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Exploring barriers of enterprise search implementation: a qualitative user study

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Abstract

Purpose – Despite a growing demand for enterprise search from practice, little is known about its implementation from an academic perspective. As the few available practice-oriented investigations show, enterprise search user satisfaction is rather low. The purpose of this paper is therefore to explore user-centric barriers of enterprise search implementation in order to increase user satisfaction.

Design/methodology/approach – Results are built on a qualitative user study in an R&D organization. Findings are gained from think-aloud observations introduced by semi-structured interviews in which ten knowledge workers explore a newly implemented enterprise search tool.

Findings – Findings illustrate barriers that knowledge workers have to overcome when adopting enterprise search to find project-relevant documents. Implementation barriers relate to selection for keywords, search query formulation, availability and adequacy of metadata, relevance judging of search results, current search strategies, and overall perception of enterprise search usefulness.

Research limitations/implications – Limitations address the piloted enterprise search software, along with its specific configuration and scope, the chosen research approach of generating qualitative findings from a single case, and the size of the involved sample of engineers. Implications address measures to increase enterprise search adoption.

Practical implications – This study provides project managers with knowledge to take appropriate actions in the early phases of enterprise search implementation, and even prior to that, to raise the success of enterprise search projects. It contributes to a better understanding of enterprise search engine user needs and assists in concretizing user requirements.

Originality/value – While existing studies primarily focus on advancing the technical perspective of search in organizations, the author elaborate on the under-investigated social and organizational aspects. The author furthermore stress the importance of user-centered approaches for enterprise search adoption.

Keywords Information retrieval, Information systems, Information management, Knowledge management, Enterprise search

Paper type Research paper

1. Introduction and motivation

Google responded to 1.2 quadrillion search queries from users around the globe in 146 languages in 2012 (Google, 2012). By ranking web sites in search result lists based on the importance of incoming links (Page *et al.*, 1999), Google steadily, over the past decade, became the archetype of an easy-to-use search tool known for excellent results. It also revolutionized the way users acquire and organize their information, and many innovations in information systems (IS) originated from the web since then.

With this transition, "web search" as a research topic developed a rich body of scientific publications over the last years: Scientific contributions range from query log analysis (Silverstein *et al.*, 1999), information quality investigation (Knight and Burn, 2005), search engine evaluation (Oppenheim *et al.*, 2000), and information-seeking exploration (Spink *et al.*, 2001; Su, 2003; Chau *et al.*, 2005) to the discussion of top level challenges including spam, content quality, quality evaluation, web conventions, duplicate hosts, and vaguely structured data (Henzinger *et al.*, 2002).

Despite existing differences, there are many web search-related phenomena in the context of enterprise IS, and searching for information behind a firewall has also become an important topic. Whereas organizational knowledge has been a widely recognized source for organizational success, innovation, and competitiveness (Tsoukas and Vladimirou, 2002; Bollinger and Smith, 2001), the increasing amount of knowledge work contributed to an explosion of corporate information stored in heterogeneous documents on file servers, in databases, and on intranets. Current knowledge-sharing phenomena relating to social computing (McAfee, 2006; Zhang *et al.*, 2010; Aral *et al.*, 2013) accelerate the rise of worker-generated content and the need for powerful search capabilities (Richter *et al.*, 2013). As a response to emerging enterprise IS with content in different formats, organizations have made notable efforts to establish intra-organizational search engines. A recent report numbers the total revenue of EU-headquartered search vendors such as Autonomy and Sinequa between €100 million and €200 million (White and Nikolov, 2013).

Against the background of the growing demand for information retrieval technology to find relevant information in organizations, also termed "enterprise search" (Hawking, 2004), it is surprising that there is a lack of research on its adoption. Whereas recent industry-oriented reports from MindMetre (2011) and Findwise (2012) showed that satisfaction with enterprise search is still comparably low, existing studies almost exclusively focus on the technical perspective of search engines, for instance search algorithms (Li *et al.*, 2013). Studies on user-centric aspects of enterprise search, especially phenomena related to information system adoption, are scarce.

With this study, we provide a case on enterprise search implementation and adoption barriers to support decision-makers in managing enterprise search projects. We shed light on how knowledge workers from the engineering domain utilize a piloted enterprise search for seeking project-relevant documents and reveal interesting challenges they experienced while exploring this tool. A strategic intention of this research is to stress the importance of qualitative user studies in investigating enterprise search challenges and barriers, aiming to increase system adoption, and user satisfaction. To explore enterprise search adoption challenges, we formulate our research question as follows:

RQ1. Which barriers hinder enterprise search implementation from a user perspective?

To approach this research question, we study enterprise search user behavior in an R&D organization. We have analyzed how knowledge workers from the engineering domain utilize the enterprise search of Microsoft SharePoint Foundation 2013, a web-based collaboration environment, during a pilot. Applying think-aloud observations introduced by semi-structured interviews, we conduct research on enterprise search implementation barriers from a social perspective. By doing so, we shed light on how engineers may factually apply enterprise search in a project work context, explore how satisfied they are by managing their newly introduced search capabilities, and investigate their overall user satisfaction. Our main contribution is the identification of user-centric

enterprise search implementation barriers related to keyword selection and search query formulation, availability and adequacy of metadata, judging the relevance of search results, current search strategies, and overall perception of usefulness.

In the next section, we provide background knowledge on enterprise search, especially its foundations and scientific coverage. We then continue with a more detailed background study and a literature review of enterprise search studies, and differentiate enterprise search from web search. The research methodology is outlined in more detail in Section 4. Section 5 presents the findings of the empirical study and enterprise search implementation barriers, and this is discussed in Section 6. The paper concludes in Section 7.

