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Functionality based
business application classification

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MASTER'S STUDY

Business software application classification
A functional perspective

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Abstract

Information Technology (IT) has undergone rapid and fundamental changes in the past decade (Guillemette & Paré 2012) and companies are more aware of the value in their data (Logan 2012). Being able to combine data from different sources can lead to new insights and thus new application types like document management and business intelligence applications have emerged. However, well-grounded guidelines for identifying, evaluating, and choosing classes when designing information systems artifacts do not exist yet (Wand & Parsons 2008). There is currently no functional overview of existing systems. (Nevo & Ein-dor 2008; Ein-Dor & Segev 1993).

This makes it hard to combine data from different applications and research fields, which results in a scattering and fragmentation of information across different areas (Ein-Dor 1993). This study seeks to provide a functionality based business application classification to provide such a structure. Additionally it shows the use of this classification through an example in which data is combined with the classification scheme to provide new information.

From a literature review and five exploratory interviews with IT system classification experts, an initial list of applications and application groups was constructed. From this list, a hierarchical application classification scheme was build and iteratively improved over 14 semi-structured interviews. The interviewees were all experts in the field of business applications.

This study has three results which complement each other. First, a table with 11 system groups, each group is divided into several system types. Second, four application categories that provide a structure used to classify different systems. The third an final result is an overview of the entire hierarchical business application classification scheme (see Appendix A).

Two main limitations were identified relating to usage of the results and to the data collection. Firstly, the concept that is classified using this study's result is business applications that have a human end-user. This means that the classification excludes for example hardware, middleware and virtual layers but also non-business related software such as computer games are excluded. Secondly, during this research a data set of 111 systems was used that was not homogeneously distributed across the different applications groups.

In future research, the result could be improved with a larger and more evenly distributed dataset for better validity. Additionally the results could be combined with other data to identify new opportunities and trends in different application groups or types as was shown in the use case in this study.

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1 Introduction

The past 50 years have been called the second industrial revolution or the information revolution (Ein-Dor & Segev 1993). The IT function has changed tremendously and undergone fundamental changes (Guillemette & Paré 2012). But with all these new trends, applications and opportunities also comes chaos. An overview of current systems is absent (Nevo & Ein-dor 2008; Ein-Dor & Segev 1993). This leads to people (re) developing the same applications, not being able to combine results and generally a scattering and fragmentation of information across different research areas (Ein-Dor & Segev 1993). Several attempts were made to try to provide such an overview (Nevo et al. 2010; Ein-Dor & Segev 1993; Zhang et al. 2011). The IT artifacts were defined, shared attributes and differences were determined, as well as a first attempt at a classification of systems studied in information systems research was presented (Nevo et al. 2010). Their study provides an overview of 12 broad groups of IT artifacts. However, it is lacking on several fronts. Firstly the scope was much too broad, thus lacking sufficient details. Secondly, the relation found between different types of information technologies and systems fail to represent the relation between different business applications, again because the scope is too big. Zhang et al. (2011) had the same scoping issue and although more complete they had a different goal with their study and did not provide a relational overview that could provide inferred characteristics of the described systems and applications.

The purpose of this study is to define and test a business application classification to provide an overview of existing systems and combat the fragmentation of research and knowledge.

1.1 Introduction to business applications

To understand what a business application is this section provides a definition of business applications and concepts that closely relate to business applications. These include: systems, software systems, information systems and IT artifacts (Mattmann et al. 2007; James A. O'Brien 1998; Ein-Dor & Segev 1993; Matook & Brown 2008; Zhang et al. 2011). Information found in scientific and non-scientific (so called 'grey') literature is presented as well as views and definitions obtained from interview data.

1.1.1 Definitions found in scientific literature

This section provides definitions found for information systems and business applications.

There are numerous definitions of what constitutes a system. Below are two examples of definitions that provide one concise and one broader definition of a system.

"*A set of interacting or interdependent entities forming an integrated whole*"
(Backlund 2000)

Backlund provides a very broad definition of a system.

"*A system is a set of interrelated components, with a clearly defined boundary, working together, to achieve a common set of objectives, accepting inputs and producing outputs, in an organized transformation process.*"
(James A. O'Brien 1998)

While O'Brien's definition is much broader, it also describes some of the elements and processes of a system.

The terms “business application” and ”information system” are often used interchangeably. Therefore, before arriving at a working definition of “business application”, definitions of "information system" need to be explored. This is done to ensure all relevant concepts and elements of a business application are known and a clear scope and definition can be provided.

Information systems are considered a subset of what is referred to as “IT artifacts” (Nevo & Ein-dor 2008; Nevo et al. 2010; Matook & Brown 2008; Zhang et al. 2011). IT artifacts are used to describe a technological concept that usually has a physical component. In contrast to information technology (IT) or information systems (IS) themes[1] (Nevo & Ein-dor 2008), which lack a physical component.
IT artifacts are often studied (Matook & Brown 2008; Nevo & Ein-dor 2008; Zhang et al. 2011). Despite this focus there is confusion about when certain studies belong to the IS discipline, or if they belong in different disciplines such as finance, management or even sociology (Zhang et al. 2011). This further complicates the discussion about the definition. Below are several definitions of Business applications, Software Systems or Information Systems.

O’Brien (James A. O’Brien 1998) defines information systems as such:

”*An information or software system is an organized combination of people, hardware, software, communications networks, data sources, policies and procedures. An information system accepts inputs and transforms them into outputs in an organized process.*” (James A. O'Brien 1998)

O’Brien has a clear definition that describes the different components as well as its functionality of transforming inputs into outputs.

The definition used by Ein-Dor and Segev (Ein-Dor & Segev 1993) is the following:

“*An information system is any computerized system with a user or operator interface, provided that the computer is not physically embedded.* “ (Ein-Dor & Segev 1993)

Ein-Dor provides a very brief definition that focuses on excluding embedded systems and systems without interfaces.

While O’Brien describes an information system by explaining its different components, thus describing what it is, Ein-Dor and Segev describe an information system by explaining what it is not. They make a distinction between information systems and embedded systems, claiming that embedded systems are a different type of system. Examples of systems not considered information systems by Ein-Dor and Segev are guided missiles and computer ignition.

For this study the definition of business applications was inspired by the previous citations.

“*Systems or applications that have a human as the end user are considered business applications.*“

[1] ** Examples include: IT governance, Outsourcing, IS success

This is different from the end-user described by Ein-Dor and Segev (1993)'s, but it is an important distinction because it excludes for example interfacing systems and middleware layers and thus provides a clear scope for this study. Furthermore, as this study focuses on business applications, these systems or applications should provide value in some form to businesses. E.g. computer games are not considered business applications, as they are a product sold by business and not often used during business hours.

An initial definition for information systems was determined in the previous section. The next section provides definitions for systems and information systems that were obtained from non-scientific (so called 'grey') literature. Grey literature was mostly obtained through the Google search engine from texts like blogs, slideshows and opinion articles. This literature will be used to improve the current definition.

1.1.2 Systems and information systems in grey literature

This section elaborates on definitions found in grey literature (non-scientific) for information systems and business applications.

In grey literature, there are several definitions of information and software systems. The Encyclopedia Britannica (Zwass 2011) provides the following definition and components of an information system.

"*an integrated set of components for collecting, storing, and processing data and for delivering information, knowledge, and digital products. The main components of information systems are computer hardware and software, telecommunications, databases and data warehouses, human resources, and procedures. The hardware, software, and telecommunications constitute information technology (IT)*" (Zwass 2011)

For this study, the focus is only on the software part of what O'Brien (1998) considers an information system.

"*An information or software system is an organized combination of people, hardware, software, communications networks, data sources, policies and procedures. An information system accepts inputs and transforms them into outputs in an organized process.*" (James A. O'Brien 1998)

This is done in order to have a clear scope and avoid confusion about what it is being classified. This means that for example hardware controllers, and middleware are excluded from this classification.
The software part of the definition that is used by O'Brien is also referred to as an information system (i.e. Ein-Dor 1993).

1.1.3 Expert views on Information systems and business applications

During this study a total of 19 people were interviewed, during those interviews there were several discussions about different definitions and views (see Appendix G). This section describes definitions observed during the interviews for information systems and business applications. Additionally it contains the definition used throughout the rest of this study.

During the interviews, it became apparent that people have varying ideas about what constitutes a software system, a business application or an information system. The main

dilemma appears to be the broadness of the definitions. Some interviewees seem to be in agreement with literature where the term information system is used to describe basically any type of computer application that is not embedded in hardware (Ein-Dor & Segev 1993). While other interviewees focus heavily on the information part, saying that they are systems that deal primarily and specifically with data in- and output. Thus excluding for example computer aided manufacturing systems and transaction processing systems. Several definitions, as stated by interviewees, are provided below.

"*A system, which has information as input and can output information. It has a strong connection with a database.*"

"*Information system would be something that allows users to retrieve and store data that is specific to their business. It enables the business and it does something with computers.*"

When asked to describe the components of information systems, the interviewees were more aligned.

"A front end, a back end and a database. Input field, something that processes information and some kind of storage"

" There is a storage part, which includes raw data, processed data and storage [...] then there is the business logic part. That takes care of the presenting, formatting, filtering or running some sort of analysis on the stored data. And then there is the user presentation part that shows the user information in a meaningful way. "

When asked to describe what parts make up an information systems the interviewees preferred a three-tier architecture. This means there is a front-end, a back-end and a storage unit or database. These are used for inputting data, data processing and outputting and storing data respectively.

Two views were considered to be dominant in literature and during the interviews. In this study business applications are considered a part of a software system, which is a subset of an information system (see **Figure 1**). Two alternative views on software systems and its components can be found in Appendix G. They are however not used in this study as they contain even more layers that are out of the scope of this study.

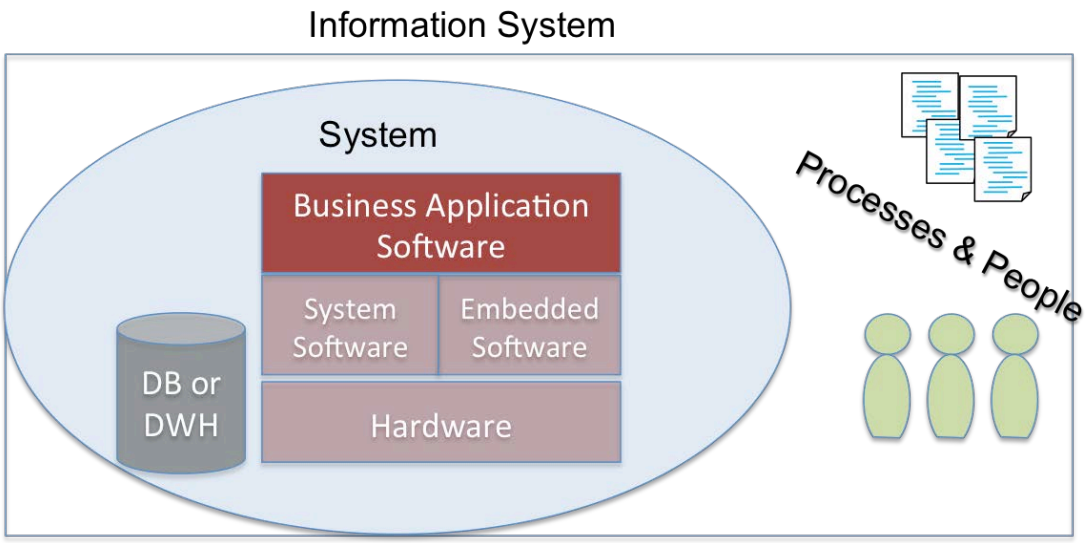

Figure 1 - Overview of an information system and several of its components, with the focus of this study, business applications, highlighted (Zwass 2011).

From the information provided above the following definition of a business application was compiled and used throughout the rest of this study.

Business application software is the software component of a computerized system that has a human end-user and is not physically embedded.

Note that business application and system are used interchangeably throughout this study.

By focusing on business applications non-business related applications such as computer- and mobile games are excluded. Furthermore, business applications are considered a subset of IT artifacts and information systems, which will become more apparent in the literature review.

1.2 Classification as an operation and classification as a result

Since the objective of this study is a business application classification, it is important to have a clear definition of what classification is. There is a clear distinction between classification as an operation (i.e. something that is performed) and classifications as a result of that operation (i.e. an object that is the result of a certain process) (Marradi 1990). The differences are explained in this section.

There are three different classification operations. First is intensional classification, where the focus is on defining the properties that a certain class has in common with other objects or events in that same class. Second is extensional classification, which focuses on grouping objects to unifying concepts. Third is class labeling, where one adds predefined labels to different events or objects to group them in classes.

When only one classification criteria is used (functionality), as is the case in this study, the result is a classification (Marradi 1990). A more accurate name, as to avoid confusion with the classification operation, is the term classification scheme. This is what will be used to describe the result of this study: a business application classification scheme (BACS).

2 Research problem, question and goals

This section provides an overview of the problem addressed by, the goals of and the research questions for this study.

2.1 Research problem

In 1993, a verified information system classification did not exist and a lot of information was scattered and fragmented across different research areas (Ein-Dor & Segev 1993). Since 1993 developments in the fields of information technology and information systems have shaped the world around us . However, to the best of our knowledge, well-grounded guidelines for identifying, evaluating, and choosing classes when modeling a domain or designing information systems artifacts do not exist yet (Wand & Parsons 2008). As a result, a clear overview of what is being built and researched is lacking or incomplete (Ein-Dor & Segev 1993). By providing a functional classification of different business applications, the authors provide such an overview. Allowing practitioners and researchers from different fields to combine their knowledge. Additionally the business application classification scheme could be used to provide a shared language for business functionality.

2.2 Research goals

- Define and verify a business application classification
- Define a business application classification method

Achieving these goals will fulfill the objectives of this study that were outlined in previous sections. Firstly, provide a functional overview of existing applications through a verified business application classification. Using this overview, the field of information systems can combat the fragmentation of research by combining knowledge and expertise from related fields. Lastly, the application classification supports practitioners by providing a common language for business application functionality.

2.3 Research question

- How can business applications be classified based on their functionality?

2.3.1 Sub-Questions

- What types of business applications exist?
- How do they relate to each other?

By gathering existing applications, from scientific literature, grey (non-scientific) literature and through means of interviews an overview of existing systems will be made. Using this data, a proposed hierarchical classification will be made. This classification will be checked for acceptance and validity through interviews.

3 Methodology and work-plan:

This section describes the study design and approach.

3.1 Research approach

For this study a design science approach is chosen. Design science focuses on designing, implementing and analyzing the usage of innovative artifacts related to information systems

(Kuechler & Vaishnavi 2008). Examples of artifacts are methodologies, terminologies and models (Österle et al. 2011). Traditional research approaches are more focused on the analysis of, for example, an artifact and the explanation or identification of (new) issues. Design science goes beyond that and can, therefore, be considered as a more applied and pragmatic approach in comparison to traditional research(Van Aken 2005).

Since design science is a more applied type of research, collaboration with practitioners is considered to be vital for the success of the research (Österle et al. 2011). In design science four phases, of which two are iterative, can be identified: analysis, design, evaluation, and diffusion(Österle et al. 2011; Kuechler & Vaishnavi 2008).

3.2 Research design

The four design science research phases, used throughout this study, will be defined and the process that was followed during each phase will be explained.

3.2.1 Analysis phase

In traditional research the analysis phase consists primarily of a literature review and exploratory interviews. In design science, this data is enriched using non-scientific literature also referred to as grey literature (Denyer et al. 2008). This approach was also adopted in this study. For the literature review articles from four major journals in the field of information systems were scanned for several keywords and combinations of those keywords (see Appendix E). Grey literature was obtained by applying the same keywords to the Google search engine that yielded information from sites like Slideshare[2] and encyclopedia Brittianica[3].

The results from the literature reviews were used in five exploratory interviews. The goal during these exploratory interviews was to get different perspectives, from various fields (i.e. Telecommunications, Public sector), diverse backgrounds (i.e. technical/programmers, less technical/analyst) with varying levels of expertise (i.e. junior, medior, senior-level personnel). Five experts working in the field of IT and software systems, but with a different domain focus, were interviewed. These were exploratory interviews in which they were requested for feedback on initial findings. This meant there were open questions about- and completeness of the literature review, potential usage/usefulness of the classification scheme and examples of business applications the interviewees had worked with. The results were used to complement the results from the literature review.

3.2.2 Design phase

During the design phase, the business application classification scheme was designed and made by the authors using two graphical tools called Bubbl.us[4] and Omnigraffle[5]. And the data gathered in the literature review and interviews. This phase, together with the evaluation phase, was iterated several times to incorporate the feedback of the interviewees (from the next phase) and improve upon the earlier classification schemes.

[2] http://www.slideshare.net/
[3] http://www.britannica.com/topic/information-system.

