture development, all case companies were pursuing more extensive integration between key business applications.
In all case companies finalizing the target business application architecture was more a process evolving in time during implementation rather than an actual step in business application architecture development. Practical constraints needed to be considered in finalizing the target business application architecture in each case company. The available resources and the money to be invested set practical limitations.

Planning, prioritising and implementation of target business application architecture
Implementation of business applications was prioritized in all case companies. The priorities were set by either management or IT management. The prioritization criteria varied between case companies, but a main criterion was what was most critical to be done. This is inline with findings by Ward and Peppard (2002). Other factors were what own resources were available and how much money could be invested. In general prioritization was not based on formal calculations, but rather on general observations in the company and in business environment.

A general characteristic for business application architecture implementation in case companies was that it took a long time. This was an interesting observation, especially considering that typically the development and planning of the main elements in business application architecture was done in a short time period. Despite that the development of target business application architecture was done in short time, the implementation of target architecture takes a long time and in practice it means that the target architecture will partly change during the time frame of implementation. Consequently, parts of the target business application architecture are always in continuous development process. Although Company 4 is in the early days of the implementation process it is already clear that business application architecture implementation will take several years also in this case company.
6 RESULTS OF THE STUDY

The aim of this chapter is to present the main results of this study. This chapter describes the results of this thesis and compares them to previous results in literature.

At the general level the aim of this study was to increase general knowledge of business application architectures and business application architecture development processes. Consequently, the objective of this study was to formulate answers to the research questions presented in Chapter 5.2. In order to reach the objective of the study a framework with which the business application architectures and business application architecture development processes could be analyzed and enhanced was first developed. The framework was developed to support a structured way of investigating the business application architecture development processes. The framework was developed based on theoretical literature of enterprise architecture frameworks and application classification models and on empirical experience in the industry. To achieve the objective of this thesis, to answer the research questions, none of the existing frameworks seemed an appropriate instrument. This was because they didn’t include features to support intensive analysis of business application architectures or business application architecture development. The following features or information could not be obtained without the business application architecture framework:

1. Except for TOGAF, a development method, a reference model for development process or development analyzing method is missing from existing enterprise architecture frameworks. Consequently it would have been impossible to analyze architecture development processes with any of the other existing frameworks

2. There are no tools available to describe and compare initial and target architectures in a thorough way in any of the enterprise architecture frameworks. Thus, an additional application classification model would have been required
even if one of the existing enterprise architecture frameworks would have been chosen as an analyzing tool

3. The existing enterprise architecture frameworks are meant to support an entire enterprise architecture, not any specific part of the enterprise architecture. Thus, they would not have provided sufficient tools for investigating one selected part of the enterprise architecture, the business application architecture, on a detailed level

4. The influence of external parties and the business environment is not included in any of the enterprise architecture frameworks

5. Analysis of business application integration is not included in any of the enterprise architecture frameworks

6. Analysis of the effectiveness of the initial business application architecture is not included in any of the enterprise architecture frameworks

7. Risk assessment of the initial business application architecture is not included in any of the existing enterprise architecture frameworks

8. Analysis of which applications are common for the whole company and which applications are local is not included in any of the existing enterprise architecture frameworks

9. Consideration of practical constraints in business application architecture development is missing from all existing enterprise architecture frameworks

The business application architecture framework as such is one result of this study. With the framework business application architectures and business application architecture development processes can be analyzed and enhanced. In previous research several enterprise architecture frameworks have been developed (e.g. Zachman 1987, CIO Council 1999, Open Group 2002, NCR Corporation 1996, Plachy & Hausler 1999). The framework proposed in this study differs from existing enterprise architecture frameworks in six main issues:

1. The framework is focused on business applications and excludes other aspects of enterprise architecture frameworks
2. The business application architecture framework has an application driven approach

3. The framework includes a reference model for business application architecture development process, which is missing from existing enterprise architecture frameworks, except from TOGAF, which has an enterprise architecture development method.

4. The framework combines features from application classification models and enterprise architecture frameworks

5. The framework is limited to a specific business sector, the manufacturing industry, because it includes features which take into account engineering function, which is characteristic for manufacturing companies

6. The business application architecture framework includes features, as listed above, which are not included in previous frameworks

The developed business application architecture framework consists of two elements: the business application classification model and the reference model for business application architecture development process. In earlier research some application classification models have been introduced (e.g. Anthony 1965, Gorry & Scott Morton 1971, McFarlan 1984, Turban 2001, Ward & Peppard 2002). However, none of these was seen as appropriate for the business application architecture framework and thus a model was developed particularly for the manufacturing industry. The business application classification model can be used for analyzing and describing business application architectures. In this thesis the reference model for business application architecture development process is used for analyzing business application architecture development processes, but it can be used for developing business application architectures as well.