2. Enterprise search background study

Enhancing knowledge workers' productivity is recognized as one of the biggest challenges in management (Drucker, 1999). A plethora of knowledge management initiatives have therefore been launched to handle organizational data, information, and knowledge in a better way by implementing knowledge management systems (Maier, 2007). Many knowledge management projects have primarily focussed on data warehousing and document repositories linked to search engines supporting the digital capture, storage, retrieval, and distribution of an organization's explicitly documented knowledge (Hahn and Subramani, 2000).

Because knowledge is a condition of access to information, and the focus of knowledge management is managed access to knowledge and information, a crucial role of information technology in knowledge management is to provide effective search and retrieval mechanisms for locating relevant knowledge (Alavi and Leidner, 2001). Being aware of all potential work-relevant information and knowledge is an important current and future task for knowledge workers (Jadaan and Stenmark, 2008). Subsequently, knowledge workers will also require powerful search capabilities behind firewalls, as by far most information found in enterprises is still unstructured, i.e. not part of relational databases (Muckherjee and Mao, 2004).

Hawking (2004) was one of the first researchers to engage with search in organizations. According to Hawking, enterprise search includes search of an organization's external and internal web sites as well as search of other electronic text the organizations have in the form of e-mails, database records, and documents on file shares. Enterprise search differs from web search in several ways, for example the notion of a good answer to a query, the social forces behind the creation of content, and the different content processes (Muckherjee and Mao, 2004).

As the theoretical foundation of enterprise search, information retrieval theory has a long history in the scientific community, especially in library and information science (Harman, 2011). It gained broader attention through the evolution of the web as a global information space and the need for better search capabilities. Compared to searching for information on the web, searches behind firewalls has gained much lower academic attention. The Seventeenth Text Retrieval Conference (TREC), a major scientific event for information retrieval research, has offered an enterprise track in the past, providing a test collection for enterprise search researchers. This proposed enterprise search test collection only includes documents of the public-facing web of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO), but no documents from a "real" corporate intranet. Search tasks related to this test collection involved generic documents and expert search, but users had to search the public-facing enterprise web for answers and resources (Balog *et al.*, 2008), and not an intra-organizational

knowledge repository. As a matter of fact, the ecosystem the TREC enterprise search test collection provided, differs from a real corporate intranet, and explorations built on it might be different to those in a real corporate environment.

In the past, evaluation in information retrieval mainly focussed on the information system part (Wu *et al.*, 2009), providing a set of queries and associated relevance judgments for a test collection like the one from the TREC enterprise search community. The effectiveness of an information retrieval system, a major topic in research, is basically measured by recall and precision. While "recall" is defined as the ratio of the number of relevant documents retrieved to the total number of relevant documents in the whole collection, "precision" is the ratio of the number of relevant documents retrieved to the total number of documents retrieved (Harman, 2011). The technical dimension of enterprise search is to a major extent satisfactorily covered by information retrieval researchers.

Though searching for information in an organizational knowledge base seems to have generated lucrative business (White and Nikolov, 2013), a literature review revealed that comparably few publications explicitly focus on "enterprise search." Surprisingly, enterprise search seems to have received little attention by the IS community, as in particular querying the repository of the Association for Information Systems revealed. Especially the social concepts of enterprise search, including "usefulness" (Davis, 1989), "user satisfaction" and "appropriation" (Stocker *et al.*, 2012), have not sufficiently investigated yet.

Subsequent practitioner-oriented desktop research revealed two widespread industry reports on enterprise search adoption: The "Enterprise Search and Findability Survey 2012" (Findwise, 2012) revealed that enterprise search user satisfaction seems to be generally low. About 60 percent of the surveyed people consider search on the web to have a significant influence on enterprise search, and they expect enterprise search to work as well as web search. The second report, "Mind the Enterprise Search Gap" (MindMetre, 2011), surveyed about 2,000 managers and discovered that about half of the respondents are unable to find the information they are seeking using their organizations' enterprise search capability in an acceptable timeframe, which was perceived as less than two minutes. Both reports outlined the phenomenon of high search expectations of users and the dissatisfying factual situation of poor user satisfaction. The reasons for this "search gap" were not revealed in any of the two reports, and have not yet been investigated by researchers in scientific empirical studies.

3. Enterprise search literature review
The results of the preliminary background analysis on enterprise search presented in Section 2 motivated the execution of a more comprehensive literature study with a bigger scope. Because this research is focussed on exploring barriers of enterprise search implementation, we limited our search to the keywords "enterprise search" and "intranet search", using the Google Scholar Search as a starting point for their literature review. This resulted in ten interesting papers, which we considered a starting point for a forward and backward reference search[1] to identify further important papers that could extend their coverage. We also extended our corpus to include papers outside the three big repositories of the scientific communities – AIS, ACM, and IEEE – to retrieve a higher number of scientific studies (see Table I).

In a long-term study of the contextual dimensions of workplace search (a synonym for enterprise or intranet search), Freund and Toms (2006) identified patterns of search behavior specific to software engineers. A group of 32 engineers had to complete search

tasks in a large high-tech company and showed patterns distinct from general web and intranet search. Wu *et al.* (2009) determined the utility of an enterprise search system by the search engine, the users, and the service provider, and argued current evaluations to focus on information retrieval system effectiveness and efficiency only, but hardly on other aspects. Weisman and Bar-Ilan (2010) developed a model to present search results from the organizational portal in the intranet and looked at information search patterns of users in large organizations to improve search interfaces. Access to action-relevant information is a key challenge for knowledge workers, who are a diverse group that perform complex tasks, have complex information needs and a certain degree of freedom in how they accomplish work. While there is general research on the information-seeking behavior of engineers (e.g. Fidel and Green, 2004; Kwasitsu, 2003), empirical studies of knowledge workers in general and engineers in particular using an enterprise search engine have not been conducted. Table II presents an overview of scientific studies on information-seeking in organizational settings along with a summary of their key findings from a user perspective. We outline communalities and differences against our own research scope, the identification of enterprise search implementation barriers.