[4] https://bubbl.us/mindmap
[5] https://www.omnigroup.com/omnigraffle

3.2.3 Evaluation phase

Evaluation, validity and acceptance testing are crucial to get to a good classification scheme. A good classification scheme should be useful (from a practitioners standpoint) and valid (from a research standpoint).

During the evaluation phase practitioners evaluate the designed and the built classification scheme, in a one-hour interview session. The interview consists of three parts. First the interviewee gets acquainted with the classification scheme through a walkthrough of the BASC by the interviewer. Second, the interviewee used the classifications scheme to classify several applications, from their own experience and based on their functionality, using the BASC. The interview concluded with a short questionnaire to evaluate their experience with the classification scheme

The questionnaire serves as a means to check for user acceptance (see Appendix C). All of the interviewees that worked with the BACS during the interviews were asked to fill out the questionnaire. The questionnaire contained statements about usefulness, ease of use, intention to use the BACS in the future, compatibility and perceived behavioral control based on Riemenschneider et al. (2002).

Participants were asked to score whether they agreed or disagreed with statements provided on a scale from one to five. A score of five would mean the participants strongly agreed with the statement and a score of one would mean the participants strongly disagree with the statement.

The interviewees were encouraged to ask questions and be critical in their evaluation of the BASC. The results of these interviews were used to improve the classification scheme and provide data on the usefulness and validity of the classification scheme.

3.2.4 Diffusion phase

The results of the research have to be actively shared with all relevant stakeholders to ensure optimal usage and acceptance of the results.

Diffusion of the research results was done in two steps. During the research itself intermediate classification schemes were shared with participants who were then a) aware of its existence and b) knew how to use it. The final results of this study were shared in multiple presentations. Furthermore, the results of this study will be implemented in the SIG methodology and used in their consulting work. All of this combined ensures that practitioners actively use the results of this study.

Phase	Actions during phase
I. Analysis	Literature review 5 Exploratory interviews
II. Design	(re) design and build BACS
III. Evaluation	Evaluation through semi-structured interview
IV. Diffusion	Implement in SIG methodology Multiple presentations

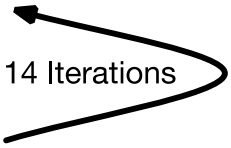

Figure 2 - Overview of the different research phases and the actions per phase.

4 Review of literature

There have been previous attempts at identifying different types of business applications, information systems and more general different types of IT artifacts. In the following sections, these attempts and their results will be discussed.

4.1 Literature on IT artifacts

There is a lot of research on IT artifacts and the identification of the different types of IT artifacts. This started at the beginning of the 21st century with a call for a clear definition of the IT artifacts (Orlikowski, Wanda 2001), followed by several other publications that sought to address this issue. Different approaches were used to answer this call. Some tried to define a very explicit artifact like a financial analysis application (Venkatesh et al. 2003) or management support system (Clark Jr. et al. 2007). A different approach was using IT artifacts and IS themes, the results of a 1200 papers content analysis, to study the academic identity of the IS research field (Nevo & Ein-dor 2008). This research was continued to when several dimensions that capture the commonalities and differences between different systems were identified (Nevo et al. 2010). A commonly used definition for the IT artifact is the one proposed by Benbasat and Zmud in 2003 (Benbasat et al. 2003; Matook & Brown 2008).

"*the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context(s).*"

However, there are several broader definitions of IT artifacts as well. As can be seen in **Table 1** (Zhang et al. 2011).

Source	Description
(Orlikowski, Wanda 2001)	"Bundles of material and cultural properties packaged in some socially recognizable form such as hardware and/or software" (p. 121)
(Benbasat et al. 2003)	"the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context(s)," "The IT artifact essentially serves as the centralizing theme for the field "(p. 186)
(Lyytinen & King 2004)	"systematic processing of information in human enterprise" (p. 541)
(Hevner et al. 2004)	"constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices), and instantiations (implemented and prototype systems)" (p. 77)
(Agarwal et al. 2006)	"the integration of the processing logic found in computers with the massive stores of databases and the connectivity of communication networks", so that it "includes IT infrastructure, innovations with technology, and especially the Internet" (p. 394)
(Nevo & Ein-dor 2008; Nevo et al. 2010)	"a composite made up of some combination of software, hardware, database and network components with an information processing capability aimed at enabling individual, group and organizational tasks "
(Zhang et al. 2011)	"An IT artifact is an entity/object, or a bundle thereof, intentionally engineered to benefit certain people with certain purposes and goals in certain contexts. It is developed, introduced, adopted, operated, modified, adapted, discarded, and researched within

	contexts and with various perspectives. "(p. 3)

Table 1 - Overview of definitions of the IT artifact by different authors (Zhang et al. 2011).

The literature on IT artifacts was a starting point upon which the BACS could be built. Several authors mention business applications or similar systems in their research that were used as input for the BACS.

4.1.1 IT artifact core elements

Besides different definitions of what an IT artifact is there are also different ideas about which core elements make up an IT artifact. Zhang et al. (2011) identify five core elements for each IT artifact: hardware, operating and system software, application software, application content and auxiliary artifacts.

Operating and system software give basic functionality to hardware and infrastructure.
Application content is the data or information that is used by the artifact.
An auxiliary artifact is a human constructed element that cannot exist by itself such as intellectual property.

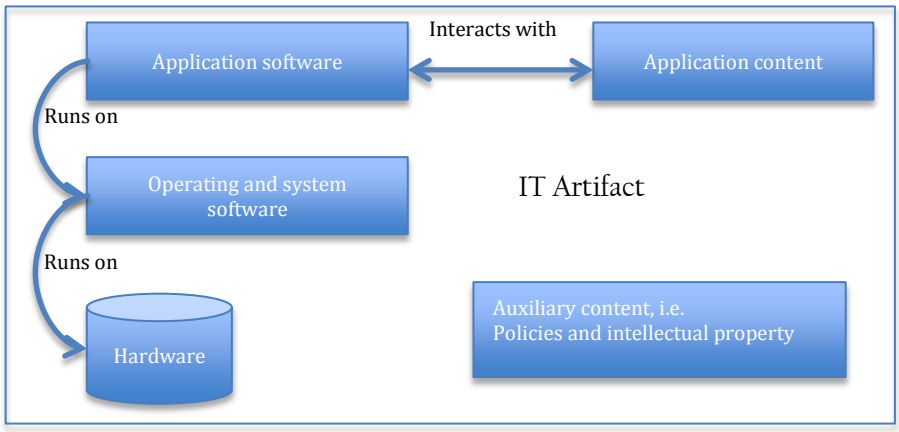

Figure 3 - Visual representations of the different core elements of an IT artifact according to Zhang et al.

Figure 3 closely resembles the overview of the components in the definition used by this study, strengthening its position. This study will focus on the application software. The other four (e.g. hardware, operating and system software, application content and auxiliary artifacts) are out of the scope of this study.

4.1.2 IT artifact characteristics and general system theory

A different approach to the identification of the IT artifacts was taken by Matook and Brown (2008). Using General Systems Theory (**Figure 4**, (Bertalanffy 1968)) they look at IT artifacts from a system point of view and they make a distinction between the different parts that together form the system. Combining this view with a specific ontology focused on software architecture (Akerman & Tyree 2006) they identify different IT artifacts by looking at several characteristics of these IT artifacts, see table 1.

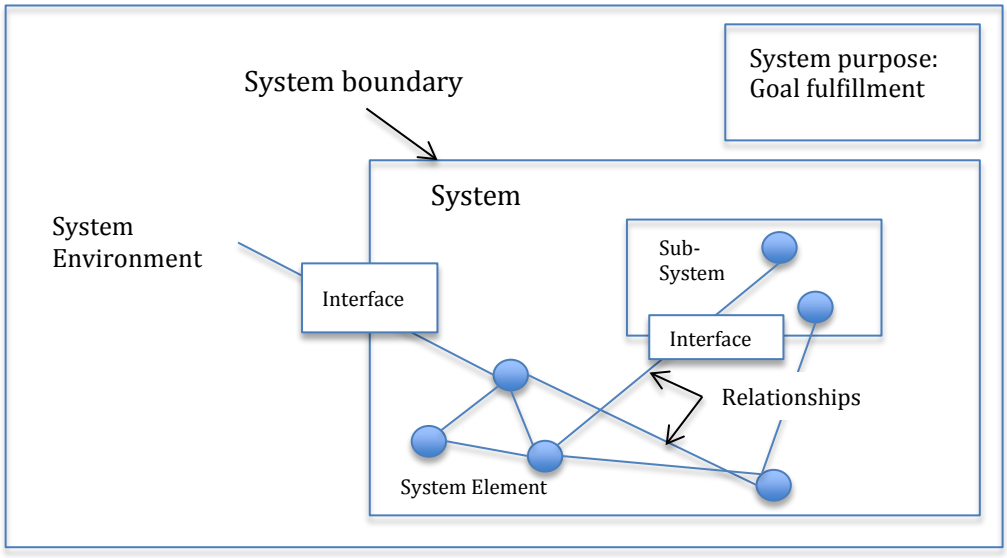

Figure 4 - Overview of a system and its components according to general systems theory.

Matook and Brown propose that IT artifacts and thus IS can be described using these characteristics. Systems that share a common goal, i.e. support managerial actions & decision-making, can have different system characteristics. A decision support system (DSS) can, for example, be a stand-alone system but could also be integrated, as is the case when a DSS is integrated into a data warehouse (Matook & Brown 2008).

Their view on systems further supports the view used in this study. Their study also provided several characteristics or properties that typical systems have. Unfortunately, the authors were unwilling to share their data, as their work was not yet published, it is expected at the end of 2016.

Characteristic	Definition	Relevant Studies
Static	Not changing or unable to take place during some period of time, usually while a system is in operation or a program is running	Bianchini et al. (2006), Rainer (1996), Gu et al. (2007), Hamadi and Benatallah (2004), vanderAalst (2000) .
Dynamic	Capable of changing or of being changed, change is constant over a time period, for an operating systems, the implication is that the system is capable of changing while it continues to run	
Adaptive	System can adjust to varying levels of requests and interaction, e.g. user skills, system parameters are automatically adjusted as conditions change so as to	Chuang and Yadav (1998), Deng and Chaudhury (1992),

	optimize performance	Fazlollahi et al. (1997), Lau et al. (2008), Yu et al. (2003).
Non-adaptive	System cannot adjust for change in response to variations of interactions	
Synchronous	Sequential events take place at fixed times, transmission to a receiver happens instantaneously, it requires no acknowledgement that preceding events have been completed	Nah et al. (2002), Ngwenya and Keim (2003), Palvia (2001), Spencer and Hiltz (2003)
Asynchronous	Specific operation is begun upon receipt of an indication (signal) that the preceding operation has been completed, and which indicates to a subsequent operation when it may begin.	
Integrated	Interaction with the connected systems parts and the environment, combines some of their functions	Caggiano et al. (2006), Chou (1998), March and Hevner (2007), Janssen and Cresswell (2005), Leifer (1988) ..
Standalone	Has no interaction and connection to the environment, system is able to operate independently of other hardware or software parts	
Stateless	Without a state, system does not remember preceding sequential events or requests among elements, after a service request has been completed, it discards the data associated with the request	Osrae et al. (2007), Schulzrinne (1996), Thomas (1997)
Stateful	Full of state, system maintains state and keeps a record of the state of interaction, data about previous requests for a service which can then be used for subsequent requests	

Table 2 - Characteristics of the IT artifact (Matook and brown 2008).

The characteristics from **Table 2** provide good means to classify business applications and on a higher level IT artifacts. These could be used in future work to expand on the classification scheme that is the end result of this study.

4.2 Literature on IS Classification

There has been some research on classification of IS in the past. Through a literature study a total of five authors, were found that have attempted a classification. Their work will be discussed in the next sections.

4.2.1 Ein-Dor And Segev

The first attempt to make an information system classification was by Ein-Dor and Segev in 1993. In their paper, they propose a classification consisting of 17 categories ranging from early data processing and computing to management information systems and expert systems. Functional component analysis was used to determine how similar different systems were. This data was combined with the first appearance of that system in literate to get an historical overview of the emergence of different types of systems. Lastly, they show

that newer types of systems result from the gradual accretion of new technologies and the loss of older ones.

Main findings:
The main findings include two paths along which IS develop and with these two paths in mind the authors predicts two new "future" systems. In addition to this they have identified 17 distinct types of information systems.

17 types of systems	
1. Early Computing	10. Scientific Computing
2. Early Data Processing	11. Managed Resource Planning
3. Management Information System	12. Managed Resource Planning 2
4. Decision Support System	13. Computer Aided Design
5. Office Information System	14. Computer Aided Manufacturing
6. Executive Information System	15. CAD/CAM
7. Group Decision Support System	16. Manufacturing Robots
8. Expert System	17. Command, Control, Communication and Intelligence
9. Mature Data Processing	

Table 3 - 17 different types of systems according from Ein-dor and Segev 1993.

4.2.2 Nevo, Nevo and Ein-Dor 2009

Nevo, Nevo and Ein-Dor wrote two papers about to IS classification. In their 2009 paper, they identify the core IT artifacts and IS themes in order to help the IS community identify their academic identity. By analyzing 1056 papers of the top two journals in the IS research field (Information Systems Research and MIS Quarterly) they were able to filter out the core (most studied) IT artifacts and IS themes. They identified two core research topics which are accompanied by a handful of IS themes and 13 core IT artifacts. These two core research interests are the design, development and management of information technologies as well as their use by and impact on individuals, groups and organizations.

Main Findings
Two core research topics were identified; along with 13 core IS themes and 11 IT artifacts. Researches focuses heavily on two topics:

1. Design, development and management of IT
2. Usage by and impact on individuals, groups and organization of IT.

IS themes	IT artifacts
1. Business Value & strategic impact on IT	1. Management support systems
2. Economics of IT	2. Communication and collaboration tools
3. Ethics & privacy	3. Inter-organizational systems
4. Individual/Group performance & decision quality	4. Infrastructure services
5. Introspective studies: IS research and identity	5. Enterprise applications
6. IS Success: IT adoption, resistance, satisfaction and use	6. Knowledge and document management systems
7. IT professionals	7. Operation systems
8. IT-based innovation	8. Resource management systems
9. IT-driven institutional transformation	9. Computer integrated manufacturing and engineering
10. Knowledge and information management	

11. Outsourcing and governance of IT	10. Consumer website
12. System design and human computer interaction 13. IS development cycle: System development, implementation, maintenance, reliability and security	11. Computer graphics

Table 4 - IS themes and IT artifacts identified by Nevo et al.

An important thing to note here is that Nevo et al. were identifying IT artifacts and not information systems or business applications. However since 9 out of the 11 artifacts are considered business applications according to the used definition this paper was considered very useful for this study. The only non-business applications in the list are operation systems and infrastructure services.

4.2.3 Nevo, Nevo and Ein-Dor 2010

Nevo, Nevo and Ein-Dor used their knowledge of IS themes and IT artifacts to look for dimensions along which the IT artifacts could be classified. A dimension should be interpreted as two opposing characteristics on a line along which different applications are spaced based on how much they adhere to the two characteristics. Nevo et al. used a multidimensional scaling approach (Nevo et al. 2010) with 87 participants. The results were interpreted using spatial mappings and led to three different dimensions along which the information technologies could be classified. The three dimensions are

1. Commerce/Transaction versus Product design/development,
2. Internal versus external focus and
3. Operational versus decision support.

The IT artifacts were mapped along the dimensions.

Main findings

The main findings in this paper are the three dimensions and how the systems are mapped along them. The three dimensions are:

1. Commerce/Transaction versus Product Design/Development,
2. Internal versus External Focus
3. Operational versus Decision Support.

The 87 participants mapped the 13 artifacts along the three different dimensions. The result of that process is shown below.

