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**Expert finding systems and Ontologies in a university setting**

Master Thesis

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Abstract

Expert finding systems (EFS) help organizations store and retrieve information about their experts who have the capability to perform specific tasks. However, the search process for the expertise information in many organizations sometimes gives inaccurate or outdated results, and the reason for that is mainly because of the static structure in which this information is stored, mostly in the form of databases. This static process of information storing and retrieving often requires constant human intervention to update the expertise information. Malmö University is one organization that uses a static database structure to store its expert information.

By utilizing the inference power of ontologies, which considers the structure of classes and their relations, rather than joining several tables as in keyword searching, we can make the search for expert information a dynamic process rather than a static one, and thus, we can reduce the amount of human intervention and errors. Utilizing expert finding systems can also determine the level of expertise available in the organization. A good example of such organization is Malmö University, where EFS can help in identifying the shortages of expertise in a specific field of study.

Therefore, we have made a case study about the expert finding system at Malmö University, where we have made interviews and discussed the expert finding search process. Then we explored the role of ontologies and how the Semantic Web (SW) technologies can be utilized to search for meaning, rather than keywords, to improve the quality of the query results for expert finding, and thus minimizing unwanted search results.

Furthermore, we study the several types of commonly used ontology design patterns (ODPs), which are predefined models to solve recurrent problems in designing ontologies, and then we suggest a suitable ODP to be used in designing an expert finding ontology (EFO) in a university setting. Then we select the content ontology design pattern, and we used it to design an EFO suitable for a university.

Keywords: Expert finding system (EFS), Ontology, Ontology Design Pattern (ODP), Content Pattern (CP)
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## Acronyms

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Chapter 1: Introduction

Each organization has a group of experts who contribute to its success and livelihood. The experts play a pivotal role in guiding their organization towards achieving its goals. Therefore, it is important to be able to find and identify the expertise information accurately and quickly.

Expert finding is “the process of seeking to find the people who might have the desired knowledge and skills” [1]. Expert Finding Systems (EFS) are computer based information systems that address this specific issue. An EFS is also called expertise location system (ELS), and it can be defined as a system that “enables users to discover subject matter experts in order to hire or acquire their knowledge” [2].

In fact, EFS contribute to make the expert information manageable and easily accessible by users. These users can be from inside the organization that might need help in performing a specific task, or users from outside the organization who want to hire an expert, and they need to assess their ability to perform a certain project.

Although a lot of effort has been done by some enterprises to facilitate the structuring and the retrieval of information in databases or content management systems, this approach is based on keyword searching, and not on the search of meaning, which limits the information systems ability to connect the chosen words with what the user has intended and what information is stored in the system. Another limitation is that keyword searching can be problematic because it is more prone to human errors like misspellings and bad choice of words.

On the other hand, by utilizing the Semantic Web (SW) technologies, we can benefit from its machine-reading capabilities, and thereby, we can avoid human errors and get more accurate search results.

The SW enables machines to understand the Semantics, or meaning, of information on the World Wide Web. It extends the network of hyperlinked human-readable Web pages by inserting machine-readable metadata about pages and how these pages are related to each other, enabling automated agents to access the Web more intelligently and perform tasks on behalf of users [4].

According to Borst [5], there are two main aspects of the SW, Linked Data and ontologies. While The Web is mainly concerned about exchanging documents, Linked Data is concerned about the exchange and combination of data between
different resources. Ontology is the science that is concerned about defining objects and describing the relationships between them [5].

The expert finding domain is an example of using the SW technologies to define the concepts of a specific domain using ontologies. Moreover, ontology engineering addresses the methods for building ontologies and represents the domain objects and the relationships between them [4].

An important part of ontology engineering and the ontology design is to benefit from previous experiences in order to avoid recurring design mistakes. One method for addressing this issue is to use ontology design patterns (ODP) to simplify the creation of a new ontology which can improve the efficiency of the building and modeling process. Additionally, ODPs guide us to choose the suitable ontology design structures, in which we can improve the ontology construction as well as increase the interoperability.

1.1 Motivation
An EFS facilitate the search process for a certain type of expert who might be needed to perform a specific task. The EFS can take the advantage of ontology while existing EFS provide a reliable source of certain types of information; ontologies on the other hand can give a clear specification of the expert finding domain and its objects and properties, and the relationships among them, with the possibility of drawing inferences [7].

Furthermore, ontologies can make this expertise information machine-readable and searchable, which can give effective and accurate results [3, 8]. However, [3, 8] neglect the user perspective that could have been an important part in designing their software framework. The user perspective aspect is discussed in more details in Section 3.1.

In addition, designing a system based on an expert finding ontology (EFO) can improve the search process, and it can make it faster and more reliable. As a result, we will get better search results when we search for expertise, which will contribute to saving time, cost and effort [2].

Despite the fact that a lot of research have previously made extensive studies about the topic of EFS [9, 12, 14], and even the ontologies design criteria related to EFS [2, 7] for that matter, however, there is still a need to explore it further to apply EFS in a university setting, because it will facilitate the search process for experts in the education field.