The literature review revealed a variety of findings. Professionals spend about 25 percent of their time doing searches. Users do not know what is available and could be found. Trust seems to be an important factor, and familiar sources are preferred. Enterprise search seems to change fast, i.e. keywords in use. All studies have in common that they have not researched the non-technical challenges of enterprise search implementation or adoption in detail. None of these papers have been dedicated to exploring enterprise search implementation barriers. Being a major scientific contributor on intranet search, Stenmark (2005a, 2010) provides an explanation for this unsatisfying lack of scientific empirical studies: While much web content is open and public, intranet-motivated information retrieval researchers must engage in a close relationship with an organization to negotiate access to intranet content, which is time consuming or sometimes even impossible due to confidentiality and secrecy. Some researchers may not appreciate the differences between corporate intranets and the web enough, as the technology stays the same. Though modes of use and content are different, researchers may have limited experience of work in corporate settings and may neglect this aspect. Almost nothing is known about intranet information seeking. While information retrieval is recognized as a precise, well-defined and algorithm-oriented act, information seeking is a more open-ended and human-oriented process.

Table III outlines differences between search on the web to search in organizations concerning search space, access to content, ranking and relevance, practiced search optimization, and nature of search results.

4. Research approach

Though quantitative approaches have dominated research in information retrieval, we apply a qualitative approach, including observations and semi-structured

Digital library	"Enterprise search" in title	"Enterprise search" in abstract
Association for Computing Machinery (ACM)	21	53
Institute of Electrical and Electronical Engineers (IEEE)	6	23
Association for Information Systems (AIS)	3	2

Table I.
A comparison of scientific papers on enterprise search in ACM, IEEE, and AIS repositories

Authors	Objective	Key findings	Link to proposed research
Fidel and Green (2004)	Engineers' perception of information sources	Engineers select information sources of the right format and the right level of detail, and have much information in one place	Exploration of general personal information-seeking behavior of engineers
	Interviews	Engineers select human information sources with whom they are familiar
Saving time is the main reason for selecting documentary sources	No investigation of enterprise search implementation
Freund and Toms (2006)	Software engineers' enterprise search behavior	Technical professionals spend about 25% of their time at work for search	Tools for complex queries are required to deal with acronyms, product names, and technical terms
	Task-based approach	Their specialized information needs are not well-served by generic enterprise search tools
Content, format, currency, and authority determine information usefulness	No explicit research on implementation or adoption
Jadaan and Stenmark (2008)	Investigates knowledge workers' information-seeking activities	Users get URLs from colleagues instead of using search engines	Personal, organizational, and global information management addressed
	Interviews	Users trust human filtering more than machines	Users trust coworker-based filtering and information provision more than search
		Users search manually instead of using search tools	Do not explicitly mention search adoption
Kwasitsu (2003)	Information source usage and selection of engineers	Significant differences in information-seeking behavior	Investigation of (general) information-seeking behavior of engineers
	Structured survey questionnaire and semi-structured interviews	The higher an engineer's education, the less likely he depends on personal memories as source of information and the less he considers information tool mastery as a source influencer	No evaluation of enterprise search engine and related adoption aspects
Laqua et al. (2011)	Pilot test and evaluation of knowledge discovery system	Employees do not know what is available on the corporate intranet, in files or stored messages	Investigation of helpfulness
	Semi-structured interviews	Evaluation of helpfulness and distractiveness of a developed prototype	No learnings on search implementation from a qualitative perspective

(continued)

Table II.
Related work in
enterprise search

Table II.

Authors	Objective	Key findings	Link to proposed research
Stenmark (1999)	Methodology for intranet search evaluation. Action research, interviews, field evaluation	Intranet search engines are different from those on the web and must be evaluated differently. Presents a collected list of search features for evaluation	Outlines a methodology for intranet search information system evaluation. No information on user-centric aspects of enterprise search
Stenmark (2005b)	Understand information-seeking behavior of intranet users. Logging analysis of intranet search engine	Number of started search sessions follow business hours. Number of terms per query differ over the day. Number of active users are higher early in the week	Quantitative aspects of corporate search usage. No information on user-centric aspects of search adoption
Stenmark (2007)	Investigates intranet search behavior. Logging analysis of intranet search engine	Intranet search behavior differs from web search. Analysis of terms, pairs, triples, and full queries used. Using term query lists can produce misleading conclusions. New terms are used more often than expected in intranet search. Most queries and terms are replaced from year to year	Focusses on general intranet search behavior. No research on search adoption
Stenmark (2010)	Examination of employees seeking information in intranets. Online survey	Employees prefer to use menus to navigate to information. Poor structures result in difficulty finding the right information	Investigation of intranet usage, including information-seeking. No qualitative learnings on user-centered aspects of search adoption
Teevan et al. (2004)	Investigation on how people motivate searches. Semi-structured interviews	Most observed search behavior does not include keyword-based search engines. Participants use contextual knowledge as a guide when navigating to a target. Search tools should support orienteering behavior	General exploration of searching behavior and strategies. No relation to search adoption
Wu et al. (2009)	Evaluation of the cost and benefit for a provider of a mediated search engine. Case study and user experiments	Using domain experts' relevance assessments in search result ranking improves precision. Search provider receives ROI and higher search success when investing in domain experts for relevance assessments	Measures cost and benefits of human intervention in enterprise search. Does not explore user-centered adoption