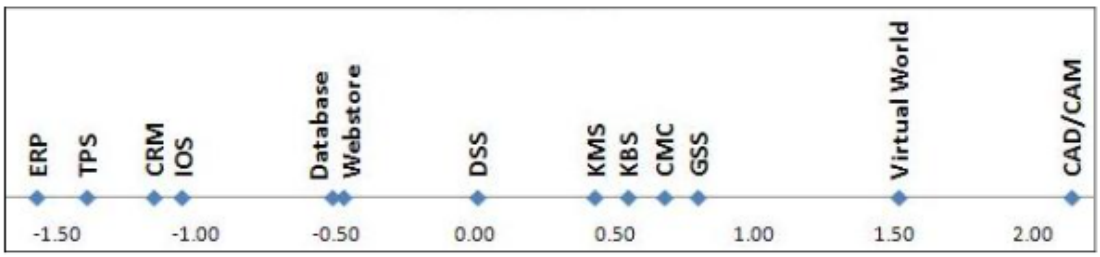

Figure 5 - Dimension 1: Commerce/Transaction versus Product Design/Development from Nevo et al. 2010

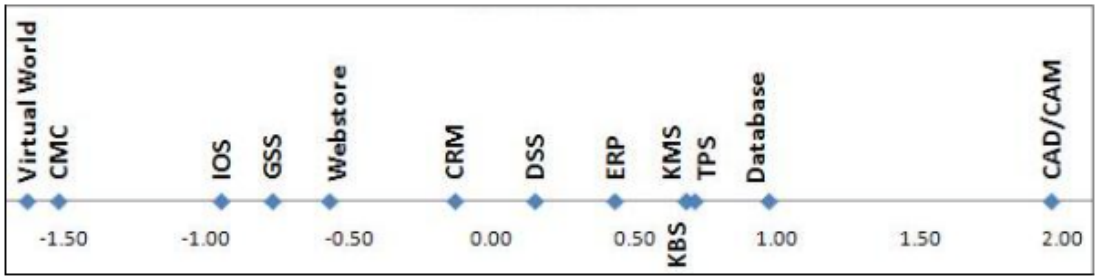

Figure 6 - Dimension 2: External versus Internal Focus from Nevo et al. 2010

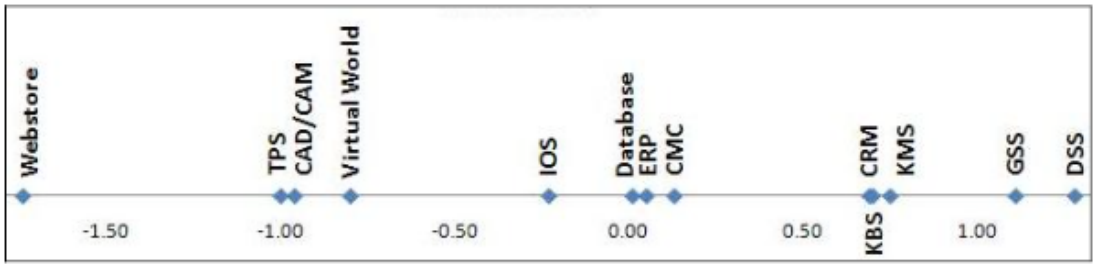

Figure 7 - Dimension 3: Operational versus Decision Support from Nevo et al. 2010

For this study the first dimension will be used, more details on that can be found in the results section.

4.2.4 Zhang, Scialdone and Ku 2011

In their paper Zhang, Scialdone and Ku (2011) are not necessarily defining an information system classification but they come pretty close with their research concerning the IT artifact. They first define what core elements constitute an IT artifact (see the previous section). One of these core elements is the application software, which fits the definition of what this study defines as a business application. Although their scope is broader the provided data is valuable for this study. They analyzed all the papers (a total of 274) that were submitted to the International Conference on Information Systems (ICIS) during a 2-year time period (2009 and 2010). They identified the core element of the IT artifact that appeared in those papers and thus were able to come up with a list of possible business applications, in their paper they refer to them as application software IT artifacts.

Main findings:

The main findings from this article are the examples of the application software they found. They mention the following systems:

Table 5 - 24 different system types according to Zhang et al.

System types from Zhang et al.	
1. Radio frequency identification (RFID),	13. Mobile IT,
2. Mobile apps,	14. Emergency response systems,
3. Airport information systems,	15. Enterprise applications (CRM, SCM, ERP),
4. Business rule management syst	16. Business intelligence,
5. Groupware,	17. Inter-organization information systems,
6. Car infotainment system,	18. E-procurement applications,
7. Business rules engines,	19. Sale point systems,
8. 3D rendering software,	20. Virtual workspace techno lo

9. Web services,	21. Media site with social networking features,
10. Portal,	22. Multimedia,
11. Online fora,	23. E-newspaper,
12. Middleware,	24. Open source software

4.2.5 Mooney, Gurbaxani and Kraemer 1995

In their research, Mooney, Gurbaxana and Kraemer seek to improve our understanding of the links between information technology and firm performance. While the business value of IT to this day remains a difficult topic they make a great contribution by outlining the different kinds of business value: Informational value, transformational value and automational value. Furthermore, they provide a business process typology that is good food for thought. In the current age almost, if not all, business processes are supported by IT. This can provide the basis of a high-level distinction between different applications based on the business processes they support.

Main findings:

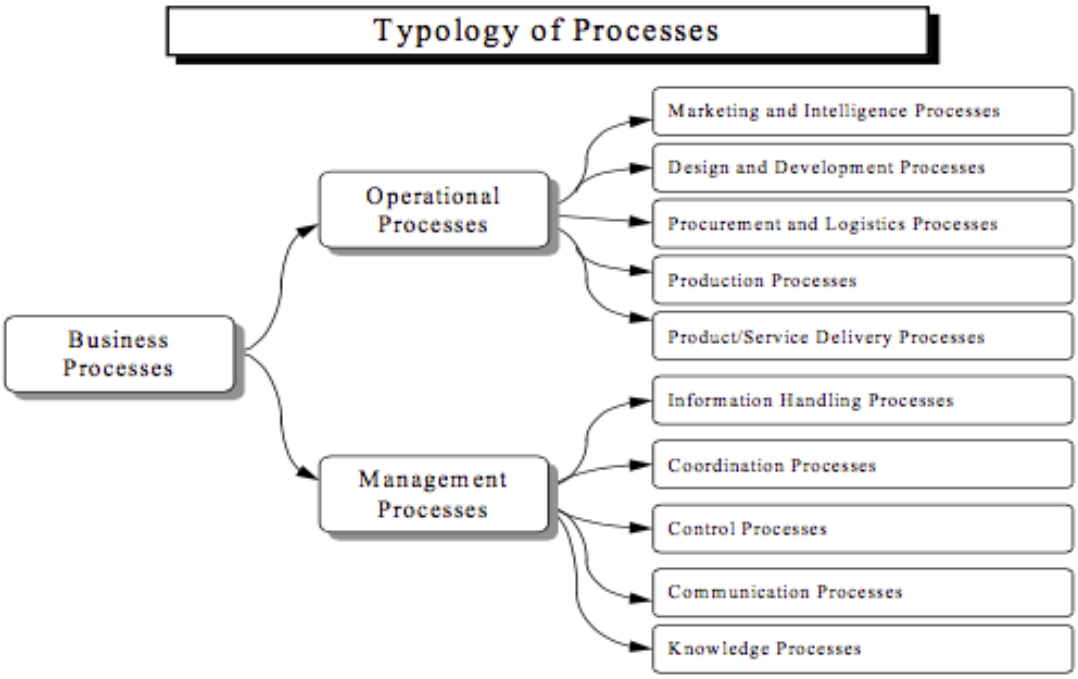

Table 6 - Typology of processes by (Mooney et al. 1995).

4.2.6 A Taxonomy of software types by Lethbridge 2008

In 2008, a software taxonomy was published (Lethbridge et al. 2008). It is a detailed list of existing software systems, with a broader scope than this study, including for example system software. They identify four categories: data-dominant software, system software, computation-dominant software, and control-dominant software.

Table 7 - Software taxonomy with four software types and examples by (Forward et al. 2008).

Data-dominant software	Examples
Communication and information	Voice, chat, email, web browsers, file sharing
Productivity and creativity	Text editors, spreadsheets, PowerPoint
Entertainment and education	Learning, games, E-books,
Personal management	Personal finance and budgeting
Strategic and operation analysis	Statistical/risk analysis, financial analysis
Corporate management	Real estate-, restaurant-, sales-management
Information management and decision support systems	Data warehouse, expert system, MIS, GIS
Transaction processing	Accounting, payroll, inventory, tax
Design and engineering software	Implementation tools, CAD, CAM, CASE,
Information display and transaction entry	Libraries, maps, traveling,
Standalone application for displaying information	
Web applications	Search engines, social network, news
System software	
Operating system	Accessibility, virtual machines, kernels
Networking/communication	
Devices and drivers	
Support utilities	Anti- virus and spyware, firewall, VPN
Middleware and system components	Database servers, UI support software
Software Back plane	Eclipse
Servers	E-mail servers, proxy servers, load balancers
Malware	Keyloggers, spyware, viruses, Trojans
Computation Dominant software	
Operations research	Computer science hard problems, Simulation software
Information management and manipulation	Inventory control, sales forecasting, search engine processing
Artistic creativity	Photo, music and video editing
Scientific Software	Idle time analysis, simulation software Image processing
Artificial Intelligence	Agents, Machine learning, virtual reality robots
Control Dominant software	
Hardware control	Firmware, device control
Embedded software	
Real time control software	
Process control software	Traffic control, nuclear plant control

Several conclusions can be drawn from this list. The simplest being that the software landscape of today is a very complex. But also that even with a list such as the one provided in the table above it remains difficult to classify certain types of systems because of their split functionality. A good example is management information systems, which is partly a decision support system and party an analytical system. Nonetheless, the list was very useful to have a

more complete overview of existing systems. But also to have good examples of what are not typical business applications (e.g. operating systems, devices and drivers)

4.3 Grey literature on IS classification

Various classifications were found in non-scientific (so called 'grey) literature and will be presented in this section. For these classifications, it is unknown how they were created unless otherwise stated.

4.3.1 ISBSG classification scheme

"The ISBSG is a not-for-profit organization that established and grows, maintains and exploits two repositories of IT history data (software metrics) to help improve the management of IT globally. " [6]

The ISBSG maintains a large benchmark of information about IT systems. The ISBSG benchmark version 12 contains more than 6,000 systems with over 125 characteristics. Examples include estimated system size and development effort, time and costs (for a full list see the ISBSG website). In this benchmark, they also use a typology to classify the systems. The main characteristics that are interesting for this research are industry sector, organization type, application group and application type.

Main findings:

Table 8 - The industry sector and applications groups from the ISBSG benchmark.

Industry sectors (1 / 2)	Industry sectors (2 / 2)	Application groups
Banking	Insurance	Business Application
Communication	Manufacturing	Real-Time Application
Construction	Medical & Health Care	Mathematically-Intensive Application
Defense & Aerospace	Mining	Infrastructure Software
Education	Professional Services	
Electronics & Computers	Service Industry	
Energy Sources	Tourism	
Environment & Waste	Utilities	
Financial	Wholesale & Retail	
Government	Insurance	

Note that the lists in **Table 9**, **Table 10** and **Table 11** are not complete only the most occurring types are shown here. Sorting the complete data set by their occurrences and picking the top occurrences determined this ranking.

Table 9 - Application groups with their respective application types part (1/2).

Application groups with details (1/2)		
#	**Business Application**	**Mathematically-Intensive Application**
1	Financial transaction process/accounting	Relatively complex application
2	Transaction/Production System	Car Design
3	Management Information System;	Network Switch Provisioning

[6] http://www.isbsg.org/isbsgnew.nsf/webpages/-GBL-About%20Us

4	Financial application area	Geographic or spatial information system
5	Financial transaction process/accounting; Client Server	Mathematical modeling; Online analysis and reporting
6	Management of Licenses and Permits	Network Management; Telecom & Networking
7	Office Information System	
8	Electronic Data Interchange	
9	Sales contact management	
10	Financial transaction process/accounting; Data Warehouse	

Table 10 - Application groups with their respective application types part 2/2. Note that this list is not complete only the most occurring types were picked.

Application group with details (2/2)		
#	**Real-Time application**	**Infrastructure Software**
1	Embedded system/real-time application	Infrastructure Software
2	Software for machine control	Operating system or software utility
3	Telecom & network management	Software development tool
4	Complex process control	Utility
5	Real-Time Application Embedded system/real-time application	

There are over 6000 systems in the ISBSG benchmark, almost 4000 of those have been classified with an application group and almost all of them have been classified with an application type.

Table 11 - Application groups and their occurrence. 3978 (66 %) of the 6000 applications has an application group.

Application Group	Number of occurrences	% of total
Business application	3642	91,55
Mathematically Intensive Application	14	0,35
Real-Time Application	272	6,84
Infrastructure Software	50	1,26
Total	3978	100

Table 12 - Application types and their occurrence. Note that this is only the top 20; there are over 500 different applications types in ISBGS.

Application type	Number of occurrences	% of total
Financial transaction process/accounting	982	32.9
Transaction/Production System	496	16.62

Management Information System	374	12.53
Relatively complex application	154	5.16
Financial application area	142	4.76
Financial transaction process/accounting, Client Server	116	3.89
Embedded system/real-time application	91	3.05
Stock control & order processing	85	2.85
Management of Licenses and Permits	72	2.41
Office Information System	60	2.01
Software for Machine Control	60	2.01
Telecom & network management	56	1.88
Sales Contact Management	55	1.84
Electronic Data Interchange	53	1.78
Financial Transaction process/accounting, Data Warehouse	46	1.54
Web-based Application	44	1.47
Online analysis and reporting	36	1.21
Customer billing/relationship management	32	1.07
Workflow support & management	31	1.04
Total	2985	100

When looking at the data in the tables above it becomes apparent why a clear business application classification can provide value for ISBSG. Almost 92% of the systems that have a system type (66%) were identified as business applications. Leaving only 8% for infrastructure software, real-time applications and mathematically intensive applications. In the ISBSG database, there were over 500 different application types of which more than 400 were only mentioned three times or less. There is a lot of duplication in the names as well as slight nuances in the naming that then form their own unique group. This supports the observations by Ein-Dor and Segev (1993) about fragmentation. An example of this is a human resource system and a human resource management system. Both seem to be the same system but are named differently and thus recorded differently. Still, it is useful to look at the top 20 occurrences in the benchmark to identify large categories of systems that have to be present in the proposed classification scheme of this research. Transaction processing and financial transactions systems seem to dominate the benchmark by making up more than 55% of the systems.

4.3.2 Classification used by a Dutch Governmental Organization

During the interviews, a classification used by the Dutch Governmental was brought to the attention of the authors. The list is given below.

System classification Dutch governmental organization	
Command & control systems	Job; case; incidents or project management
Customer relationship management system	Logistics or supply planning & control
Data warehouse system	Management reporting
Device/interface driver	Online analysis/reporting
Document management	Online sales or end customers

Electronic data interchange	Case management system
Financial transaction processing & accounting	Data management tool
Workflow support & management	Other

This classification is typical for how classification is usually done in organizations that lack a clear classification. An empirical list is made, often far from being exhaustive. To remedy this, a category called "other" is added. Examples of applications that are missing are analytical applications, functional applications like Sales & Marketing and non-financial or more generic transaction processing systems.

4.3.3 Classifications from the web

Various classifications can be found on the web. Website like SlideShare[7], where people can easily share presentation slides, are filled with classifications or presentations about information systems. However, the majority of those are incomplete and it remains unclear how they were established. An example is provided below. It is from a presentation for a lecture for students for Information System Control & Audit an organization in India. It can be found on SlideShare and is provided by VR Talsaniya. They have three application groups namely: Operation support systems, management support systems and office automation systems. These groups all contain several systems as is depicted below.

Web classification		
Operation support systems	Management support systems	Office automation system
Transaction processing systems	Management information system	Text processing systems
Process control systems	Decision support system	Document management system
Enterprise collaboration systems	Executive information system	Electronic message communication systems
		Tele- and video conferencing systems

This is a great example of a non-exhaustive classification. A lot of systems are missing such as analytical systems and once again functional applications. Again it remains unclear how it was constructed.

4.4 Overview of artifacts found

This section provides an overview of all the artifacts found during the literature review. First all of the scientific artifacts will be presented followed by the artifacts from grey literature.

4.4.1 Scientific artifacts overview

Author:	Ein-Dor and Segev (1993)	Nevo, Nevo and Ein-Dor (2009)	Zhang, Scialdone and Ku (2011)	Lethbridge 2008
Artifact type	Information Systems	IT artifact	IT artifact	Software
1.	Early Computing	Management support systems	Radio frequency identification (RFID),	Data-dominant software

[7] http://www.slideshare.net/

2.	Early Data Processing	Communication & collaboration tools	Mobile apps,	Communication and information
3.	Management Information System	Inter-organizational systems	Airport information systems,	Productivity and creativity
4.	Decision Support System	Infrastructure services	Groupware	Entertainment and education
5.	Office Information System	Enterprise applications	Business rule management	Personal management
6.	Executive Information System	Knowledge and document management systems	Car infotainment system,	Strategic and operation analysis
7.	Group Decision Support System	Operation systems	Business rules engines,	Corporate management
8.	Expert System	Resource management systems	3D rendering software,	Information management and decision support systems
9.	Managed Resource Planning	Computer integrated manufacturing and engineering	Web services,	Transaction processing
10.	Scientific Computing	Consumer website	Portal,	Design and engineering software
11.	Mature data processing	Computer graphics	Online fora,	Information display and transaction entry
12.	Managed Resource Planning 2		Enterprise applications (CRM, SCM, ERP),	Standalone application for displaying information
13.	Computer Aided Design		Mobile IT,	Web applications
14.	Computer Aided Manufacturing		Emergency response systems,	System software
15.	CAD/CAM		Middleware,	Operating system
16.	Manufacturing Robots		Business intelligence,	Networking/communication
17.	Command, Control, Communication and Intelligence		Inter-organization information systems,	Devices and drivers
18.			E-procurement applications,	Support utilities
19.			Sale point systems,	Middleware and system components
20.			Virtual workspace technology,	Software Back plane
21.			Media site with social networking features,	Servers
22.			Multimedia,	Malware
23.			E-newspaper,	Computation Dominant software

24.		Open source software	Operations research
25.			Information management and manipulation
26.			Artistic creativity
27.			Scientific Software
28.			Artificial Intelligence
29.			Control Dominant software
30.			Hardware control
31.			Embedded software
32.			Real time control software
33.			Process control software

Table 13 - Overview of all artifacts observed in scientific literature.