We also need to provide an empirical study that considers the needs of the users to determine the usefulness of an EFS at a university, which have not been sufficiently explored before, especially in connection with ODPs. For example,
Malmö University uses a static database system to store and retrieve expertise information via a Web interface as shown in Figure 1.

![Malmö University's Personal search system](image)

**Figure 1:** Malmö University’s Personal search system

The included information is the name, the position, and contact information of personal. This information is static in nature and often requires constant human intervention in order to fill in and update the information. Therefore, we need to explore how ODPs can be applied [10] to university setting, and then suggest a suitable ODP to use in designing an EFO.

1.2 Goal

Although the subject of EFS was previously investigated by different researchers [9, 12, 14], we intend to connect EFS concepts with SW technologies and to explore ODPs and suggest the most suitable ODP to be used for EFS in a university setting. Hence, an EFS based on SW technologies can facilitate the process of finding expertise in the different areas of academic research and knowledge.

Thus, the goal of this study is to explore whether an EFS in a university setting can help in improving the search process for expertise, and, for example, how can the SW technologies concepts be used in designing an ontology for expert finding in a university setting. We will use Malmö University as our case study, and as an example of an educational institute that can benefit from using ontologies in EFSs.
1.3 Research question
- What are the needs for using an EFS in a university setting?
- How can ontology design patterns help in designing an ontology for an EFS in a university setting?

1.4 Delimitations
Our study is limited to Malmö University, and the subjects that were interviewed are mainly teachers and students. The students are divided into two categories, those who are currently studying computer science, and others who have previously studied at Malmö University in different disciplines.

The delimitation in the ontology design we introduce is that it does not include a tool to retrieve information from the internet about the latest research or tasks achieved by the experts and their related work.

1.5 Thesis overview
- In Chapter 1, we start with the introduction of our thesis and with a brief description of the EFS and ontologies. Then we discuss our motivation and goal, and we present our research question and the expected results.

- In Chapter 2, we introduce the background and the literature review of the work done previously by others in the related subjects of study.

- Our research method is explained in details in Chapter 3.

- Then we discuss our results of the interview study, and we present the design of the EFO in Chapter 4.

- Finally, we conclude our research with a summary and a discussion of our topic in Chapter 5.
Chapter 2: Background and literature review

We begin this chapter by presenting EFSs in general in Section 2.1. Then, in Section 2.2 we explore ontologies and SW technologies, and we discuss how this relates to EFS in Section 2.3. Finally, we address ODPs in relationship to EFS in Section 2.4.

2.1 Expert Finding Systems

To improve the efficiency of finding knowledge about the individuals who are considered key experts in an organization, EFSs have been proposed as a solution to users’ problems who wish to use this expertise knowledge or find a specific expert to perform a certain task.

Expertise is the knowledge about a specific domain measured by the level of understanding and skills about this domain and the ability to solve its problems [11]. Finding experts in this advanced world we live in is not an easy task especially when we consider the vast amount of knowledge and areas of expertise that exist.

EFSs are usually maintained in the form of databases that have to be continuously updated, and which store the related information about a certain expert who serves “as a source of information and as someone who can perform a given organizational or social function” [12]. Furthermore, there have been some attempts to automate the Expert finding process, such as Microsoft’s SPUD [13] which is a knowledge management at Microsoft, Hewlett-Packard’s CONNEX which is a guide to knowledgeable people within HP Labs [46], and the SAGE People Finder [47], and there are still some systems that use manual data entry such as Skillview [48].

2.1.1 Benefits of expert finding systems in a university setting

Maybury [2] indicates that an EFS can be used to evaluate the efficiency of the organization by classifying or categorizing the expertise knowledge, this can actually help in defining the weaknesses or lack of expertise in a certain area in order to plan to acquire this type of knowledge in the organization.

Hammar et al. [7] elaborates on this by addressing the expert finding project at Jonkoping University and explained the importance of this project to help the university to find the relevant expertise such as teachers and researcher, and they divided the searching for expertise into two main stages:

- Internal Expert finding: searching among the expertise inside the university and classify each expertise depending on his/her background, role and responsibility
• External Expert finding: searching among the expertise outside the university, thus showing the expertise background and how this expert can contribute in performing a certain tasks.

We see that these concepts can also be applied in an educational institute to evaluate the knowledge level in a university, and determine the needs in order to increase the level and quality of education the university can offer.

2.1.2 Competency and socially aware expert finding
An equally important aspect to consider in designing an EFO is the social awareness of the participants and their relationships to experts. Braun and Schmidt [14] propose that this view must be considered in designing an EFS.

In fact, in an EFS, it actually affects the information given depending on who is asked about this. For instance, asking the expert himself/herself may result in inaccurate information because of an exaggeration on his/her part of their specific expertise.

On the other hand, if someone who is at a conflict with this expert is asked, this person might give a lower value to the expertise of the expert in question, thus leading to inaccurate information fed into the EFS, and consequently leading to wrong search results because the information was originally based on human emotions.

