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# **Technical Conception and Implementa- tion of an IT-System supporting the flex- ible Distribution of Documents within a large scale Sales Organization**

Master Thesis at Ulm University

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## **Abstract**

This thesis aims to discuss and present an IT system to distribute documents within a large scale sales organization. Therefore, different sales applications on the market are analyzed and described. Based on this analysis, requirements for the IT system are defined. The requirements are divided into client-side and server-side requirements. The server application is realized using an existing ECM system to support the content throughout the enterprise content life cycle. Therefore, an evaluation of existing ECM systems is performed with a criteria catalog based on the requirements. Afterwards, the conception and architecture of the IT system are described, followed by further insights into the technical implementation of the mobile application. Finally, the features of the overall IT system are discussed and an outlook on how to extend the IT system is presented.



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# 1

## Introduction

It is no secret that the success of companies depends, among others, on sales. Sales organizations and therefore sales representatives are crucial because of selling services or products. Thereby, profits are maximizing, market share is expanding and sales are increasing. For this, sales representatives have to meet customers and explain how the offered services meet the customers need by demonstrating the company's service. Thereby, often paper based marketing material is used. However, this has many disadvantages. Paper based marketing material may be outdated because of price changes and it is not possible to perform an interactive demonstration (e.g., dynamical price-quantity diagrams or videos). Another point is the weight of paper that must be transported to a customer meeting which results often in logistical problems.

### 1.1. Motivation of this Thesis

With the increased prevalence of mobile devices and the expansion of the internet, new possibilities for companies have begun to arise. Sales organizations use IT systems to improve processes and therefore increase the value of the company itself. For example, mobile applications connected with a central IT system can provide sales representatives. They can thereby use mobile devices to demonstrate company's service and will not rely anymore on paper based marketing materials. This saves time and money and probably increases the customer satisfaction because of, for example, parallel activities.

This thesis covers the creation of an IT system supporting the flexible distribution of documents and evaluates powerful tools that may be used for the realization. Thereby,

## 1. Introduction

requirements on the IT system have to be collected. There are already different IT systems supporting the flexible distribution of documents. These tools have to be evaluated and compared based on given requirements. The evaluation can be performed with different decision making methods. These need to be analyzed. A criteria catalog has to be created for the evaluation to strongly justify why an option is preferred. The implemented IT system is to be used in practice for a company to provide a fast and reliable access to documents on all mobile devices. The name of the company has been anonymized, so it is named *Epsilon*.

### 1.2. Structure of this Thesis

The thesis starts with fundamentals, which are needed for the further course of this thesis. In section 3 existing sales applications on the market are described. Section 4 presents an overall overview, functional requirements and nonfunctional requirements for the client and server. Based on these requirements an evaluation of already existing Enterprise Content Management systems is performed in section 5. For an better understanding with respect to the overall IT system, the conception and architecture is described in section 6. Section 7 provides further insights into the technical implementation. Finally, section 8 discusses the features of the overall IT system, concludes this thesis and provides an outlook on how to extend the IT system.

# 2

## Fundamentals

The following sections cover requirements for the further understanding of this thesis. Section 2.1 introduces some fundamental terms in the context of enterprises and information technology. Based on these terms, section 2.2 describes an Enterprise Content Management system based on its components. Finally, section 2.3 introduces the decision making theory for an evaluation in this thesis.

### 2.1. Content, Documents and Information

The differences between content, document and information is presented in figure 2.1 based on the conceptual hierarchy. On the lowest level are characters, which can be a letter from the alphabet, a number or a special character (for example "1", "6" or "."). Data is defined as a character in combination with syntax. It contains various sequences of characters (for example "16.09.2015"). Information is data with a specific context (for example "Deadline: 16.09.2015"). A document is defined as a group of information (for example "master's thesis timeline"). Content results in combination of different electronic resources. These are structure information, describing metadata, layout and raw-content (for example "master's thesis"). There are different variants of content. These are unstructured content, weakly structured content and structured content, homely unstructured content does not match any structure, pattern or recurrent logic (for example letters). Weakly structured content contains predictable data at any position of the document (for example bills). Structured content can be evaluated automatically. The position of elements is predefined (for example remittance slip) [Rig09, Egg07].



## 2.2. Enterprise Content Management Systems

Nowadays, producing documents has increased rapidly because of the technological evolution. About 80 percent of enterprise documents are represented as emails, word documents, digital images or PDF files in the industrial sector [Goo13]. Companies are not able to handle these structured and unstructured documents manually based on their importance [Rig09]. Another problem is the handling of distributed information by different departments and therefore missing information about the data access. Companies are more competitive if their documents are more accessible [AG15]. To prevent these problems and improve the services of companies, an overall IT-System is needed.

### 2.2.1. Definition

The term *Enterprise Content Management* (ECM) has been introduced by the worldwide association for enterprise content management, the *Association for Information and Image Management* (AIIM) international, in 2001. AIIM defines ECM as *the strategies, methods and tools used to capture, manage, store, preserve and deliver content and documents related to organizational processes*. According to this definition, ECM is not just a single technology, a methodology or a process [Eur15b, Bla15, Goo13, Eur15a].

The fundamental features of ECM can be described as a system that allows the management of unstructured information. Thereby, a fast access of data will be guaranteed. Unstructured information does not have any formal structure.

### 2.2.2. Components

Based on the definition of AIIM, ECM can be divided into five components: Capture, manage, store, preserve and deliver. Figure 2.3 shows an overview about these components in the context of ECM. This component model is function-based and not to be regarded as an architecture [Kam15].

## 2. Fundamentals

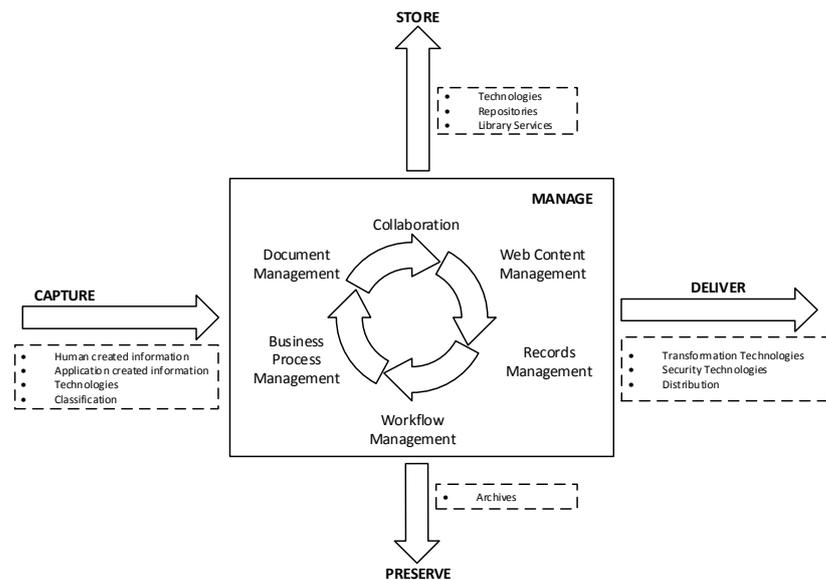


Figure 2.3.: Enterprise Content Management components [Eur15a].

### 2.2.2.1. Capture component

The Capture component is also called Input component and includes functionalities and components for the collection (generating, capturing, preparing and processing) of digital or analog information for the Manage Component [Pro06, Goo13, Kam15].

**Information** Capture of analog information means the transformation of human created information into electronic information. Human created information can involve all form of information (for example drawings, paper documents or microfilms). Capture of digital information is the data extraction of application created information like XML documents or e-Forms and is mostly captured automatically or semi-automatically [Kam15, Rig09].

**Technologies** The process of capturing, storing and retrieving of analog documents is named as *document imaging*. It improves the readability and therefore the quality of documents, for example by removing isolated pixels or rotating documents. There are

## 2.2. Enterprise Content Management Systems

different kinds of recognition technologies for digital generation of information. These technologies are described in the following [Kam15, Eur15a]:

- **Optical Character Recognition (OCR):** A technique which transforms analog-typed information (images of characters) into machine-readable characters (editable and searchable text).
- **Handprint Character Recognition (HCR):** HCR is an extension of OCR and transforms handprinted analog information into machine-readable characters.
- **Intelligent Character Recognition (ICR):** ICR is in addition to HCR and OCR. ICR includes mechanisms to improve the recognition, for example, by using comparisons with context information or learning fonts during processing.
- **Optical Mark Recognition (OMR):** OMR detects marks (for example bar-codes) in a predefined area with very high accuracy. It is typically used for processing questionnaires.
- **Intelligent Document Recognition (IDR):** IDR automatically identifies and categorizes documents by layout or structure.

The process of capturing, storing and indexing of digital information is named as *Computer Output to Laser Disk/Enterprise Report Management (COLD/ERM)*.

The digitized information are represented in an uniform structure and format by aggregation technologies. These digitized information need to be classified to be used by the Manage Component.

**Classification** The classification is an essential step of the capture component and contains indexing and categorization of digital documents. These will be complemented by descriptive attributes. The classification process identifies specific attributes of digital documents or database records for easily and fast retrieving [Eur15a].

There are different methods to classify digital documents which will be described in the following according to [Rig09]:

## 2. Fundamentals

- **Template-Classification:** Template classification is based on input designs. Static elements like headlines allow the classification of documents easily. These documents are, for example, letters or bills.
- **Classification with associative search:** Classification is based on the analysis of content. Documents will be classified by comparison of the content with associated target classes.
- **Phrase-Classification:** The classification is based on phrases and is mostly used in formalized communication.
- **Image-Size-Classification:** A classification by the format of the document. It is typically used for driver-licenses or recipes.

### 2.2.2.2. Manage component

The Manage component is used for the management, processing and use of information [Eur15a]. It consists of *Collaboration*, *Document Management*, *Records Management*, *Web Content Management* and *Workflow/Business Process Management* components, which are described in the following [Kam15].

**Collaboration** Collaboration allows multiple users to work at the same content with different tools. There are two different types of collaboration: Synchronous collaboration and asynchronous collaboration. Synchronous collaboration on the one hand is the interaction in real time – for example instant messaging or a video conference. Asynchronous collaboration on the other hand is the time-shifted interaction – for example email [Egg07, Eur15a].

Collaboration contains the following functions according to [Kam15]:

- Shared usable information databases.
- Shared, simultaneously and controlled editing of information.
- Knowledge based on skills, resources and background data for shared editing of information.

## 2.2. Enterprise Content Management Systems

- Administration components like whiteboards for brainstorming, schedules or project management.
- Communication applications.
- Integration of information from other applications.

The advantages of collaboration are saving costs and time. These advantages means faster reactions and increasing productivity [Egg07].

**Document Management** Document Management controls the life cycle (capture, receiving, repository, administration, retrieval and processing) of documents through an enterprise [Egg07, Eur15a]. The administration requires different information about the documents. These are the document by itself, metadata about the document, an unique identification key, information about the structure and rules. The retrieval of documents is performed using metadata and an unique identification key. Rules are used to define the lifetime, life cycle, access rights and different behaviors of documents [Egg07]. According to [Egg07] the especially functions of Document Management are the following:

- Description and marking of documents
- Update and version management of documents
- Distribution of documents
- Search/retrieval of documents
- Archiving and deletion of documents
- Definition of responsibility for the administration of documents

Another related concept in the context of ECM is called *Digital Asset Management*. The focus thereby are media data and images [Egg07].

**Records Management** Some documents need to be archived, for example according to law. The administration of this task is done by the Records Management. It archives

## 2. Fundamentals

records with additional information like status, version or editor of the document. A record is thereby defined as an unchangeable document. The main functions are the following according to [Rig09, Kam15]:

- Mapping of structured indexes into orderly storage of information.
- Thesaurus-based unique indexing of information.
- Administration of record retention schedules and deletion schedules.
- Protection of information based its attributes.
- Use of standardized meta-data for the unique identification and description of the information.

**Web Content Management** Web Content Management includes the management of content for the presentation of websites. This includes the representation of information from the database on websites, tools for the administration of information and protection of layout, structure and functionality of websites. The essentially functions of Web Content Management are the following according to [Kam15]:

- Creation of new or editing of existing information in a controlled generation and publishing process.
- Preparation and administration of information for the website.
- Automatic conversion for different representation formats, personalized display and versions.
- Secure separation of access to public and non-public information.
- Visualization for internet representation.

**Workflow/Business Process Management** Generally the Workflow Module and Business Process Management includes a connecting, managing and controlling function in the ECM model.

The Workflow Module represents processes of the Enterprise Content Life Cycle. Thereby, the efficiency will be increased through faster processes. Generally there

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are two different types of Workflows. These are Production-Workflows and Ad-hoc-Workflows. Production-Workflow are highly structured, what means that it contains a set of predefined sequences. Ad-hoc-Workflow are unstructured and contains process sequences that are determined by the user during runtime. The Workflow Module in the ECM model can be realized as *Workflow Solution* with autonomous clients or as *Workflow Engine* without requiring an own client [Kam15, Egg07]. The essentially functions of Workflow are the following according to [Kam15]:

- Imaging of process and organization structures.
- Capture, administration, visualization and delivery of information.
- Embedding of processing tools for data and documents (for example Microsoft Office Products).
- Parallel and sequential processing and recording of procedures.
- Reminders, deadlines, delegation and other administration functionalities.
- Monitoring and documentation of process status, routing and outcomes.
- Tools for the configuration and displaying of processes.

The Business Process Management module integrates all relevant applications within an enterprise including monitoring of processes and combination of all required information. The essential functions of Business Process Management are the following according to [Kam15]:

- Complete workflow functionality.
- Process and data monitoring.
- Enterprise Application Integration (EAI).
- Business Intelligence (BI).

Figure 2.4 shows the relationship between Workflow Management and Business Process Management.

## 2. Fundamentals

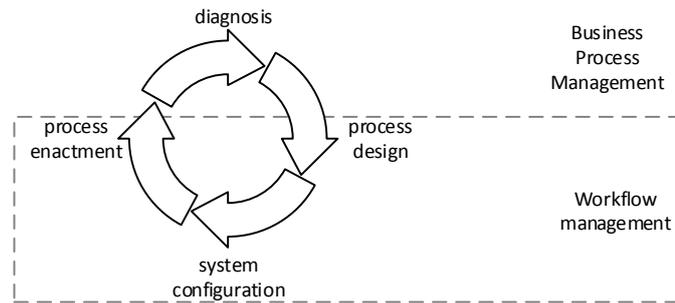


Figure 2.4.: Relationship between Workflow Management and Business Process Management [AHW03].

### 2.2.2.3. Store component

The Store component is used for the storage of temporary information that does not have to be archived. According to the definition of [Eur15a], it can be divided into three different types: Library Services, repositories and technologies. Library Services are administration components and handle access to information, repositories contains storage locations and storage technologies [Kam15].

**Library Services** The Library Services are responsible for the storage of information by the capture and manage component. It also provides search and retrieval functions. The location of the storage is determined by the characteristics and classifications of the information. It also provides version management to handle different versions of information and check-in/check-out functionality to control the information provision. If the ECM contains any Document Management System or Record Management System the functionalities are handled by these systems. Logging functions to keep track of document changes are also a part of the library service [Kam15].

**Repositories** Repositories are a part of Document Management System [Eur15a]. There are different repositories to store information. These are file systems (mostly

## 2.2. Enterprise Content Management Systems

used for temporary content), content management systems, databases (mostly used for access information but can also be used for documents or media assets) or data warehouses (represents information from different sources) [Kam15].

### 2.2.2.4. Preserve component

The Preserve component handles the long-term storage of unchanging information. Therefore, it is important to detect the most cost-effective and reliable medium and mechanism for the archiving. The essentially mediums and mechanisms are the following according to [Kam15]:

- **Write Once Read Many (WORM):** These are media like CD-R and DVD-R.
- **WORM-Tape:** Magnetic tape with WORM characteristics.
- **Content Addressed Storage (CAS):** Magnetic hard drive storage that is protected by software against overwriting, erasure and editing.
- **Network Attached Storage (NAS)/Storage Area Networks (SAN):** Can also be used if they meet the auditing acceptability.
- **Microfilm:** Can also be used as backup medium if the information is no more in usage and if there is no machine processing required.
- **Paper:** Paper can also be used as long-term storage medium, because it does not require migration and can be read without any technical aid.

### 2.2.2.5. Deliver components

The Deliver component (also named as Output Management) provides timely and secure access of information from the Manage, Store and Preserver component. It also contains functions that are used as input for the Store and Preserve component, and can be divided into three categories [Kam15]: Transformation technologies (for example COLD/ERM, XML, PDF, Converts and Viewers, Compression and Syndication), security technologies (electronic signatures or media asset management) and distribution. The

## 2. Fundamentals

objective of deliver components is to optimally provide the information for each recipient and control the use of information as far as possible.