In total 74 artifacts were found during the literature review. However, there are two things to keep in mind. First, there is duplication among the various sources so the actual total unique artifacts are much lower. Second, not all of these artifacts are business applications. For example hardware and middleware are not considered business applications but are in this list.

4.4.2 Grey literature artifact overview

Author:	ISBSG database	Governmental classification	Classification from the web
Artifact type	Systems	Applications	Systems
1.	Financial transaction process/accounting	Command & control systems	Operation support systems
2.	Transaction/Production System	Customer relationship management system	Transaction processing systems
3.	Management Information System	Data warehouse system	Process control systems
4.	Relatively complex application	Device/interface driver	Enterprise collaboration systems
5.	Financial application area	Document management	Management support systems
6.	Financial transaction process/accounting, Client Server	Electronic data interchange	Management information system
7.	Embedded system/real-time application	Financial transaction processing & accounting	Decision support system
8.	Stock control & order processing	Workflow support & management	Executive information system
9.	Management of Licenses and Permits	Job; case; incidents or project management	Office automation system
10.	Office Information	Logistics or supply	Text processing systems

	System	planning & control	
11.	Software for Machine Control	Management reporting	Document management system
12.	Telecom & network management	Online analysis/reporting	Electronic message communication systems
13.		Online sales or end customers	Tele- and video conferencing systems
14.		Case management system	
15.		Data management tool	
16.		Other	

Table 14 - Overview of all artifacts observed in non-scientific literature.

In total 41 artifacts were found in grey literature. However, the same two limitations as for the scientific literature list should be kept in mind. First, there is duplication among the various sources so the actual total unique artifacts are lower. Second, not all of these artifacts are business applications. For example electronic data interchange and data warehouse systems are not considered business applications but are in this list.

5 Results and discussion

This section will present one intermediate result and the final version of the business application classification scheme. Several versions of the classification were made and improved throughout the interviews with IT experts. To provide insight into the processed followed when improving the classification scheme, one example is provided in this section.

Most of the experts that were interviewed either analyze business applications on a daily basis or have substantial knowledge and experience in the IT industry and have been in contact with various application types. One intermediate classification will be discussed to provide some insight in the thought processes behind it. Prior to this, however, the different entities used by the business application classification scheme will be introduced.

5.1 Business application classification scheme entities

This section provides insight in the three hierarchical levels used by the classification scheme.

The classification scheme has three levels using three entities:

1. Business application *categories*
2. Business application *groups*
3. Business application *types*

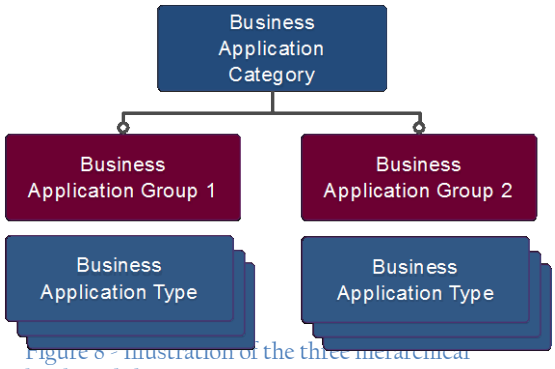

Figure 8 - Illustration of the three hierarchical levels and their entities.

Business application could be replaced with system, resulting in system categories, system groups and system types. The distinction in three different entities is important because it provides the user with a top-down approach to using the classification scheme in the classification process.

Note that each of these entities is a subset of the ones mentioned before it, meaning that an application group is a subset of an application category and an application type is a subset of an application group.

5.2 Business application categories

This section provides insight in the different business application categories and provides details on how they were constructed.

The business application categories are:

1. Operational systems
2. Supportive systems

The business application categories are based on the work from of Mooney et al. (1995) and the value chain from Porter (Porter & Millar 1985).

5.2.1 Operational and supportive systems

It is widely accepted that business processes can be split up into core business processes and supportive processes (sometimes called management processes)(Aguilar-Savén 2004; Mooney et al. 1995; Ross et al. 2006). For this study, the same distinction is made in business application software. Just as there is core-business and supportive business, there is also

software that enables core-business and software that enables support business. In this study they are defined as operational systems and supportive systems.

5.2.1.1 Operational systems

The core business is defined as:

"the processes that embody the execution of tasks comprising the activities of an organization's value chain. In effect, operational processes constitute the "doing of business." (Mooney et al. 1995).

During the interviews several, other definitions of core business systems were observed such as primary systems, business critical systems and customer facing systems.

5.2.1.2 Supportive systems

The second category is called supportive systems. Which are applications or systems that enable personnel that is not involved in the core business to do their work. Everything that is not included in the previously mentioned definition of core business is considered supportive business. An example is the system group business functions (i.e. Human Resource, Marketing, Finance etc.). The business functions require systems to do their work but are usually not involved in the core business of the company. Note that the core business varies per industry or domain. In for example, a production facility Human Resources (HR) and the HR application play a supportive role while in an employment agency HR is their core business.

Systems that support core business processes were referred to as primary systems while systems that supported supportive business processes were referred to as secondary systems by some of the interviewees. The authors think this is another great way to typify the two different types of systems as the word primary emphasizes that these systems are critical for business.

5.2.2 Operational systems breakdown into sub-categories

The operational systems category is broken down into two sub-categories: Transactional and Creational. They are based on the dimension Commerce/Transaction versus Product Design/Development (Nevo et al. 2010). In their paper Nevo et al. report that the dimension can be interpreted as differentiating between information technologies that focus on product design and development versus commerce or transactionally oriented technologies.

This dimension is represented in **Figure 9**. This dimension differentiates between systems that focus on product design and development versus systems that focus on commerce or transactions. The systems on the left-hand side are characterized as providing support for commerce and transactions. Information technologies on the right-hand side were linked to product design and development (Nevo et al. 2010).

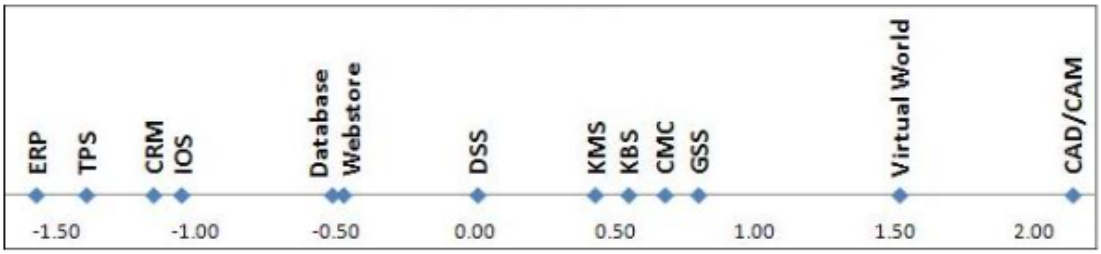

Figure 9 - Dimension from Nevo et al. 2010 with their identified systems mapped on the dimension commerce/transaction (left side) versus design and development (right side).

Applications that are on the edges of the scale in **Figure 9** (a score of smaller than -1 or larger than 1) are better described using this dimension then applications that are around the middle point (0).

5.2.2.1 Creational systems

Looking at the right side of **Figure 9** (everything larger than 1.00) this leaves only virtual worlds and CAD/CAM systems for the design/development category. Since virtual worlds is considered middleware and thus outside the scope of this study only CAD/CAM systems remain. A high-level category that only classifies one type of system is not very meaningful, thus the decision was made to expand the definition of this category. The creational category not only focuses on the design, development and manufacturing of products but also on the design, development and creation of knowledge or information. Thus, this category also incorporates analytical systems that process data to provide knowledge or information.

5.2.2.2 Transactional systems

Transactional and commerce-oriented systems area on the left side of **Figure 9**. Examples include transaction processing systems (TPS) and enterprise resource planning systems (ERP). TPS and ERP are examples of a system group and a system type. They will be explored in more details in sections to come.

To finalize the business categories section they now look like this:

1. Operational systems
    - Creational applications
    - Transactional applications
2. Supportive systems

The classification scheme with only the classification categories can be visually represented like this:

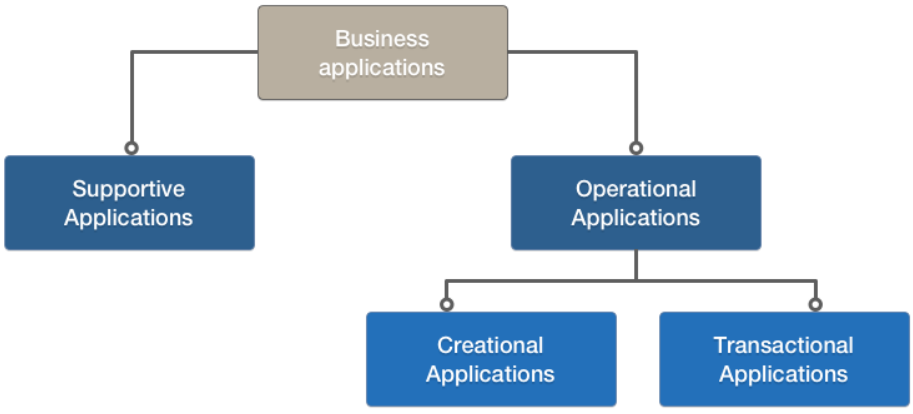

Figure 10 - The classification backbone, showing only the classification categories.

Figure 10 is the backbone of the classification scheme that is the result of this study. When combining the now defined system categories with **Figure 8** the classification scheme looks like this:

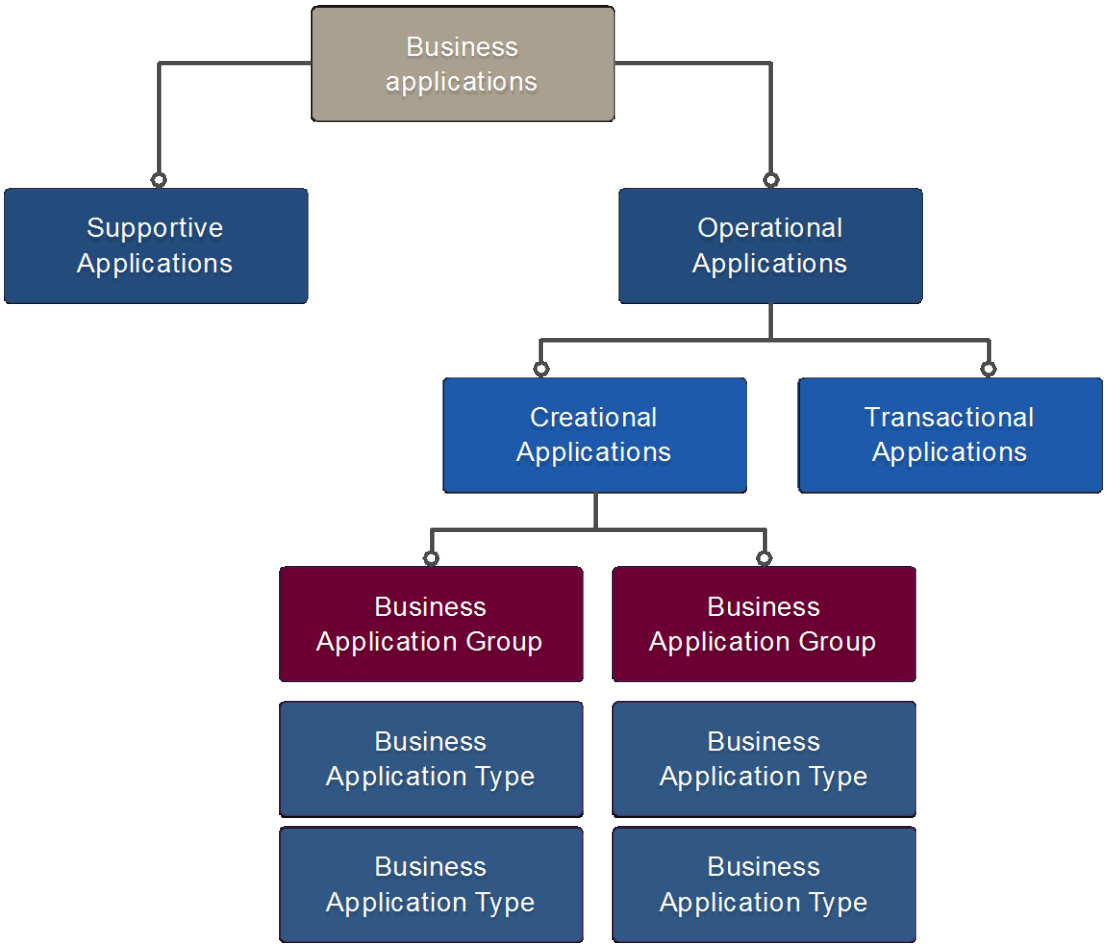

Figure 11 - The classification scheme with the final system categories and blank examples of business application groups and business application types.

In the next section, the business application groups and application types will be introduced to complete the business application scheme.

5.3 Business application groups

The tendency was found to group systems and provide examples of these groups (Nevo et al. 2010; Zhang et al. 2011). The examples for each system group are called system types in this study. It was decided to adhere to this tendency as it provides a nice structure that can benefit from the previously defined application categories. Two examples are provided here that illustrate why grouping systems also works well in practice.

Example 1.

Consider two systems:

1. Resource allocation system, where are my resources located?
2. Inventory control system, how much of each resource do I have?

Both systems deal with resource management (system group), however on a lower level they have separate functionality (different system types). While resource allocation deals with geographical data, the inventory control system deals primarily with the amount of resources available and compares those with the expected demand (from a managed resource planning system or component) in order to figure out if more inventories are required. For just in time management (Kannan & Tan 2005) for example, both systems play an important role.

Example 2.
Compare another two systems:

1. Financial transaction processing system, used in banking
2. Transaction processing system that tracks duration of phone calls, used in telecommunications companies

Both belong to the same system type, namely transaction processing systems. Yet their functionality on a lower level is different. A financial transactions system deals primarily with financial transactions and usually deals with them in batches, while a telecommunications transaction system focuses more on gathering data such as duration and location of a call or different user request and thus is a real-time always online system.

These examples supported the observations that it is possible to group systems based on their functionality. These groups contain multiple sub-systems (called system types in this study) such as the examples provided earlier. The intermediate list of systems is provided below in **Table 15**.

5.4 Business application types

Different system groups and system types were gathered through a literature review and five exploratory interviews with people that assess software applications on a daily basis. The interviews were held to verify the lists found in literature and to gather additional expertise from experts in the field of application rationalization[8]. The results of this phase can be found in **Table 15**. It provides an overview of different system groups and system types belonging to that group.

#	System Group	System Type	Sources
1.	Management and executive support	DSS, MIS, EIS, KBS, Expert Systems	(Nevo et al., 2009) (Matook, Brown, 2008), (Nevo et al., 2010)
2.	Resource management	Chargeback, resource allocation	(Zhang et al. 2011), Expert interviews
3.	Consumer website	Web store	(Nevo et al., 2010), (Zhang et al. 2011)
4.	Knowledge and document management	KMS, Document management system	(Nevo et al., 2010) (Nevo et al., 2009)
5.	Enterprise applications	Enterprise systems, ERP, CRM, HR IS, Accounting IS, Inventory IS	(Nevo et al., 2009) (Zhang, Ping 2011) (Nevo et al., 2010)
6.	Computer integrated manufacturing and engineering	CAD, CAM, CASE, MRP	(Nevo et al., 2010) (Nevo et al., 2009)
7.	Operational systems	Electronic Payment systems, TPS	(Nevo et al., 2010) (Nevo et al., 2009)
8.	Infrastructure services	Networks, Databases. Operating systems, Hardware	(Nevo et al., 2009)
9.	Communication and collaboration	Group support system, Computer Mediated Communication	(Nevo et al., 2010) (Nevo et al., 2009)

[8] Application rationalization is the radical reshuffling and optimization of a (business) application portfolio. This can be done based on several characteristics such as quality-, functionality-, size- and age of the systems.