In the empirical part of this study four case companies were analyzed using the business application architecture framework. The empirical analyses followed the logic of the reference model for business application architecture development process and sought answers to the research questions. The research questions were:
**Research question 1:** What common factors can be identified in initial business application architectures in the case companies?

**Research question 2:** How the business application architectures have been developed in the case companies?

**Research question 3:** What common factors can be identified in target business application architectures in the case companies?

In the following chapters 6.1, 6.2 and 6.3 the presentation of the results of the empirical part of the thesis is organized according to the research questions.

### 6.1 Common factors in initial business application architectures

The analysis of the initial business application architecture was performed in a different way in each case company. In companies 3 and 4 the analysis was executed in an organized manner. In companies 1 and 2 some parts of the analysis were executed in an organized manner, but not the entire process.

There were no common drivers, changing the initial business application architecture which could have been identified in all case companies. In Company 1 the drivers were risks in the initial architecture; a low level of integration between applications and a lack of support for the Front end. In Company 2 the drivers were to harmonise incoherent applications architecture in different sites and to strengthen the Front end and Management tools. In Company 3 and Company 4 some similarities could be identified, because in both companies the initial business application architecture was non-integrated and the objective was to improve the transparency of the supply chain. Additionally, Company 3 was aiming to improve consistency and accuracy of information in the business application architecture and Company 4 was aiming to reduce the complexity of their initial business application architecture. In all case companies the level of
integration was low and the only common factor was the trend to increase the level of integration in the business application architecture in one way or another.

In all case companies there were several applications in the initial business application architecture, which were identified as very effective. In all cases these were small applications customized for a specific task. This finding is against the principle of favouring COTS packages (e.g. Fox et al. 1997, Davenport 1998, Kara 1999, Wiers 2002). However, these effective customized applications were used for very definite tasks, such as printing invoices for a certain market area. Therefore, the conclusion should be to favour COTS in major business applications but not to be too strict and allow the possibility for specific customized applications when applicable. In general there is a clear trend towards commercial software instead of in-house developed applications (e.g. Tyrväinen et al. 2004). A similar finding was that it appears that companies using commercial applications had more unused features in their initial business application architecture than companies with customized applications. This may be because particularly ERP applications are complex and made to fit many different types of organizations. Thus, there may be a lot of features not suitable for a particular company (Geishecker 1999, Parr & Shanks 2000).

In terms of risks in the initial architectures the main risks were related to small vendors or obsolete technology. In Company 4 the main risk was related to the general complexity of the initial business application architecture.

The initial business application architectures had several similarities in all case companies. In the Engineering applications the set up of the initial architecture was very similar. All case companies had one or more CAD applications and most companies also had PDM applications as Engineering applications. Another common factor appeared to be that all larger companies (Company 2, Company 3 and Company 4) had invested in Management tools already in the initial architecture more than smaller companies. Clearly the weakest category of business applications in the initial business application architecture was the Front end. Only Company 4 had invested in developing Front end
applications in the initial architecture. Accordingly, the emphasis on investments in developing the target business application architecture was in Front end applications in Company 1 and Company 2. Company 3 had to put effort in developing Back end applications before they could concentrate on Front end applications.

6.2 Business application architecture development processes

In all case companies the business requirements were determined first and the business application architecture and the business application architecture development was clearly based on the business requirements. According to several authors this is an essential prerequisite for successful utilization of information systems (e.g. Gwynne 2001, Feld & Stoddard 2004). Business requirement determination and business application architecture development were mostly driven by IT management, although more intensive involvement of business management would have been useful. Most of the IT management representatives that were interviewed were hoping for more support from business management in the business application architecture development process. Also, according to several previous studies intensive involvement and support of business management is essential for successful IT management (e.g. Broadbent et al. 1994, Ross et al. 1996, Ross and Weill 2002).

The stakeholder groups that have been defined in the business application architecture framework (management, IT management and users) were involved in the development process, but the level of involvement varied between case companies. External parties influenced the business application architectures in part of the case companies. External parties influenced the business application architectures in case companies, which were an integrated part of a supply chain in their industry. According to several other studies this is an increasing trend in many industry sectors (e.g. McLaren et al. 2002, Tarn et al. 2002).
As one result it can be concluded that none of the case companies had a real information architecture. Only in a few case companies a high level information architecture had been developed. These high level information architectures were very similar in all case companies. This is a similar finding as introduced by Van Den Hoven (2003). According to Van Den Hoven (2003) most enterprises do not have a well-integrated view of their data and as a result, the enterprise’s data is fragmented, inconsistent and redundant. However, all representatives of IT management that were interviewed stated that it would be useful to have an information architecture. Niederman et al. (1991) made similar findings in their study among IT executives. In the survey they found that information architecture was ranked as the number one priority among IT executives at the time.