Property	Search on the web	Search in organizations
Search space	Interlinked web pages in standard formats	Heterogeneous content (structured and unstructured, files and databases)
Access to content	Search has indexed open content; access rights are not relevant	Complex group and role structures with access rights
Ranking and relevance	Relevance of a web page is (initially) calculated by assessing how many links in which quality point to it	No link structure between documents per default; requires different modes of relevance assessment
Practiced search optimization	Information on the web "wants" to be found and is optimized for search (through SEO – search engine optimization)	Employees are not motivated to optimize documents they have created for search
Nature of search results	Searchers are satisfied with a good answer (out of many possible good answers); search queries are of a more common nature, and many sources provide good answers	In many search cases there is only one document relevant for a particular user, and exactly this one has to be retrieved as fast as possible

Table III.
Search on the web
vs search in
organizations

interviews, to learn more on how knowledge workers in an R&D company use enterprise search, and how they perceive its overall usefulness. While past researchers focussed on the technical aspects of search engine evaluation including data gathering, organization of the search index, search features, interface and docs, and operation and maintenance, we want to elaborate on the under-investigated social aspects to identify barriers that hinder enterprise search implementation from a user perspective.

The empirical study took place in an Austrian organization that conducts research and development projects in the vehicle industry. It employs about 200 people, of whom about 90 percent are engineers. The case organization is currently preserving most of its project-relevant information in folders on a file server, applying a rigorous access rights policy. The enterprise search of Microsoft SharePoint 2013 Foundation, a web-based collaboration platform, has been made available as a pilot to facilitate information search and acquisition[2]. However, the comprehensive collaboration functions of Microsoft SharePoint 2013 Foundation have not been piloted.

Microsoft SharePoint's enterprise search capabilities are utilized to index the documents in the project folders of the two divisions, information and process management, and mechanics and materials, which are located on a file share. We had the opportunity to guide and support the information technology department in evaluating the enterprise search capabilities of Microsoft SharePoint 2013 Foundation with the aim to learn more about enterprise search user behavior in general, and about the requirements of engineers in particular. Their main goal was to reveal which barriers hinder enterprise search implementation from a user perspective.

The study data were collected by conducting ten guided observations of engineers, five from the information and process management division and five from the materials and mechanics division. All participants had to perform search tasks and examine their search experience along the way by having them think-aloud on what they did in the search interface, and why. The respondents were selected carefully to cover different roles, i.e. junior, senior, and lead researchers/engineers.

Before the observations took place, we explained the idea of implementing enterprise search to the participants and asked them the following questions about themselves

and their work: Which tasks do you perform in your department (e.g. project leader)? On which projects do you work (e.g. project XY)? What type of documents do you typically create with which tools (e.g. minutes of meeting created with Microsoft Word)? What information do you need to perform your aforementioned tasks (e.g. current project protocols)? How and how long do you search for information and documents to satisfy your information needs (e.g. 30 minutes per day)? Asking these questions was required to prepare the observations that immediately followed the interviews. With the help of these questions, we could recall a recent instance in which the engineer was looking for particular information in the past to perform a meaningful search task in Microsoft SharePoint 2013 Foundation.

In the past, researchers have used think-aloud tests in this domain, primarily to study user behavior in web search when aiming to work on prepared tasks (Maglio and Barrett, 1997; Muramatsu and Pratt, 2001). The participants in the presented case were assisted during the experiments. Due to the diversity of projects and the rigorous access right policy, preparing generic search tasks suitable for all participants was not feasible. This is not a problem, as we wanted to investigate how participants search and what kind of challenges they faced. The participants had to recall their information need for a specific project task carried out in the past, and then experience the enterprise search to find their requested information. The chosen research strategy allowed the comparison of enterprise search in general in a past situation, providing insights on usefulness and user satisfaction.

All interviews as well as the think-aloud observations were recorded and transcribed. We were especially interested to investigate the search behavior of engineers, study how they formulate search queries, investigate the characteristics of their vocabulary and experience their perception of the usefulness of enterprise search for their work. We applied a strategy similar to Fidel and Green (2004) and met first to analyze a set of transcribed observations to establish the first high-level categories, then analyzed the transcripts individually once they felt the categories were developed well enough. Two researchers independently analyzed all transcribed observations, subsequently discussed new emerging high-level categories and got rid of any discrepancies in the results. The established categories cluster the major findings of this paper on a sufficiently high level to establish a limited set of user-centric implementation barriers of enterprise search.

Table IV provides anonymized information on the ten study participants, including position in organization, required project information, and perceived time used for daily search, gained through the interviews. It excludes any confidential information, e.g. concrete project tasks, or concrete project names.

5. Study results: barriers of enterprise search implementation

This section includes the presentation of findings on enterprise search implementation barriers. In a first step, the participants had to find suitable keywords and formulate a meaningful search query, optionally using the faceted search to narrow down the result set, while recalling a concrete information need of the past (Barrier 1). When the hit list was shown, they had to judge the relevance of their search results by using the available information and navigation (Barrier 2). Availability and adequacy of metadata was an important aspect for both, finding documents (i.e. through metadata in the document content) and filtering search results (i.e. through metadata as document property) (Barrier 3). Because the piloted enterprise search is a new tool for information seeking, participants had to compare the perceived benefits of enterprise

Test user	Position in organization	Required project information	Average time used for search per day
T1	Senior researcher, project manager	Minutes of meeting, project protocols	Not specified
T2	Project staff	Literature, external information sources, description of tasks, presentations	30 minutes
T3	Junior researcher	Visio templates, process documentation, Word documents for proposals, presentations	10 minutes
T4	Software developer	Minutes of meeting	15-30 minutes
T5	Project manager	Information about project management, content activities, and literature	30 minutes
T6	Project manager, cluster management	Templates, protocols, reports, images of evaluations	Not specified
T7	Lead researcher, project manager	Own documents, external information	15 minutes
T8	Project manager, project worker	Project and task descriptions	No daily search
T9	Group manager	Status reports, cooperation contracts, calculation sheets, official documents	15-30 minutes
T10	Project manager, project worker	Presentations, protocols, spreadsheets of controlling department, contracts, etc.	15 minutes

Table IV.
Background
information on
participants

search to their usually practiced information-seeking strategy (Barrier 4). At the end of the observations, each participant had to evaluate the overall usefulness of enterprise search from what they experienced (Barrier 5). Figure 1 is a visualization of these five barriers, along with their relationships. The following subsections outline the identification of the user-centric implementation barriers in more detail.