2.2 Ontologies and Semantic Web technologies
Semantic Web helps in understanding the meaning of information on the Web, and the two main aspects of SW are Linked Data and ontologies. In fact, using SW technologies can make the expert information search process more effective by giving more accurate results based on the meaning of the search query.

Guarino [20] defines several types of ontologies:

• Top-level ontologies: define very general concepts (such as space, time, and actions) which are highly reusable across several domains and applications.
• Domain and task ontologies: define the concepts of a given domain (such as mechanic, electronic, medical domains) or task (such as diagnostics).
• Application ontologies: specializes and adapts domain and task ontologies for use in specific contexts.

This thesis focuses on the subject of domain ontologies for expert finding.
An integral part of the subject of ontology is the Web Ontology Language (OWL) which gives information an explicit meaning to make it machine-readable and thus make it easier to automate the information exchange on the internet. The W3C states that OWL “is a Semantic markup language for publishing and sharing ontologies on the World Wide Web. OWL is developed as a vocabulary extension of RDF (the Resource Description Framework)”⁴ ... RDF is “a framework for representing information in the Web”². In other words, RDF is a “standard for encoding metadata and other knowledge on the Semantic Web”³.

2.2.1 Advantages and disadvantages of using Semantic Web techniques.

One main benefit of using ontology is that it “can be used by automated tools to give more power to advanced services such as more accurate Web search, intelligent software agents and knowledge management” [4]. Thus, ontologies are used for the purpose of enabling knowledge sharing and reuse, and it should clearly define a certain domain of knowledge and describe the concepts and the properties and the relationships in between. In fact, the term Semantic Web defines a "Web of data" that enables machines to understand the meaning of information on the World Wide Web [4].

Hammar et al. [7] suggests some benefits of the SW:

- By allowing users to query for concepts rather than keywords. For example, the user writes a simple keyword and the system will semantically match this keyword and finds the expert related to the matching concepts.
- Increase the accuracy of the queried information.
- Common concepts originating from different resources are interlinked using standardized vocabularies to allow the users to query for information, rather than simple data.

Consequently, the above discussion emphasizes that ontologies can help in creating dynamic information structures that can be easily accessed, modified, and expanded. Nonetheless, there are some drawbacks in using SW ontologies that must be pointed out.

A major drawback is the increasing of the complexity in the ontology because increasing the number of the classes and the properties of the constructed

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¹ http://www.w3.org/TR/2004/REC-owl-features-20040210/#s1.1
² http://www.w3.org/TR/2002/WD-rdf-concepts-20021108/
³ http://www.rdfabout.com/intro/
ontology will probably increase the difficulties of alignment with other existing related ontologies [15]. Another drawback is the use of different words that mean something to a certain person and mean something else to another person, which leads to inaccurate results at least to one of them. One important drawback is the invasion of privacy, because of the vast amount information that can be easily available about a certain person can be misused by anyone to hurt them in some way or another for any reason.

2.2.2 Ontology characteristics
McComb [16] describes the difference between an efficient ontology and other ontologies by measuring the characteristics of the ontology which are:

- Expression: is the feature in ontology that enables information interpreting and making inferences while the system is running [16].
- Elegance: the ontology need to build an elegant representation for the ontology and at the same time use the ontology for storing the documents as well as finding the similarities.
- Inclusion and exclusion criteria: the ontology needs to contain a method that describes inclusion and exclusion criteria.
- Cross referencing capability: finding the distinction plays an important role because if we change our distinctions it might have side effects on other systems.
- Inference: is the ability to find and connect the additional information to our information.
- Foreign-language support: it is better to add foreign-language in order to make the ontology more powerful and effective.

2.3 Semantic Web technologies for expert finding systems
The EFSs described in Section 2.1 have major drawbacks such as [21]:

- They depend on continuous human database maintenance which is expensive and time consuming.
- They require the experts to spend their valuable time to enter and update information about their expertise.
- The expertise of an expert can often change which leads to an outdated information in the database.
- The descriptions of the expertise are often general in nature and sometimes are incomplete.

That is why several EFS based on SW technologies have been presented, such as [22] and [23] because the above problems can be addressed by utilizing the inference power of ontologies, thus minimizing human errors. Additionally, the common thing between [22] and [6] is that they try to introduce EFSs in the light of SW technologies.
2.3.1 Semantic Web techniques for Expert finding

Punnarut & Sriharee [22] discussed some techniques and mechanisms; the method they have adopted is expert analysis which is based on asking questions and establishes a dialog with expertise to measure their abilities for the desired task. Punnarut & Sriharee proposed a system using the advantage of ontology to classify and analyze the expertise skills, which can be summarized as follows:

- A process to build the skill classification ontology.
- A methodology of data mining to determine expertise of the researcher.
- The matching and ranking methodology in retrieving the relevant researchers who may have competency matched to the desired expertise.
- Another system is used to act as a database to store the profiles and all the related information for the expertise in their system.