10.	Inter-organizational systems	Supply Chain Management Systems, IOS, Electronic Markets, EDI	(Nevo et al., 2010) (Nevo et al., 2009) (Zhang et al. 2011),
11.	Virtual Worlds		(Nevo et al., 2010)
12.	Men Machine interface	Process controllers, Factory controllers	Expert interviews
13.	Mobile applications		(Zhang et al. 2011)
14.	Business intelligence applications	Analytical systems	(Zhang et al. 2011)
15.	Data and image processing	Traffic Camera systems	Expert interviews
16.	Incident/case management, workflow management		Expert interviews (Zhang et al. 2011)

Table 15 – Overview of the first results; a list of system groups and system types that were a combination of literature and five exploratory interviews

All authors cited in **Table 15** performed an extensive literature review to get a complete overview of business applications or IT artifacts. Thus instead of performing another thorough literature review to look for individual systems we relied on the previous work of these authors and on the interviews with experts to get to a list as exhaustive as possible. The categories (the skeleton) provide a way to be able to classify new systems in the classification by providing a high-level functional classification (operational versus support and transactional versus creational for operational systems).

5.5 Intermediate result

Wen reviewing the list with several of the experts that it became apparent that at this point it was still quite ambiguous what the classification scheme was trying to classify. Not all of the systems were on the same architectural level, as several interviewees also noted:

"*For example an operating system is on a level below functional applications. Same goes for virtual worlds versus a management information system*"

"*You are mixing middleware, hardware and software systems all in one*"

"*There are categories that are really generic, such as operational systems while others are really specific such as a web store*"
- Interviewees from the exploratory interviews

To remedy this problem a clear definition of business applications was constructed (see **Figure 1**). The elimination of systems that were not considered business applications (i.e. operating systems and infrastructure services) led to a new list. These systems were mapped on the skeleton and verified with a more extensive round of interviews and literature. The list of systems can be found in **Table 16**.

#	System name	Examples	Sources
1.	Management and executive support	DSS, MIS, EIS, KBS, Expert Systems	Matook, Brown, 2008 Nevo et al. 2010 Nevo et al. 2009 Ein-dor et al. 1993
2.	Resource management	Managed resource planning, resource allocation, Supply Chain Management	Nevo et al. 2010 Ein-dor et al. 1993 Nevo et al. 2009
3.	Functional applications	HR IS, Finance IS, Customer Relationship Management	Nevo et al., 2010 Expert interviews

4.	Design, engineering and manufacturing	CAD, CAM, CASE, Visualization software,	Zhang, Ping 2011 Nevo et al. 2010 Ein-dor et al. 1993 Nevo et al. 2009
5.	Communication and collaboration	Group support system, Computer Mediated Communication	Nevo et al. 2010 Ein-dor et al. 1993 Nevo et al. 2009
6.	Operational and transactional	Transaction processing systems, Electronic Payment systems	Zhang, Ping 2011 Nevo et al., 2010
7.	Inter organizational	Electronic Data Interchange (EDI),	Nevo et al., 2009 Nevo et al., 2010
8.	Security	SIEM, Virus scanner,	Expert interviews
9.	Analytical	SIEM, Splunk, BI tools, SPSS, R	Matook, Brown, 2008 Ein-dor et al. 1993
10.	Knowledge and document management	Document management systems	Nevo et al., 2010
11.	Geographical tools	GIS, Navigation, Port base,	Expert interviews

Table 16 – Results of the second design and evaluation phase, an overview of business applications.

This new list of systems was mapped on the classification categories (the skeleton) resulting in a classification scheme. This classification scheme was tested during structured interviews with application experts and several problems with the intermediate version were found. These will be described in more detail in the next section.

5.5.1 Intermediate classification discussion

This section provides the discussion of the results for the intermediate result and identify areas of improvement for the final classification scheme.

Four issues with the intermediate result were identified:

1. System types are not all on the same level
2. The knowledge and communications systems group lacks internal cohesion
3. The management information systems and decision support systems groups often evoke confusion during the interviews.
4. Process controlling applications do not have a place in the classification

These issues are explored in more detail in the next section.

5.5.2 Issue explanation

A more detailed explanation of the four issues is provided below. How these issues were remedied is described in the section follow this one.

Issue 1: System types are not on the same level

Several interviewees noted that not all system groups have mutually exclusive commonly exhaustive system types. The system types for the system group analytical systems are several random examples while the system types for resource management systems appear to be an exhaustive set of systems. Meaning systems either fall into one of those system types or provide a combination of functionality of these system types, as is the case with for example an ERP system. Several ERP systems were found to have resource allocation, inventory control and managed resource planning combined in one system, usually with additional integration to finance or sales systems.

One reason for this could be that some system types are so well known or so big those they are seen as the category itself. One interviewee illustrated this nicely with an analogy from the medical industry. When people require pain medication they usually ask:
Do you have an aspirin?
Do you have a paracetamol for me?
While what they are actually asking for is a painkiller. The same thing happens with some of the system types in the classification. Consider the example of Business Intelligence systems. Business Intelligence (BI) is a buzzword and people often call something a BI system. Most BI systems analyze a big heap of data using statistics or an algorithm, making it an analytical system.

The groups for which this problem was identified are design engineering & development, analytical systems, case or event management systems, personal productivity and functional applications. How this was solved will be discussed in section 5.5.3.

Issue 2: Knowledge and Communication group
Communication systems, when compared with knowledge and document management systems, were often found to be distinctly different during the interviews. However, all three system types are in one classification group. When reviewing the system types in the knowledge and communication group it was found that the relation between knowledge and communication systems was not as strong as initially believed. Because hardly any system could be identified that had a strong communication as well as knowledge or document management component. So while knowledge and document management fit well together (to manage knowledge optimally often requires some form of document management) communication systems are an outlier in this system group.

Issue 3: Management Information Systems and Decision Support Systems groups
A number of the interviewees were confused about the location of- and distinction between management information systems (MIS), decision support systems (DSS) and analytical systems. MIS have a strong analytical component and often have a more advanced reporting function when compared with regular analytical systems. However, the main functionality of a MIS is analyzing (company) data in order to draw meaningful conclusions and support decision-making. This proved difficult to classify because this meant it could be located in three different system types (analytical system, MIS and DSS). Furthermore, it was observed during the interviews that while the systems in the resource management group seemed exhaustive, the systems in DSS and MIS had the same functionality. But depending on the end user the focus of the system differs (Decision support versus Analysis). These two issues led us to believe that we were once again dealing with a combination of systems grouped in the same category, just like for the knowledge and communication group. While these systems had more internal cohesion (they all do the same thing) their location in the classification scheme evoked a lot of confusion and discussion during the interviews.

Issue 4: Process control systems
During the interviews, it appeared that there was no system type that identified process-controlling applications. Examples of such applications are systems that provide an interface for a user to control the brewing process in a brewery or the open and closing process of a sluice. While large parts of these processes are automated definitely not all of it is. They were identified earlier in the study, as software for machine control and men machine interface

systems but were not in the intermediate result. It was pointed out in the interviews, through the two above-mentioned examples, that process controllers such as man machine interfaces deserve a place as the experts observed many of those systems.

5.5.3 Issue remedies

The issues explained above had to be remedied in the final version of the classification. These remedies are provided below.

Solving issue 1: System Type Level

The different system types were reworked to provide more meaningful system types. These had to be as much on the same level as possible, rooted in interview or literature data and could be found within the limited time frame of this master study. The results can be found in **Table 17**.

Solving issue 2: Knowledge & Communication Systems

It was decided to split the knowledge and communication system group into two new groups with better internal functional cohesion. The first group focuses on communication and was thus called Communication Systems. The second group deals with document and knowledge management and was thus named Knowledge and Document Management.

Exhaustive system types for communication systems had to be found. Communication happens either asynchronous or synchronous. Synchronous interactions are those that happen more or less at the same time. Asynchronous ones do not (Caladine 2006). It was therefore decided to have two types of systems for the communication systems group, asynchronous communication and synchronous communication. E-mail, a website and chat are considered to be in the first category, while video conferencing and VOIP systems are part of the latter.

The knowledge and document category contains the remaining system types: knowledge management system, document management system and content management system.

Solving issue 3: Management information systems, decision support and analytical systems

An interesting observation from one of the interviewees was that while MIS are heavily researched and described in literature, they are rarely observed in reality. The interviewee mentioned, despite his 25 years of experience with management and IT, never having seen a MIS. This lead to the idea that MIS are less important then they appear to be in literature.

Three distinct functionalities are generally observed in a management information system according to literature: analysis, decision support and reporting (Clark Jr. et al. 2007). Because of the lack of observations of these systems it was decided to split the decision support systems (which were found during the interviews) from MIS. MIS were given their own system type in the group of Functional Applications; the decision support system type was moved to the Analytical Systems group. Decision Support Systems focus primarily on decision support and are thus considered a separate category. Because the decision support functionality usually relies on analysis they are put in the Analytical Systems Group. When a Decision Support System supports primarily management and has additional reporting functionality it's considered to be a MIS.

Solving issue 4: Process Controlling applications
The brewery example could be put in the Design, Engineering and Manufacturing Group in the Computer Aided Manufacturing system type. But for example for process controllers that do not create anything this wouldn't work. Therefore, it was decided that this type of system deserves its own system group. Because of their largely transactional nature (controlling processes requires lots of check with measurement systems) it was decided that this group should be in the Transactional System *Category*. To not cause another system group with an issue one exhaustive System Types were made for Process Controlling Applications. These are called production process controllers (factories, breweries etc.) and non-production process controllers (sluice, bridges etc.)

Applying these four solutions to the intermediate classification scheme provides a better classification scheme that evokes less confusion. It is, therefore, easier to use and in the end provides a better overview of different business applications and their relation to each other in the form of a classification scheme.

5.6 Final result

This section provides the final business application classification scheme. This consists of a table with all the system groups and system types (**Table 17**), an overview of the system categories (**Figure 10**) and finally the complete business application classifications scheme with all the system groups, the associated system types and how they all relate to each other. The section concludes with the discussion of the final business application classification scheme.

The final list of system groups and system types is presented in **Table 17**.

#	System Groups	System Types
1.	Process Controllers	Creational Process controller, Non-creational Process Controller
2.	Transaction Processing Systems	Real-time Processing Systems, Batch Processing Systems
3.	Resource Management Systems	ERP, Managed Resource Planning, Inventory Control, Resource Allocation, Managed Resource Planning
4.	Case Management Systems	Case Management System, Incident Management System,
5.	Design, Engineering & Development Systems	Computer Aided Design, Computer Aided Manufacturing, Computer Aided Engineering
6.	Analytical Systems	Algorithmic Applications, Statistical Applications, Decision Support Systems
7.	Authentication and Portals	Client Portals, Identity and Access Management
8.	Communication Systems	Asynchronous Communication Systems, Synchronous Communication Systems
9.	Functional Applications	Management Information System, HR,

		Administrative System, Finance, Sales/Customer Relationship Management System, Legal, Facility management, Marketing
10.	Knowledge and Document Management Systems	Knowledge Management, Document Management, Content Management
11.	Personal Productivity Applications	

Table 17 – The final list of system groups and system types, the result of the literature review and first set of structured interviews.

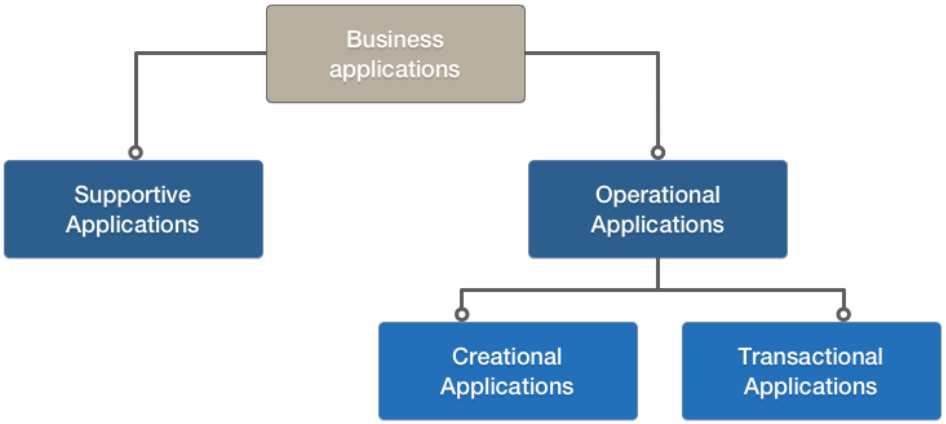

Figure 12 – The skeleton for the Business Application Classification Scheme with the Business Application Categories providing the classification structure.

#	System Groups
1.	Process Controllers
2.	Transaction Processing Systems
3.	Resource Management Systems
4.	Case Management Systems
5.	Design, Engineering & Development Systems
6.	Analytical Systems
7.	Authentication and Portals
8.	Communication Systems
9.	Functional Applications
10.	Knowledge and Document Management Systems
11.	Personal Productivity Applications

Table 18 – The System Groups.

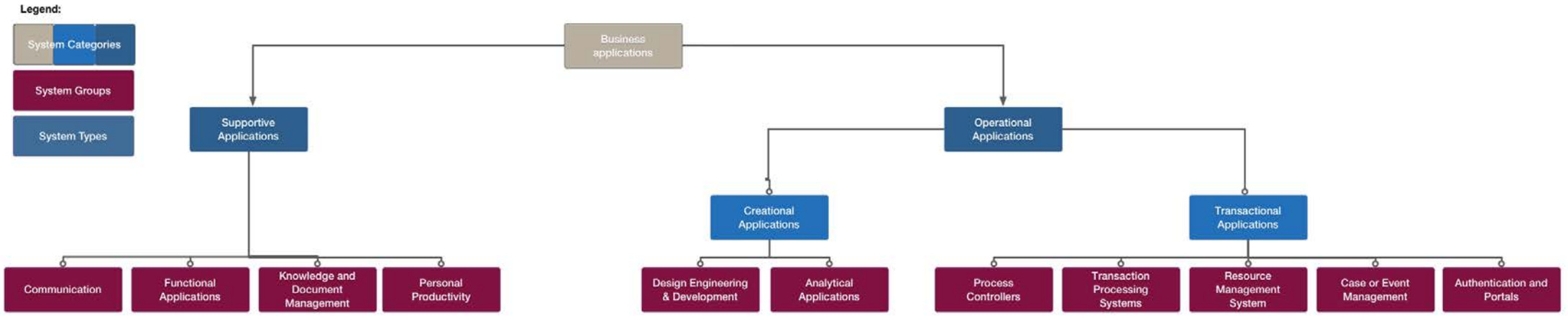

Figure 13 – The business application classification scheme with the business application categories and business application groups

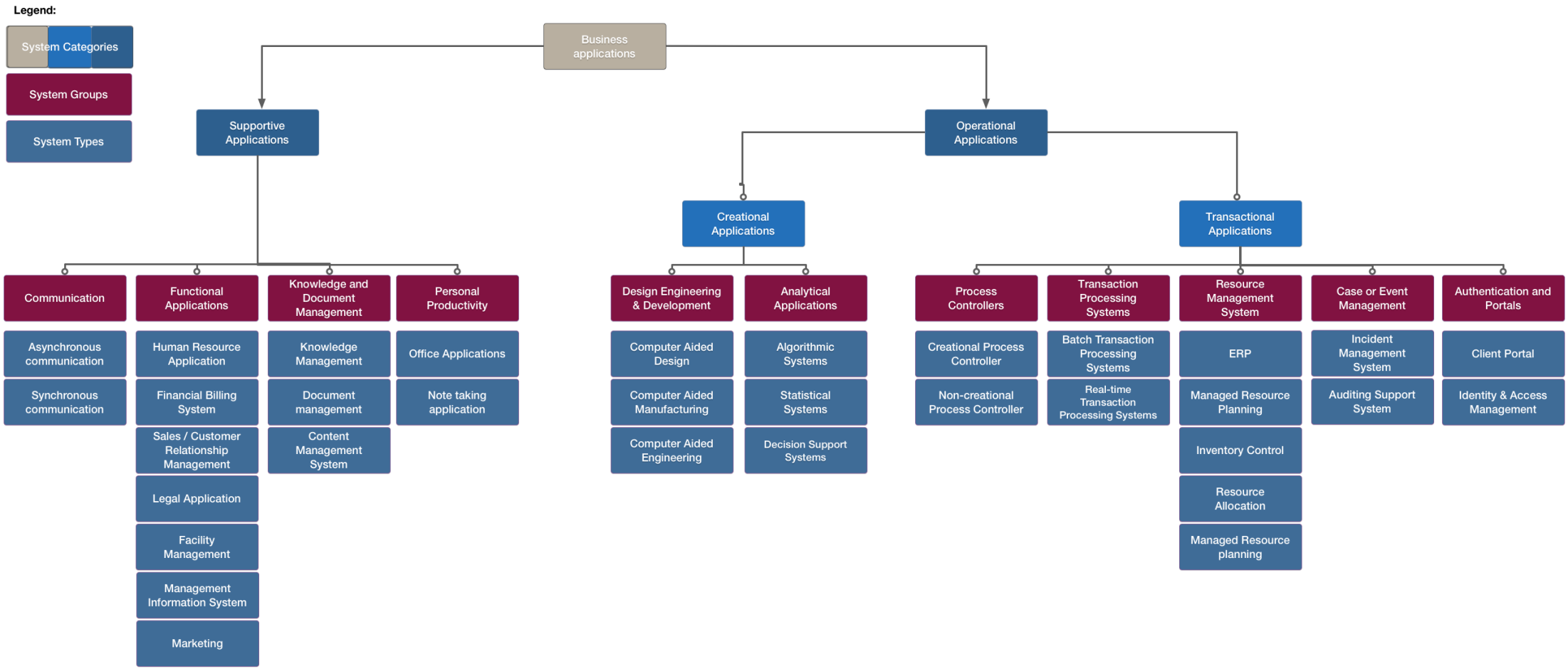

Figure 14 – The business application classification scheme with the business application- categories, groups and types.