5.1 Barriers related to keywords selection and search query formulation
To take advantage of an enterprise search capability, participants have to first find the appropriate keywords for their search query. This study showed the underlying thinking process of finding the best keywords to be more or less challenging. If participants had more existing knowledge about the searched information, e.g. the file type and the name of the requested document, they faced fewer problems in formulating a useful first query. "I have packed all my information together. I know that the object is a meeting document, i.e. a docx. Surely 'Stuttgart' will be a term in this document. And 'project meeting' should also be included" (T2). Employees who are aware of the existence of document "archetypes" like project proposals, meeting minutes, and project agendas, had fewer challenges to formulate useful queries. "Well, I am looking for a project
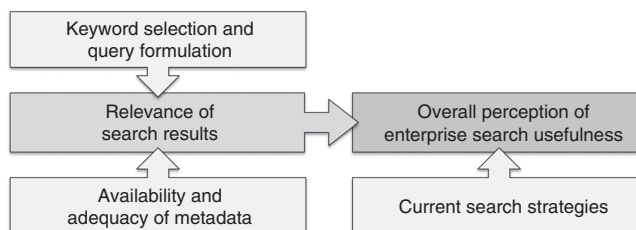

Figure 1.
Overview on barriers
of enterprise search
adoption

agenda. Well ok, but I do not know how and where it has been saved [on the file server], because I have never had a look at it before" (T2). In this project-based organization, most documents were linked to concrete projects. Project names followed a nomenclature, i.e. they have a long title, short title, acronym or another case-specific code. The study participants either used a short title or acronym when building their queries. Many queries led to search results not including the project document the participant was looking for. This was always the case when one of the terms used in the keyword search was not included in the content of the desired document: for instance, the project's full name was used in the search query, but the document only contained the project acronym.

Findings showed document content and structure to play an essential role when searching for information. A user who is aware of the textual content of a document, including author, place, date, project name as well as widely used terms (e.g. meeting minute) may find it much easier to create successful search queries, as this study showed. To illustrate this challenge, we refer to a search task where a participant aimed to retrieve a protocol of the "GNOME" project meeting held in Stuttgart in June 2013. The participant formulated the query "project meeting Stuttgart GNOME," which seems rather obvious, because he knew the project name and the location of the meeting. Nevertheless, he could not find the desired document by using this query. A manual browse through the GNOME project folder thereafter shed more light on the desired document. It was definitely located in the GNOME folder, but did not include the term "Stuttgart" in the document content. Other project meeting protocols, of which this particular searcher was aware, did include the location of the project meeting in its content.

A certain level of commonality in document content and terminology is required to use the potential of enterprise search and rank requested documents in top position without having to use multiple search queries, as this study showed. If the textual content in documents does not follow simple and agreed rules or practices, search query construction will be much like guesswork, as one participant mentioned. "Theoretically we have a convention concerning the formulation of names. But some people use hyphens or underscores. Sometimes even space characters are used. But I think that is a problem in general for all search engines. I would never come up with the idea to separate AreaZ [Area Z]" (T9). Unfortunately, a certain amount of knowledge of the potential content of a desired document and the terminology used is required to formulate a successful query.

Codified information can be retrieved more easily if employees follow norms and structures in document creation. In the investigated case, document names should basically follow a meaningful vocabulary, i.e. they are constructed including the document archetype, creation date, and author information (e.g. 20131211_AXB3_Meeting_Maier). But this rule is not too strictly enforced. There have been different naming schemes used across employees, project teams, and departments. The building blocks of a file name have also sometimes been separated by space characters, hyphens or even underscores, and sometimes neither of those. "Ok, here it is [pointing at a document]. But the one I was looking for definitely should have a different file name. I just expected it could have been named so [according to the keywords used to query it]. But it seems PC files [PC = pam crash, i.e. a software package used for crash simulation] follow a different nomenclature" (T7). While a human will not expect problems when mentally processing the file names, the piloted enterprise search tool did.

5.2 Barriers related to relevance judging of search results
To a major extent, enterprise search engines initially calculate the relevance of the hit list based on the keywords used in the search query. Search results include only

documents for which the authenticated user had appropriate access rights. It may happen that important documents are missing in the hit list, whenever a user does not have the required access rights, as the explored case showed. A user may think that there are no documents available matching the query, because the enterprise search did not highlight insufficient access rights. The evaluation showed that the appearance of keywords in document content was the primary factor for the relevance sorting. The built-in relevance model of the search engine was the primary aspect for perceiving the enterprise search usefulness. All participants preferred the searched document to appear first in the hit list and almost never paginated the result list beyond the first page.

Due to an absence of version control and document management systems, the usual practice was to keep all versions of a document in the same folder on the file server and label them with ascending numbers. For many search queries the built-in relevance model of the enterprise search engine did not rank the latest version of a requested document number one. "Ok this is the current version. But I wonder why the current version is at the end of the hit list" (T1). If the latest version of a document appears in the back slots of the hit list on the first page, the participants were not satisfied and questioned the search engine behavior. Some participants identified a feasible workaround, which was to copy the document location (folder) from the search results into the Windows file explorer to open the current version of a document manually. "Yes, but this is not the current document. This is a version 5 and the current version has a number 6. It has to be sorted differently, latest first" (T2). The employees criticized the relevance model of the enterprise search and demanded a different sorting algorithm, which should always top rank the latest version of a document.