Although Ravikarn and Gridaphat have evaluated their system in order to check the functionality and the ability of the system to obtain the required expertise, however, it was not clear that they have considered the user needs in their study. However, making the heterogeneous knowledge integrated requires a method to create and maintain a data cloud which provides added value to an organization, therefore, the Semantic Scout [23] addresses an important issue in providing Semantic support within large organizations to facilitate searching for expertise from inside the organization and exploit their experience for the relevant tasks or projects before switching from inside the organization expertise to find the expertise from outside the organization.

Equally important, a great attention must be paid to the user friendliness and usability aspect for designing ontology for EFSs. After all, if the user feels that it is too complicated, the user will simply ignore it arguing that their time is valuable and they have much more important work to do. Currently EFSs are coming more and more important because they help in finding the right expertise to perform relevant tasks. The “Spree” EFS [9] describes a methodology for finding expertise automatically by providing an online tool, in which the searcher sends a query and gets an answer from an expert online.

The following are the steps defined in the Spree method:

- A spree member is looking for an expert to answer a query.
- Request to answer the query are sent to the relevant expert.
- One expert agrees to answer the query and joins the questioner in an online chat.

The process of searching for information such as expertise for a relevant task is quite complicated and it required some steps and a system that simplifies these processes in order to be used by users who search for the relevant expertise or
related information. Spree’s approach tries to solve some of the knowledge management problem areas identified below:

- Making the knowledge pluggable for the user.
- Organizing the existing knowledge.
- Exchange the ideas between the users.

The Spree system aims to identify an expert using documents describing his/her qualification profile [9]. Moreover, they discuss how knowledge management can find, store and distribute the knowledge, and describe different approaches of knowledge management and the way to solve problems using Spree’s approach.

Furthermore, the Spree system discusses the designing algorithm which describes the use of ontology and shows its mechanisms. However, the drawback in this search system is that it sometime gives insufficient results in the searching operation which obligates us to change the search words in order to get the wanted results, thus increasing the time consumed and cost of the search process.

2.3.2 Information integration in EFS
Baldassarre et al. [23] suggest the following steps in order to achieve information integration:

- Describe a methodology that comes from an easy integration of existing information sources in different formats.
- Improve information exchange and retrieval within and outside the Organization.
- Develop a powerful cognitive support for strategic decision makers.
- Reinforce collaboration within the organization.

Furthermore, Zhang et al. [3] have emphasized that the improvement of enterprise sharing and integration of information is related to developing methods that are going to define the concepts and the relationships of enterprise business metadata. Zhang also indicate that standardizing the definition of the unification of enterprise Metadata has a crucial impact on business-to-business information integration and sharing.

Additionally, metadata provides information foundation for information exchange and system interpretation and explains how building the ontology has an effective impact to the sharing of knowledge and interoperability of heterogeneous systems.

2.3.3 Benefits of Semantic Web in EFS
Semantic Web technologies make the system more reliable, flexible and adaptable by reducing the problems related to legacy and inconsistent data access and retrieval. Baldassarre et al. [23] have described a software framework called
the Semantic Scout which offers Semantic support to functionalities such as competence finding, social networks discovery, etc. Baldassarre et al. argue that the scope for Semantic scout is to make data interoperable in designing information access for a wide range of data consumers, human or machine agents.

Some other scenarios of utilizing SW technologies have been used and explained by Malgorzata and Oldakowski [8] who give an example of the design of human resource ontology and an ontology based recruitment, which is similar in many aspects to the idea of expert finding ontologies.

Mochol and Oldakowski [8] illustrate the need for developing more reliable search systems than the currently used ones that depend on keyword searching rather than the search of meaning.

2.4 Ontology Design Patterns and their types

Ontology design patterns define a few steps for building the ontology and describe the effect of ontology engineering approach on SW which causes the increase of interoperability. For example, Aranguren et al. [25] adopted the reusability approach to reduce the cost of modeling an ontology in a cell-cycle domain.

Different types of ODPs have been proposed:

- Structural ODPs
- Correspondence ODPs
- Content ODPs
- Reasoning ODPs
- Presentation ODPs
- Lexico-Syntactic ODPs

These different types of ODPs are used to simplify the ontology modeling and to present guidelines to the developer who might be interested in using a suitable ODP to design an ontology, thus, reducing the recurrence in building the same ontologies and repeating the same mistakes. OntologyDesignPatterns.org [18] is a SW portal dedicated to ODPs for the SW developed in the context of the Neon project [25]. Consequently, ODPs guide us to choose the suitable ontology design structures, in which we can improve the ontology construction as well as increase the interoperability.

Blomquist [6] defines the ODP as:

An ontology pattern is a set of ontological elements, structures or construction principles that intend to solve a specific
engineering problem and that recurs, either exactly replicated or in an adapted form, within some set of ontologies, or is envisioned to recur within some future set of ontologies.

Thus, the benefit of ODP is to avoid mistakes that could happen while building the ontology. Furthermore, ODPs have an impact on improving the quality and coverage of the resulting ontologies.

Additionally, ODPs can increase the quality of the constructed ontology by reducing the time consumed in building the ontology while giving us the building block for the desired ontology. But one major point we have to take it into our consideration is that using ODPs requires choosing the right and most suitable ODP for the desired ontology in order to get a more functional constructed ontology which serves the requirements.