5.6.1 Final Result Discussion

One thing that is worth noting is that, despite the undertaken efforts to achieve it, not all system groups have mutually exclusive and commonly exhaustive system types. Currently, this was remedied by providing common examples or leave the system types blank altogether. System groups still lacking this are the following:

1. Case management systems
2. Authentication and portals
3. Personal productivity

Possibilities to solve this will be discussed in the future work section. For now several reasons for why these systems lack commonly exhaustive and mutually inclusive system types will be discussed. For the first system group: case management systems, the reason is that the majority of the dataset used to validate the different categories were case management and transaction processing systems. Because of the huge diversity in this system groups it was impossible to define meaningful system types that would be mutually exclusive and collectively inclusive. Therefore, it was decided to provide two of the most common examples, rather than a mutually exclusive and collectively inclusive set of system types.

The second system group, Authentication and portal systems, is a relatively new group with a distinct functionality that is different than all the other system groups and, therefore, deserves their own system group. However, because they are fairly new, and thus not very often observed (yet), it is hard to know if there are different types of authentication and portal systems. It was decided to just provide examples for now and that this area should be further explored in future research.

For the last group, personal productivity, it was decided not to attempt a mutually exclusive and collectively inclusive set of system types because that area changes so rapidly it would probably be outdated very quickly. The authors felt that it is more important to recognize an application as being for personal productivity, rather than what specific type of productivity enhancing it does.

6 Evaluation of results

This section describes the business application classification scheme acceptance and validity as tested by the authors. Additionally a use case is presented.

Earlier in this study a good result was defined as: is acknowledged from a practitioner's perspective to be useful and accepted from a researchers perspective to be valid. These two options will be explored below. Acceptance and the intention to use a new artifact depend among others on the perceived usefulness (will this enhance my performance) and the ease of use (how much effort does it take) (F. Davis 1989; V. Venkatesh and F. Davis 2000).

6.1 Classification Acceptance

This section provides the reader with the results for testing the classification acceptance as described in section 3.2.3 Evaluation phase. A short summary of the results of the questionnaire is in Table 19. For a complete overview of the results see Appendix B.

Aspect of acceptance	Percentage 4 or 5
Ease of use	86%
Usefulness	31%
Behavioral intention	71%
Compatibility	50%
Perceived behavioral control-internal	89%

Table 19 - Survey results for 14 interviewees on five aspects of acceptance from Riemenschneider et al. 2002. The questionnaire scores were on a scale from one to five with one being the lowest and five being the highest score.

The scores for ease of use, perceived behavioral control and behavioral intention control are all above 70%. From this it was concluded that that the classification is easy to use, the number of constraints why one would not be able to use the BACS are limited and that participants have the intention to use the classification in their work.

However, the score of only 31% for usefulness is concerning. To explain this score it was broken down in its sub scores (see **Table 20**). The classification is regarded as useful in their job by 43% and 64% thinks the advantages outweigh the disadvantages. The scores for increased job performance, effectiveness and productivity are very low. When prompted with the question "why the interviewees felt this way?" several reasons were provided for the low score.

Interview questions for Usefulness	Percentage 4 or 5
The classification is useful in my job	43%
Using the classification improves my job performance	14%
Using the classification increases my productivity	14%
Using the classification enhances the effectiveness of my work	21%
Using the classification makes it easier to do my job	29%
The advantages of using the classification outweigh the disadvantages	64%

Table 20 - The six questions used in the questionnaire to check for usefulness and the percentage of four and five (agree and strongly agree respectively).

The most common reason, provided by the interviewees, was that in their current job, they don't look at applications from a functional perspective. This is aligned with 50% of the interviewees indicating that the BACS is compatible with their work (and thus for 50% it is not). Furthermore, those interviewees indicated that they did find the BACS useful, just not in their current job and therefore they gave a negative score. The second reason mentioned by several of the interviewees was that the context in which it is used is what provides the value and potentially increased effectiveness and performance. If they would know typical problems, trends or other information about the different groups that would be valuable and useful. The authors feel that this explains the lower score for usefulness. This is backed up by the fact that 71% of the interviewees had the intention to use the classification in the future and thus sees potential value in it.

6.1.1 Acceptance conclusion

Based on the information provided above the authors conclude that the business application classification is easy to use (86%), the number of constraints why one would not be able to use the business application classification scheme are limited (89%) and that participants have the intention to use the classification in their work (71%). While users found the business application classification useful and had the intention to use it, it was not always found useful in their work (43%).

6.2 Classification Validation

This section provides the reader with the validation of the BACS.

During the interview phase the interviewees, using the BACS, classified 111 systems. (see Appendix F). For this study, a system group is considered to be valid if it contains at least 5% of the total number of systems classified. This is in line with the expectations from the interviewees that a system group should represent a meaningful number of systems. Having too many small groups makes the BACS harder to work with, it takes more time to get to know the BACS and requires more data to draw general conclusions from it overall making it less useful. For this dataset that meant a minimum of six systems per group (5% of 111 systems). Furthermore, every system type that was identified should adhere to at least one system from the dataset to determine if it's not a purely theoretical phenomenon. A summary of the appendix is provided below.

System Group	#	% Of total
Analytical Systems	13	11,71 %
Design Engineering & Manufacturing Systems	3	2,7 %
Process Controllers	7	6,31 %
Transaction Processing Systems	17	15,32 %
Resource Management Systems	14	12,61 %
Case & Event Management Systems	24	21,62 %
Authentication and Portals	8	7,21 %
Personal Productivity	0	0 %
Communication Systems	3	2,7 %

Functional Applications	16	14,41 %
Knowledge and Document Management	6	5,41 %
Total	111	100%

Table 21 - A summary of Appendix F, an overview of the system groups and the % of the total systems that fall in each respective group.

From **Table 21** it is clear that the groups Design Engineering & Manufacturing Systems, Personal Productivity and Communication systems do not adhere to the criterion of 5% or more than 6 systems. Despite not matching this criterion the authors believe it to be valid groups. Reasons for this are provided below.

System Categories	#	% Of total
Operational	86	77,48 %
Creational	16	14,41 %
Transactional	70	63,07 %
Support	25	22,52 %
Total	111	100%

Table 22 - Summary of appendix X, an overview of the system categories, a breakdown of the operational category in the sub categories and the % of the totals systems that fall in each respective category.

From **Table 22** one can conclude that the dataset is skewed towards operational systems (77% of the total dataset). As the data was obtained from interviews with practitioners that analyze systems on a daily basis this follows logically. By definition, a company's s primary, mission-critical and core business systems are more important than a company's secondary or supportive systems. Therefore, these systems are analyzed and optimized more frequently and sometimes by third party experts, such as the Software Improvement Group[9] (SIG). This explains why the dataset, which was obtained largely from SIG consultants, is skewed towards operational systems. For this reason, the supportive systems category is under-represented. Despite attempts from the authors to improve the sample distribution by interviewing practitioners from other fields and companies the same distribution in the dataset remained. However the fact that they are not in this dataset doesn't mean they don't exist. There are clear examples in literature of both personal productivity (Forward et al. 2008; Melville et al. 2004) and communication systems (Morrison & Liu Sheng 1992; Sher & Lee 2004). The same holds true for design, engineering and manufacturing systems, these systems were among the very earliest of business applications (Ein-Dor & Segev 1993). So despite it being surprising that the three groups are underrepresented in the dataset the authors believe all three under-represented system groups are valid system groups. Future work with a bigger dataset that has a better distribution is needed to check whether or not this statement holds.

6.2.1 Validation conclusion

Based on the results described above the authors conclude that the business application classification scheme is valid 8 out the 11 system groups have a decent amount of systems (more than 6 or 5% of the total dataset). 3 out of the 11 do not fit the criteria; they are however believed to be valid criteria for reasons explained earlier. It does, however, warrant future research to confirm this conclusion.

[9] http://www.sig.eu

6.3 Use Case example

This section provides a brief example of a use case for the business application classification scheme.

A dataset was obtained from SIG for 10 case management systems and 9 transaction processing systems for a total of 19 systems. In addition to the classification, the volume (in man-months) and the star rating were known. The volume is an estimate of the code volume based on the effective lines of code divided by a certain productivity rating per language. One line of COBOL for example usually takes longer to write then a line of PHP, this is reflected in the productivity rating that is used to calculate the volume. The rating is the maintainability rating as calculated by SIG using the SIG/TÜViT maintainability model and is a measure off code or software quality. It is on a scale of 0.5-5.5 or 1-5 stars.

SIG already utilized this data for benchmark purposes but does not yet look at trends within system groups or system types. This example illustrates such a use case.

Case Management	1	2	3	4	5	6	7	8	9	10
Rating (1-5)	3,53	2,09	2,05	3,16	3		3,1	3,36	1,52	2,77
Volume (man-months)	4,34	47	150	173	202	310	132	183	1296	1453

Table 23 – Part one of the dataset of 19 systems, showing the 10 case management systems with their rating and their volume

Transaction Processing	1	2	3	4	5	6	7	8	9
Rating (1-5)	1,78	1,79	2,1	2,26	3,44	2,65	3,8	2	1
Volume (man-months)	1914	2876	813	770	46	422	120	1200	2256

Table 24 – Part two of the dataset of 19 systems, showing the 9 case management systems with their rating and their volume

Three graphs were made to visualize this data: the volume per system type, the rating per system type and the volume versus the rating for all the systems.

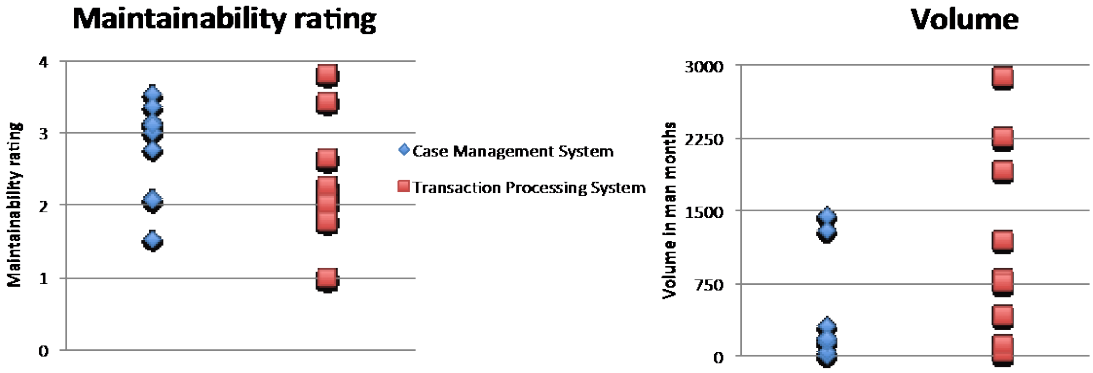

Figure 15 – Two graphs showing the maintainability rating according to the SIG/TuVIT maintainability model and the volume for the two types of systems.

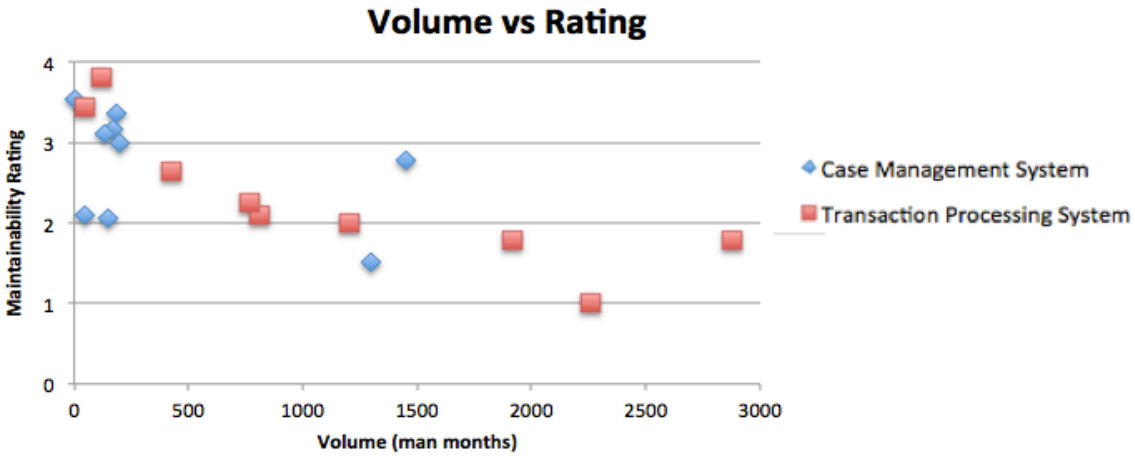

Figure 16 – Showing the volume versus the rating for the two types of systems.

One should be wary of drawing conclusions based on only a few data points. However, it does illustrate a potential use case for the business application classification scheme. By combining existing knowledge with the classification, one can gain new insights. An example of that is that from this data it shows that transaction processing systems, in general, have larger volumes than case management systems. With other types of data, like maintenance costs, system age etc. more of these trends could be discovered and used to provide better service or build applications using this knowledge.

Note that this is just one potential use case for the classification many more uses could be explored in future research or application of the classification scheme.

7 Limitations

This study is subject to several limitations. Limitations with regards to data collection and limitations regarding the usage of the BACS were identified. Both will be described in more detail below along with ways to reduce the impact of these limitations on the end result.

7.1 Data collection limitations

In this section, limitations regarding data collections methods are described as well as methods that were used to minimize the effect of these limitations.

7.1.1 Data collection limitations for literature

This study heavily relies on data from literature and interviews. Since the primary sources for the gathered literature were Google Scholar, Google and The Leiden University. This might mean that relevant articles or other types of information were missed because it was unavailable through these search engines or libraries. Nevertheless, it is believed that the literature review was in depth enough to suit the purpose of this research and provide a foundation for the interviews. Which leads to the second limitation

7.1.2 Data collection limitations for interviews

As is always the case in interviews, the results might be subject to interviewer bias, as the interviewer might unintentionally steer interviewees in their response and/or provide additional information that was acquired from earlier interviews. This bias is limited as much as possible by utilizing the same interview formats in every interview set, meaning the same type of questions and overall structure was adhered to.

7.1.3 Data collection limitations for the dataset of 111 systems.

The dataset that was gathered from the interview, the 111 systems, are also subject to limitations. The most notable limitation is that the systems are not equally distributed across the different categories and groups. 77% of the systems fall in the operational category leaving only about 23% for the supportive systems category. The conclusion from a larger data set where the distribution was closer to 50/50 would have been stronger. Increasing and or improving the dataset could solve this problem. This would ensure that enough applications fill the group thereby decreasing the importance of the distribution. A second solution could be to start a new dataset from different sources; this might lead to a different distribution closer to 50/50. Due to time constraints these paths were not pursued, but the authors feel that with this dataset a good proof of concept was provided nevertheless.

7.2 Usage limitations

This section describes the limitations that apply to using the end result of this study; the BACS. Most notable is the fact that not all business applications have one clear functional goal. Second is that the added benefit of the classification depends heavily on the context in which it is used. Third is that the BACS describes only business applications.

All three limitations are described in more detail below along with measures that can be taken to avoid these limitations.

7.2.1 Systems lacking one clear functional goal

A description of the limitation and ways to counteract the limitations are described in this section.

Limitation description
Not all business applications have one clear functional goal (e.g. only one functionality). It often happens that systems bridge multiple roles and thus provide a diversity of functionality. In fact for some applications their purpose is to be able to provide different functionality to different users using the same data (e.g. Enterprise Resource Planning system, ERP). However, this makes it hard to classify the system in one system type.