### 2.3. Decision-Making

This section covers fundamental decision making knowledge as a basis for the further course of this thesis. Section 2.3.1 provides an overview followed by different MADM methods in section 2.3.2.

#### 2.3.1. Overview

The *Oxford Dictionaries* defines decision-making as *the action or process of making important decisions*<sup>2</sup>. Furthermore, a decision has an overall goal, attributes (or criteria) as well as alternatives. Figure 2.5 shows the relation between these decision elements in the whole process of decision-making.

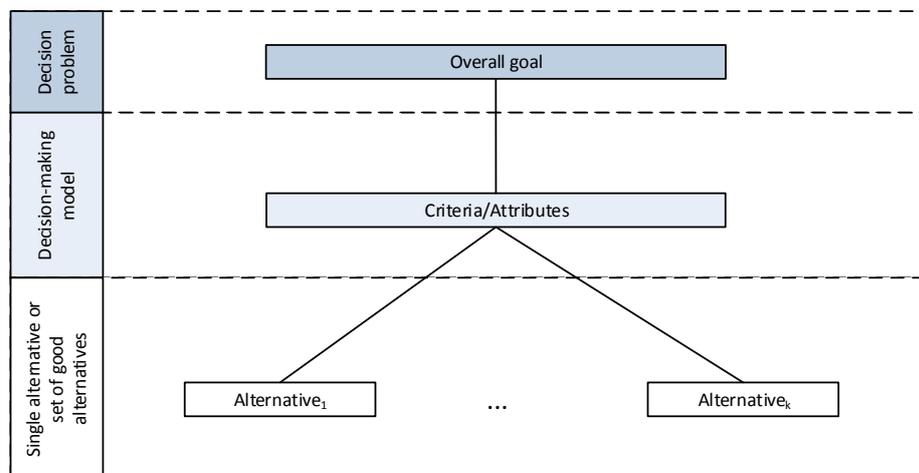


Figure 2.5.: Overview of the whole process of decision-making<sup>3</sup>.

<sup>2</sup><http://www.oxforddictionaries.com/definition/english/decision-making>

<sup>3</sup>Source: [KO14] with modifications by the author.

## 2.3. Decision-Making

Decision-making is divided into two categories based on the number of attributes. *Single Criterion Decision Making (SCDM)* and *Multi Criteria Decision Making (MCDM)* models. The overall goal of SCDM models depends on a single attribute while the overall goal of MCDM models depends on multiple criteria.

MCDM models are generally classified into *Multiple Attribute Decision Making (MADM)* methods and *Multi Objective Decision Making (MODM)* methods based on the domain of alternatives. On the one hand, MODM methods have a large number (up to infinity) of alternatives in a continuous domain. MADM methods, on the other hand, have a finite number of alternatives in a discrete domain and rank the alternatives completely or partially [KO14]. The methods in each category are also classified into different categories based on their type of information from the decision maker.

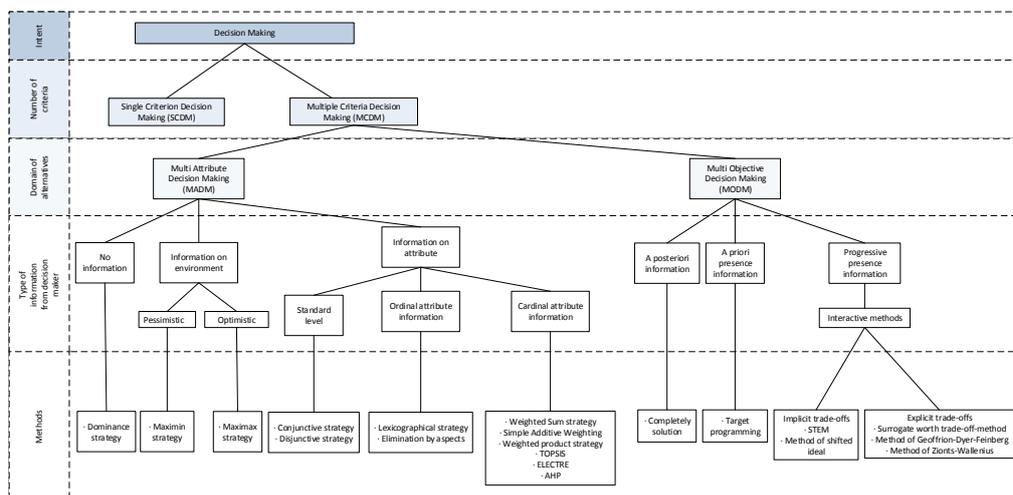


Figure 2.6.: Overview about decision-making<sup>4</sup>.

Figure 2.6 shows an overview about decision-making methods. This thesis deals only with a finite number of alternatives within a discrete domain. Therefore, MODM methods are not considered in this thesis. For more information about MODM methods consider [HPMY12].

<sup>4</sup>Source: [Oss13], [ZG91] and [Lez06] with modifications by the author.

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### 2.3.2. MADM methods

This section presents different MADM methods. These are Dominance Strategy, Maximin and Maximax Strategies, Conjunctive and Disjunctives Strategies, Lexicographic and Elimination by Aspects Strategies, Weighted Sum and Weighted Product Strategies, TOPSIS Strategy, ELECTRE Strategy and the Analytic Hierarchy Process.

#### 2.3.2.1. Dominance Strategy

The *Dominance Strategy* is a decision-making method that does not require any information about the attributes. It is mostly used as pre-selection for other decision-making methods to reduce the number of alternatives.

The method declares an alternative  $i$  as dominant if it is at least one attribute better and in no attribute worse than the other alternatives  $j$  with  $j = 1, \dots, n$  and  $j \neq i$ , where  $n$  is the number of alternatives. It compares all possible constellations of alternatives pairwise. If alternative  $j$  dominates alternative  $i$ , then alternative  $i$  will be eliminated.

If alternative  $i$  dominates alternative  $k$  and alternative  $k$  dominates alternative  $l$ , then alternative  $i$  also dominates alternative  $l$ . This means that dominance is transitive. It is therefore enough to compare the alternatives pairwise to determine the dominant alternatives. The dominance strategy needs  $(n - 1)$  comparisons in the best case and  $\frac{n*(n-1)}{2}$  comparisons in the worst case, where  $n$  is the number of attributes [Lif09, Oss13, MOK07].

#### 2.3.2.2. Maximin and Maximax Strategies

Other than the Dominance Strategy, the *Maximin and Maximax Strategies* require comparable attributes that can be measured on a homogeneous scale. The Maximin Strategy evaluates alternatives based on their weakest attribute without consideration of other attributes. For this, the matrix in equation 2.1 is calculated, where  $Attr_i$  is the  $i$ th attribute,  $A_j$  is the  $j$ th alternative,  $w_{ij}$  is the weight of the  $i$ th attribute and the  $j$ th alternative,  $n$  is the number of attributes,  $m$  is the number of alternatives and  $\min(w_{ji})$  is the weakest

attribute  $Attr_i$  of alternative  $A_j \forall i = 1, \dots, n$ . The alternative with the maximum value in column  $min$  is the preferred alternative [Oss13].

$$\begin{array}{l}
 \text{Alternative/Attribute} \quad Attr_1 \quad Attr_2 \quad \dots \quad Attr_n \quad min \\
 A_1 \\
 A_2 \\
 \vdots \\
 A_m
 \end{array}
 \begin{pmatrix}
 w_{11} & w_{12} & \dots & w_{1n} & \min(w_{1i}) \\
 w_{21} & w_{22} & \dots & w_{2n} & \min(w_{2i}) \\
 & & & & \vdots \\
 w_{m1} & w_{m2} & \dots & w_{mn} & \min(w_{mi})s
 \end{pmatrix}
 \quad (2.1)$$

The Maximax strategy works analog with the column  $max = \max(w_{ji})$  (best attribute) instead of  $min$  to detect the preferred alternative with the maximum value [MOK07].

### 2.3.2.3. Conjunctive and Disjunctive Strategies

The *Conjunctive and Disjunctive Strategies* define a threshold for the alternatives and require comparable attributes that can be measured on a homogeneous scale. All alternatives will be divided into acceptable alternatives and non-acceptable alternatives based on the threshold.

The conjunctive method, on the one hand, requires that all attributes of an alternative have to meet the threshold. If an alternative  $i$  reaches this condition, then it will be added to the acceptable alternatives. Otherwise it will be added to the non-acceptable alternatives.

The disjunctive method, on the other hand, requires that at least one attribute of an alternative  $i$  has to meet the threshold. If alternative  $i$  reaches this condition, it will be added to the acceptable alternatives. Otherwise it will also be added to the non-acceptable alternatives.

The threshold can be raised step by step till only one alternative meets the requirement. Thereby, the number of acceptable alternatives can be set to one but the method is not compensatory. This means that weakness of attributes will not be balanced. Therefore, it is recommended to use the method only to identify the acceptable and non-acceptable alternatives [MOK07, Oss13].

## 2. Fundamentals

### 2.3.2.4. Lexicographic and Elimination by Aspects Strategies

The *Lexicographic Strategy* requires comparable attributes that can be measured on a homogeneous scale. It starts with the ranking  $r = Attr_1, \dots, Attr_n$  of all attributes based on the importance of attributes, where  $Attr_i$  is the  $i$ th attribute and  $n$  is the number of attributes.

The alternative with the best value in the most preferred attribute is the best alternative. If two or more alternatives have the same value, then the process will be repeated with the next most preferred attribute till the best alternative remains or all attributes are considered [Oss13].

It is possible to get a ranking of alternatives by eliminating the best alternative and repeating the whole process with the others [MOK07].

The *Elimination by Aspects Strategy* method combines the Lexicographic Strategy (see section 2.3.2.4) with the Conjunctive Strategy (see section 2.3.2.3). The comparison is like the comparison of Lexicographic Method but attributes that does not meet a specified standard will be eliminated from further considerations [MOK07].

### 2.3.2.5. Weighted Sum and Weighted Product Strategies

The *Weighted Sum Strategy* is especially used in single dimensional problems and requires cardinal attribute information. *Simple Additive Weighting* (SAW) is a method of Weighted Sum Strategy and is one of the most popular method of MADM [TH11].

The Weighted Sum Strategy requires information about the attributes provided by the decision maker [TH11]. These are:

- an importance weight for each attribute and
- a weight for each attribute with respect to the alternatives.

The best alternative is determined by equation 2.2, where  $r_{ij}$  is the weight of the  $i$ th alternative and the  $j$ th attribute,  $w_j$  is the importance weight of the  $j$ th attribute,  $n$  is the

number of attributes and  $m$  is the number alternatives [Mat12].

$$A_{best}^{WSM} = \max\left(\sum_{i=1}^n r_{ij} * w_j \mid \forall j = 1, \dots, m\right) \quad (2.2)$$

The process of Weighted Sum Strategy can be summarized with the following steps according to [Hüb07]:

1. **Identification of attributes and alternatives**
2. **Evaluation of alternatives**
3. **Determination of attribute weights**
4. **Additive aggregation of weighted partial preference values**
5. **Sensitivity analysis**

The *Weighted Product strategy* is similar to the Weighted Sum Strategy. The difference between the two strategies is the multiplication instead of the addition of attributes [Mat12]. Therefore, the best alternative can be determined by equation 2.3 with the same variables.

$$A_{best}^{WPM} = \max\left(\prod_{j=1}^n \left(\frac{r_{kj}}{r_{lj}}\right)^{w_j} \mid \forall k, l = 1, \dots, m\right) \quad (2.3)$$

### 2.3.2.6. TOPSIS Strategy

The *TOPSIS Strategy* (Technique for Order Preference by Similarity to Ideal Solution) was created by Ching-Lai Hwang and Kwangsun Yoon in 1981 and requires cardinal attribute information. It was introduced as a MADM method without any articulation of preference information. There are different applications of TOPSIS (i.e., *fuzzy TOPSIS*) [HY81, Tav12, AMSA11, HM15, PZ15].

The TOPSIS Strategy creates an additional positive ideal alternative and an additional negative positive ideal alternative. The best alternative is identified with the farthest distance from the negative positive ideal alternative and the closest distance to the positive ideal alternative. Thereby, TOPSIS calculates for each attribute the distance from the negative ideal solution and the distance to the positive ideal solution [Tav12].

## 2. Fundamentals

The process of TOPSIS strategy can be divided into the following steps [HM15, PZ15]:

1. **Modeling of the decision problem:** In the first step the decision maker has to detect all relevant attributes and alternatives based on the decision problem.
2. **Calculate the standardized decision matrix:** Creation of the standardized matrix in equation 2.4, where  $w_{ij}$  is the standardized weight of the  $i$ th alternative and the  $j$ th attribute).

$$\begin{array}{c}
 \text{Alternative/Attribute} \\
 A_1 \\
 A_2 \\
 \vdots \\
 A_m
 \end{array}
 \begin{array}{cccc}
 \text{Attr}_1 & \text{Attr}_2 & \dots & \text{Attr}_n \\
 \left( \begin{array}{cccc}
 w_{11} & w_{12} & \dots & w_{1n} \\
 w_{21} & w_{22} & \dots & w_{2n} \\
 \vdots & & & \vdots \\
 w_{m1} & w_{m2} & \dots & w_{mn}
 \end{array} \right)
 \end{array}
 \quad (2.4)$$

3. **Calculate weights for each attribute and construct the weighted standardized decision matrix:** Rate each attribute based on the importance of the attribute. Generally, TOPSIS does not define a rating score for the attributes but mostly values between 1 (low priority) and 5 (high priority) are used. Then multiply the weighted standardized decision matrix with the rated attributes to get the weighted standardized decision matrix.
4. **Calculate virtual alternatives:** Identification of the positive and the negative ideal solution. The best attributes of the weighted standardized decision-matrix will be put together to get the positive ideal solution (see equation 2.5, where  $w_i$  is the best value of the  $i$ th attribute in relation to each alternative).

$$A = w_1^{best}, \dots, w_n^{best} \quad (2.5)$$

The calculation of the negative ideal solution works analogous with the worst attributes instead of the best attributes.

5. **Calculate the distance to the virtual positive and virtual negative ideal solution for each alternative:** The distance is an euclidean distance. Therefore, the euclidean distance between the virtual positive ideal solution and alternative  $i$  have

to be calculated with:

$$D_i^+ = \sqrt{\sum_{j=1}^m (w_{ij} - w_j^+)^2} \quad (2.6)$$

where  $w_j^+$  is the value of the  $j$ th attribute from the virtual positive ideal solution.

**6. Determine the relative closeness of each alternative to the virtual positive ideal solution:** Calculate the index  $C_i^+$  for each alternative  $i$  with:

$$C_i^+ = \frac{S_i^-}{S_i^+ + S_i^-} \quad (2.7)$$

The index  $C_i^+$  determines the relative closeness to the virtual positive ideal solution and can be used to create a ranking of alternatives.

### 2.3.2.7. ELECTRE Strategy

The term *ELECTRE* is an acronym for *Elimination Et Choix Traduisant la Réalité* (elimination and choice expressing the reality) and was proposed by Bernard Roy and his colleagues at a consulting company. ELECTRE is classified as an outranking method of decision-making. An outranking method uses aggregating preference information instead of value function approach.

The method exists in different versions. These are ELECTRE *I*, ELECTRE *II*, ELECTRE *III*, ELECTRE *IV*, ELECTRE *IS* and ELECTRE *TRI*, and are all based on the same fundamental concept that will be described in the following. ELECTRE *I* (devised by Bernard Roy in 1968) is one of the earliest outranking multi-criteria evaluation methods.

The ELECTRE method needs the following information from the decision maker:

- an importance weight  $g_j$  for each attribute
- a weight for each attribute with respect to the alternatives

Generally, ELECTRE can be described with the following steps according to [TSSR15, F15]:

## 2. Fundamentals

1. **Normalizing the decision matrix:** Calculate the normalized decision matrix by replacing the weight based on the following calculation:

$$w_{ij} = \frac{w_{ij}}{\sqrt{\sum_{i=1}^M w_{ij}^2}} \quad (2.8)$$

where  $M$  is the number of alternatives and  $w_{ij}$  is the standardized weight of the  $i$ th alternative and the  $j$ th attribute.

2. **Weighting the normalized decision matrix:** Weight the values of the normalized decision matrix with the importance weight of the attributes based on the following calculation:

$$w_{ij} = w_{ij} * g_j \quad (2.9)$$

where  $g_j$  is the weight of attribute  $j$ .