In terms of data quality all case companies considered their quality of data inadequate and a significant area for improvement. Poor data quality was mainly a consequence of maintaining the same data entities in various applications.

In developing the target business application architecture some common aspects among case companies could be identified. None of the case companies had used an enterprise architecture framework in developing the target business application architecture. However, Company 1 and Company 2 had used part of the business application architecture framework proposed in this thesis in developing their target business application architecture. Both companies had used the business application classification model included in the business application architecture framework. The suggested business application classification model was also applicable in analyzing business application architectures in Company 3 and in Company 4.

When comparing the reference model for business application architecture development process to the actual development processes in case companies, it can be concluded that most of the phases included in the reference model were performed in all case companies. However, there were variations in how these phases were executed and in which order.
The time spent in developing a target business application architecture varied substantially. Three of the case companies created their target business application architecture in a fairly short period of time. One case company spent a long time developing their target business application architecture. In this case company business application architecture development was more like a process that evolved over time rather than a development project as such. Regardless of the time used in developing the target business application architecture, the actual implementation of target business application architecture took several years in all case companies.

On the basis of this research practical constraints in architecture implementation effected the duration of the implementation more than the end result. The most common constraint was the availability of resources. As one consequence of a long implementation period, it was natural that additional elements were attached to the target business application architecture during the process.

During prioritizing and implementing of the target business application architectures similar features could be found in all case companies. All case companies had noted that Back end applications needed to be on a proper level before implementing or enhancing Front end applications. However, each case company was in a different development phase. The case companies which already had sufficient Back end applications in place were planning to invest in Front end applications and those who still had development areas in Back end applications were prioritizing them before investing in Front end applications. This supports findings by Riihimaa and Ruohonen (2002) concerning the emphasis of information systems development in Finnish organizations.

6.3 Common factors in target business application architectures

In Back end applications Company 1 and Company 2 relied on commercial ERP applications and Company 3 had an in-house developed application, which covered the same functions as an average ERP application. In the initial architecture Company 4 did
not have a single application for standard ERP functions, instead they had several
different developed or customized applications. However, in the target business
application architecture Company 4 was planning to implement a commercial ERP
application. Based on the results of this study the companies appeared to move towards
commercial ERP applications despite the criticism towards them (Geishecker 1999, Light
et al. 2001). However, keen generalizations should be avoided because of the small
number of companies studied in this thesis.

Clearly, a common phenomenon in the development of target business application
architectures was that all case companies were pursuing towards a more integrated
architecture than what they had initially. This is a similar finding as the well-documented
general trend towards ERP applications, which facilitates integration across the enterprise
(Davenport 1998, Poston & Grabski 2001). However, according to this study, a similar
trend is applicable also in the scope of the whole business application architecture and not
just in the scope of ERP applications. As a result target business application architectures
included less applications and less complexity but provided the same functionality as the
initial architecture. On the other hand, typically the actual number of different
applications didn’t decrease in the target architecture. This was because the target
business application architecture had more functionality and features to be supported than
the initial architecture. This is understandably a consequence of the general increase of
information technology usage.

In general the target business application architectures had several similarities in all case
companies. Particularly the Engineering applications set up was comparable. All case
companies had a PDM and one or more CAD applications as Engineering applications.
Another common factor appeared to be that all larger companies (Company 2, Company
3 and Company 4) had invested in Management tools more than smaller companies.
Additionally, a common difference between initial and target business application
architectures appeared to be that all case companies had a more versatile set up in Front
end applications in their target architecture than they had in their initial architecture.
Based on this study it appears that Management tools and Communication applications were set as common applications in the target business application architecture for the whole company and payroll applications were set as local applications. In other application categories there was more diversity between the applications that should be common and those that should be local in different companies. All companies that had more than one site, Company 2, Company 3 and Company 4, were aiming towards a common ERP application for the whole company.
7 CONCLUSIONS AND DISCUSSION

This chapter presents the conclusions of this thesis and the contribution of the study is discussed. This chapter shows the evaluation of the developed framework and the implications for theory and practice. In the end of this chapter the validity of the study is discussed and some suggestions for further research are made.

7.1 Evaluation of proposed business application architecture framework

The business application architecture framework has been built based on several application classification models and enterprise architecture frameworks. Therefore the theoretical background of the framework is solid. Additionally, the framework is based on empirical experience in the industry. Accordingly, the overall foundation base is strong. However, this broad background is also a potential weakness, because application classification models and enterprise architecture frameworks have not been combined before. Thus, the business application architecture framework is exploring a new field of research where the amount of previous research is limited and hence there is little earlier knowledge to lean on. Consequently, the developed business application architecture framework needs to be tested further.