We have taken into consideration that choosing a suitable ODP is an effective way in order to improve the functionality of the constructed ontology and to avoid recurrent design problems or mistake, as well as save the time and effort consumed in building such ontologies. However, determining the suitable ODP may put the designer in a puzzle situation while addressing several types of ODPs in different projects.

In the following subsections, we discuss each of these ODPs to know their different characteristics. Different types of ODPs are illustrated in Figure 2.
Figure 2: Types of Ontology Design Patterns
**Structural ODPs**
In the Structural ODP there are two types, the Architectural and the Logical ODPs. The developer can use the Architectural ODP for the external frame of the ontology. The Architectural ODP also depends on the Logical ODP for internal aspects of the ontology design, and it is concerned about the effect of the overall shape of ontology, and it aims to construct a skeleton of the ontology in order to achieve the ontology goal.

In fact, the Architectural ODP consists of two types [25]:

- Internal: based on terms collected from the Logical OP specifically to be used in designing the internal ontology.
- External: “defined in terms of meta-level constructs” [25] that help in linking the current ontology with other related ontologies in other educational institutions.

Logical ODPs are “a formal expression, whose only parts are expressions from a logical vocabulary, which solves a problem of expressivity” [18]

Logical ODPs has two types [25]:

- Logical macros: provide a shortcut to model a recurrent logical expression.
- Transformation patterns: translate a logical expression from a logical language into another.

**Content ODPs**
Content Ontology Patterns are distinguished networked ontologies that have their own namespace or domain which can answer the competency questions (CQs) [25]. Moreover, content patterns (CPs) are small ontologies that mediate between use cases and design solutions [26].

Content ODPs has characteristics such as [10]:

- Computational: CPs is language-independent.
- Small and autonomous: which consist of few classes and the relation between them.
- Hierarchical: A CP can be an element in a hierarchy.
- Cognitively relevant: CP visualization must be compact and easy to identify with.
• Linguistically relevant: linguistic patterns are called frames, which can be described as a “lexically founded ODP” [10].
• Best practices: It describes a modeling best practice.

Correspondence ODPs
Correspondence ODPs include Reengineering ODPs and Alignment ODPs [18]

• Reengineering ODPs: “is transformation rules applied in order to create a new ontology” [18].

• Alignment ODPs are patterns for linking two existing ontologies.

Presentation ODPs
Presentation ODPs deal with usability and readability of ontologies from a user perspective. Presentations ODPs contain two types of patterns [18]:

• Naming ODPs: can increase the readability and understanding of the Ontology by humans.
• Annotation ODPs: provide annotation properties to improve the understandability of ontologies.

Reasoning ODPs & Lexicon-Syntactic ODPs

• Reasoning ODPs are logical ODPs applications that use the reasoning engine to obtain certain reasoning results.

• However, Lexicon ODPs consist of systematically structured words that allow for extracting their meaning [18].

2.5 Ways of selecting ODPs
ODPs offer a solution to many developers who want to benefit from existing ontology models to minimize the time and effort in the design process of the ontology.

When selecting an ODP, the developer can study the different types of the ODPs that already exist and relate closely to the domain of the ontology the developer wants to design, and try to find the ones that are most relevant to the CQs of the ontology to be designed [25].

Then, the developer can compare the proposed ontologies and choose the one, or combination of two or more ODPs, that are most suitable to help compose, specialize and expand the ODP chosen to reach the required ontology design.
Chapter 3: Research Method

Our research is a case study, and depending on our research questions and the nature of our research we adopt a qualitative method approach in the form of conducting interviews with potential users of an EFO. The quantitative method approach is not suitable to answer our research questions because of the nature of our research which explores the need for an EFO, and there is no mathematical or computational techniques used which normally characterize the quantitative approach.

Additionally, we consider the design of ontology for an EFS in a university setting, therefore, we have studied and compared the different ODPs that can be related to this ontology in order to benefit from currently available technology and avoid recurrent design mistakes.

In this chapter we discuss the interviews relating to the needs for EFS in Section 3.1, then we discuss the methodology to construct ontology in Section 3.2, and finally, we discuss the threats to validity in Section 3.3.

3.1 Interviews related to identifying the needs for an EFS
There are four main types of interviews: structured, unstructured, semi-structured, and group interviews [11]. The interview type used in our study is structured because we have a group of preset questions that we want the interviewees to answer. Our interview was in the form of a questionnaire, mainly using e-mail, but we have also conducted personal and phone interviews.

Benefiting from our previous experience as employees, we found relative ideas concerning our research topic which helped us in formulating our interview questions. Moreover, we have analyzed ODPs and suggested a suitable pattern to use in designing an EFO.

We have conducted structured interviews as a method of collecting raw data in which we ask specific set of questions to certain individuals in the form of a questionnaire to help us in the ontology design process to decide on the appropriate ODP to apply to an EFS in a university setting in general, and at Malmö University in particular.