3. **Determine the concordance and discordance sets:** All alternatives will be compared pairwise. Therefore, a concordance set  $C_{kl}$  and a discordance set  $D_{kl}$  will be calculated. The concordance set contains all alternatives that are better than alternative  $l$ ; i.e., better means that  $w_{kj} \geq w_{lj}$  for attribute  $j$ . The discordance set, on the other hand, contains all alternatives that are worse than attribute  $l$ ; i.e.,  $w_{kj} < w_{lj}$ .
4. **Calculation of the concordance and discordance index:** The power of each concordance set is represented via a concordance index. Analog the discordance index. The concordance set is calculated with:

$$K_{h,i} = \sum_{j \in C_{kl}} g_j \quad (2.10)$$

The discordance set is calculated with:

$$D_{h,i} = \frac{\max_{j \in D_{kl}} |w_{kj} - w_{lj}|}{\max_j |w_{kj} - w_{lj}|} \quad (2.11)$$

5. **Construct preference-relation:** The last step calculates a threshold value  $c$  that can be determined as average concordance index:

$$c = \frac{1}{M(M-1)} \times \sum_{k=1}^M \sum_{l=1}^M C_{kl} \mid \forall k \neq l \quad (2.12)$$

Analog a threshold for the discordance dominance  $d$  can be calculated:

$$d = \frac{1}{M(M-1)} \times \sum_{k=1}^M \sum_{l=1}^M D_{kl} \mid \forall k \neq l \quad (2.13)$$

Alternative  $j$  outranks alternative  $k$  if  $C_{jk} > c$  and  $D_{jk} < d$ .

### 2.3.2.8. Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a method of the decision theory to solve decision problems and was developed by Thomas L. Saaty between 1971-1975 while working as a professor at the Wharton School of Business (University of Pennsylvania, Philadelphia) [FRL15, AH08, Jun94]. It is an often used method which is rooted in the structure and the easy usage compared with other methods of the decision theory [OL99]. AHP needs cardinal attribute information and is based on three principles: decomposition, comparative judgments and synthesis of priorities. These three principles cause the popularity of AHP. The decomposition applies identification of the objective, definition of the criteria (or attribute) and selection of alternatives based on the problem. The criteria will be divided into manageable sub-criteria. These sub-criteria can also be divided into more specified sub-criteria and will be ordered in a hierarchic structure before they will get successively dissolved. The comparative judgments applies the pairwise comparisons of criteria to solve the decision problem with respect to their parent node. This is the most effective way to compare properties. The decision maker is able to concentrate on the comparison of two properties without any influences. Furthermore, the consistency will also get improved. The synthesis of priorities applies the calculation of each alternative. For this the local priorities of the criteria in a cluster will be multiplied

## 2. Fundamentals

with the priority of the parent element. After all criteria have been calculated the ranking of the alternatives can be determined by adding back all priorities [Tsa08].

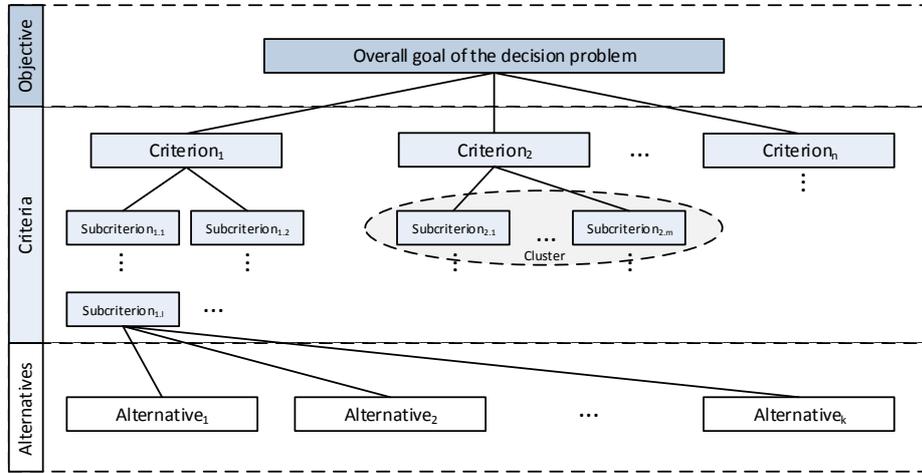


Figure 2.7.: Hierarchy of AHP [Koo15, Gir15].

**Axioms** AHP is based on four axioms (the fourth was added later) [RGF09, Tsa08]:

1. Reciprocal:

$$a_{ij} = \frac{1}{a_{ji}} \quad (2.14)$$

where  $a_{ij}$  is the weight of the  $i$ th attribute and the  $j$ th alternative. The axiom means that if an alternative (or attribute)  $i$  is 2 times better than an alternative (or attribute)  $j$  then  $j$  is  $\frac{1}{2}$  as good as  $i$  [Jun94].

2. Homogeneity:

$$a_{ij} \neq \infty \quad (2.15)$$

If the decision maker compares two alternatives (or attributes)  $i$  and  $j$  then  $i$  is not infinitely better than  $j$ . In other words: The comparison of the two alternatives (or attributes) should not differ too much.

3. Independence of judgments within the hierarchy: The axiom means that it has to be possible to transform the decision problem into a hierarchy. Every cluster in the hierarchy is only depending on the next higher level and depends only the next lower level. The attributes of one cluster are not allowed to affect themselves. This requires that the structure of the hierarchy looks like figure 2.7.
4. Expectations: The last axiom means that all attributes (or criteria) and alternatives that matter in the decision problem have to be represented in the hierarchy.

**Process** The process of AHP can be described with 6 steps according to [CR10] (see figure 2.8). These steps will be described in the following. Note that step 2, 3 and 5 are characteristically for the AHP process [BM94].

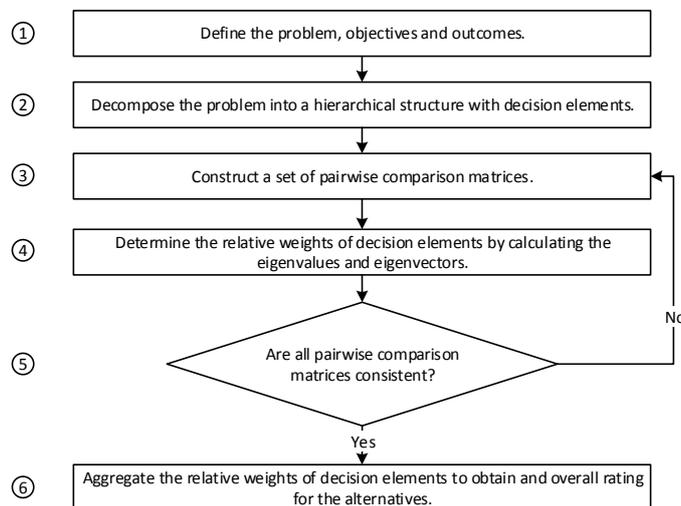


Figure 2.8.: Process of AHP according to [CR10].

1. **Defining problem, objectives and outcomes:** The most creative task in solving a decision problem might be the definition of decision elements that are important [Saa90]. The definition of decision elements is the basis for AHP and can be separated in two parts:

- Defining objectives, criteria and

## 2. Fundamentals

- Defining possible alternatives.

Criteria are attributes based on objectives. These criteria can be broken down into sub-criteria. However, these may also be broken down into additional sub-sub-criteria and so on.

2. **Decomposition of the problem into a hierarchical structure:** The decision elements (overall goal, criteria and alternatives) will be arranged in a decision hierarchy (see figure 2.7). The overall goal is on top level of the hierarchical structure followed by possible sub-goals, criteria, possible sub-criteria and finally the alternatives on the lowest level. The sub-elements on the next lower level of an element are also named cluster. It is important to map the decision problem into the hierarchic structure completely according to axiom 4. This means that each element of the hierarchic structure has to be in relation with the element in the next higher level. According to [IL15] it is recommended that each cluster has seven plus or minus two elements.
3. **Construction of comparison matrices:** AHP uses a simple pairwise comparison of criteria based on the next higher element. Therefore, the decision maker responds the question which criteria is more preferred with Saaty's discrete judgment scale (see table 2.1) in consideration of axiom 4. He thought that five discrete attributes (1 = equal importance, 3 = moderate importance, 5 = essential or strong importance, 7 = very strong importance and 9 = extreme importance) would be enough to judge qualitative decisions. The judgment scale has been proven in practice and validated by physical and decision problem experiments. Each element of one cluster will be compared in a matrix (see equation 2.16, where  $A_i$  is the  $i$ th attribute). It is clear that  $a_{ii} = 1$  as each element has equal importance to itself. Furthermore, it is enough that the decision maker only compares a triangular part of the matrix ( $a_{kl}$  with  $k = 1, \dots, n$  and  $l = k, \dots, n$ ) because the remaining weights can be completed with axiom 1 (reciprocal axiom). Therefore, AHP needs

$\frac{1}{2}n(n - 1)$  comparisons [Ahl13, MK13].

$$A = \begin{matrix} & A_1 & \dots & A_n \\ \begin{matrix} A_1 \\ \vdots \\ A_n \end{matrix} & \begin{pmatrix} a_{11} & \dots & a_{1n} \\ & \ddots & \\ a_{n1} & \dots & a_{nn} \end{pmatrix} \end{matrix} \quad (2.16)$$

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective.
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another.
5	Essential or strong importance	Experience and judgment strongly favor one activity over another.
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice.
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation.
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed.
Reciprocals		If activity $i$ has one of the above numbers assigned to it when compared with activity $j$ , then $j$ has the reciprocal value when compared with $i$ .
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining $n$ numerical values to span the matrix.

Table 2.1.: Fundamental scale according to [Saa90].

#### 4. Determination of the relative weights by calculating the eigenvalues and eigenvectors:

According to [Ahl13] the elements of the matrix can be described as

$$a_{ij} = \frac{w_i}{w_j} \quad (2.17)$$

## 2. Fundamentals

where  $w_i$  is the weight of the  $i$ th attribute (table 2.1). This equation can be transformed with axiom 1 into

$$\Rightarrow a_{ij} * \frac{w_j}{w_i} = 1 \quad (2.18)$$

and

$$\Rightarrow \sum_{j=1}^n a_{ij} * \frac{w_j}{w_i} = n \quad (2.19)$$

This equation can be transformed into

$$\Rightarrow \sum_{j=1}^n a_{ij} * w_j = n * w_i \quad (2.20)$$

The matrix has an unit rank because every column is a constant multiplied with the first one. Therefore, there is a single eigenvalue  $\lambda_i$  with  $i = 1, \dots, n$  and  $\forall i \neq 0$ . It is also known that  $\sum_{i=1}^n n\lambda_i = \text{tr}(A) = n$  because  $\text{sum}_{i=1}^n na_{ii} = n$ . This non-zero eigenvalue will be denoted with  $\lambda_{max}$  with  $\lambda_i = 0, \lambda_i \neq \lambda_{max}, \lambda_{max} = n$  [Tsa08]. Therefore, equation 2.20 can be transformed into

$$\Rightarrow A * w = \lambda_{max} * w \quad (2.21)$$

and

$$\Rightarrow A * w - \lambda_{max} * w = 0 \quad (2.22)$$

This equation can be transformed into the following eigenvalue problem. The eigenvector  $w$  in equation 2.23 represents the weight vector of the pairwise comparison matrix.

$$\Rightarrow (A * -\lambda_{max} * I) * w = 0 \quad (2.23)$$

or

$$\Rightarrow \det(A * -\lambda_{max} * I) = 0 \quad (2.24)$$

where  $A$  is the comparison matrix,  $\lambda_{max}$  is the eigenvalue and  $I$  is the identity matrix. The solution of equation 2.24 are the eigenvalues  $\lambda_{max}$  of  $A$ . There are different algorithm to calculate the eigenvalues like *Jacobi eigenvalue algorithm*,

inverse or power iteration. A eigenvector can be determined for each eigenvalue of  $A$ . The solution for the absolute weight factors is the maximal eigenvalue  $\lambda_{max}$  of the eigenvector  $w_{max}$ . The latter can be calculated with equation 2.24 and is the absolute weight factors of the different criteria [Ahl13].

An example for the calculation of the relative weights based on the power iteration is given in the section A.2 according to [MK13, Koo15].

5. **Consistency check:** A matrix is declared as consistent if alternative  $i$  is 2 times important as alternative  $j$  and alternative  $j$  is 5 times important as alternative  $k$  then alternative  $i$  has to be 10 times important than alternative  $k$ . Saaty suggested to use the consistency index  $C.I.$  to determine if a  $n$ -by- $n$  matrix is consistent or inconsistent (see equation 2.25) [BCFG06]. The consistency of a matrix can be determined with the consistency ratio  $C.R.$  (see equation 2.26) based on  $\lambda_{max}$ . The random consistency ( $R.C.$ ) is shown in table 2.2. The matrix is consistent if  $C.R. \leq 0.1$ . If the decision is absolutely consistent then  $\lambda_{max} = n$ . Otherwise the judgment of the hierarchy should be completely revised because the decision will not be adequate [MK13].

$$C.I. = \frac{\lambda_{max} - n}{n - 1} \quad (2.25)$$

$$C.R. = \frac{C.I.}{R.C.} \quad (2.26)$$

n	1	2	3	4	5	6	7	8	9
RC	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Table 2.2.: Random consistency indices for different number of criteria  $n$ .

6. **Calculation of the global weight of each alternative:** The rank of the alternatives is determined by calculating the global weights of alternatives. The global weight can be calculated with

$$p_i^{alternative} = \sum_j w_j * l_{ij} \quad (2.27)$$

## 2. Fundamentals

where  $p_i^{alternative}$  is the global weight of the  $i$ th alternative,  $w_j$  is the weight of criterion  $j$  and  $l_{ij}$  is the local priority with respect to criterion  $j$  and the  $i$ th alternative. The alternative with the highest global weight is the best alternative.

# 3

## Related Work

Currently, there exists variety of sales applications on the market. Two examples for mobile sales applications are *Digital Sales Aid* and *Showpad*. These applications are discussed and described in the following based on internet research.

### 3.1. Digital Sales Aid

*Digital Sales Aid* (DSA) is a mobile iOS application from Salesforce mobile team that provides functionalities to find, share and deliver product information to customers. The application is integrated with Salesforce CRM. Therefore, the content library can be used and data can also be associated with leads, contacts, accounts and opportunities. Content can be updated on the website<sup>1</sup> using a WYSIWYG editor. Users of DSA are able to download and synchronize content to the mobile device. Thereby, files can be opened offline by browsing through preset categories or searching by title. DSA supports the most common file types such as Microsoft Office files, PDF files, photos or videos. Additionally, interactive HTML5 content is also supported. Figure 3.1 shows an example of HTML5 content in DSA. Users are able to access recent activities by a historical view [BR15].

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<sup>1</sup><http://www.salesforce.com>

### 3. Related Work

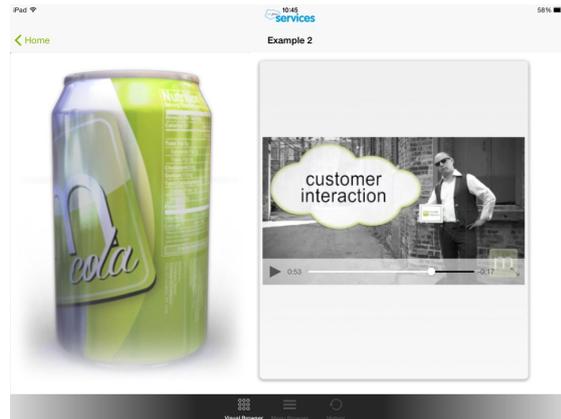


Figure 3.1.: HTML5 model cola example in DSA.

## 3.2. Showpad

*Showpad - Sales Acceleration* (Showpad) is a combination of an online platform and a mobile application. The mobile application is available on iOS, Android and Windows Phone. It provides built-in integration with common cloud hosting services like Box, Dropbox and Google Drive. Thereby, content can be uploaded and managed from a cloud-based file-sharing application. Showpad is organized using *channels* that function like categories to create content structure. Users are able to synchronize content, profiles, internal branding and custom forms. Once synchronized, content can be opened without a connection to the internet.

The mobile application supports most common file types such as Microsoft Office files, PDF files, videos, photos and also HTML5 content. Users are able to access files by browsing or searching (see figure 3.2). The look and feel of the mobile application can be customized to meet the company's guidelines and branding, as presented in figure 3.3 [BR15].