On a general level the aim of the study was to increase general knowledge of business application architectures and business application architecture development processes. Consequently, the objective of this study was to formulate answers to the research questions presented in Chapter 5.2. In order to reach the objective of the study a framework with which the business application architectures and business application architecture development processes could be analyzed and enhanced was first developed. Because the aim of this study was not to build the framework itself but rather to increase general knowledge of business application architectures, the emphasis of evaluating the
developed framework is on assessing what information could be gathered about business application architectures by using the framework.

According to March and Smith (1995) efficiency, understandability and ease of use are important metrics in evaluating any constructs or methods as an outcome of a research. The business application architecture framework was used in four case companies. Based on those case studies and the results presented in the previous chapter, the framework appears to be an effective analyzing tool. Also, the framework is simple enough to be understandable and easy to use without any particular training. It would be valuable to be able to use the framework for developing business application architectures, which would require more evidence on the framework’s effectiveness. However, two case companies studied in this thesis, namely Company 1 and Company 2, had used parts of the business application architecture framework introduced in this thesis and found it useful and effective in developing and analyzing their business application architecture. Accordingly, there is some evidence of its validity. Company 1 and Company 2 have used the business application classification model for several years now and they find it useful in analyzing and developing their business application architectures. Furthermore, both companies use the business application classification model in illustrating their business application architecture in internal as well as in external forums. In addition to using the business application classification model extensively Company 1 and Company 2 have used elements of the reference model for business application architecture development process in developing their target business application architectures. Järvinen (2004) has added some new metrics of evaluation on the evaluation criteria by March and Smith (1995). Järvinen (2004) proposes to integrate the building and use phases of an artifact. This means to include the maintenance of an artifact in the evaluation criteria. Business application architecture framework clearly meets the criterion for easy and cost effective maintenance, because there is no particular maintenance required.

As well as Company 1 and Company 2, there is at least one additional company, referred in Appendix B as Company 5, which is using the business application classification
model for similar purposes as Company 1 and Company 2 (Business development manager of Company 5, phone interview on January 11th 2005). Company 5 is not a case company in this thesis. Consequently, it can be argued that the business application architecture framework has influenced the business practices in some companies.

The business application architecture framework consists of two elements: the business application classification model and the reference model for the business application architecture development process. Based on the case studies in the manufacturing industry the business application classification model is a powerful instrument in describing and analyzing business application architectures. This is because as shown in the results of the study in Chapter 6, there were a number of issues which could not have been investigated without the classification model. The classification model enables comparing and visualizing business application architectures in different companies. Additionally, it enables the illustration of integration between the business applications in a company. Also, it is possible to present the common and business unit level aspects of business application architectures and illustrate multiple business application architectures, for instance in different business units simultaneously. The business application classification model classifies applications in five categories: Front end, Back end, Engineering, Management tools and Communication. Based on this thesis this classification is applicable. Additionally, this classification model enables describing information flow and integration between various business applications. This is a valuable feature. This study does not examine if the business application classification model is applicable for other fields of business. To the same extent the reference model for the business application architecture development process is used in the manufacturing industry in this study. The developed reference model is more complex than the business application classification model and as such it is more difficult to judge its applicability in the manufacturing industry alone.

In the case companies of this study the reference model for the business application architecture development process proved to be useful, because valuable information could be collected by using it. As well as the business application classification model
also the reference model for the business application architecture development process enabled obtaining information which could not be acquired with existing enterprise architecture frameworks. For instance the analysis of the business application architecture development process as such would have been difficult with existing enterprise architecture frameworks, because most of them do not have a development method, a reference model for development process or a development analyzing method at all. Also features such as risk assessment and influence of external parties are not included in enterprise architecture frameworks.

It was interesting to find out that a general business application architecture framework could be used in analyzing business application architecture development processes, although the architecture development process had gone through different routes in each case company. Thus, there is some evidence that the reference model for the business application architecture development process appears to be applicable in variable cases. However, within the scope of this thesis the reference model for the business application architecture development process has not been tested in other business sectors than in the manufacturing industry and in the manufacturing industry only in four case companies.