There are many perspectives that relate to EFS. For example, there is an organization perspective that considers the requirements, the type of information to be provided and the security issues. Another perspective is the expert himself/herself and the information that he/she is willing to publicize. This perspective overlaps with the organizational perspective. However, the most important perspective is the user perspective, which considers the actual user’s
expectations from such EFS, and the user friendliness aspects that have to be considered.

In this research, we take the user perspective as the focus of our research of EFS in a university setting and then the use of ontologies in that aspect; therefore, we have made interviews with potential users to such a system to explore the need for searching for expertise information in an effective manner, both regarding the speed and accuracy, and in order to achieve that, ontologies and SW technologies concepts which can be applied. Therefore, we have conducted an empirical study to determine whether there is a need for an EFS in a university setting.

The context of our study is Malmö University in southern Sweden. We formulated 10 interview questions that we have asked potential users to such an EFS. These questions were the result of our brain storming to try to get information on the background of the user to add credibility to their responses. We also made these questions simple and straight forward to be suitable for a wide range of user’s level of expertise and education.

The subjects for this study were previously known to us and they were carefully selected to represent different levels of backgrounds and experiences. The subjects range from teachers, students, and external users from the industry and society.

Because this is a qualitative study, we choose a small sample of potential users with different backgrounds in order to collect concise answers that are related to EFSs in particular. We have received a total of 12 answers, divided as follows:

- 7 out of 10 e-mail interviews have been answered
- 2 personal interviews
- 3 telephone interviews

Most of the data collection was in the form of e-mail responses, and notes taken on paper when personal and telephone interviews were conducted, and the length of the personal and telephone interviews was between 10 to 15 minutes long.

There are some advantages and disadvantages of the different interview methods. We actually find the personal interviews the most reliable method, than the phone interviews, whereas the e-mail questionnaire is very convenient and time and cost effective. The disadvantage is that both to the researcher and the interviewee, there is also the risk that the interviewee may misunderstand the questions and thereby may give incorrect responses, but because of the limitations in time and the difficulties to schedule appointments with the interviewees, we satisfy ourselves with the results of the e-mail questionnaire in addition to the results of five personal and phone interviews.
3.2 Methodology to construct the ontology (design and creation)

We adopted the following methodology outline given by McComb [16] because it clearly describes the methodology on how to build an ontology:

- Define the purpose and scope
- Analysis and define the metadata and relationship
- Express the framework with OWL DL (Web ontology language, description logic).

The above outlines are described in more details in the following chart represented by Uschold and King [46], who suggested the following steps which are illustrated in Figure 3 below for creating the ontology:

![Figure 3: Shows The method suggested by [46] for designing enterprise ontology](image)

By applying these steps, we can define the purpose, which is to create an EFO, and we can define the scope which is a university setting. We can also analyze the collected information from interviews and other research, and then, we can define the metadata and the relationships between the objects in the ontology.

Furthermore, we can use the ODP to generate the ontology expression which we will evaluate, and upon satisfaction, we can build the desired ontology. In our example, we found that the content ODPs are most suitable for designing the EFO, because it meets the required analysis and definitions, as we will show in Section 4.5, and it is closely related to domains that define roles and responsibilities. Additionally, CODPs are small, simple models that can be easily adapted and combined in order to specialize and expand to satisfy the required CQs.

We can choose the suitable ODP manually by going to ODP portal such as www.ontologydesignpatterns.org [18] and go through the different ODPs listed to compare and evaluate the different types to see which one of the ODPs best answers the CQs and then specialize it to suit the specific needs of the ontology.
3.2.1 Software tools for designing ontologies

There are many useful tools that can be used to facilitate the designing of ontology such as Protégé [17] and the Neon Toolkit [18]. We have used Protégé because it is an easy, yet an effective, tool to use as an ontology editor with a number of plugins to help in the design and validation of an ontology.

All of the models for designing an EFO have similar characteristics in regards to defining a domain, classes and the relationships between these classes. However, the XD tools from the Neon Toolkit [18] is the preferred method used for an EFS ontology, because it provides the ability to divide the overall problem into smaller models which makes it easier to handle and to connect the models together.

Furthermore, the XD Tools helps in choosing the suitable ODP based on the CQs. The XD tools also provide a utility to test the smaller models as well as the overall design of the ontology.

Although we have used Protégé to design our ontology in this thesis because we have more experience in this tool, we have benefited from the concepts introduced in the XD tools which very similar to Protégé.

3.2.2 Using software technologies and ODPs for EFS

An ODP aims to improve the way to construct a new ontology by offering a template or by giving hints to the designer in order to simplify building the ontology and by using a model to avoid repeating the same design or construction mistakes over and over, thus, we can choose the specific pattern based on the requirements to be fulfilled. Therefore, a brief description of the different ODPs [25] has been introduced in the literature review chapter in order to give some background on those types of ODPs.

In fact, the content ODP is a strong candidate to apply for an EFS in a university setting, and we can design our ontology in a more effective way by applying the related guidelines of the XD tools [18], which contain the following steps to help design the ODP [19]:

- Select a story to start with.
- Identify your domain.
- Identify the information to be presented and it objective.
- Select competency question.
- Match the competency question to determine the ODP
• Transform the competency question into query.
• Select the Content ODPs to reuse.
• Take the XD Tool advantage to import and specialize the ODPs.
• Test the model against the CQs.
• Release module.
• Integrate, test and fix.
• Release new version of the ontology.