### 3.3. Comparison

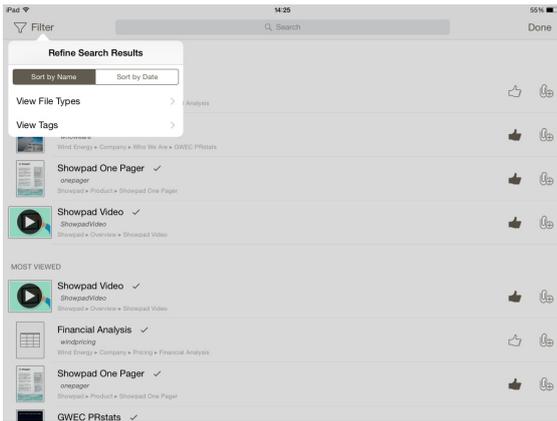


Figure 3.2.: File search in Showpad.



Figure 3.3.: User interface in Showpad.

### 3.3. Comparison

In this section, two different sales applications are described. Both mobile applications offer offline functionality and the most common file types. The functionality of both is very similar. Users need to login into the application and the synchronization of content is automatically initiated. After the synchronization is successfully completed, users are able to view all available files. The user access control of both systems can be managed from one single point by system administrators.

The results of this analysis are also used for the requirements analysis in section 4. Thereby, CRM systems receive no consideration.



# 4

## Requirements

The research goal of this thesis is the design and implementation of an IT system supporting the flexible distribution of documents to mobile devices. The first part of this section describes the desired IT system. Based on this description, requirements for the IT system are defined. Requirements are crucial for the development of software applications because, thereby, a precise software development is guaranteed. The requirements are divided into *client-side* and *server-side* requirements. These are further divided into *functional* and *non-functional* requirements.

### 4.1. Overview

The IT system should provide the marketing department of *Epsilon* with the distribution of documents (e.g., marketing materials) for sales representatives. Using such a system, they would have up-to-date documents and would be able to perform interactive product presentations at the customer's location. The IT system consist of a client application and a server application. The client has to be a smart mobile application to be present IT system to be present at customer visits. An overview about the fundamental functionality of the IT system is presented in figure 4.1 using the example of a document release process.

There are four involved groups of actors, called product managers, marketing managers, IT administrators and sales representatives.

#### 4. Requirements

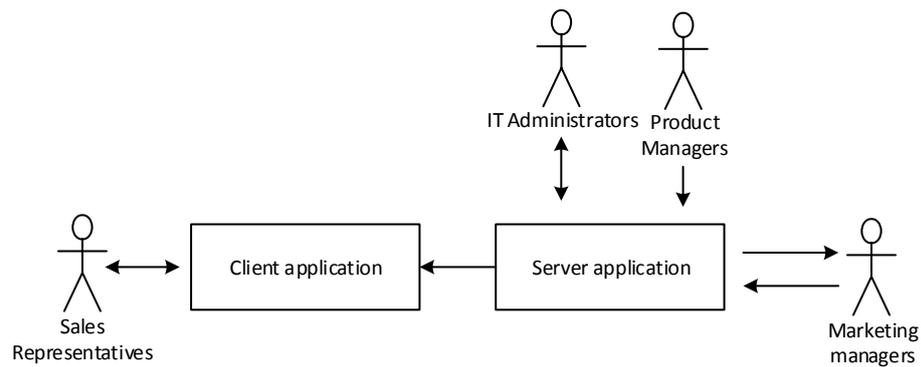


Figure 4.1.: Document release process.

- *Product managers* create and distribute initial documents of products, which contain basic information about products (for example data sheets). The created documents are hosted on the server.
- *Marketing managers* edit documents and create attractive documents (e.g., multimedia documents or brochures) in cooperation with different (not specified) agencies. Therefore, they are downloading, editing and uploading the documents on the server and assigning the documents to specified user groups or users (e.g., sales representatives in specified countries).
- *IT administrators* manage the server application. This includes primarily the administration of access rights.
- *Sales representatives* use the documents assigned by marketing managers for product presentations at the customer.

An use case diagram represents actions of an user with the system. These actions are represented as diagram and are mostly applied in software engineering methods that are based on the UML [Son03]. The use case diagram for the client application is presented in figure 4.2 whereas the use case diagram for the server application is seen in figure 4.3 based on the describe document release process (see figure 4.1).

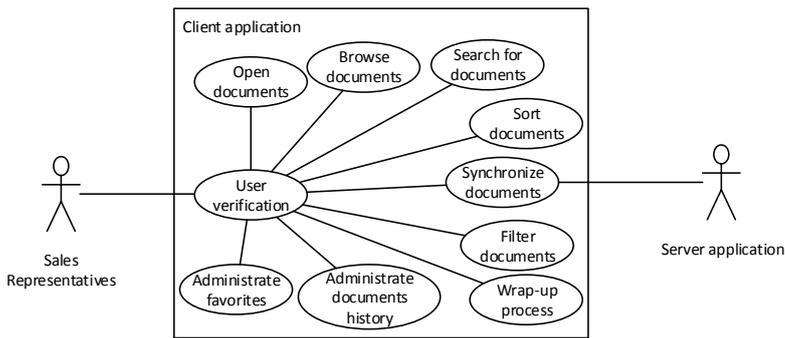


Figure 4.2.: Use case diagram of the client application.

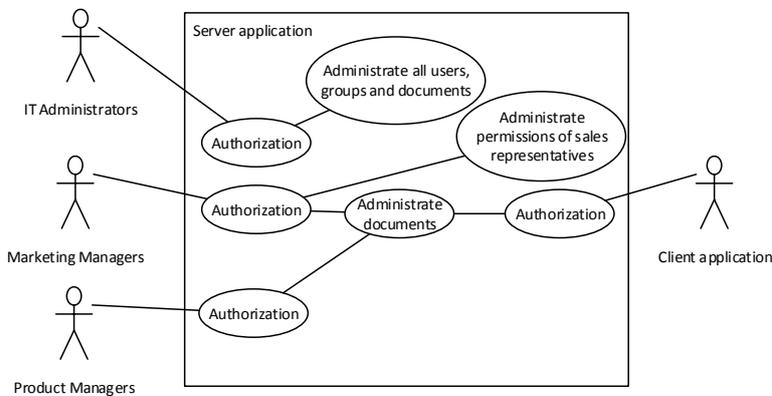


Figure 4.3.: Use case diagram of the server application.

## 4.2. Client Application

This section describes the requirements for the client application. The requirements are divided into functional and non-functional requirements.

### 4.2.1. Functional Requirements

Functional requirements define the functions of the system.

- **CFR1 Login functionality:** The client application has to provide a sign-in and sign-out functionality for sales representatives. Thereby, sales representatives

#### 4. Requirements

can be identified and authorized for different interactions with the server-side IT system.

- **CFR2 Browse and access documents:** An crucial function of the client application is to access and view documents.
- **CFR3 Sort documents:** There should be a function to sort documents alphabetical.
- **CFR4 Search function:** To enable fast document access, a search function should be provided.
- **CFR5 Filter:** Sales representatives should be able to filter documents using specified tags.
- **CFR6 Synchronization:** The documents on the client application needs to be synchronized with the documents on the server application. Therefore, a synchronize function to download the documents and keep them up to date needs to be provided.
- **CFR7 History:** To assist sales representatives keep track of documents they have recently used, a history needs to be provided.
- **CFR8 Summarize:** The mobile application has to provide functions to wrap-up a customer visit.
- **CFR9 Favorite functionality:** A favorite functionality for documents needs to be provided for the preparation of customer visits.
- **CFR10 File types:** The mobile application has to provide PDF files, HTML5 applications and MP4 files.

##### 4.2.2. Nonfunctional Requirements

Nonfunctional requirements define characteristics of the system.

- **CNR1 Mobile application:** The client has to be provided as smart mobile application. Due to the fact that sales representatives of *Epsilon* mostly use Apple iPads, the mobile application needs to be compatible to iOS.

- **CNR2 Layout:** The layout should be intuitive and logical. It should also meet the *Epsilon* styleguide.
- **CNR3 Multilingualism:** The mobile application has to be offered in multiple languages as it will be used EMEA wide. Therefore, it should be easy to add further languages.
- **CNR4 Offline functionality:** Selected documents must be available offline to guarantee a product presentation at customer visits without any problems. Sales representatives need to prepare customer visits by downloading all necessary documents. This function must be provided by the client.
- **CNR5 Performance:** The mobile application should provide fast access to the files.
- **CNR6 Dedicated corporate solution:** The mobile application should be a developed in-house.

## 4.3. Server

This section describes the requirements on the server application. These are also divided into functional and non-functional requirements.

### 4.3.1. Functional Requirements

Functional requirements define functions of the system.

- **SFR1 Document administration:** The server application needs to provide functionality for the administration of enterprise content. Thereby, it is important to consider the enterprise content lifecycle (section 2.1).
- **SFR2 User administration:** To manage the authorization of users, the server application also needs to provide mechanisms for the user administration.
- **SFR3 Document assignment:** The server application has to provide a mechanism to assign user rights to documents.

#### 4. Requirements

- **SFR4 Web accessibility:** It should be possible to administrate the documents using a web browser.
- **SFR5 Application programming interface:** The server application must provide an API for connecting the server and the client application.
- **SFR6 Microsoft Office support:** Microsoft Office files are, among other file types, commonly used at *Epsilon*. Therefore, this requirement has to be fulfilled but is actually not premeditated. It is added to say ready for future development.
- **SFR7 Workflow support:** The server application should support workflows to improve the productivity and efficiency of business processes.

##### 4.3.2. Nonfunctional Requirements

Nonfunctional requirements define characteristics of the system.

- **SNR1 Usability:** It should be user-friendly to administrate the server application.
- **SNR2 Hosting:** *Epsilon* prefers an internal hosting. Therefore, the server application should be an on-premises software.
- **SNR3 Support:** To leverage the availability of the server application, technical support is also required.

# 5

## Evaluation

The server application should be realized using an existing ECM system (see section 2.2) to support the content throughout the enterprise content life cycle. Therefore, an evaluation of existing ECM systems has to be performed to find the best match. The first section provides an overview about existing ECM systems. Then the criteria catalog for the evaluation is described followed by the actual evaluation using the AHP method.

### 5.1. Enterprise Content Management market

Nowadays, there are lot of ECM systems. The worldwide market of ECM systems grew by 8,6% in 2013 [GSC<sup>+</sup>14]. Gartner Inc., an american information technology research and advisory firm, evaluated 22 different ECM systems in *Magic Quadrant for Enterprise Content Management* [GSC<sup>+</sup>15] from September 2014. Another independent technology and market research company, Forrester Research, evaluated 13 providers in *The Forrester Wave: Enterprise Content Management, Q3 2013* [WLCMJ15] from September 2013. Based on these studies in addition with fundamental investigation, ECM systems were selected as potentially alternatives. They will be shortly described in the following and in section A.1, based on internet recherche and interviews with contact persons of the ECM sales team.

- **Agorum Core:** Agorum Core is a Document Management System platform in its current version 7.7.0 and was released on Mai 2015. It is available in two different versions, Agorum Core Open (free software) and Agorum Core Pro (commercial). Agorum Core Pro is in five different licenses available. Detailed information about

## 5. Evaluation

the differences can be found at [Ago15b]. The platform itself provides multilingual support and can be fully customized by configuration files. The main features of Agorum Core are document search, manage documents, workflows, information retrieval (via wikis and forums) and collaboration. A detailed overview about the provided features can be found at [Ago15a].

- **OpenText ECM Suite:** The OpenText ECM Suite is an aggregation of management applications that include document management, record management, email management and web content management. The management software is divided into content management, records management, archiving, capture, email solutions, content-centric applications and ECM in the cloud, platform and developer extensions, and OpenText Brava (a collaboration software). OpenText introduced OpenText Cloud to provide services for the management, the collaboration and messaging [GSC<sup>+</sup>14].
- **M-Files DMS:** The current version of M-Files is M-Files 2015 and was released in April 2015. It is available as cloud version or as on-premise version. The producer describes M-Files as an enterprise information management system that manages all business contents (documents, projects and business processes) in combination with intelligence by different systems. M-Files uses a metadata model for the file management. Therefore, the solution is very flexible because files are not hard-coded and users are thereby able to customize the context to their requirements [GSC<sup>+</sup>14]. More information can be found at [MF15].

### 5.2. Criteria Catalog

The Magic Quadrant for Enterprise Content Management study by Gartner provides a general overview of already existing ECM systems but does not match the requirements on the IT system with its weighted requirements. To identify an ECM system that completely meet the defined requirements (see section 4), an evaluation based on the defined requirements in addition to the functionality of ECM systems has to be performed.

The criteria catalog for the evaluation is presented in the following based on the top-level criteria and its sub-criteria.

- **System:** The system criteria summarizes all general functional properties of the ECM system and can be divided into the following sub-criteria:
  - **Costs:** Costs can be broken down into two main categories: These are one-time costs and regular costs. One-time costs include, for example, ECM purchase costs, additional fix costs for offline functionality or support costs (general functionality services). Regular costs include, for example, license costs per year, training costs or support costs (special standby services).
  - **Installation:** The installation can be broken down into the complexity of the installation, requirements and the functionality of the installation. Complexity of the installation includes expenditure of time and general complexity during the installation. Installation requirements can be divided into the number of requirements and its complexity. The functionality of the installation of an ECM contains possible features of automated install routines or recovery processes of backups.
  - **In-house:** In-house is a special requirement of *Epsilon*. On the one side the category contains information about possible target audiences and on the other side *Epsilon* specified attributes. For example: If *Epsilon* is able to provide support, install the ECM system or develop add-ons to extend the functionality.
  - **Support:** The support includes general availability (7/24, weekdays or weekend support) and different types of support. These are online/offline support, videos and workshops. Workshops contain sessions or web conferences.
  - **Scalability:** This criteria rates if the ECM system is able to scale properly to large dimensions. It also includes any kind of limitations relating to the scalability.

## 5. Evaluation

- **Documentation:** The documentation can be divided into an user-guide and a documentation based on the software development kit or the application programmable interface.
- **Usability:** The usability criteria measures the level of usage of the ECM system. A system with a good usability is a system that is close to users needs and requirements. The criteria can be divided into the following sub-criteria:
  - **User interface:** Usability of the user interface contain adaptability of the user interface by itself. This includes, for example, customization of the data representation or the design.
  - **Access to information:** The access to information can be divided into the representation of information, access types and media integration. Representation of information can be performed with various types like, for example, lists, hyperlinks, calendars, contacts, tasks or surveys. There are generally different access types, like access via web, mobile or desktop application. Media integration is defined as the provided file types by the ECM like, for example, office documents, PDF files or multimedia files (like videos or audios).
  - **User and rights management:** The user and right management is crucial for security, for example for the authorization. It can be divided into three sub-criteria: Supported directory services, administration tasks and granularity of rights management.
- **Extensions:** Another criteria are extensions, which allows the customization of the ECM to users needs. They can be divided into the following sub-criteria:
  - **Connection:** The connection can also be divided into the extension via plugins and via application programming interfaces. In this criteria catalog, plugins are characterized by the difficulty level of the installation, the stability and the complexity. There are different application programming interfaces, for example web service or SAP.
  - **Workflow support:** The workflow support is characterized by the difficulty level of the integration and the compatible workflow systems. The difficulty

level of the integration is differentiated between the general handling of workflow integration and the necessary time for integration.

- **Multilingualism:** The multilingualism differentiates between predefined languages and extensions. Extensions can be differentiated between templates and self-created files. Thereby, the complexity of the creation process is relevant.
- **Administration of documents:** The administration of documents is a core functionality of an ECM system and can be divided into the following sub-criteria:
  - **Indexing:** The term indexing describes the process of applying metadata to a document in the context of an ECM system.
  - **Offline functionality:** Offline functionality can be divided into two different use cases: View and edit documents.
  - **Document functionality:** The document functionality supports users in the management of documents. This includes the following sub-criteria: Annotations on the document, editing of documents (for example multi-user support), searching for documents (for example efficiency or range of search), version management of documents, archiving documents and importing documents.
- **Security:** Another important aspect of the criteria catalog is security. It can be divided into the following sub-criteria:
  - **System stability:** The system stability of an ECM system is crucial within an enterprise as documents have to be available at all time.
  - **Data protection:** There are different possibilities to create backups of the ECM system (for example incremental backups). The backup can be characterized by the complexity, the procedure, the needed time and the compression rate. Another important characteristic is restoring individual documents in case of a failure.
  - **Logging:** Logging contains the range and the details of the log.

## 5. Evaluation

- **Encryption:** There are different encryption methods. These are, for example, the public key cryptography.

### 5.3. Evaluation

The evaluation to find the best matching ECM system is achieved using the AHP method (see section 2.3.2.8). AHP allows handling dependencies in different hierarchies of the structure and also considers cognitive tendency to order elements in categories. Another advantage of this method is the respect for quantitative and qualitative attributes during the decision making process by the fundamental scale. AHP is able to decide complex decision problems and also provides consistency checks to rate the quality of the results [MK13].