Participants were also requested to comment on the enterprise search interface, while submitting their queries. Being an out-of-the-box configuration of Microsoft SharePoint 2013 Foundation Server, no customizing was done concerning design and functionality, except including engineering files in the search index. Much criticism of the participants concerned search results ranking and the filtering mechanism through facets. Almost all participants found the functionality of filtering search results by a scroll bar to be too coarse. They demanded an input field type for the creation or change date from a starting point to an end point. "When I search documents of the last project status meeting, I want to filter from May to June. [..] The current way is too troublesome for me and would take too long" (T10).

The participants also faced problems with the facet "file name extension", which basically allows a user to filter the hit list according to the appearance of specific file types. At first glance, the enterprise search only shows a limited set of file types, which led to confusion. "The interface should set a marker somehow, if the hit list is filtered" (T6). Surprisingly, using the facets was not intuitive enough for the participants, as they also used the file type as a term in their search query, while the user interface suggests filtering file types by selecting the appropriate facets after the hit list is shown.

5.3 Barriers related to availability and adequacy of metadata

Metadata generally refers to data about data and may, for example, include "author", "title", "creation date", "modification date", and "file name." Metadata is especially helpful to filter search results if search engines provide filtered navigation called facets in enterprise search as a mechanism to reduce the number of listed results. But this case revealed the occurrence of metadata as a phenomenon. "I always ask myself if these are authors and a title from the PowerPoint template only. However, it [pointing at the search result] tells me slide one as a title. Why does it show me 'slide one' and not the real title of

the presentation?" (T9). The observations showed non-administered metadata to limit the potential of search engines in practice. "Ok, that's what has been extracted. But this comes from the template, and no one ever changes it" (T10). If employees do not edit and update metadata, their documents will be enriched by metadata out of context.

In this case, incorrect or non-updated meta-information has often been the result of employees reusing office files, but not building on their templates. For example, participants used an official template once for a project presentation, but then always reused their once personalized project presentation as a base for all further presentations. By doing so, they perceive an individual benefit and save work time while not always having to fill out the same standard information in project presentations. As a result, the search engine could not utilize the potential of metadata and therefore produce search results based on wrong or outdated metadata, as this study has shown. "Ok, there usually is something [metadata] in our files. But that is not cultivated here [in this company], as nobody has ever needed it" (T4). While employees often tend to ignore metadata cultivation, search engines highly use metadata to provide search results of high relevance ranked on top: "Honestly, I have never done this. But obviously we would have to work more with metadata, when we want to take advantage of a search engine" (T9).

Participants also carried out a series of queries to retrieve engineering data, most notably simulation files. Simulation files are either American Standard Code for Information Interchange (ASCII)-coded or binary. The implemented search engine was only able to retrieve binary engineering files if the search query more or less exactly matched the file name. In the case of ASCII-coded files, the content was also indexed. This allowed searching for engineering files similar to office documents. If engineering files included a header with meta-information and comments, employees could find them more easily. If engineering data only consisted of "source code" or "mathematical code", it was much more difficult or even impossible to deliver a successful search. "It depends from file to file. I try to do it [add meta-information to engineering files], but I do not always think about it regularly. It is not organized systematically. One can observe if colleagues are doing it and copy their behavior. But sometimes we are not precise enough" (T8). The more meta-information is added to engineering files, the better it is for the search engine. But the majority of participating engineers in this case had little interest in documenting their engineering files with meta-information. A similar phenomenon was investigated before in the domain of software development, which faces similar challenges (Strohmaier *et al.*, 2007). A goal conflict between production (i.e. creating engineering files or software code) and documentation (i.e. adding meta-information in engineering files, adding documentation to software code) may hinder the potential of enterprise search.

5.4 Barriers related to current search strategies
The evaluation shed light on how participants satisfied their information demand without enterprise search. Face-to-face conversations between colleagues were the number one instrument for information acquisition, followed by e-mail, as our study revealed. Information on the location of a particular document on the file server was often retrieved via face-to-face conversations, e-mails or instant messaging. Many participants internalized a scheme of project-based document storage and perceived limited challenges in retrieving information from there, when browsing the folders.

This was not surprising, because over time organizations and humans have developed processes and practices on how to organize information and knowledge. This is often

counted to information and knowledge management, and both topics have attracted interest in the scientific community over the last two decades. Researchers distinguish between individual and organizational knowledge management. Enterprise search may collide with internalized individual and organizational information and knowledge structures, which was the case in this study. This can happen when information is stored on file servers in a structured way and the structure is more or less known to the information seeker. "The problem when looking [for information] is that I have to know a lot about it before. I therefore prefer a clear folder structure that I can easily browse" (T10). Search engines were then not valued enough, if employees felt more comfortable in satisfying their information demand by browsing known folder structures (e.g. project folders) and not by using keyword search.

In the past, some participants evolved individual search strategies, sometimes even supported by tools including desktop search, which is provided by the Windows operating system and allows searching for documents in folders and even indexing the content of most prominent file types. "When I am connected to my company network, I use desktop search. I even save my search queries to, for example, search for all documents which have been edited today [in my project folder] to keep updated. I can save my query and make shortcuts to it. Whenever somebody is creating a document, such as after a project meeting, I am instantly informed about it and do not have to search anymore" (T2). Some employees applied simple information acquisition practices to make search obsolete. Others saved links to project tasks (i.e. their folders), to quickly become aware of which documents have been updated. "This has so often undergone a change in name and I don't know its current one. On my notebook is a link to it which makes work for me as easy as it is" (T8). One participant even created an own search environment. "In Free Commander, I have both – an overview of where I am and a search for content. This tool is amazing" (T10). Even in the absence of enterprise search capabilities, participants created useful practices to satisfy their information demand in the explored case, and they rated them with a high usefulness.