3.3 Threats to validity
In our research there were many threats to validity that we have to consider:

1. The interviewed subjects chosen were previously well known to us and that might affect the answers given by the interviewees.

2. We have used three different kinds of interview methods: Email, phone and personal meetings, and this can give different answers depending on the interview method and not purely on the discussed subject of expert finding.

3. There is also reliability threats in which the interview questions were dependent on the researcher and their background.

4. The lack of experiences on the subject of expert finding among the interviewees poses a credibility threat.

5. The interview questions were about Malmö University and this may cause transferability threat because the results cannot be generalized.
Chapter 4: Results

This research focuses on the needs for an EFS to improve the search for expertise in an educational institution using ontologies which can give better search results on the information queried for each expert. In a word, SW techniques are most suitable to achieve our goal in this research “because they are particularly suitable for integrating different data sets and allow the application to be easily extended in the future” [1].

In this chapter, we analyze the interview results in Section 4.1, and in Section 4.2 we formulate the CQs that the EFO should be able to answer and we discuss how these CQs help us in designing a basic model for an EFO, and this in turn helped us in the design of the EFO with the help of the Protégé tool in in Section 4.3, and we compare the different ODPs and choose the appropriate one to use in Section 4.4. In section 4.5 we validate the Ontology, and finally, we address the benefit of an ontology based EFS in section 4.6.

4.1 Analysis of the interview results

In order to crystallize our idea referring to EFS project, this requires some form of data cleaning and organizing of the collected data from the interviews to prepare the data to be processed.

The first step following data collection and prior to data analysis is to process and consolidate the interview notes and the e-mail correspondences. This requires data cleaning, organizing and coding to prepare the data for analysis. Ideally, consolidation and processing is conducted by the team of interviewers who completed the data collection [40].

The interview questions are made to determine the need for the EFS in a university setting form user perspective which lead us to improve the desired system. Additionally, we have taken into consideration the potential user suggestion for designing EFS which were gathered from the interview it well affect in increasing the functionality of the expert finding system.

The following is our analysis of the qualitative data that we have gathered as a part of our empirical study in the form of interview questions.

1. *Can you please tell us a little about your background?*

   We began our interview with a question on the background of the person interviewed in order to determine their credibility to our research subject.
We have interviewed people with different educational levels and backgrounds to get a wide range of information from people who might benefit from using such a system.

2. **In your view, is there a need for an expert finding system at Malmö University?**

Most of the people interviewed indicated that there is actually a need for an expert finding system at Malmö University. However, some of the interviewees did not have an opinion.

The answers that we have gathered from the interviewees, suggest that an expert finding system at Malmö University can be beneficial.

3. **Why do you feel that such an expert finding system will be useful?**

Many of the potential users interviewed have indicated that such a system can actually be useful because it will facilitate the searching process for an expert.

The reason mentioned by some of the interviewees is that an EFS will give faster results; others indicated that it will give more specific information about experts. Other reasons were also given such as it will make finding contact information about experts an easier task.

4. **Who would benefit from this expert finding system?**

All of the participants have expressed that students, staff members, media and external organizations can have an interest of such a system. This suggests that a wide range of users may find such a system beneficial.

5. **Have you ever been in a situation where you found it difficult to find the expert you want?**

The answers to this question have indicated that finding experts in a university have been a troublesome task to many of the interviewees, which explain the needs for the users in searching for an expert.

6. **What kind of expertise are you most interested in?**

Users have had different views on the experts they are interested in; while some indicated that they are interested in information about teachers, staff members, and IT experts.

The answers to this question will help us in determining the objects of our research that can eventually be useful in choosing the proper ODP.
7. **What are the most interesting types of information about a certain expert that you would search for?**

Again, most of the interviewees mentioned that contact information and background are most interesting; some even thought that the type of research done by these experts is an important piece of information to include.

Accordingly, this helped us in determining the properties of our research objects that can eventually be useful in choosing the proper ODP.

8. **Do you prefer free text search or would you like to select the expertise from a list, or both?**

Most of the interviewees preferred a selection from a list, although some would like to use both, therefore we also recommend a free text based search because there can be a possibility that the user will not find the required information in the list. However, one might argue that if the information is not in the list, then it doesn’t exist, but we leave this to the ontology designer to determine.

9. **What kind of user interface is preferred, a dedicated software or a Web interface?**

This question is mainly related to future work and to the user friendliness aspect that the designer needs to take into consideration, and as we see from the results, a Web interface is preferred by all the interviewees.

10. **Do you have any suggestion to improve the search?**

In order to improve the search in expert finding system, we wanted to get some suggestions from the potential users. Some interviewees did not have any suggestions to improve the search process, but this can be related to the lack of experience or background in this field.