#### 5.3.1. Input parameters

The AHP evaluation is realized with BPMSG<sup>1</sup>, an online AHP application. Input parameters for the calculation are the hierarchical structure, the weight of the criteria as well as the alternatives.

##### 5.3.1.1. Hierarchical structure

The hierarchical structure of the criteria has been presented in section 5.2. The overall goal of the decision making problem is named as *Find the best matching ECM system*. This hierarchical structure is transformed for the usage with the online AHP system (see listing 5.1).

Listing 5.1: Input text for the AHP hierarchy

```
1 Find the best matching ECM system: System, Usability,  
2 Extensions, Administration of documents, Security;  
3 System: Costs, Installation, In-House, Support, Scalability,
```

<sup>1</sup><http://bpmsg.com/academic/ahp-hierarchy.php>

4 Documentation; Usability: User interface, Access to  
 5 information, User and rights management; Extensions:  
 6 Connection, Workflow support, Multilingualism;  
 7 Administration of documents: Indexing, Offline  
 8 functionality, Document functionality; Security: System  
 9 stability, Data protection, Logging, Encryption;

### 5.3.1.2. Criteria

The criteria are weighted based on the importance of the presented requirements (see section A.3). The result of the weighted criteria is presented in table 5.1. As the matrices are reciprocal, only half of the comparisons are presented.

	System	Usability	Extensions	Administration of documents	Security
System	1	1	1	1/3	1/3
Usability		1	1/3	1/3	1
Extensions			1	3	3
Administration of documents				1	3
Security					1

Table 5.1.: Weight of the criteria

## 5. Evaluation

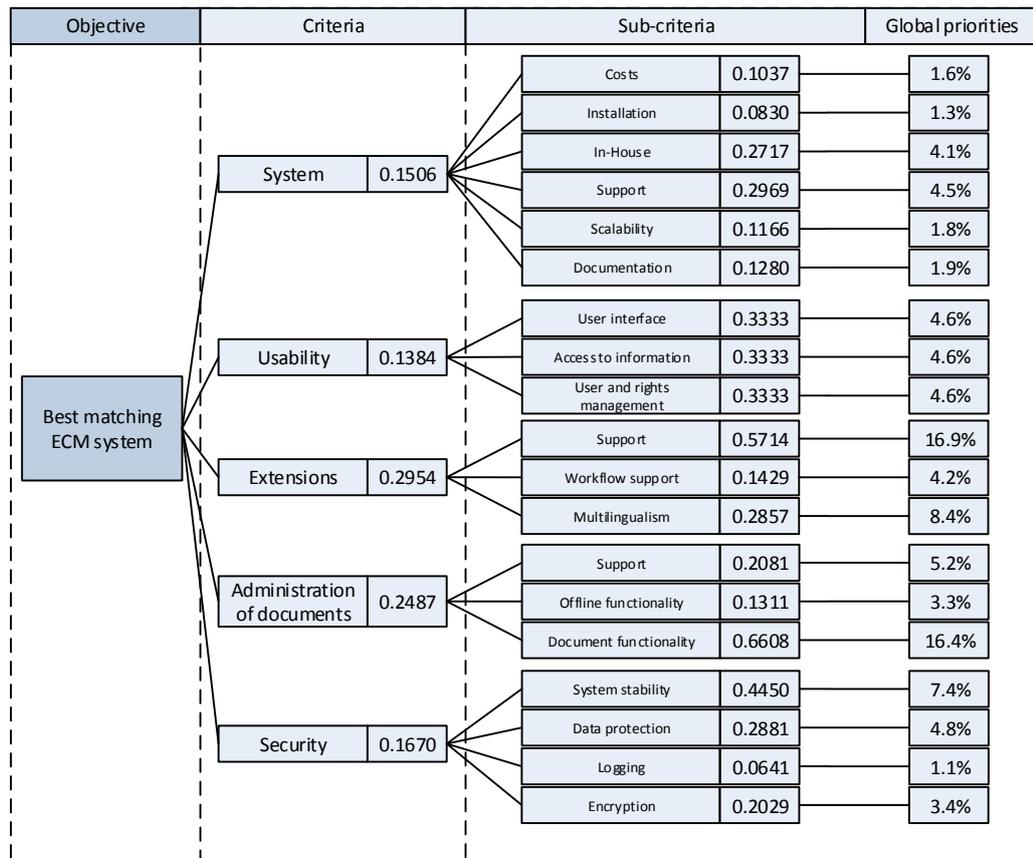


Figure 5.1.: The weighted hierarchical structure of the decision problem.

### 5.3.1.3. Alternatives

A feature-based overview of the introduced ECM systems (see section 5.1) is presented in table 5.2. The information is based on internet recherche and interviews with contact persons of the ECM systems.

### 5.3. Evaluation

Product	RM	DMS	Wf	Technical support	Multilingual support	Supports MS Office	In-house usage
Share Point 2013	✓	✓	✓	✓	✓	✓	✓
Alfresco One	✓	✓	✓	✓	✓	✓	X
Agorum Core	✓	✓	✓	✓	✓	~	X
Bitfarm-Archiv	✓	✓	✓*	✓	✓	✓*	X
ELO Enterprise	✓	✓	✓	✓*	✓*	X*	X
IBM Connections	✓	✓	✓	✓	✓*	✓*	✓
Logical DOC	✓	✓	✓	✓*	✓*	✓*	X
Xerox DocuShare	✓	✓	✓	✓*	✓*	~	X
OpenText ECM Suite	✓	✓	✓	✓*	✓*	~	X
Docu Ware	✓	✓	✓	✓	✓*	~	X
Liferay Portal	✓	✓	✓	✓	✓	✓*	X
Hyland Software OnBase	✓	✓	~	~	~	✓*	X
EMC Documentum D2	✓	✓	✓	✓*	✓*	~	X
Saperion ECM	✓	✓	✓*	✓*	✓*	~	X
HP Autonomy ECM	✓	✓	✓*	✓*	~	~	X
Newgen OmniDocs ECM Suite	✓	✓	~	✓*	✓*	~	X
Oracle WebCenter Content	✓	✓	✓	~	✓*	✓*	X
M-Files DMS	✓	✓	✓	✓*	✓*	✓	X

Table 5.2.: Feature-based overview of ECM systems. The ~ means that there was no information present via internet research nor according to a contact person. The \* means that there are limitations.

## 5. Evaluation

To reduce the number of potential ECM systems, the dominance strategy (see section 2.3.2.1) is used. Thereby, the *in-house usage* criteria of an ECM system is not considered. The resulted ECM systems after applying the dominance strategy are *Microsoft SharePoint*, *Alfresco One* and *Liferay Portal*. In addition to these ECM systems, *IBM Connections* was also added because of its already existing in-house usage.

**Microsoft SharePoint** : Microsoft SharePoint 2013 is a business collaboration platform in its current version SharePoint 2013 SP1. The latest update was released on September 2014 [Mic15g]. Microsoft SharePoint is available in three different versions. Microsoft SharePoint Foundation 2013, Microsoft SharePoint Server 2013 Standard Edition and Microsoft SharePoint Server 2013 Enterprise Edition. General core capability areas of Microsoft SharePoint are collaboration, social computing, portals, search, records management, business intelligence and composite applications. An overview of a Microsoft SharePoint 2013 farm is demonstrated in figure 5.2.

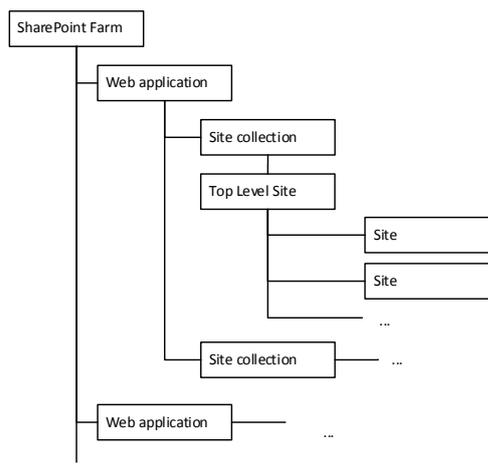


Figure 5.2.: SharePoint Hierarchy [Mic15e, Goo13].

Thereby, a site type can be one of the following categories [Mic15e]:

- **Collaboration:** Collaboration sites contain team sites, blogs, develop sites, project sites and community sites. They may be used, for example, to interact with various

people, collect ideas, observations and expertise, build, test and publish apps for Office, or manage and collaborate on a project.

- **Enterprise:** Enterprise sites contain document center, eDiscovery center, records center, business intelligence center, enterprise search center, my site host, community portal, basic search center and visio process repository. These sites are used, for example, to manage documents, manage preservation, search and export of content, presenting business intelligence content, delivering an enterprise-wide search experience or view, share or store visio process diagrams.
- **Publishing:** Publishing sites contain publishing portal, enterprise wiki, product catalog, publishing site and publishing site with workflow. These sites are used, for example, for publishing knowledge or managing product catalog data.

Microsoft SharePoint uses lists and libraries as repositories. An advantage of document libraries are tools to control access rights in terms of adding, deleting, editing or reading documents. Therefore, a detailed user access management is available. Lists store data in rows and columns like Microsoft Excel spreadsheets or databases [Cur13]. Microsoft SharePoint offers an office web apps service application, which provides a browser-based viewing and editing of Microsoft Office documents [Goo13]. There are two features to provide multilingualism in Microsoft SharePoint, called Multiple Language User Interface (MUI) and Variations (Enhanced translation workflow and machine translation services). The MUI feature changes the display language for default UI elements. Custom UI elements that have been added using third-party plugins are not translated automatically. The Variations feature works with the site content. Thereby, published sites from the pages library are copied automatically and queued for translation and publishing [Mic15c].

The platform requires at least a hardware with 8 GB RAM, 64-Bit 4 core processor and 80GB disk space [Mic15f] and supports the following directory services [Mic15d]:

- Active Directory Domain Services (AD DS) 2003 SP2 and AD DS 2008
- Sun Java System Directory Server version 5.2
- Novell eDirectory version 8.7.3

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- IBM Tivoli version 5.2

Microsoft SharePoint provides the following APIs:

- Server-OM-APIs for Silverlight applications, web part, ASP .NET web applications or applications for SharePoint
- .NET-Client-OM-APIs for .NET applications
- JavaScript APIs for web part, ASP .NET web applications, applications for SharePoint, HTML/JavaScript applications or applications for Office
- REST/OData for ASP .NET web applications, applications for SharePoint, HTML/JavaScript applications, applications for Office, LAMP web applications or iOS/Android applications.
- Silverlight-Client-OM-APIs: Silverlight applications, web part, ASP .NET web applications or applications for SharePoint
- Mobile Silverlight-APIs for Windows Phone Silverlight applications or Windows Phone XNA applications

Microsoft provides support for Microsoft SharePoint via web, a 7/24 support via phone, on-premises support by a Microsoft partner, support by video tutorials for administrators and end users and support by training from Microsoft partners.

**IBM Connections Content Edition** : IBM Connections Content Edition uses the ECM software IBM FileNet P8 Content Manager. IBM FileNet P8 Content Manager contains functionality for the administration of relevant documents and contents. This includes version control, check-in/check-out, WebDAV (an extension of the HTTP protocol that allows clients to perform web content authoring operations), PDF publishing and Microsoft Office integration. Thereby, the platform provides the handling of unstructured data like scanned paper documents, HTML, XML, PDF documents, emails, video or audio files and provides the management of complex files [IBM15]. IBM FileNet P8 is based on three core components. These are content engine (CE), process engine (PE) and workplace (WP) / workplace XT (WP XT) (see figure 5.3).

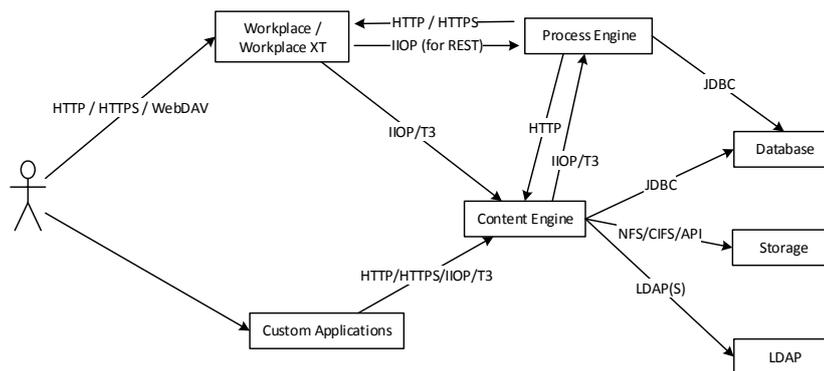


Figure 5.3.: IBM FileNet P8 core components [IBM15].

- **CE component:** The CE component is a J2EE Java Bean application that provides services for creating, retrieving, updating, deleting and securing all content. It also provides interfaces for handling event-based actions, document life cycle and integration with various storage mediums. It provides a java and .NET API, which offers methods to create, retrieve, update and delete objects, folders and documents.
- **PE component:** The PE component provides workflow management like personal inboxes, work object routing, group queues, process tracking and process orchestration capabilities.
- **WP / WP XT:** These components provide user interfaces for the work with the CE and PE components.

IBM FileNet P8 Content Manager also provides the localization of content in different storage systems and databases. Therefore, attributes, content with phonetic search like word stem or synonyms are used. Such queries can also be stored for future requests. It also provides templates for processes, formulas, classifications, definitions, search formulas and user interfaces. The provided operating systems, databases and directory services are presented in the following:

- **Operating systems:** Microsoft Windows, Sun Solaris, IBM AIX, HP-UX and Linux.

## 5. Evaluation

- **Databases:** IBM DB2, Microsoft SQL Server and Oracle.
- **Directory Services:** Microsoft Active Directory, Novell eDirectory and Sun Java System.

The IBM Connections platform provides standards like J2EE, XML and SOAP. It also provides enterprise application integration. The objective management service administers content, controls relations between content and its external objects, security concepts, processes, information about the lifetime and enterprise application integration transactions. The J2EE Content Engine allows for searching, classifying, saving data from foreign repositories.

IBM provides support via web, a 7/24 support via phone, on-premises support, support by video tutorials and support by training.

**Alfresco One** : Alfresco One is a Java based system. Therefore, it runs on all operating systems that are able to run Java Enterprise Edition. The architecture of Alfresco is presented in figure 5.4.

Alfresco offers two primary web-based clients. These are Alfresco Share and Alfresco Explorer. Alfresco Share is implemented using Spring Surf and manages the collaboration aspects of content management and streamlining the user experience [Alf15b]. Alfresco Explorer is implemented using Java Server Faces and exposes all features of the content application server [Alf15b].

Alfresco content application server provides the following services:

- Content services (transformation, tagging, metadata extraction)
- Control services (workflow, records management, change sets)
- Collaboration services (social graph, activities, wiki)

Programmatic access is supported via HTTP and SOAP, application access by CIFS, FTP, WebDAV, IMAP and Microsoft SharePoint protocols. Microsoft SharePoint protocols additionally enable Alfresco One the connection to Microsoft Office applications. There are mobile applications for the mobile platforms iOS and Android available. Alfresco One provides additionally SDKs for Android, iOS and Appcelerator (applications

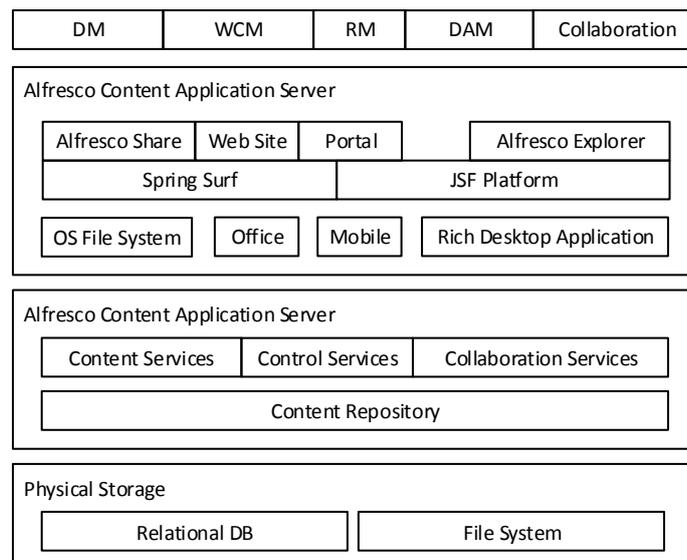


Figure 5.4.: Architectural components of Alfresco One [Alf15b].

in JavaScript) [Alf15c]. The application programming interface can be realized by a JavaScript API (ECMA Script), a RESTful API, a Repository FreeMarker Template API and a surf platform API. Alfresco uses Content Management Interoperability Services (CMIS) for creating, querying, updating and deleting documents and folders. REST calls are used for functionality that does not support CMIS [Alf15a]. The user access is controlled by roles. Thereby, it is possible to determine what a user is allowed to do. Detailed information about the user access can be found at [Alf15e]. Alfresco supports the following authentication mechanisms: NTLM, authentication and user registry export through the LDAP protocol, authentication and user registry export from Active Directory through the LDAP protocol, authentication through a windows domain server, authentication through a kerberos realm and authentication using an external SSO mechanism. Alfresco handles multilingual document support by the share UI, which decides what language is desired based on the browser's locale settings.