5.5 Barriers related to overall perception of enterprise search usefulness

At the end of their observation, the participants were requested to rate the overall usefulness after performing their search tasks for their project work. They were asked to judge the relevance of the new search capability for their job. Many participants felt slightly unfamiliar with using a search engine, even though the search interface was kept simple. "I think one has to rethink when using a search engine, as this is different from browsing folders. When one gets used to it, I think it could save time. I think my perceived time-saving of 10 minutes [per day] by using such a search could be realistic" (T7).

Users who know the current organizational information structure and information storing practice very well perceived enterprise search to provide limited benefit for their work. Opening the search interface in their browser, formulating good keywords for search queries and filtering the hit list needs more time than controlled browsing on the file server for half of the participants, as this study showed. "I think I need more time with enterprise search than doing it as usual" (T6). This is the case when participants do not immediately see the requested information in the hit list, which especially happened in known item search. Through intelligent browsing in a project-specific folder they could easily proceed to their requested document and immediately got an overview of the folder structure in the file explorer. "Browsing

project folders, I would become aware of a folder called 'recommendations.' When I open this folder, I would have found the requested document. This would not be the case in enterprise search. I prefer hierarchical structures, as they allow me to explore [the information space] step by step" (T1).

Finding the "right" office documents was a challenging task. The existence of more than one version of "this document" having minimal differences made it difficult to find the "right one" and sorting the by date was not possible. This was not made easier by the high number of office documents in the hit list. Surprisingly, the participants were confident in searching for engineering files, and they could find them fast and without facing major challenges. "Yes, this definitively makes sense. I have seen that this was more complicated with office files simply because there are more of them" (T9). No participant voiced the demand for generally exploring the information space via enterprise search, i.e. receiving an overview on all kinds of information on a certain topic or project.

6. Discussion
The results show how engineers use a newly introduced enterprise search tool, and how they may satisfy their demand for information with search. During observations, we let the participants think aloud about the meaning of their actions. We got detailed insights in how participants selected keywords and formulated their search query, how they judged the relevance of search results by the help of available and adequate metadata, and how they perceived the overall relevance of search results against their practiced information-seeking strategies. All participants were performing their job in a knowledge-intensive environment with restricted access to project-relevant information located on a file server. Their roles ranged from junior roles with limited access upto senior roles, having access to more than one project folder.

We investigated the introduced search engine against the background of the existing organizational environment. Not surprisingly, every participant had already developed a personal information-seeking strategy in the explored case, including the frequent use of face-to-face conversations, participating in formal and informal project meetings, and using instant messaging for online communication. A lot of project-relevant knowledge was codified into what we called "document archetypes," including meeting minutes, project proposals, and project reports. Common understanding on those existed among the participants, but the deduction of meaningful search query keywords was challenging (e.g. an inclusion of the archetype "project agenda" as a concrete keyword).

Most participants felt familiar with project-based structures and practices in terms of folder hierarchies and how to browse them. Participants often created shortcuts to important folders and documents (e.g. folder URLs) to bookmark and easily recall the location of regularly used documents. Some of them even developed concrete search strategies involving available tools like built-in Windows desktop search to find out which documents were recently updated in a specific project folder. A successful enterprise search must therefore generate added value to current information-seeking strategies to be perceived as useful for their job, which was not always the case.

During the observation, participants were instructed to recall concrete information-seeking tasks of their past and then use the new enterprise search to find and retrieve a required document, a challenge termed "known item search" (Oglivie

and Callan, 2003). It is the dominant search strategy, whenever employees are aware of the existence of a particular information artifact, but do not know its exact location in the knowledge base. Most participants perceived finding such a "known document" challenging. There were different reasons, ranging from inappropriately selected keywords, an unsatisfying relevance model of the enterprise search engine, misleading document and content structure, to false or inappropriate metadata, and misused enterprise search filtering technique. Some of them argued that it was much easier to find known documents when browsing the folder structure they were familiar with. In their small world of accessible project-relevant information, this proved to be a feasible strategy. None of them had access to all projects and all had only access to project-relevant content according to their particular role from project member to project leader. Most participants therefore had access to a limited body of information and at least some knowledge on how to manage it effectively. Surprisingly, no participant expressed the need to use the new enterprise search capabilities to get a quick overview on what information was available on a particular topic, i.e. using an explorative search approach as introduced by e.g. Marchionni (2006) to prevent "reinventing the wheel." The study participants did not demand exploratory search during the interviews or during the observations.

Due to the absence of strictly supervised norms on how to create file names, and how to use project names and acronyms and other meta-information in documents (e.g. a project name that is searched for can have practiced acronyms like A1T1, A1 T1, A1-T1, A1_T1, GNOME, etc.), and which document archetypes to be described by whatsoever terms (e.g. meeting minute, minutes, moms, etc.) most participants perceived a limited ability of enterprise search to support them. This fact was even perceived stronger as the piloted enterprise search solution was not able to establish links between all possible instances of a concept (e.g. A1T1 is the same as GNOME). The common causes of semantic mismatches leading to missing relevant information when searching including acronyms, synonyms, hyponyms, and metonyms have recently been discussed by Cleverley (2012) in a search-related article. In the absence of enterprise search, the semantic mismatch is a smaller challenge, as humans may be able to handle meanings, commonalities and differences in document names, terms, and archetypes. In the case of an enterprise search implementation, the machine has to cope with all these challenges thoroughly. If names, content and metadata are not well prepared before the launch of an enterprise search solution, employees will experience limited usefulness. To cope with the metadata challenge, employees would need templates specifically easing metadata editing and synchronization to a controlled metadata vocabulary (e.g. a flat list of concepts).