Limitation solution
This limitation can be prevented or solved in two ways. First, most systems have one primary role which is made possible-, or accompanied by several other functionalities. So a system could have a primary classification and one or several other supporting functionalities. An example of this is a case management system. Most of the system deals with allowing different users to access and work on different cases; part of this work, however, is often automated using some kind of transaction processing system. So while the main system is a case management system there are also other components present.
Second, the BACS can be used to classify the different components of a system. As the BACS is designed to be an overview of all business functionality most if not all of the functional components of the system can be classified using the BACS. The resulting classification would then be on a lower level than a classification of the entire system, but valid and useful nonetheless. An example of this would be a management information system (MIS). A MIS usually has two or more components. Arguably the most important part is the analytical component that provides the user with insight in the (often complicated and abundant) data. Additionally there is a reporting component that provides pre-formatted reports at regular intervals.

7.2.2 BACS describes only business applications
A description of the limitation and ways to counteract the limitations are described in this section.

Limitation description
As is made clear in the scope of this study and the title of the classification scheme the BACS describes only business applications. This means it excludes a lot of other systems such as middleware, computer games and direct hardware controller without a user interfaces.

Limitation solution
This is a clear limitation, however not one that should endanger the usefulness of the BACS. Some literature provides an overview of the different middleware systems and includes business applications as well as non-business applications (A. Forward, T.C. Lethbridge, 2008). It could serve the purpose of providing an overview of those systems. More importantly however the value of the BACS doesn't come from being able to describe everything it lays in combining knowledge from different areas. See limitation 2 in the previous chapter for more details.

8 Conclusions, implications and recommendations

Initially a research question and two sub-questions were defined to achieve two goals (see section 2). This section will briefly go through each of the research questions to provide answers to those questions and discuss fulfillment of the goals. The sub-questions will be addressed first, as the answers to those questions are crucial to answering the main research question.

8.1 Sub-RQ1: What types of business applications exist?

Through the literature review and verification interviews, 11 system groups were found. Each of these groups contained two to six system types. For a complete overview see **Table 17** or Appendix A.

8.2 Sub-RQ2: How do business applications relate to each other?

Through feedback from the interviewees a hierarchical classification was found suitable by the authors to represent the relations between the different groups for two main reasons. First, by having a hierarchical structure one has an intuitive method to use the classification. One can simply use a top-down approach to reach the right system type or system group. Second, by having a hierarchical classification the characteristics of different systems can be inferred to each other. Meaning that everything that is higher in the classification is true for all systems below it.

8.3 RQ: How can business applications be classified based on their functionality?

Based on the answers from the sub-research questions the final classification could be constructed. For an overview of the final classification scheme, the different system groups, system types and the structure see Appendix A.

8.4 Fulfillment of research goals

- Define and verify a business application classification
- Define a business application classification method

With the classification scheme presented in the results section (see Appendix A) both goals have been fulfilled. The business application classification scheme (BACS) presents a functional overview of the different business applications categories, business application groups and business application systems. Systems or applications can be classified by going from top to bottom and matching the system that is being classified to the definition provided for each category, group or type. Fulfilling goal number two.

8.5 Implications for practitioners and researchers

With the business application classification scheme (BACS) practitioners and researchers are able to easily (ease of use 86%) determine the functional type of a system. Combining this with other relevant data, such as prior work or system characteristics can help practitioners in their work. It allows researchers, but also practitioners, to combine knowledge from related fields which in turn can lead to cross-pollination and exchange of best practices and ideas. Examples of related fields are different systems types that belong to the same system group. This was illustrated with an example for the maintainability and volume of two types of systems during this study (see section 6.3.)

Combining data using a structured classification scheme combats the fragmentation of research that was described earlier in this study. Additionally the BACS can be used to provide a common language between practitioners, researchers, technical and non-technical people when discussing application functionality. Lastly, it can be used to look for trends in certain system types or system groups that might be relevant for their specific business, industry or research field.

Overall the BACS can be used to allow practitioners and researchers from different fields and industries to combine their expertise, benefit from existing knowledge and build better applications.

8.6 Recommendations for future work

During this research some interesting opportunities for future work arose.

8.6.1 Mutually exclusive and commonly exhaustive system types

There are currently three system groups (case management systems, personal productivity systems and authentication and portal systems) that have either most occurring examples, or no system groups. For the overall validity, it would be better to also determine mutually exclusive and commonly exhaustive system types for these three groups. A good starting point would be to gather more information specifically about case management systems and authentication and portal systems. One could then look for common characteristics and see if they can be grouped according to those characteristics. Due to time constraints this was not done for this study.

8.6.2 Matching the business application classification scheme with suitable data

The BACS by itself doesn't provide much value for researchers or practitioners besides having a common language. The value comes from the usage of the classification.
Adding context and data to the BACS makes it far more useful and is where the BACS provides its true value. For researchers being able to combine relevant data for different system types to see what is available and thus not having to reinvent the wheel can save tremendous time and effort. Practitioners mentioned several times during the interviews that the BACS would be more useful if certain trends, reoccurring problems or other data could be matched with different system groups or system types of the BACS. Furthermore, the BACS could be used for application rationalization purposes and checking for duplicity in your application landscape. These are all examples that show that the value of the BACS is in the usage and not in its existence itself. These paths could be further explored in future research.

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10 Glossary

Application Category – the highest level in the classifications scheme, there are two categories and two sub categories. See appendix D and section 5.2 for more details.

Application Group – the intermediate level in the classification scheme. Application groups have 2 to 6 application types each. Examples of an application group are resource management systems and analytical systems.

Application Type – the lowest level in the classification scheme. Different applications types are grouped together to form an application group.

Business application - is the software component of a computerized system that has a human end-user and is not physically embedded.

Information system - an information system is a system that that consists of a software, hardware, people and processes. It transforms inputs to outputs in a structured way.

IT artifact – a physical product that is the result of a certain process. Typical IT artifacts are source code, a software application, a classification scheme or a structured method to make or create something.

IT theme – non-physical concept that relate to information technology. Examples include ethics, IT value and knowledge management.

IS artifact – the same as an IT artifact but for the research field of information systems.

IS theme – the same as IT theme but for the research field of information systems.

Maintainability rating – A metric used by the Software Improvement Group to represent software quality. It measures how maintainable a piece of code is on a benchmarked scale of 1 – 5 stars. 1 star systems are the 5% worst maintainable systems and 5 star systems are the 5% best maintainable systems in the benchmark.

Volume – A metric used by the Software Improvement Group to represent the size of a software application. It is a function of lines of code divided by productivity per programming language. The result is an estimate for the volume in man months (man months of effort it would take to rebuild the same system).

System category – see application category
System group – see application group
System type – see application type

Star rating – see maintainability rating

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Appendix A. Final results overview: classification categories, system groups and system types

This appendix will have an overview of all the different data for the final business application classification scheme (BACS). Meaning the system categories that provide the structure, the different system groups that are attached to the structure and the different system types that are part of a system group.

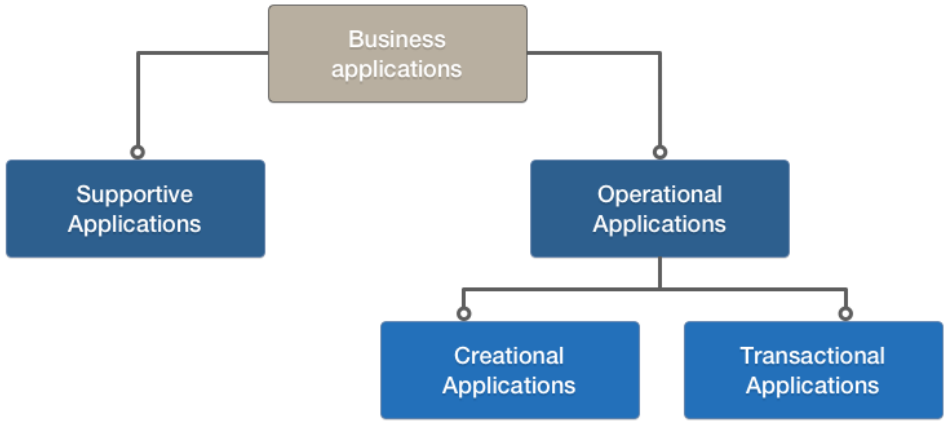
Sub - RQ1: What types of business applications exist?

#	System Groups	System Types
1.	Process Controllers	Creational Process controller, Non-creational Process Controller
2.	Transaction Processing Systems	Real-time Processing Systems, Batch Processing Systems
3.	Resource Management Systems	ERP, Managed Resource Planning, Inventory Control, Resource Allocation, Managed Resource Planning
4.	Case Management Systems	Case Management System, Incident Management System,
5.	Design, Engineering & Development Systems	Computer Aided Design, Computer Aided Manufacturing, Computer Aided Engineering
6.	Analytical Systems	Algorithmic Applications, Statistical Applications, Decision Support Systems
7.	Authentication and Portals	Client Portals, Identity and Access Management
8.	Communication Systems	A-synchronous Communication Systems, Synchronous Communication Systems
9.	Functional Applications	Management Information System, HR, Administrative System, Finance, Sales/Customer Relationship Management System, Legal, Facility management, Marketing
10.	Knowledge and Document Management Systems	Knowledge Management, Document Management, Content Management
11.	Personal Productivity Applications	

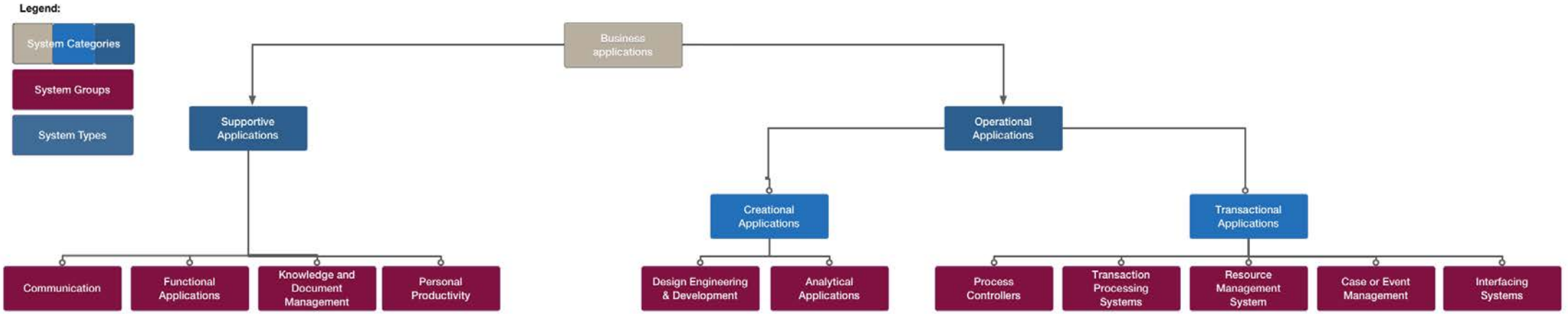
The table above provides a list of all the system groups and system types that are the result of the literature review, exploratory interviews and semi structured interviews.

Sub - RQ2: How do business applications relate to each other?

A hierarchical classification scheme was adopted to represent the relations between different business applications. Another level was made in addition to the two levels that were previously defined: business application groups and business application types. The structure to which the different system groups and types were linked looks as follows:

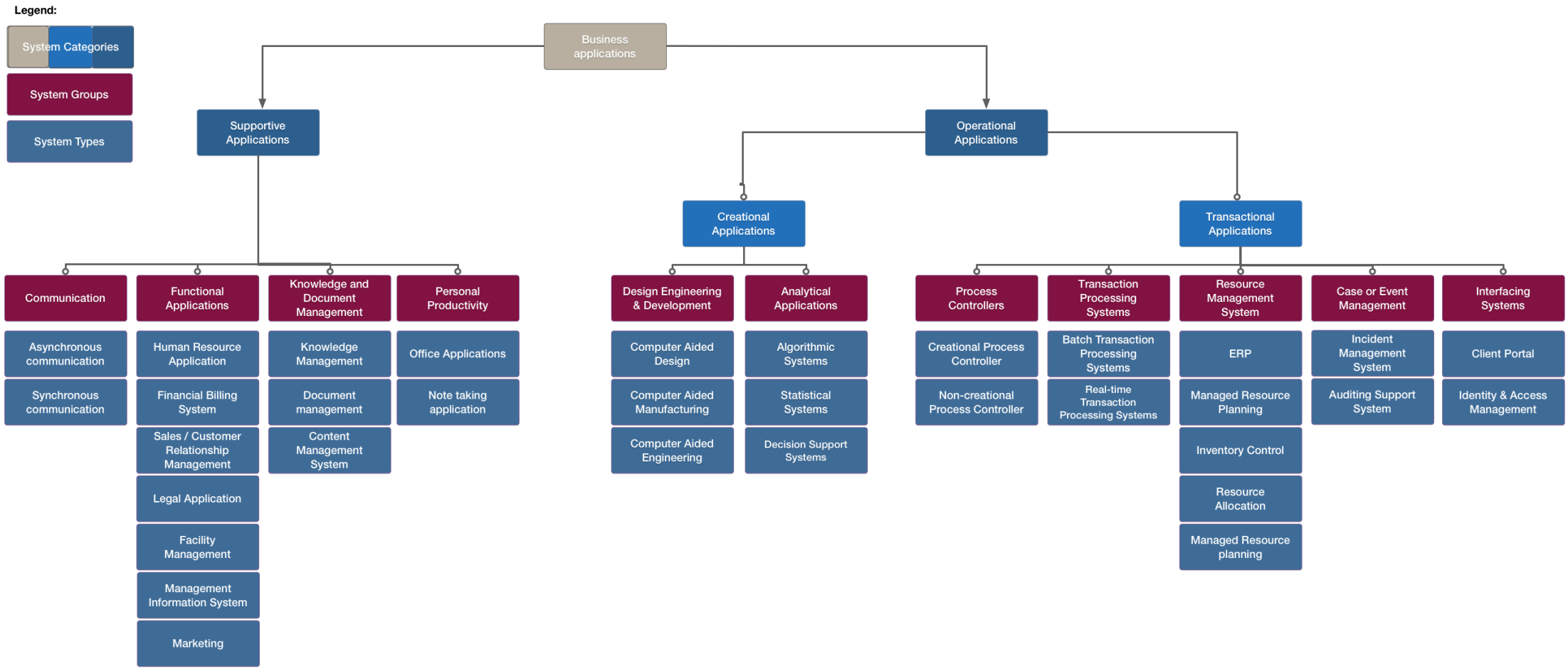


The figure above shows the classification scheme structure to which the different system groups and types will be linked.



The figure above shows the classification structure with the system groups from RQ1 attached.

RQ1: How can business applications be classified based on their functionality?



The figure above shows the final business application classification scheme with all the system categories, system groups, system types and their relation to each other.

Appendix B. Acceptance questionnaire results

Interviewee number	_	Aspect

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	X	Mode	% ≥ 4	average
1. Ease of use	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4,07	4	100 %	
2.	4	3	4	4	4	3	4	4	4	3	4	5	4	4	3,76	4	71,43 %	
3.	5	4	4	3	4	2	5	4	4	4	5	5	3	4	4	4	71,43 %	
4.	4	4	5	3	4	3	5	5	3	4	4	4	4	4	4	4	71,43 %	
5.	4	4	5	4	4	3	4	4	4	5	4	5	2	4	4	4	78,57 %	
6.	4	4	5	4	4	4	5	3	5	4	4	5	4	4	4,21	4	85,71 %	
																		86%
7. Usefulness	2	3	4	3	2	5	4	3	5	2	4	3	3	5	3,43	3	35,71 %	
8.	2	4	3	3	2	3	3	2	3	2	3	3	3	5	2,93	3	7,14 %	
9.	2	2	3	2	2	4	3	2	3	3	3	3	3	5	2,86	3	7,14 %	
10.	2	2	3	3	2	4	3	2	3	3	3	3	4	5	3	3	14,29 %	
11.	2	4	3	2	2	3	4	2	3	3	4	3	3	5	3,07	3	21,43 %	
12.	4	4	4	3	2	3	5	5	3	4	4	3	4	4	3,71	4	57,14 %	
																		31%
13. Behavioral intention	4	4	4	4	2	4	4	5	5	4	4	4	4	4	4	4	85,71 %	
14.	3	4	4	3	2	4	4	2	3	3	3	4	4	4	3,36	4	42,86 %	
																		71%
15. Compatibility	4	4	2	2	3	4	3	2	3	2	2	4	4	4	3,07	4	35,71 %	
16.	4	4	4	3	3	3	4	2	4	2	4	4	3	4	3,43	4	50 %	
																		50%
17. Perceived behavioral control	4	5	5	5	4	4	5	5	4	2	4	3	4	4	4,14	4	78,57 %	
18.	4	5	5	3	4	4	5	5	4	4	4	4	4	4	4,21	4	85,71 %	
																		89%

Appendix C. Questionnaire for acceptance testing

Aspect	Questions
Ease of use	1) Learning the classification was easy for me
Ease of use	2) I think the classification is clear and understandable
Ease of use	3) Using the classification does not require a lot of mental effort
Ease of use	4) I find the classification easy to use
Ease of use	5) The classification is not cumbersome to use
Ease of use	6) Using the classification does not take too much time
Usefulness	7) The classification is useful in my job
Usefulness	8) Using the classification improves my job performance
Usefulness	9) Using the classification increases my productivity
Usefulness	10) Using the classification enhances the effectiveness of my work
Usefulness	11) Using the classification makes it easier to do my job
Usefulness	12) The advantages of using the classification outweigh the disadvantages
Behavioural intention	13) Given the opportunity I would use the classification
Behavioural intention	14) I intend to use the classification in the future for my work
Compatibility	15) The classification is compatible with all aspects of my work
Compatibility	16) Using the classification fits well with the way I work
Perceived behavioural control	17) I feel that there is no gap between my existing skills and knowledge and those required by the classification
Perceived behavioural control	18) I have the knowledge necessary to use the classification

Appendix D. Systems and their definitions

This appendix provides an overview and definition of all the different application categories, application groups and applications systems used by the classification scheme.