Alfresco One provides three different support variants. These are departmental, enterprise and premier. All of these support variants provide support via web, phone and

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forums. The enterprise and primer support additionally provide 24x7 support. Detailed overviews are available at [Alf15d].

**Liferay Portal** : Liferay Portal is also a Java based platform system. Therefore, it runs on all operating systems that are able to run Java Enterprise Edition. Liferay Portal contains two core components: Liferay CMS and Liferay Collaboration [JHK<sup>+</sup>15]. Features of Liferay CMS are, for example, a web content management system, a repository that houses documents, video, audio, images and other media types (these can also be other content repositories like, for example, Alfresco or Documentum), creation of metadata sets, creation of different workspaces, a web UI interface, templates, live page editing and scheduling, search functionality across all assets and multi-language support. It provides built-in support for more than 40 languages and it is also possible to add other languages. Liferay Portal supports check-in/check-out, sort and manage mechanisms. Features of Liferay Collaboration are, for example, knowledge bases, wikis, message boards, blogs, reportings, rss feeds, activity tracking, instant messaging, an AJAX-based webmail client, calendars, dynamic data lists, polls. Detailed information can be found at [Lif15b]. Liferay Portal uses SharePoint protocols to work with Microsoft Office files. Some technical specifications are presented in the following [Lif15c]:

- **Operating systems:** Microsoft Windows, Linux, Unix
- **Databases:** IBM DB2, MySQL, Oracle, PostgreSQL, SQL Server, Sybase
- **Web Services:** JSON, Hessian, Burlap, REST, RMI, Spring HTTP, WSRP and WebDAV
- **Single Sign On:** CAS and Siteminder. Support for JAAS, JOSO, LDAP, Netegrity, Microsoft Exchange.
- **Security:** Pluggable Authentication, Email Verficiation, Granular Permissioning, LDAP Authentication, Session Management

Liferay Portal requires 300MB of disk space and at least 1 GB of RAM. According to [Lif15a], Liferay supports the following performance:

- Liferay Portal can support 27,000 virtual users on a single server

### 5.3. Evaluation

- Liferay Portal's Document repository supports 10,000 virtual users while accessing 2,000,000 documents in the document repository.
- Liferay Portal's WCM supports 300,000 virtual users on a single Liferay Portal server with average transaction times under 50ms and 35% CPU utilization.

Liferay provides two different support variants. These are Gold (8/5 support via web and phone) and Platinum (24/7 support via web and phone). Support via videos or tutorials is available at the website of Liferay<sup>2</sup>. It is also possible to book training sessions. On-premises support is generally not provided directly by Liferay.

The described alternatives have to be weighted in the next step. The result of the evaluation is provided in the following and in section A.4. As the matrices are reciprocal, only half of the comparisons are presented.

In-House	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	3	9	9
IBM Connections		1	9	9
Alfresco			1	1
Liferay				1

Support	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	3
IBM Connections		1	1	3
Alfresco			1	3
Liferay				1

Connection	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	3	3	3
IBM Connections		1	3	3
Alfresco			1	1
Liferay				1

<sup>2</sup><http://www.liferay.com/university>

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Multilingualism	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	3	3	1/3
IBM Connections		1	1	1/3
Alfresco			1	1/3
Liferay				1

### 5.3.1.4. Result

The result of the evaluation is presented in figure 5.5. Based on these results, the following rating of ECM systems is presented:

1. Microsoft SharePoint (30.4%)
2. IBM Connections Content Edition (26.4%)
3. Alfresco One (21.4%)
4. Liferay Portal (21.8%)

Thereby, Microsoft SharePoint is selected as server component.

Objective	Criteria	Sub-criteria	Global priorities	Microsoft SharePoint	IBM Connections Content Edition	Alfresco One	Liferay Portal	
Best matching ECM system	System	Costs	0.1037	1.6%	0.0070	0.0070	0.0007	0.0009
		Installation	0.0830	1.3%	0.0031	0.0031	0.0031	0.0031
		In-House	0.2717	4.1%	0.0217	0.0153	0.0020	0.0020
		Support	0.2969	4.5%	0.0128	0.0128	0.0128	0.0064
		Scalability	0.1166	1.8%	0.0044	0.0044	0.0044	0.0044
		Documentation	0.1280	1.9%	0.0048	0.0048	0.0048	0.0048
	Usability	User interface	0.3333	4.6%	0.0115	0.0115	0.0115	0.0115
		Access to information	0.3333	4.6%	0.0152	0.0152	0.0092	0.0065
		User and rights management	0.3333	4.6%	0.0132	0.0132	0.0132	0.0066
		Support	0.5714	16.9%	0.0667	0.0469	0.0276	0.0276
	Extensions	Workflow support	0.1429	4.2%	0.0167	0.0117	0.0069	0.0069
		Multilingualism	0.2857	8.4%	0.0235	0.0138	0.0138	0.0334
		Support	0.2081	5.2%	0.0129	0.0129	0.0129	0.0129
	Administration of documents	Offline functionality	0.1311	3.3%	0.0082	0.0082	0.0082	0.0082
		Document functionality	0.6608	16.4%	0.0411	0.0411	0.0411	0.0411
		System stability	0.4450	7.4%	0.0186	0.0186	0.0186	0.0186
	Security	Data protection	0.2881	4.8%	0.0120	0.0120	0.0120	0.0120
		Logging	0.0641	1.1%	0.0027	0.0027	0.0027	0.0027
		Encryption	0.2029	3.4%	0.0085	0.0085	0.0085	0.0085
					<b>30.4%</b>	<b>26.4%</b>	<b>21.4%</b>	<b>21.8%</b>

Figure 5.5.: Result of the AHP process.

# 6

## Conception and Architecture

This section covers basic issues in respect to the concept and architecture. At first, the architecture of the overall IT system is described in more detail. Based on this architecture both the server and client component are discussed.

### 6.1. Architecture

The high-level data flow of the overall IT system is presented in figure 6.1. The mobile application uses the REST API provided by Microsoft SharePoint to request and receive content (i.e., documents). Generally, the mobile application stores and represents a virtual copy of the content from Microsoft SharePoint. Sales representatives navigate through this virtual copy and are able to download and open selected files based upon their privileges. The mechanism of the virtual copy guarantees that the storage of the mobile device will not get unnecessary full with unused files. A disadvantage of the mechanism is that sales representatives have to prepare a visit by downloading the necessary files. In case this preparation phase, a function to receive and download all files is also available.

## 6. Conception and Architecture

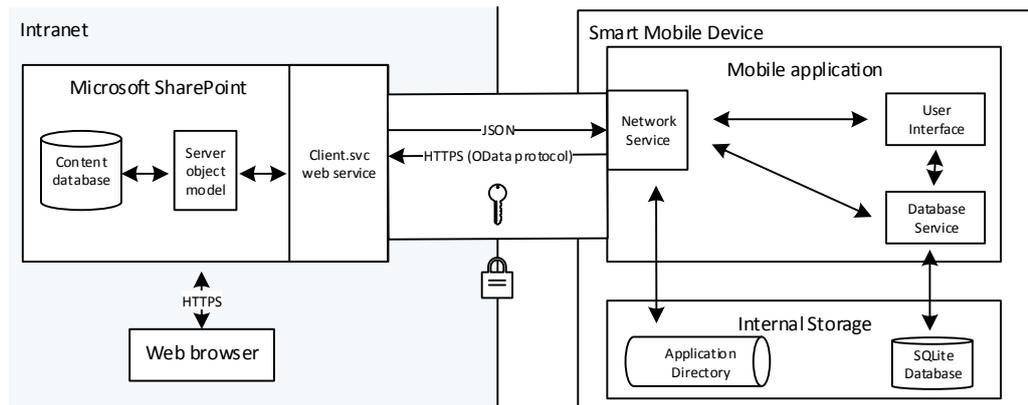


Figure 6.1.: High-level data flow of the overall IT system.

### 6.2. Server

Microsoft SharePoint 2013 provides all necessary functions of the requirements (see section 4) without any additional extensions. It only has to be configured. The configuration includes user administration and metadata of files.

The REST API of Microsoft SharePoint is fully comparable to the `server object models` and provides interactions between any technology that supports REST and Microsoft SharePoint 2013 [Mic15b]. The `client.svc` web service handles constructed RESTful HTTP requests using the Open Data Protocol (OData) standard, which corresponds to the desired client object model API. RESTful HTTP requests are used to perform typical CRUD operations against Microsoft SharePoint entities [Mic15b]. Possible HTTP methods for the RESTful service are shortly described in the following [Mic15b]:

- **GET**: To read a resource.
- **POST**: To create or update a resource.
- **PUT**: To update or insert a resource.
- **DELETE**: To delete a resource.

RESTful HTTP request examples to demonstrate Microsoft SharePoint REST service are described in the following [Mic15b]:

URI	Method	Description
<code>web/title</code>	GET	Retrieves the title of a list.
<code>lists</code>	GET	Retrieves all lists on a site.
<code>lists/getbytitle('listname')</code>	GET	Retrieves a single lists meta-data.
<code>lists/getbytitle('listname')/items</code>	GET	Retrieves items within a list.
<code>lists/getbytitle('listname')?select=Title</code>	GET	Retrieves a specific property of a document.

The URL endpoint has to be appended to `http://server/site/_api/`, whereby `server` represents the name of the server, whereas `site` specifies the name or path to the specified site [Mic15b]. Detailed information about the syntax of SharePoint RESTful services can be found on [Mic15a, Mic15b].

### 6.3. Client

The client application needs to be compatible with an iPad device based on the requirements in section 4. There are generally four possible development variants for the mobile application: Web application, hybrid application, mixed application and native application.

- **Web application:** Web applications (for example jQuery Mobile Applications) are typically developed with web technologies like HTML5, CSS3 or JavaScript. Thereby, they are platform independent and only need a web browser for the execution. Web applications are websites with the look and feel of native applications but provide only limited access to hardware components [SSP<sup>+</sup>13].

## 6. Conception and Architecture

- **Hybrid application - web:** Hybrid applications use the same web technologies as web applications. The applications, however, run within a native application container like the WebView component in iOS. Thereby, the application can use additional features of the devices hardware [SSP+13].
- **Hybrid application - mixed:** Hybrid applications are also developed with web technologies. However, the HTML5 elements will be mapped to the corresponding native platform elements during build time of the application [SSP+13].
- **Native Application:** Native applications are specifically developed for one respective platform. Thereby, the standard API of the platform is used. Native applications offer the best possible functionality because of the direct use with the provided programming libraries and interfaces [SSP+13].

According to [SSP+13], native applications should be used if the application is performance critically or if the application needs specific features of the device. Because of this the client application is implemented as native application because of its performance critically requirement (see section 4.2).

### 6.3.1. General Workflow

This section describes the high-level workflow of the mobile application. Thereby, figure 6.2 presents an overview about the general workflow. The first activity after the mobile application has been started is to check if there are valid user credentials available (e.g., the user was successfully logged-in at least one time on the server). If so, the application checks if new metadata is available by sending a RESTful HTTP request to Microsoft SharePoint. The request is running asynchronous in background that sales representatives will not recognize any activity. After the request was sent, the sales representative is forwarded to the *Browse screen*. The *Browse screen* presents all available content for the sales representative based upon his rights. They can switch between the *Browse screen*, *Recents screen*, *Info screen*, *Favorites screen* and *Wrap-Up screen* and are also able to start a content synchronization. Individual activities like, for example, filter or search functions are not presented in this figure.

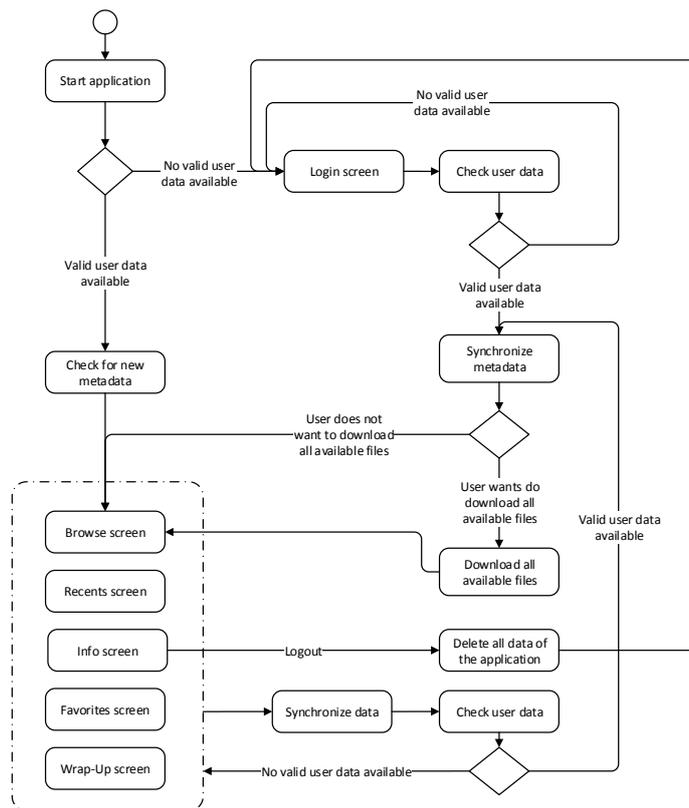


Figure 6.2.: General workflow of the mobile application.

If there is no valid user data available the the application presents the *Login screen*. Thereby, sales representatives are able to enter their username and password. After sales representatives confirmed their credentials, a RESTful HTTP request to verify the data is send to Microsoft SharePoint. If the entered credentials are not valid, the sales representative will get an error message and returns to the *Login screen*. Otherwise the metadata of the mobile application will be synchronized with the server application. The synchronization means that the mobile application will receive the content structure of the available data (i.e., the files and folders with metadata like title, length or modification date) and stores these data in the local database. If the synchronization is completed the sales representatives will be asked if they want to download all files to make them

## 6. Conception and Architecture

available for offline usage. After the procedure is completed the sales representative will be forwarded to the *Browse screen*.

### 6.3.2. Data structure

As already described, the mobile application provides an image of the available content structure from the server application. The virtual copy on the mobile application is generally metadata based. Thereby, it is possible to completely change the structure of the representation easily as the structure is not hard-coded. After discussions with contact persons, the mobile application should provide the same folder based structure as Microsoft SharePoint to ensure familiarity with the already known system.

### 6.3.3. Metadata

The metadata based representation needs different information to handle the folder based structure. These are described in the following:

- **Unique ID:** The content needs an unique identifier number to address the content.
- **URI:** A URI to the content is required to download and save the content.
- **Modification date:** The modification date is needed to detect changes on resources.
- **Size:** The size is needed to get information about the download process. Thereby, sales representatives are able to estimate the needed time for the download based on the internet bandwidth.
- **Title:** The title is used for the representation of the file on the iOS device.

### 6.3.4. Data model

The structure of the data model is presented in figure 6.3 and will be described in the following. The `File` table contains an attribute `length` that provides information

about the file size, an attribute `guid` (Global Unique ID) to identify the resource and an attribute `is_local` that provides information if the file exists local. The `Folder` table also contains an attribute `guid` for the identification and an attribute `item_count` that provides information about the number of items the folder contains. More information about the `Folder` and `File` table are provided by the `Metadata` table. The latter contains attributes `created_at`, `updated_at`, `client_url` (provides information about the relative file path in Microsoft SharePoint) and `title` (provides information about the representation). The `FileLogWrapUp` table contains attributes about the location of the sales representative (`longitude` and `latitude`) and a timestamp attribute `created_at`. Information about a customer visit is presented by the `WrapUp` table. The table contains like the table `Favorite` and `Recent`, an attribute `name` that provides information about the representation and timestamp attributes (`created_at` and `updated_at`). The `FavoriteItem` table contains an attribute `created_at` that represents a timestamp. The `FileLogRecents` table contains attributes about the location (`longitude` and `latitude`) and a timestamp attribute `created_at`.