The reference model for the business application architecture development process consists of several phases. In case studies the focus was in analyzing the content of the phases rather than the execution order. In evaluating the applicability of the reference model it can be concluded that most of the phases in the reference model were relevant in all case companies. Clearly the biggest difference between the reference model and the execution of business application architecture development in case companies was in the information architecture phase. This was because an information architecture did not exist in any of the case companies. However, all the IT management representatives that were interviewed confirmed that an information architecture would be useful for their company. Accordingly, information architecture appears to be a relevant part of the reference model for the business application architecture development process, although empirical evidence in case companies does not support its existence.
Morganwalp (2003) has listed desired features for enterprise architecture frameworks. According to Morganwalp an enterprise architecture framework should encompass enterprise-wide views, facilitate systems integration (i.e. integration between applications and business processes), be driven by or founded upon business requirements and be flexible enough to support frequent changes in technology and/or business. To some extent these features are applicable for the business application architecture framework and the proposed business application architecture framework can be measured against them.

The business application architecture framework proposed in this thesis encompasses enterprise-wide views because management, IT management and users have been considered as stakeholders. The framework also facilitates systems integration, because ‘IT and business alignment’ –phase has an essential role in the framework. Equally, the framework is clearly driven by business requirements. Flexibility of the framework is ensured with the application driven development approach and the ‘Change management’ –phase.

### 7.2 Implications for theory

A framework for analyzing and enhancing the development processes of business application architectures has been presented in this thesis. In this study the framework is used to increase general knowledge of business application architectures and business application architecture development processes. The theoretical contribution of this study consists of two essentials: the developed business application architecture framework and the knowledge added to the existing literature by using that framework.

The presented framework includes two main elements: the reference model for the business application architecture development process and the business application classification model. The framework utilizes some features from existing enterprise architecture frameworks (e.g. Zachman 1987, Open Group 2002) and from existing
application classification models (e.g. McFarlan 1984, Ward & Peppard 2002). The contribution of the business application architecture framework is that it is based on a different approach than the enterprise architecture frameworks presented in previous research. This means that the business application architecture framework is focused purely on business applications and excludes other parts of enterprise architecture. Consequently, the business application architecture framework enables to specify and refine the existing theory concerning business application architectures.

The framework presented in this study combines features of application classification models and features of enterprise architecture frameworks. In addition the framework includes a reference model for the business application architecture development process, which is not included in previous enterprise architecture frameworks. The reference model for the development process is based on the application driven approach, which is a new perspective compared to existing enterprise architecture frameworks. Furthermore, a new application classification model for business applications is presented. In the classification model the classification criterion is the purpose of the application. This is different than in most of the previous application classification models, where the classification criterion is typically the type of management activity that the application supports or the level of management that uses the application. Additionally, the business application classification model presented in this study takes into account requirements that are specific for one industry. Previous application classification models are generic and do not consider any such requirements.

The developed framework was used in this thesis to find answers to the presented research questions and thus to increase general knowledge of business application architectures and the business application architecture development processes. The framework enabled intensive analysis of business application architectures and business application architecture development. The framework is focused on business applications and it included the reference model for the business application architecture development process. Thus, it provided sufficient tools for investigating a business application architecture on a detailed level. In this study the elements of new knowledge are the
better understanding of business application architecture development processes, comparison of initial and target business application architectures, the integration of business applications, the use of information architectures and the influence of external parties and the business environment to the business application architecture. Furthermore, the business application architecture framework supported the risk assessment of the initial business application architecture and the understanding of practical constraints in architecture development.

The theoretical contribution of this study comes from the developed business application architecture framework and the knowledge added to the present research by using that framework. The business application architecture framework is formed of a new reference model for the business application architecture development process and a new business application classification model. These tools can be used in analyzing and enhancing the development of business application architectures. By using these instruments the existing theories are contributed by increasing knowledge of the business application architectures and the phenomenon of business application architecture development processes in industrial companies. The framework enabled refining existing theories so that the detailed and specific characteristics of business application architectures are taken into account.

### 7.3 Implications for practice

The developed business application architecture framework was used in four case companies for analyzing the business application architecture development processes. Two of these companies have also used the framework in developing their business application architectures. Based on these cases the framework seems to be a useful tool for analyzing and enhancing business application architectures, although the number of cases in this thesis is limited and one should be careful in generalizing the results of this study. The framework consists of the classification model and the reference model for the business application architecture development process, which can be used together or
individually for practical purposes. In practice, a clear benefit of the business application architecture framework compared to any of the enterprise architecture frameworks is that it is much simpler and provides a reference model for analyzing business application architecture development and can also be used in developing a business application architecture. Two of the case companies are using the developed business application architecture framework in analyzing and developing their business application architectures. In addition one company, which is not a case company in this thesis, has adopted the business application classification model and is using it as part of their business practice. Accordingly there is some evidence that the business application architecture framework is useful in practical business application architecture development work.