Application Categories

There are two system categories: operational applications and supportive applications. The operational application category has two sub-categories: creational applications and transactional applications. All four will be described in the sections below.

1. Operational applications
    a. Creational applications
    b. Transactional applications
2. Supportive applications

1. Operational applications

Operational applications are the applications that are critical for an organization. These types of systems were also referred to as primary systems or mission critical systems by the interviewees. They are the systems that drive and enable the core business of an organization.

a. Creational applications

Creational applications create physical- or informational products. Physical products are code, goods and/or designs. While an informational product is new knowledge or information created from data. Examples of these systems are analytical systems and computer aided manufacturing systems (CAM).

b. Transactional applications

Transactional applications focus on executing or supporting people in the execution of transactions and events. Examples of these systems are resource management systems and transaction processing systems.

2. Supportive applications

Supportive applications are applications that enable a business's secondary or supportive processes. Typical examples of such processes are found in the Human Resources and Finance departments. Examples of these systems are HR system, Finance system and knowledge and document management systems.

Application groups and types

For each system category several application groups were identified. They will be described and defined in this section.

Operational applications

1. Creational
    a. Design Engineering and Manufacturing
    b. Analytical applications
2. Transactional
    c. Resource Management System
    d. Transaction Processing System
    e. Case or event Management

f. Process Controllers
g. Authentication and Portals

Supportive applications

h. Functional applications
i. Communication
j. Knowledge and Document Management
k. Personal Productivity

In the next section each system group will be defined and the system types associated with each group will be provided and described.

Creational systems

a. Design Engineering and Manufacturing

Computer Aided Design, Computer Aided Manufacturing, Computer Aided Engineering/

These are systems that deal with designing and manufacturing of a product or controlling the processes and machinery that do so.

Computer Aided Design (CAD) systems are systems that allow the user do design an artifact. A **Computer Aided Manufacturing** system **(CAM)** allows the user to automatically determine the required materials for a design. CAD/CAM are often combined to be able to design and immediately plan the resources necessary to make a new product. **Computer Assisted Engineering (CAE)** systems are systems that supports developers and engineers.

b. Analytical Applications

Algorithmic systems, Statistical systems, Decision Support systems

These are systems that create, previously non-existing knowledge or information from data by applying statistics or algorithms.

Algorithmic systems analyze data based on a predetermined algorithm. They aggregate data based on certain parameters (for example country or continent) or analyze the data to find reoccurring events and new information or knowledge. **Statistical systems** analyze data using statistics to look for trends and other statistically relevant event. It usually involves finding data about data (meta-data). A **decision support system** or DSS is a computer-based system for a manager or managers that helps them in making a decision in the process of solving a semi-structured decision. The DSS usually produces periodic reports or the results of mathematical simulations (Raymond, 1990).

Transactional systems

c. Resource Management

Resource allocation, Inventory control, Managed resource planning, Supply Chain Management, ERP,

Systems whose primary function is managing and allocating company resources such as personnel, inventory and time.

Resource allocation deals with where the resources are. **Inventory control** provides you with information about how many resources you have. **Managed resource planning** provides you with information about how many resources you need. **Supply chain management systems** provide an overview of the resources in the entire supply chain, producers, warehouse, retailer etc. **Enterprise Resource Planning (ERP)** is a system that automates and integrates many or most of firm's business processes. Sometimes called enterprise systems, ERP systems promise integration of business processes and access to integrated data across the entire enterprise (Gattiker 2005).

d. Transaction Processing Systems (TPS)

Batch transaction processing systems, real-time transaction processing systems

A system that captures, enters, stores, retrieves, and processes the relevant details of business events and generates the information and documents necessary for running the business (Coutts & Dove 2001). These processes are usually automated and require no human intervention.

Batch transaction processing systems process transactions or request in groups or batches. They collect transactions until a certain thresh hold (time, amount, etc.) is reached and then execute the entire batch at once. Batch transaction processing systems are typically used in banks. **Real-time transaction processing systems** are systems that handle request and transactions in real-time, they don't save up until a threshold is reached. Real-time transaction processing systems are used regularly in the telecommunications industry.

e. Case and event management system

Incident management system, auditing support system

A **case and event management system** processes or supports the processing of transactions, cases, events or incidents. The system usually requires human intervention to be able to complete a case/event or incident report. A case, event or incident is something that is clearly started by a specific user or customer and accordingly handled/solved by (other) users.

f. Process controllers

Creational process controller, non-creational process controller

Process controlling systems are systems that control a usually heavily automated process. They are typically used in a production or monitoring environment such as a product production plant or nuclear power plant.

Creational process controllers control processes that create usually physical goods such as a chemical production plant or a brewery. **Non-creational process controllers** control non-production processes such as the opening and closing of dams and sluices.

g. Authentication and Portals

Identity and access management, Client Portal

Authentication and portal systems is a new category of systems. They often provide the interface between a human and a combination of several other systems or services.

While **identity and access management systems** deal primarily with verifying the user, a **client portal goes** beyond that. A client portal usually requires your identity but also provides you the interface to lots of other services and processes. An example of a identity and access management system is the DIGiD system used by the Dutch government. An example of a client portal is mybank.com* or myinsurance.com* where you can access your own account and client information.
* These are fictional examples. Every bank now does online banking that one usually enters through a portal.

Supportive applications

h. Functional applications

HR system, Finance system, Sales/Customer relationship management system, Legal system, Facility management system, Management Information System, Marketing system

Functional applications are systems that support personnel working in business functions like: Human Resource, Finance, Management Legal and Sales. Examples are HR systems, Financial Accounting systems, Case Management Systems and Customer Relation Management (CRM) systems.

Systems that deal primarily with employee data and are used by HR personnel are usually considered **human resource systems.** Companies often have systems that support their financial administration and billing, these systems are referred to as **financial systems.** Sales department or similar functions often use a customer relationship management system (CRM system) or similar systems to keep track of their customer and sales data. **Management information systems** usually have several different functionalities including, the ability to produce reports with a fixed and standard format, an organization wide decision making process,(Asemi et al. 2011), aggregation of data and some kind of analytical functionality to analyze this data.

i. Communication and collaboration

A-synchronous communication systems, synchronous communication systems

Communication systems allow groups or individuals to communication and collaborate. Examples of communication systems are email or a website.

A-synchronous communication systems are systems in which communication doesn't happen at the same time. Examples of this are e-mail, a website or text messages. **Synchronous communication** is communication where you have instant feedback. Examples are i.e. video conferencing and voice over IP.

j. Knowledge and document management

Document management system, knowledge management system, content management system

Knowledge management systems and document systems enable employees of any organization to access the organization's sources of information and solutions. (Hashim, Nafaizatulnaniah 2009)

Document management systems focus specifically on managing different documents and document types and usually also provide backup functionality and make the documents accessible from multiple devices and locations. **Knowledge management systems** are often

paired with document management systems but instead of focusing on documentation they focus on retaining and spreading knowledge throughout the organization. Company Wikipedia is an excellent example of a knowledge management system. **Content management systems** are systems that allow you to modify the content of for example a different application. A website usually has a content management system to manage what is shown on the website.

k. Personal productivity

These systems support individuals in their work and are oftentimes simpler or smaller systems. For example office application that enables the user to work with spreadsheets and slideshows.

Appendix E. Keywords and journals used in literature review

Table 25 - Keywords and journals used in the literature review of the analysis phase.

Keywords used in literature search	Journals searched through during literature review
Information System classification	ACM Transaction on Information Systems
IS classification	Communications of the Association for Information Systems
IS Typology	Management Information Systems Quarterly (MISQ)
IS role	Journal of Management Information Systems
Information system role	
Information system typology	
Information Technology Classification	
IT classification	
IT Typology	
IT function	
IT contribution	
Information Technology Typology	
Taxonomy	

Appendix F. Overview validation data

System Category or System type	Total	System Group Total	Category Total
Operational			86
Creational			16
Analytical	7	13	
Statistical	1		
Algorithmic	3		
Decision support	2		
Design engineering & Manufacturing		3	
Computer Aided Design (CAD)	1		
Computer Aided Manufacturing (CAM)	2		
Computer Aided Engineering	0		
Transactional			70
Process Controllers	1	7	
Production process controller	1		
Non-production process controller	5		
Transaction Processing Systems	9	17	
Real-time Transaction Processing Systems	3		
Batch Transaction Processing Systems	5		
Resource management systems	1	14	
ERP	5		
Resource allocation	3		
Inventory control	1		
Supply Chain Management	3		
Managed resource planning	1		
Case & event management systems	18	24	
Incident management system	6		
Authentication and portals		8	
Client portal	5		
Identity & access management	3		
Support			25
Personal productivity	0		0

Communication	3		3
Functional applications	1		16
HR IS	0		
Finance IS	1		
Sales IS/ CRM	4		
Legal IS	1		
Marketing	3		
Administrative systems	1		
Management Reporting (MIS)	5		
Knowledge and document management			6
Knowledge management system	3		
Content Management System	2		
Document management system	1		
TOTAL	**111**	111	111

Appendix G. Alternative views on software systems

This appendix provides two alternative views on software systems. The first is the Zachman framework published in 1987, the second is a construct derived from interviews. It is referred to here as the middleware architecture view. It resembles the definition used in this study (**Figure 1**) but has an extra middleware layer.

Zachman framework

The Zachman framework links different architectural perspectives with their respective architecture documents (Zachman 1987). One of the conclusions he drew was that there is no such thing as *the* information systems architecture, there are several. What you think an architecture is depends on what you are doing. Architecture is relative and this relativity causes problems when communicating about architectures. To remedy this Zachman proposed his Zachman framework, see Figure 17.

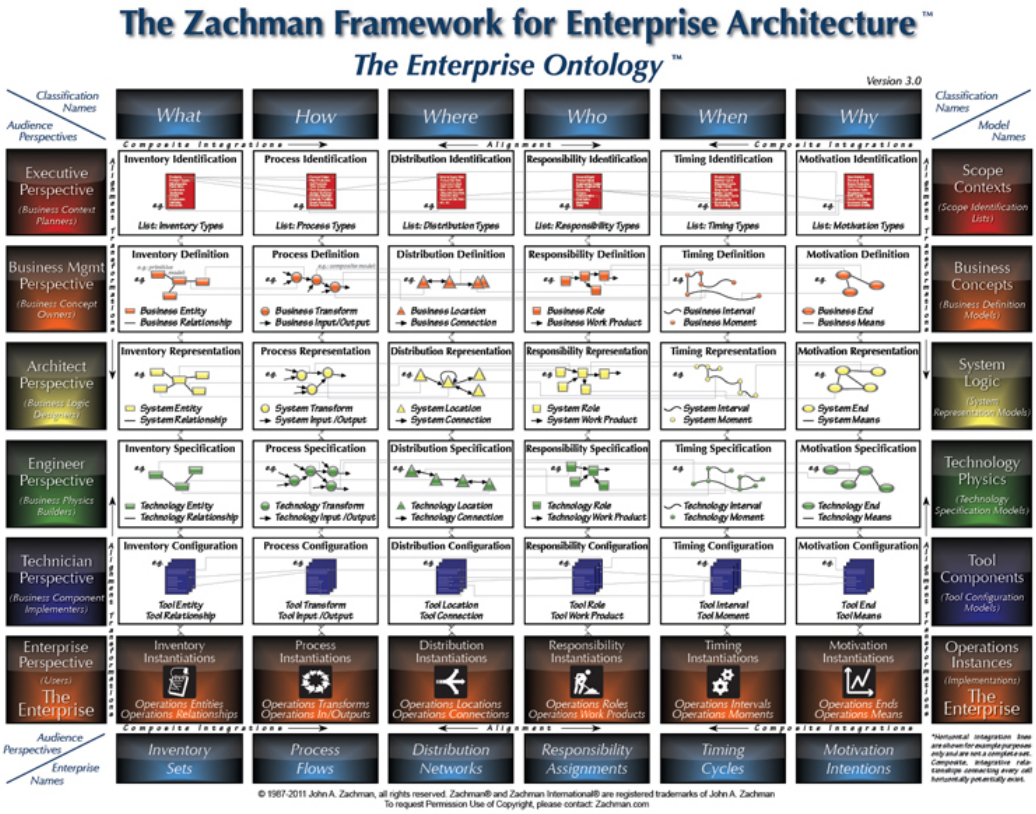


Figure 17 – Zachman framework combining different perspectives with different documentation names

The business application classification scheme, the result of this study, belongs in the upper middle region of the Zachman framework; it does not provide a technical perspective, but neither a purely executive perspective. It, among other things, provides a shared language.

Middleware Architecture View

There is one more view that was mentioned several times (or some form similar to this one) during the interviews (see Figure 18).

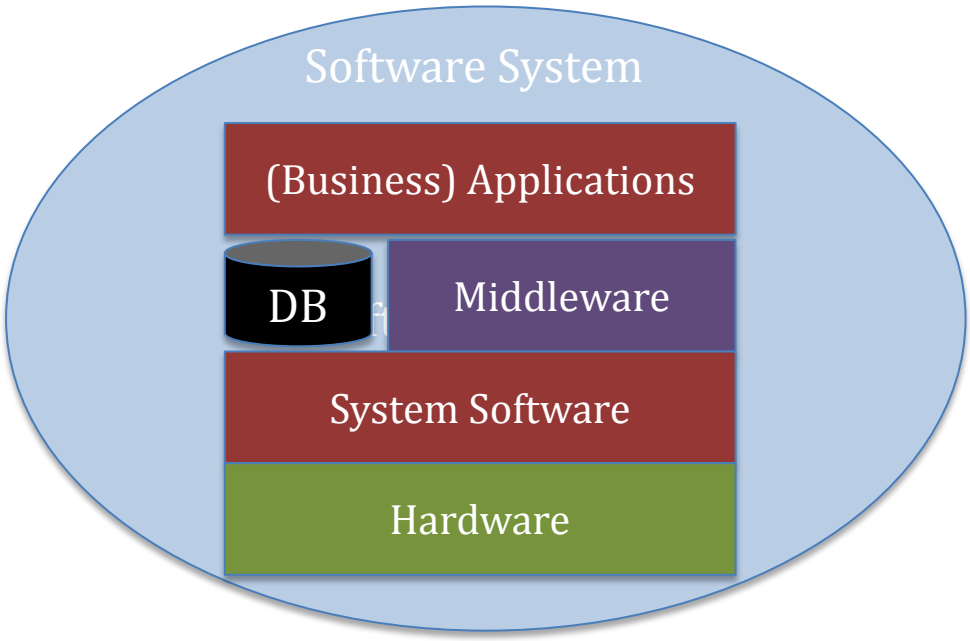


Figure 18 - Another view on a Software System and its components derived from the interviews

Hardware and databases

The hardware components are the physical components that software runs on. Information systems are primarily delivery vehicles for data that is stored in databases or a data warehouse. A database or a data warehouse is a collection of data, records or information usually organized or sorted in some way that useful information can be extracted. Connections can be wireless through wireless networks or for example radiofrequency identification (RFID). But connections are also made through (glass) fiber cables in for example local area networks (LAN). Software components will be discussed in more detail below.

System software

System software is the operating system. It manages the hardware, data and program files, and other system resources and provides the user with means to control the computer. This generally happens through a graphical user interface (GUI).

Application software

Application software are programs designed to handle specific tasks for users, therefore a system or application requires an end user. Applications like resource management systems and transaction processing systems are considered application software. More examples are applications that keep track of transactions, case and file tracking systems, or applications that schedule, routes and track package deliveries for an overnight carrier.

Business applications are also a subset of IT artifacts and information systems as described in literature

Middleware

Middleware is software that connects different software components or business applications. It is often considered software glue and it is usually the software in the middle or in between application software and system software. Examples of middleware are web servers and application servers. Middleware is first mentioned in 1968 (Naur et al. 1968).