Participants perceived the usefulness of enterprise search for their job differently. Those who were familiar with organizational structures and document practices did not feel the need for using new search capabilities at all on the one hand, and addressed search challenges (e.g. the semantic mismatch) to a larger extent on the other hand. The demand for the best match seemed to overrule other positive effects, i.e. the possibility to further explore the information space for useful information. About half of the participants acknowledged the potential of enterprise search. But some of them especially argued the challenges of preparing the organization for it, i.e. synchronizing document names, homogenizing relevant textual content in document content, metadata, and document titles.

Without an enterprise search engine, the need for standardization, homogenization, and controlled vocabulary in documents and metadata is perceived to be low, as humans can more or less cope with these challenges. No knowledge worker will

recognize a need to invest personal resources in e.g. metadata maintenance, as the individual benefit from maintained metadata is low without search. But if an enterprise search engine is introduced in such an environment, the machine will suffer from this chaos and its potential cannot be tapped. Enterprise search will require a prepared environment, e.g. controlled metadata, to be useful to employees. Without enterprise search there will probably be no metadata maintenance, and without any metadata maintenance there will probably be no successful enterprise search implementation, resulting in a chicken-egg situation. Without a prepared field, the user satisfaction with enterprise search will have to remain low like reported by the industry reports of Findwise (2012) and MindMetre (2011).

Several limitations of the authors' study are noteworthy: First, the implemented enterprise search is an out-of-the-box installation of Microsoft SharePoint 2013 Foundation, which is freely available but has limited possibilities for search customization. Piloting a differently and highly customized solution with a variety of project-based facets might have led to different study results. Second, all study findings are generated from a single engineering R&D company case, which is classified by a specific environment consisting of people, documents, processes, and practices. Applying the same research approach in a different case can create different outcomes, as for example document content and metadata can be managed in a more systematical way in other organizations. Third, all study data is generated from interviews and think-aloud observations of ten participants, only. Interviewing and observing more participants from other domains might have generated additional insights on enterprise search user satisfaction. The study was restricted to a manageable sample of study participants, which will make it more difficult to generalize to all knowledge workers. Fourth, recalling a recent instance in which a knowledge worker was looking for a particular document could impact them to use their previous path to find information, because they may try to remember how they found it before affecting perceived usefulness. Fifth, the implemented enterprise search has only indexed documents on a file share. There were neither searchable databases (i.e. structured content) nor content indexed in social software, resulting in a narrow but concrete search scope.

The implications of the conducted study can be summarized as follows: When implementing enterprise search, responsible project managers have to consider social and organizational aspects on the same level as technical ones. While users will expect enterprise search to work as well as web search, the concepts differ on various aspects, including search space, ranking and relevance, practiced search optimization, and nature of search results affecting implementation and adoption. The causes of enterprise search implementation barriers may be lowered, if project managers manage to better prepare organizations for enterprise search implementation before launch, including the provision of adequate and up-to date metadata in files to be indexed. Enterprise search users will find difficulties in query formulation, and teaching them how to use enterprise search in the best possible way will be very useful. As enterprise search will have to compete against previous search strategies, accompanying measures including an explanation of enterprise search value and usefulness together with concrete search cases may facilitate adoption.

7. Conclusion
We conducted a study on enterprise search implementation barriers by exploring an enterprise search pilot in a small and medium R&D enterprise. We interviewed and

observed ten engineers from two engineering domains by letting them think aloud what they did and why, while for the first time utilizing an enterprise search engine to find project-relevant documents on file shares.

We identified a demand for their qualitative user study, because little academic attention has been paid to the exploration of enterprise search implementation barriers and user satisfaction. We regard our contribution as a pioneering work and want to form a baseline for future empirical studies. We do not aim to generalize the results statistically, but want to learn more about the under-investigated qualitative aspects of enterprise search implementation barriers, hence the qualitative research approach. We neither measure the benefits of enterprise search in terms of recall and precision, nor in terms of return on investment, but want to gain knowledge on how and why employees may consider enterprise search helpful in the workplace. Our study should empower responsible project managers to identify meaningful actions for raising enterprise search satisfaction by preparing the organization.

The main contribution of this study is a detailed illustration of enterprise search implementation barriers pictured by user statements. Identified enterprise search implementation barriers include keyword selection and query formulation, availability and adequacy of metadata, relevance of search results, current research strategies, and overall perception of enterprise search usefulness. We observed how newly introduced search capabilities have to compete against internalized and more or less successful individual information-seeking practices. Another finding is the knowledge worker's need for support to define a best personal enterprise search strategy. While known item search as a strategy prevailed in this case, the potential of explorative search as a different search strategy remained untapped. How to develop an efficient and effective personal search strategy depends on current information and knowledge-sharing practices, and on how personal and organizational engineering information and knowledge are organized.

The study holds the potential to be continued in a larger longitudinal case, observing how enterprise search implementation will evolve in future. It will enable application-oriented researchers and project managers to identify potential and pitfalls when implementing enterprise search tools in their organizations, which will increase the success of their project as well as user satisfaction.

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Notes

1. Forward reference search: a search for literature citing a specific source. Backward reference search: identifying and examining the references or works cited in an article of interest (see http://libguides.fau.edu/content.php?pid=245983&sid=2031471).

2. For a detailed picture of functionality please see the Microsoft SharePoint TechNet Site, https://technet.microsoft.com/en-us/library/jj219738.aspx, and for a picture of the search user interface please visit the Microsoft Tech Blog: http://blogs.msdn.com/b/nadeemis/archive/2012/12/20/manually-adding-search-query-suggestions-in-sharepoint-2013-using-powershell.aspx

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