As one result of this thesis it was revealed that case companies did not have an information architecture, but when the researcher suggested it they all regarded it as a useful tool. The empirical part of this study includes a simple sketch for modeling an information architecture, which practitioners can exploit in their work.

None of the case companies had used an enterprise architecture framework or similar tool in developing their initial business application architecture. As an implication for practice this study suggests that using a business application architecture framework or some other tool described in the literature review of this thesis is an efficient way to develop business application architectures.

Clearly a trend in all the case companies was to aim towards more integrated target business application architectures. As an implication for practical IT management this indicates that effort should be put into ensuring that the business application architecture forms an integrated entirety rather than a non-integrated collection of high performance stand alone applications. Accordingly, in the light of this study it seems more preferable to have an integrated business application architecture based on average applications rather than investing in best-in-class applications, which are not integrated with each other.
As the case companies aspired towards a higher level of integration within the company, they also aimed towards a higher level of integration within their supply chain. This goal was emphasized in case companies which were an insepable part of the supply chain in their industry. This finding can be recognized as a general trend in many business sectors, where the supply chain integration is an increasing phenomenon. This is partly because companies are focusing on their core competencies and thus outsourcing major parts of their operations. This requires even closer integration with their partners to ensure fluent information and material flow in the supply chain. For instance if a company outsources its manufacturing the challenge is to integrate the business applications of this manufacturing partner with the company’s own business applications. As discussed earlier, in reality it is already a challenge to integrate the manufacturing function with the rest of the company and thus the degree of difficulty is much higher when manufacturing is not within the same company. A prerequisite for an integrated supply chain is that the business application architecture within the company itself is integrated first.

Although the trend is towards integrated entireties, one should not forget the requirement for flexibility in designing a business application architecture. Business environments are changing at an accelerating speed which requires flexibility from business application architectures. One result of this study was that business application architecture development and implementation took several years in all case companies. Consequently, the architecture has to be flexible so that it can adapt to emerging changes in requirements during the development and implementation of the architecture.

In addition to supply chain integration other emerging trends in information systems development are the emphasis of Front end applications and of knowledge management. Case companies in this study put effort in building their Back end applications before they invested in Front end applications. This seems a sensible way to proceed, because Front end applications can not work efficiently without proper Back end applications. For instance, a Front end application for quotation management is not useful if there is no Back end application, in this case an order management application, to which the
quotations can be transferred as orders. In terms of knowledge management case companies had some applications for transferring knowledge between organizations and some applications, such as data warehouse, for collecting information. However, in general case companies were rather on the level of gathering and managing information than on the level of actual knowledge management.

7.4 Evaluating the validity of the study

Yin (1994, p. 33) lists four criteria for judging the quality of any research as construct validity, internal validity, external validity and reliability. Patton (1990, p. 461) presents that the credibility of a qualitative inquiry depends on three distinct but related inquiry elements:

1. Rigorous techniques and methods for gathering high-quality data that is then carefully analyzed with attention to issues of validity, reliability and triangulation
2. The credibility of the researcher
3. Philosophical belief in the phenomenological paradigm, that is, a fundamental appreciation of naturalistic inquiry, qualitative methods and holistic thinking.

The construct validity of the research depends on how well the selected measures reflect the phenomenon under investigation. In this study the phenomenon of business application architectures and development of business application architectures were studied. For this purpose an analyzing framework was developed. One objective of the framework was to provide common tools and measures for analyzing case companies. The framework forms the measures used in the empirical part of this study. Here the measures mean the indicators, as described by Yin (1994, p. 34), that reflect and describe the business application architecture development phenomenon. These measures have been developed based on earlier research and experience in the industry. As described in the empirical part of this study the developed measures have been used in a similar way in each case company. Construct validity of the study can be evaluated by first evaluating the measures described as part of the business application architecture framework. Then
it can be assessed if these measures reflect the development of business application architectures.

Using multiple sources of evidence has increased the construct validity of the case studies. The analyses were based on interviews, written documents and observations. This process is described in more detail in Chapter 5.3 Data collection from the case companies. Using multiple sources of evidence also supports triangulation of data sources as described by Patton (1990). Triangulation of data sources means comparing and cross-checking the consistency of information derived at different times and by different means (Patton 1990, p. 467). In this study this is done by using several sources of evidence. Additionally, as proposed by Yin (1994), key informants have reviewed the case study report draft.

Internal validity measures the logic between observations and inferences. Internal validity is not a concern for descriptive case studies (Yin 1994, p. 35). However, Yin (1994, p. 35) continues that concern for internal validity in case study research can be extended to the broader problem of making inferences. Basically a case study involves inferences every time an event can not be directly observed. This study is mainly descriptive, but inferences are made based on interviews and other observations. In addition to using interviews, other sources of evidence were used to validate the interviews and when possible, several people were interviewed concerning the same issues to increase internal validity of inferences. In case design literal replication was used in different case companies to find out if similar inferences can be made in other case companies.