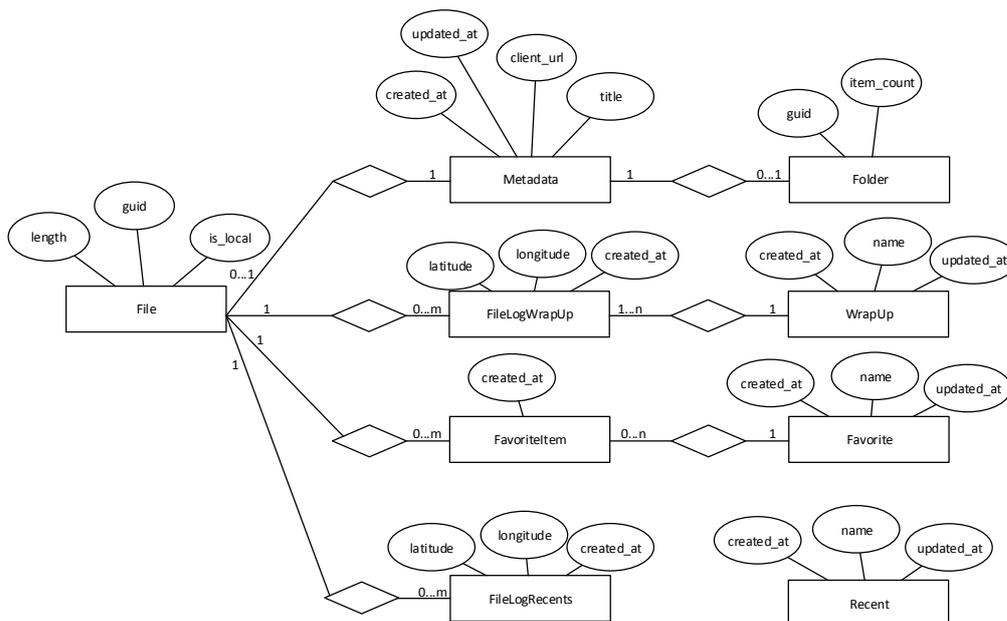


Figure 6.3.: ER-Diagram of the mobile application.

## 6. Conception and Architecture

### 6.3.5. Files

Files are stored in `ApplicationDirectory/files/guid.filetype` on the internal storage of the iOS device. The `guid` is thereby the global unique identifier of the file and is provided by the database. The `filetype` is extracted by the `client_url`. If the user downloads a file successfully the `is_local` attribute of the file in the database will be updated and set to `true`. The mobile application needs to support PDF files, MP4 files and HTML5 applications. Based on discussions with contact persons, HTML5 applications are provided as ZIP packages with a predefined folder structure. Thereby, an `index.html` file has to be present in the root directory of the ZIP packages. This file is used as entry point if sales representatives starts a HTML5 application.

### 6.3.6. REST API

The connection of the mobile application with Microsoft SharePoint is realized using the REST API. The RESTful HTTP request to receive all items in the document library `Epsilon` is presented in listing 6.1.

Listing 6.1: REST request to receive all items in the document library `Epsilon`

```
1 http://server/site/_api/web/getbytitle('Epsilon')/Items
```

The XML response is presented in listing 6.2. Thereby, all available files and folders in the document library `Epsilon` are listed. The `FileSystemObjectType` provides information about the type of the element (e.g. file or folder). Detailed information about the file or folder (for example the *servers relative URI*) are available using an additional RESTful HTTP request for the specific file or folder.

Listing 6.2: XML response of the REST request

```
1 <entry m:etag="2">
2   ...
3     <d:FileSystemObjectType m:type="Edm.Int32">0
4     </d:FileSystemObjectType>
5     <d:Title>Product Propof</d:Title>
```

```
6      <d:Modified m:type="Edm.DateTime">2015-05-11
7      T11:59:52Z</d:Modified>
8      <d:GUID m:type="Edm.Guid">733bf668-2204-42ff
9      -a62f-995c9c291e15</d:GUID>
10     ...
11 </entry>
12     ...
```

The mobile application uses JSON responses instead of XML because of its reduced data size. Therefore, the RESTful HTTP request `Accept` header is set to `application/json;odata=verbose`. The components of the mobile application will be described in the following section in detail.



# 7

## Implementation

The following section describes implementation aspects of the mobile application. Microsoft SharePoint will thereby not be described as all necessary functions are provided by default and no further implementation needed to satisfy the requirements described in section 4.3. Therefore, this section concentrates on the implementation of the mobile application.

### 7.1. Model-View-Controller

The mobile application is developed based on the Model-View-Controller (MVC) architecture. MVC divides a software application into three parts: The *model* manages the data model, the *view* represents the output and the *controller* manages interactions. Figure 7.1 presents the collaboration of the MVC components [Sch12].

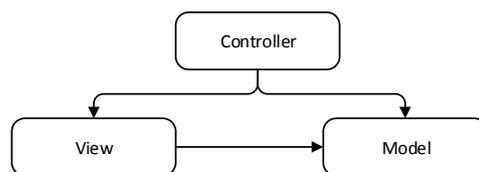


Figure 7.1.: Collaboration of the MVC components [Sch12].

## 7. Implementation

### 7.1.1. Model

An overview of the model classes in the mobile application is presented in figure 7.2. These can be categorized into three different categories: Models for *Cells*, Models for *iOS Core Data* and *Service classes*.

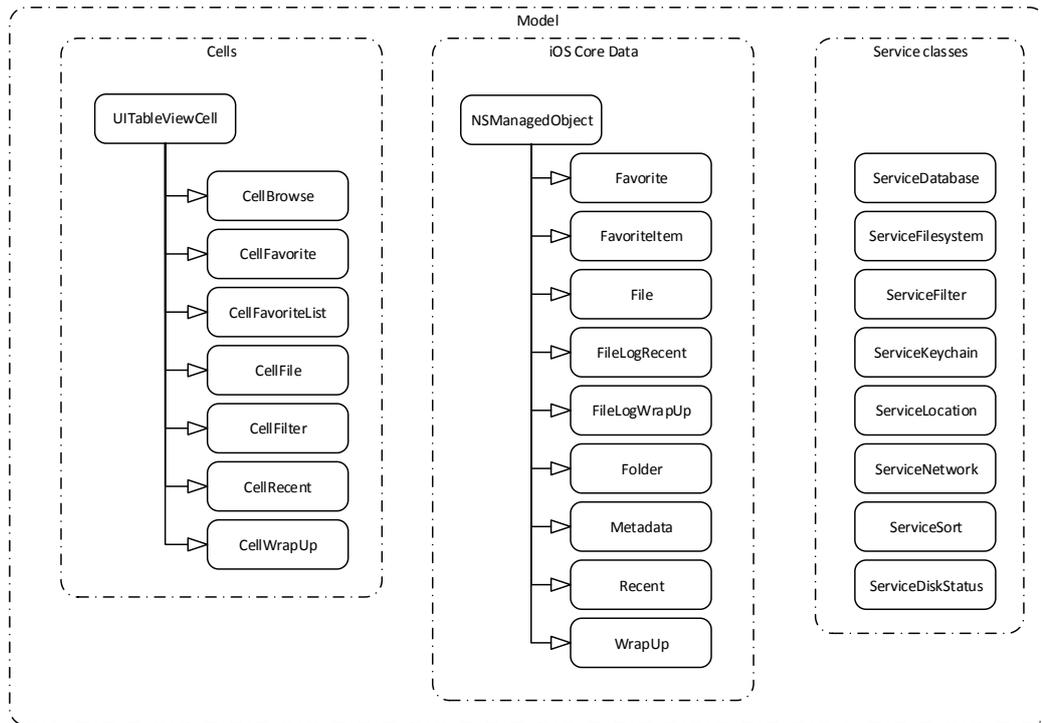


Figure 7.2.: Class diagram of the models in the mobile application.

There are different types of service classes available. Some of them are historically created and are not used actually any more like, for example, *ServiceLocation*. Important service classes are described in the following:

- **ServiceDatabase:** The ServiceDatabase class provides operations for the communication with the database of the mobile application. These are, for example, methods to get all files in a specified path or to add a file to a favorite list.

- **ServiceFilesystem:** The ServiceFilesystem class provides functions for dealing with the file system. These are, for example, functions to create directories or delete files like the database file (e.g., during the log-out process).
- **ServiceKeychain:** The ServiceKeychain class provides functions to store and retrieve configuration values like the username and the password.
- **ServiceNetwork:** The ServiceNetwork class provides functions to retrieve meta-data and download files from Microsoft SharePoint.
- **ServiceDiskStatus:** The ServiceDiskStatus class provides functions for the info screen. Thereby, information about the free disk space and used space are presented.

### 7.1.1.1. Notification

There are generally two different types of notifications: Pull or push notifications. The difference between these two types will be described based on the scenario of the mobile application. On the one side, if the mobile application uses pull notifications, the client has to ask the server if there are new files available. On the other side the server informs the client about new files (i.e., push notification). After discussions with contact persons, the mobile application uses pull notifications to check for updates. The procedure to check for new files is presented in the following:

1. Initialize a variable `newFilesCount` for new or changed files with 0.
2. Send a RESTful HTTP request to receive all available files for the sales representative from the document library.
3. Loop through all items (e.g., files and folders)
  - if the item is a file then send another RESTful HTTP request to receive metadata about the file
    - If the file type of the file is supported by the mobile application (the supported file types are separately stored within the mobile application) then check the file if the metadata has changed. If the metadata has

## 7. Implementation

changed or the file does not already exist in the local database increment the variable `newFilesCount`.

The user interface represents the calculated variable `newFilesCount` to inform sales representatives about possible updates (and if so, how many files need to be updated).

### 7.1.1.2. Update Metadata

The method to update new metadata is presented in the following. The method is used if a sales representative logs in or wants to synchronize for updates.

1. Initialize an array with string dictionary types for the files (`files`) and an array string dictionary types for the folders (`folders`).
2. Send a RESTful HTTP request to receive all available files for the sales representative from the document library.
3. Initialize an integer array for the index of files (`indexFiles`) and an integer array for the index of folders (`indexFolders`).
4. Loop through all items (e.g., files and folders)
  - if the current item is a file then store the current index to the array `indexFiles`. Otherwise store the index to `indexFolders`.
5. if the length of `indexFolders` and `indexFiles` is 0 then return.
6. Otherwise continue and loop through the array `indexFiles`.
  - Send another RESTful HTTP request to receive metadata for the file
  - Initialize a string dictionary type for the file (`file`) and store all metadata.
  - Append `file` to `files`.
7. Loop through the array `indexFolders`
  - Send another RESTful HTTP request to receive metadata for the folder
  - Initialize a string dictionary type for the folder (`folder`) and store all metadata.

- Append `folder` to `folders`.
8. Filter all files based upon the supported filetypes of the mobile application.
  9. Loop through all files in the local database (`localFile` is the current item).
    - Initialize a variable `removeLocalFile = true` that provides information if the file in the database should be removed.
    - Initialize a variable `removeFile = true` that provides information if the file by itself should be removed.
    - Loop through all `files` (`file` is the current item).
      - if the global unique ID of `localFile` equals the global unique ID of `file`
        - \* Compare `localFile` and `file` if the `length` or `updated_at` attribute changed. If the attributes are not changed then set `removeLocalFile = false`.
        - \* Update the metadata of the local file with the received metadata `file`.
        - \* Set the variable `removeFile = false`
    - if `removeLocalFile` is true then delete the local File and update the attribute `is_local` of the local file in the database.
    - if `removeFile` is true then delete the file in the database as the file does not exist anymore in the repository of Microsoft SharePoint.
  10. filter `files` for new files (files that are not in the database yet and store these filtered files in the database)
  11. Loop through all folders in the local database (`localFolder` is the current item).
    - Initialize a variable `removeLocalFolder = true` that provides information if the folder in the database should be removed.
    - Loop through all `folders` (`folder` is the current item).

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- if the global unique ID of `localFile` equals the global unique ID of `file`
    - \* Update the metadata of the local folder with the received metadata
    - \* Set the variable `removeLocalFolder = false`
  - if `removeLocalFolder` is true then delete the folder in the database as the folder does not exist anymore in the repository of Microsoft SharePoint.
12. filter *folders* for new folders (folders that are not in the database yet and store these filtered folders in the database)

### 7.1.2. View

An overview about the view classes of the mobile application is presented in figure 7.3. *Cell* classes contains `UITableViewCell` elements and the `LaunchScreen` presents the view during the start of the application. All other user interface elements are included in the `Main.storyboard` file.

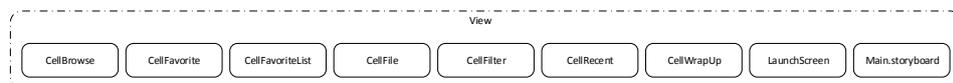


Figure 7.3.: The view classes of the mobile application.

The user interface of the mobile application is realized using a split view (see figure 7.4). The left side of the split view contains the navigation including a tabbar with buttons (browse, favorites, wrap-up, recents and info). The right side of the split view contains detailed information for the selected navigation item.

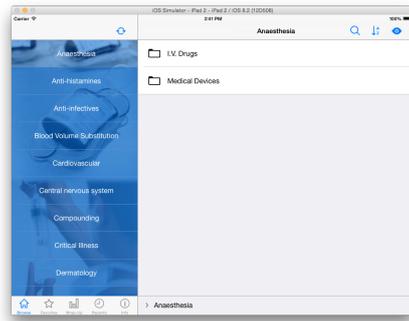


Figure 7.4.: Basic user interface of the mobile application.

### 7.1.3. Controller

The relationship of the controller classes is presented in figure 7.5. It represents the technical implementation of the general workflow described in section 6.3.1. All Controller views except the `SplitController` and the `TabController` inherit from `UIViewController`. The `SplitController` inherits from `UISplitViewController` and the `TabController` inherits from `UITabBarController`.

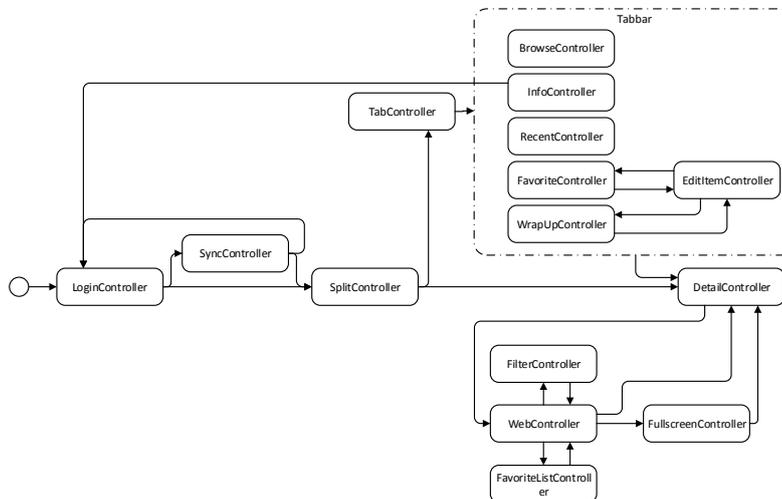


Figure 7.5.: General workflow of the controller classes.

## 7. Implementation

The interaction with files and folders is implemented in the `DetailController`. If the user selects a file that is not already downloaded on the mobile device then the download will be automatically started in the background. The user gets information about the download process and the file size during the download (see figure 7.6).

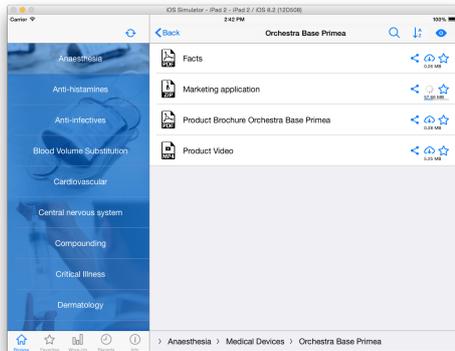


Figure 7.6.: Download on the mobile application.

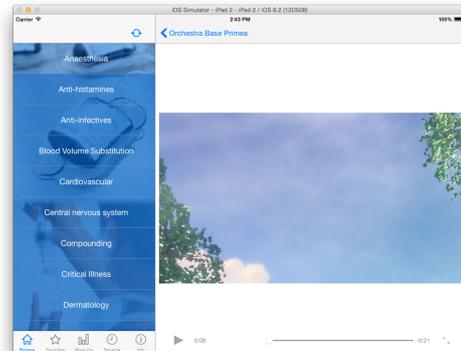


Figure 7.7.: View playback on the mobile application.

If the user selects a file that is already present on the mobile device it will be opened via a `WebView`. Video files (MP4 filetypes) are embedded in a HTML file (see listing 7.1) which will then be loaded.