External validity deals with the generalisability of the research findings. This study was limited to a selected field of business, the manufacturing industry. This may affect the possibilities of expanding the results to other business sectors. However, focusing on the manufacturing industry was seen as a strength of the study, because it provided the opportunity of considering the unique requirements of this industry. Literal replication of case design was used in all four case companies to increase the external validity of results within the manufacturing industry. It is important to note that unlike in survey research in
case study research generalisability does not mean to necessitate large samples. This is because survey research relies on statistical generalization, whereas case study research relies on analytical generalization (Yin 1994, p. 36). Lee and Baskerville (2003, p. 239) also note that even if the research findings would have been tested in a larger number of companies it would only be possible to claim that results are generalizable to the companies that were tested and not to other companies.

To find answers to the presented research questions, one aim of this study was to develop the business application architecture framework. The framework was developed for the manufacturing industry. When making generalisations about the use of the developed framework in other industry sectors, the following limitations should be mentioned:

- The business application classification model includes features that are specific for the manufacturing industry. Therefore, unless further developed, the possibilities to use it in other business sectors are limited.
- The reference model for the business application architecture development process is more applicable to be used in other business sectors. At least the application classification model should however be redesigned before expanding to areas outside the manufacturing industry. The reference model for the business application architecture development process has not been used or tested in any other business sector than in the manufacturing industry and thus it should be tested before use.

Reliability is often measured by how well another researcher is able to repeat the results with the same data. Potential weakness of the case study method is the lack of replicability: the results are to some extent dependent on the researcher. However, it should be noted that the emphasis in replicability is on doing the same case study again rather than replicating the results to another case study (Yin 1994, p. 36). A prerequisite for appropriate reliability is sufficient documentation of the case study. In order to improve the reliability of this study, the same procedures, such as case study design and data collection methods, were executed in each case. These have been described in more detail in chapters 5.1 and 5.3. Additionally, multiple case study design was used. Multiple
case study design improves reliability, because the same case study design is repeated in multiple cases.

According to Patton (1990) the credibility of the researcher is one of the three inquiry elements that affect the credibility of qualitative inquiry. Patton (1990, p. 472) states that the researcher should report any personal and professional information that may have affected data collection, analysis or interpretation. In this study the researcher had a professional role in two of the case companies, which is reported and described in more detail in Chapter 5.1.

The third inquiry element that affects the credibility of qualitative inquiry is the philosophical belief in the phenomenological paradigm (Patton, 1990). Patton (1990, p. 482) states that one of the beliefs that affects how people react to qualitative data, is how people think about the idea of truth. Instead of claiming that the researcher’s findings are the ultimate truth Patton suggests describing the pattern of data as the researcher’s perspective based on his analysis and let the reader judge the perspective using his/her common sense and using the information to contribute with his/her own perspectives. Accordingly, in this study the patterns of the data are described on a fairly detailed level which contributes as one perspective of the business application architecture development processes.

7.5 Suggestions for further research

In this study the business application architecture framework was developed for analyzing purposes. One theme for future studies would be a case test study to evaluate and possibly further develop the proposed reference model for the business application architecture development process and the business application classification model. The aim of this additional research could be either to evaluate the business application architecture framework as an analyzing instrument or to evaluate it as a business application architecture development tool. Based on this study the business application
architecture framework is applicable for analyzing the development of business application architectures and if more evidence could be collected it would increase the value of the framework.

In this thesis the manufacturing industry was selected as the field of business to be studied. One aspect for further research could be to select another field of business and to test if the proposed business application architecture framework and results of the empirical case studies are still valid.

Another potential research area would be to use the proposed business application architecture framework in a larger population of companies. In this study the case method was chosen because the research topic is new and relatively complex. The aim of this study was to provide a better understanding of business application architectures as a complex phenomenon. Thus, it would be easier for further researchers to exploit the results of this study to formulate a relevant survey. This survey could collect more information about business application architectures and business application architecture development processes in other companies.
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APPENDIX A: QUESTIONNAIRE FRAME FOR CASE COMPANIES

Company background
- Sales, personnel, organization

Initial business application architecture
- How initial business application architectures have been analyzed?
- Are there any particularly effective applications in your initial business application architecture?
- Have you recognised unused potential in applications in your initial business application architecture?
- Have you evaluated risks concerning business application architecture (e.g. vendor risks, technology risks)
- Level of integration (interfaces between applications, what data is integrated)
- Key drivers in making changes in business application architecture
  - Old legacy systems => forced to replace
  - Changes in business environment
  - Changes in company structure
  - Exploit possibilities for new business opportunities (e.g. additional sales through internet)

Business application architecture development
- Has there been any particular method in developing target business application architecture?
- How business requirements and business application architecture is aligned?
- What were the critical business requirements or critical success factors that affected on the business application architecture development?
- What were common requirements and business unit level requirements?
- Different stakeholders involved in business application architecture development (for instance business management, IT management, users)?
- Influence of external parties (partners, customers, suppliers, competitors) and environment to business application architecture?

Information architecture
- Do you have information architecture (or list of information requirements) => e.g. have you mapped what data exist in which systems (e.g. product, customer and/or supplier data)?
- Have you created information architecture before application architecture?
- Is your information architecture independent from application architecture?
- How much you have information entities overlapping in various applications?
- Quality of information (how accurate the data content is)?
### Elements of business application architecture

<table>
<thead>
<tr>
<th>Back End</th>
<th>Initial architecture</th>
<th>Target architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warehouse management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invoicing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payroll</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR management systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement</td>
<td></td>
<td></td>
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<tr>
<td>Integration software</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Archiving</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Front End                                     |                      |                     |
| Quotations                                    |                      |                     |
| CRM (analytical and contact management)       |                      |                     |
| Web portal (functionality)                   |                      |                     |
| Order functionality for customers             |                      |                     |
| Spare part management                         |                      |                     |
| Availability information                      |                      |                     |
| Purchase order functionality for suppliers    |                      |                     |
| Demand forecasts                              |                      |                     |
| Document management                           |                      |                     |
| Electronic invoicing                          |                      |                     |
| Electronic purchasing invoices                |                      |                     |

| Engineering                                   |                      |                     |
| Product Data Management                       |                      |                     |
| CAD                                           |                      |                     |

| Management tools                              |                      |                     |
| Business intelligence (external information)  |                      |                     |
| Data warehouse                                |                      |                     |
| Budgeting applications                        |                      |                     |
| Supply Chain Management                       |                      |                     |
| Reporting applications                        |                      |                     |
| Forecasting                                   |                      |                     |

| Communication                                 |                      |                     |
| Communication, mobile services                |                      |                     |
| Collaboration                                 |                      |                     |

### Target architecture
- How far are you from your target architecture?
- Was target architecture clear from the beginning or has it evolved over time?
- Level of integration (interfaces between applications, what data is integrated)
- Centralized elements of architecture vs. local elements?

**Planning and prioritising of business application architecture**

- How application architecture has been developed in time (order of implementation)?
- Priority of different applications?
- Is this implementation order based on enterprise architecture planning point of view or more because of external reasons or reasons like acquisitions, changes in company structure etc.?
- What practical constraints have been considered in business application architecture development?
  - Large investments
  - Legacy systems
  - Know how of various systems
APPENDIX B: INTERVIEWS IN CASE COMPANIES

Interviews in case companies

CASE COMPANY 1

<table>
<thead>
<tr>
<th>Date</th>
<th>Duration</th>
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<tr>
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</tr>
<tr>
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<td>3 hours</td>
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</tr>
<tr>
<td>June 23, 2004</td>
<td>2 hours</td>
<td>IT Responsible</td>
</tr>
<tr>
<td>June 23, 2004</td>
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<td>Co-ordinator, Order fulfilment process</td>
</tr>
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<td>August 18, 2004</td>
<td>1 hour (on the phone)</td>
<td>Co-ordinator, Order fulfilment process</td>
</tr>
<tr>
<td>September 10, 2004</td>
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CASE COMPANY 2

<table>
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<td>CEO</td>
</tr>
<tr>
<td>May 13, 2004</td>
<td>2,5 hours</td>
<td>Business area Director, Business unit 1</td>
</tr>
<tr>
<td>August 6, 2004</td>
<td>1 hour</td>
<td>Managing Director, Business unit 6</td>
</tr>
<tr>
<td>February 25, 2004</td>
<td>1 hour</td>
<td>Director of Business Development</td>
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<td>September 7, 2004</td>
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<td>Business area Director, Business unit 1</td>
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CASE COMPANY 3

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<td>IT Manager</td>
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CASE COMPANY 4

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</thead>
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</tr>
<tr>
<td>June 10, 2004</td>
<td>1 hour (on the phone)</td>
<td>IT Director</td>
</tr>
<tr>
<td>August 18, 2004</td>
<td>1 hour (on the phone)</td>
<td>IT Director</td>
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COMPANY 5 (company that is using business application classification model)

<table>
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<tr>
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