Listing 7.1: Method that is called if the `WebView` appears

```
1 override func viewWillAppear(animated: Bool) {
2     if (webViewPath.pathExtension == "mp4") {
3         var webData: NSString =
4             "<html><head></head><body>" +
5                 "<video id=\"waterfallVideo\" controls=\"true\"
6                 allowfullscreen=\"false\" src=\""+webViewPath.
7                 stringByAddingPercentEscapesUsingEncoding
8                 (NSUTF8StringEncoding)!+"\" width=\"690\"
9                 height=\"690\"/>" +
10            "</body></html>"
11        self.btnFullscreen.hidden = true
12        self.btnFullscreen.userInteractionEnabled = false
```

```

13         wvContent.loadHTMLString(webData as String,
14         baseURL: NSURL(fileURLWithPath: NSBundle.
15         mainBundle().bundlePath))
16     } else {
17         var url = NSURL(fileURLWithPath: webViewPath)
18         var request = NSURLRequest(URL:url!)
19         wvContent.loadRequest(request)
20     }
21 }

```

If the user selects a ZIP file (HTML5 application), it will be extracted into a temporary directory on the mobile device. After extracting, the `index.html` file in the root folder of the ZIP file will be loaded inside the `WebView` of `DetailController`. The implementation of this process is demonstrated in listing 7.2.

Listing 7.2: Method that extracts and start a HTML5 application.

```

1     func startHTMLApp(filePath: String) {
2         let tmpDir = NSTemporaryDirectory() as String
3         let unzipStatus = SSZipArchive.unzipFileAtPath(filePath,
4         toDestination: tmpDir)
5         webViewPath = tmpDir.stringByAppendingString
6         (filePath.lastPathComponent.stringByDeletingPath
7         Extension).stringByAppendingString("/index.html")
8         performSegueWithIdentifier("DetailToWeb", sender: self)
9     }

```

## 7.2. Frameworks and Libraries

The mobile application uses different frameworks and libraries. The most important will be introduced shortly in the following. The administration of frameworks and libraries is mainly managed with `CocoaPods`, a dependency manager for Swift and Objective-C

## 7. Implementation

Cocoa projects. The handling of the dependency manager is very easy. An existing XCode project has to be initialized with the command `pod init`. This creates a `Podfile` containing default values. The `Podfile` contains the used frameworks of the current iOS application with its version. An example of a `Podfile` is demonstrated based on the mobile application in listing 7.3 (MCD is thereby the name of the mobile application).

Listing 7.3: Podfile of the mobile application.

```
1 source 'https://github.com/CocoaPods/Specs.git'
2 platform :ios, '8.2'
3 use_frameworks!
4
5 target 'MCD' do
6   pod 'Alamofire', '1.2'
7   pod 'SwiftyJSON', '2.2.0'
8 end
```

Frameworks are commonly described like `pod <name of the framework>, <version>`, whereby `version` may be represented as complex structure. For example like `'> 0.1'` (any version higher than 0.1) or `'~> 0.1'` (Version 0.1 and the versions up to 1.0, not including 1.0 and higher) [Coc15].

The `Core Data` is a framework for object life-cycles, object graphs and persistence [App15a]. It is used by `ServiceDatabase` to handle the SQLite database access within the mobile application. The main features of the framework are described in the following according to [App15b]:

- Change tracking and undo support.
- Maintain Relationship.
- The framework loads only data that is currently needed.
- Automatic validation of property values.
- Schema migration.

- Optional integration with the applications controller layer.
- Grouping, filtering, and organizing data in memory and in the user interface.
- Sophisticated query compilation using `NSPredicate`. Thereby, complete queries can be executed. An overview about the syntax of regular expressions can be found on [ICU15].

The `SwiftJSON` framework handles JSON responses using `swift`. The mobile application uses this framework because of its easy handling of JSON data.

HTTP-REST requests and responses are handled with `Alamofire`, a HTTP network library written in Swift. It provides neat features like chainable request/response methods, authentication with `NSURLCredential` (is needed for the authentication with Microsoft SharePoint) and progress closure.

Another called framework is called `SSZipArchive` and is a simple library for working with ZIP files. The framework is manually added as no compatible `CocoaPods` version is provided. It is used to unzip the already mentioned HTML5 applications.

## 7.3. Summary

In this section different aspects of the technical implementation are presented. At the beginning the MVC components of the mobile application are described. Code examples highlight interesting implementation aspects of these components. Afterwards, relevant frameworks and libraries are discussed.



# 8

## Conclusion and Outlook

This section summarizes concepts and approaches for developing the overall IT system. Furthermore, an outlook for additional features and other ways to extend the application is given.

### 8.1. Conclusion

The purpose of this thesis is to improve the distribution of documents within a sales organization. The first part of this thesis introduces fundamentals, which are needed for the further course of this thesis. Thereby, ECM systems are introduced and described. There are many different methods to evaluate decision problems. This thesis can not deal with the whole spectrum of decision making theory. Thereby, MODM methods are introduced to evaluate decision making problems with a finite number of alternatives in a discrete domain [KO14]. Further, functional and non-functional requirements on the overall IT system are defined describing actions on the server and client application. Based on the requirements, an evaluation to find the best matching ECM system as server application is performed with AHP. Thereby, different systems in the ECM market based on studies in addition with fundamental investigation were selected as potentially alternatives. The evaluation figured out that Microsoft SharePoint is the best matching ECM system as server application. Afterwards, the conception and architecture of the overall IT system is presented. The client application is implemented as native iOS application based on the requirements. In addition, some implementation highlights of the mobile application is presented. This section provides an overview about the thesis and requirements comparison followed by an outlook.

## 8.2. Requirements comparison

This section discusses requirements from section 4 in regards to their successful realization.

Requirement	Achieved	Description
CFR1	✓	Sales representatives are able to sign-in and sign-out.
CFR2	✓	Documents can be accessed and viewed.
CFR3	✓	A sort functionality is realized.
CFR4	✓	A search functionality is also realized.
CFR5	✓	A filter functionality is also realized.
CFR6	✓	The synchronization is realized. Thereby, sales representatives are able to download all available files, selected files or only the structure of the repository.
CFR7	✓	A history functionality is also implemented.
CFR8	✓	A basic wrap-up functionality is realized.
CFR9	✓	A favorite functionality is realized.
CFR10	✓	PDF files, HTML5 applications and MP4 files are supported by the mobile application.
CNR1	✓	The mobile application is compatible to iOS.
CNR2	✓	The layout matches the <i>Epsilon</i> styleguide.
CNR3	✓	Multilingualism is supported by Base Internationalization.
CNR4	✓	Selected files are stored on the mobile application. Thereby, no internet connection is requirement to open these files.
CNR5	✓	The mobile application provides fast access because it is implemented as native application without any middle-ware.
CNR6	✓	The mobile application was developed in-house.

Requirement	Achieved	Description
SFR1	✓	Document administration is provided by Microsoft SharePoint.
SFR2	✓	User administration is provided by Microsoft SharePoint.
SFR3	✓	Document assignment is provided by Microsoft SharePoint.
SFR4	✓	Web accessibility is provided by Microsoft SharePoint.
SFR5	✓	An API to connect any application with Microsoft SharePoint is provided.
SFR6	✓	Microsoft Office is supported by Microsoft SharePoint.
SFR7	✓	Microsoft SharePoint supports workflows.
SNR1	✓	The administration is user-friendly via web browser.
SNR2	✓	Microsoft SharePoint is an on-premises software.
SNR3	✓	Support for Microsoft SharePoint is available.

### 8.3. Outlook

The realized IT system offers a lot of possibilities. Furthermore, it may be desired to offer a customer visit preparation process. Therefore, the handling of the mobile application would be more comfortable. An example for such a process is described in the following:

1. In the first step, the sales representative has to select the industrial sector of the customer. For example pharmaceutical or biotech.
2. Then the interested categories of the customer have to be selected. For example like infusion-therapy or drugs.
3. Finally, some tags can be added. For example antibiotic.
4. Based on this input, matched content could be selected in Microsoft SharePoint and automatically be downloaded to the mobile device.

Additionally, the IT system could be connected to the customer relationship management system to provide more information about customers. Thereby the customer satisfaction could be increased. Another idea to improve the overall IT system is to connect the mobile application with calendars of the sales representatives. Thereby, customer visits could be prepared in time. Necessary content could be automatically downloaded. The customer visit could also be analyzed during a wrap-up process or by statistics like

## *8. Conclusion and Outlook*

opened files during the customer visit. As it can be seen, the overall IT system is a great potential and versatile use for sales organizations.



## Appending

### A.1. Enterprise Content Management systems

- **Bitfarm-Archiv:** Bitfarm Archiv is an open source Document Management System platform in its current version 3.5.4 and was released on December 2014. It provides features like revision safe archiving, integrated open source OCR full text indexing (section 2.2.2.1), automatic keywording and workflow support [Bit15].
- **ELO ECM Suite 9:** Elektronischer Leitz Ordner (ELO) is a software platform in its current version 9. It is available in three different versions, ELOoffice (recommended for small organizations), ELOprofessional (recommended for medium-sized organizations) and ELOenterprise (recommended for large organizations). Detailed information about the variants can be found at [ELO15]. The ELOenterprise variant includes an integrated workflow, OCR full text indexing (section 2.2.2.1), automatic keywording and an enterprise search technology.
- **LogicalDOC:** LogicalDOC is a Document Management System. Its current version 7.3 exists in three different versions, LogicalDOC Enterprise & Cloud, LogicalDOC Business and LogicalDOC Community. An overview about the differences between these version can be found at [Log15]. The core features of LogicalDOC can be divided into document management, document import and synchronization, collaboration, administrative, protocols and integrations.
- **Xerox DocuShare:** According to a contact person of Xerox, DocuShare was the first web-based Document Management System offered to the market in 1997. The latest version 6.6.1 R2 was released in November 2014. Its main features

## A. Appending

can be described as core content management, business process automation, intelligent Capture, collaboration and governance, risk and compliance [Xer15]. The management tool supports multiple languages. These can be downloaded and edited with a localization kit.

- **DocuWare:** DocuWare is a product suite of document management software and is generally available as DocuWare Cloud or as DocuWare on-premise. There are three licensing variants available, DocuWare Business Server (recommended for small organizations with one server), DocuWare Professional Server (recommended for medium-sized organizations with unlimited file cabinet size) and DocuWare Enterprise Server (recommended for large organization with unlimited support of organizations) [Doc15a]. An overview about the functionality of DocuWare can be found at [Doc15b].
- **Hyland Software OnBase:** OnBase is an ECM software product suite by Hyland and is currently in version 15. The developer organizes the capabilities of OnBase 15 in capture, manage, access, integrate, measure and store component. Detailed information can be found at [Hyl15]. According to [GSC<sup>+</sup>14], Hyland has increased its presence in larger enterprises.
- **EMC Documentum:** EMC Documentum is an ECM platform by EMC Corporation and is available as on-premise system and as online system in the cloud. It provides all elements of an ECM system by a set of full-functioned and scalable products [GSC<sup>+</sup>14]. The advanced, configurable client for Documentum ECM is named as Documentum D2. More information about EMC Documentum D2 can be found at [EMC15].
- **Lexmark Enterprise Software:** Enterprise Software, formerly Perceptive Software, is a stand-alone software by Lexmark International. The fundamental functionality includes capture, workflow capabilities, search and analytics technologies, content management and a cloud-based video content management platform [GSC<sup>+</sup>14][Lex15].

## A.2. Analytic Hierarchy Process: Power iteration

- **HP Autonomy ECM:** Autonomy ECM is an ECM Suite by HP and includes tools for capture, process automation, records management and governance, documentation and WCM [GSC<sup>+</sup>14]. More information can be found at [HP15].
- **Newgen Omni Suite:** Newgen Omni Suite is a software suite by Newgen Software, an India company. It includes several software like OmniDocs, OmniScan, OmniFlow, records management system and ZapIn. The functional components of Newgen Omni Suite can be divided into document management, capture and imaging, workflow, records management, WCM, social and extended components (for example like digital asset management, advanced searches or email archival). More information can be found at [New15].
- **Oracle WebCenter Content:** Oracle WebCenter Content is an enterprise content management solution and includes document management, capture and imaging, OCR, BPM, records and retention management, digital asset management and web content publishing. The enterprise content management solution can be completed by Oracles Portal offerings (for example Oracle ERP tools [GSC<sup>+</sup>14]). More information can be found at [Ora15].

## A.2. Analytic Hierarchy Process: Power iteration

The calculation of the eigenvalue uses a iterative method based on *squaring*, *normalization* and *calculation* of the weight.

	Evaluation Matrix			Normalized Matrix			row-sum	Weight
	$A_1$	...	$A_n$	$A_1$	...	$A_n$	$r_i$	$w$
$A_1$	$a_{11} = 1$	...	$a_{1n}$	$\frac{a_{11}}{c_1}$	...	$\frac{a_{1n}}{c_n}$	$r_1$	$w_1 = \frac{r_1}{n}$
$\vdots$			$\vdots$	$\vdots$		$\vdots$	$\vdots$	$\vdots$
$A_n$	$a_{n1} = \frac{1}{a_{1n}}$	...	$a_{nn} = 1$	$\frac{a_{n1}}{c_1}$	...	$\frac{a_{nn}}{c_n}$	$r_n$	$w_n = \frac{r_n}{n}$
$c_j$	$c_1 = \sum_{i=1}^n a_{i1}$	...	$c_n$	1	...	1	$n$	1

### A. Appending

1. Firstly the evaluation matrix has to be normalized. Therefore, the sum of the columns ( $c_j = \sum_{i=1}^n a_{ij}$  where  $n$  is the number of columns) have to be calculated. The elements of the matrix have to be divided through the calculated sum of the columns ( $a_{ij} = \frac{a_{ij}}{c_j}$  with  $i = 1, \dots, n$  and  $j = 1, \dots, m$ ) to get the normalized matrix. Then the rows of the normalized matrix will be added summarized ( $r_i = \sum_{j=1}^n a_{ij}$ ). The weights of the alternatives (principal right eigenvector) are calculated by dividing the summarized rows through the number of elements in the row ( $w_i = \frac{r_i}{n}$ ).
2. In the second step the evaluation matrix of step 1 has to be squared. The square evaluation matrix will be used to calculate the weight of the alternatives according to step 1. The process of *squaring, normalization, calculation of the weight* will be repeated as long as the values of the calculated weight differentiates strong.

### A.3. Analytic Hierarchy Process: Criteria

	Costs	In- stallation	In- House	Support	Scal- ability	Docu- mentation
Costs	1	3	1/3	1/3	1/3	1/3
Installation		1	1/3	1/3	1/3	1/3
In-House			1	1/3	5	5
Support				1	5	3
Scalability					1	1
Documentation						1

Table A.1.: Weight of the system criteria

	User interface	Access to infor- mation	User and rights management
User interface	1	1/7	1/5
Access to information		1	3
User and rights man- agement			1

Table A.2.: Weight of the usability criteria

### A.3. Analytic Hierarchy Process: Criteria

	Connection	Workflow support	Multilingualism
Connection	1	5	3
Workflow support		1	1/5
Multilingualism			1

Table A.3.: Weight of the extensions criteria

	Indexing	Offline functional- ity	Document func- tionality
Indexing	1	3	1/5
Offline functionality		1	1/5
Document functionality			1

Table A.4.: Weight of the administration of documents criteria

	System stability	Data protec- tion	Logging	Encryption
System stability	1	3	7	3
Data protection		1	5	3
Logging			1	1/5
Encryption				1

Table A.5.: Weight of the security criteria

A. Appending

**A.4. Analytic Hierarchy Process: Attributes**

Installation	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Scalability	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Indexing	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Offline functionality	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Document functionality	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

#### A.4. Analytic Hierarchy Process: Attributes

System stability	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Data protection	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Logging	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

Documentation	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	3
IBM Connections		1	1	3
Alfresco			1	3
Liferay				1

Workflow support	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	3	3	3
IBM Connections		1	3	3
Alfresco			1	1
Liferay				1

User and rights management	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	3
IBM Connections		1	1	3
Alfresco			1	3
Liferay				1

A. Appending

costs	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	9	9
IBM Connections		1	9	9
Alfresco			1	1/3
Liferay				1

Access to information	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	3
IBM Connections		1	1	3
Alfresco			1	3
Liferay				1

User interface	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	3
IBM Connections		1	1	3
Alfresco			1	3
Liferay				1

Encryption	MS SharePoint	IBM Connections	Alfresco	Liferay
MS SharePoint	1	1	1	1
IBM Connections		1	1	1
Alfresco			1	1
Liferay				1

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**Declaration**

I hereby declare that I wrote the master thesis independently and used no other aids than those cited.

Ulm, .....

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