However we have received one suggestion about using filtering options to simplify and speed up the search process, and we’ve received a couple more suggestions about making the search simple enough to suit the novice users.

Based on the views we have gathered from the interviewees, who indicate that an EFS in a university setting can be useful to find the queried expertise quickly and easily, and this supports our view that an EFS in a university can help in finding the experts.
Despite the existence of some legacy solutions, “an automated system would be faster” as some interviewees indicated. The EFS can also be beneficial to students and staff members of the university, as well as outside educational and industrial organizations. And all of the interviewees prefer a Web interface to find experts and their expertise. We refer the reader to Section 3.1 where we discuss each question asked and the answers that the interviewees have given.

4.2 Designing a basic model for an expert finding ontology
The preceding analysis of the interviews made with potential users of EFS in a university setting help in formulating CQs. Competency based questions or CQs are interview questions that require candidates to provide real life examples as the basis of their answers. In simpler terms, the CQs are the core questions that the ontology must be able to solve and answer.

Candidates should not talk in broad terms, be too general or use their imagination when replying to interviewers. Instead, candidates should use specific situations from their life as examples when answering this type of interview question. Candidates should explain why they made certain decisions, how they implemented these decisions and why certain outcomes took place, and after conducting interview with potential user, we gather raw information that need to be summarize in order to generate the competency question.

To evaluate the ontology, we have to start from the problem that the ontology is trying to solve, and in order to do that we have to define the requirements that the ontology use to represent the tasks and their solutions. These requirements are called to the CQs [21].

Therefore, we formulated the competency question depending on the following aspects:

- We have deep understanding of our project and the research question in which that led us to generate related question in order to guide our research.
- Ask specific question that make the interviewees give sufficient answer and not talk about other things that are not related.
- When formulating CQs we wanted to get users inputs to determine whether EFS is beneficial.

Consequently, we have formulated the following CQs that should be answered by the designed ontology:

- What is the contact information of the expert (i.e. title, name, telephone, address, etc...)?
- What is the position of the expert at the university?
- Which faculty does the expert belong to?
- What is the academic background of the expert?
- What are the areas of expertise of the expert?
- Who are the colleagues of this expert in the same department?
- What is the expertise level of this expert?
- What courses does this expert teach in the university?
- When did this expert acquire his/her knowledge?
- What research projects did this expert participate in?
- When did this expert participate in a certain research?
- Who teaches research methodology?

Please note that the preceding CQs are just to show examples of what the ontology can or should answer. Naturally, it is up to the designer and the institution or organization to formulate their own CQs and adapt the ontology to be able to answer them.

Based on the CQs formulation and what we have discussed in Section 3.2 about ontology construction methods, we introduce the following example in Figure 4 where we can see that the expert is the center of the domain, and this expert has some information which can be used in an ontology design to show how the concepts in an EFS can relate to each other.
4.3 The design of the expert finding ontology

In Section 3.2, we have discussed the different methodologies to construct ontologies, and then we study and compare the different ODPs in more details in Section 4.4 in order to choose a number of possible types that can help us in designing the EF ontology.

Although we have not actually used the XD tool in designing our ontology, but we have used the related XD tools guidelines (mentioned in Section 3.2.2) and applied it in Protégé to design our EFO as explained in the following steps:

- Select a story (or subject): EFS
- Domain: at a university
- The classes that we have identified are:
  A. Event: Describes the time when a specific event took place
  B. Expertise: Describes the area of expertise
C. Publication: Describes the publications made by the expert
D. Research: Describes the researches made by the expert.
E. University: Describes the university that the expert belongs to now.
F. Person: Describes the expert weather a staff member or a student.
G. To design the ontology we define the classes and the properties and the relationships between them.

- Selecting CQs: example: Who teaches research methodology?
- Matching CQs to determine possible ODP: the Agent role type in the Content ODP matches this type of CQs.
- Test the model against the CQs: for example, the ontology answers “Annabella teaches Research Methodology” as a response to the question in point 4 above.

The remaining steps were not implemented in the scope of this project.

In Figure 5, we see that Marie is a member of the Person class and she teaches the CIS course and she is a colleague to Annabella in the computer science department who teaches Research methodology course.

The Figure also illustrate how the ontology answer the CQs for example

- What courses does this expert teach in the university?
- Who are the colleagues of this expert interested in the same field of research?
We have designed the ontology with the help of the XD Tools guidelines and by using Protégé, and the following Figures show how does this design look like:

To illustrate, Figure 6 represents the classes in the ontology.

![Figure 6: The ontology classes in Protégé](image)

After defining the classes, we define the object properties, which relate the objects to each other, as shown in Figure 7.

![Figure 7: The ontology object properties in Protégé](image)
Then we define the datatype properties which relate the objects to the datatype values, for example name or phone number.

![Data property hierarchy: topDatoProperty](image)

**Figure 8 : The datatype properties**

### 4.4 Selecting ODPs for expertise finding

When choosing the appropriate ODP to apply, the designer needs to consider whether the selected ODP is the most applicable one to fulfill the requirements of the ontology design to be developed. Moreover, in order to decide which ODP is the most suitable one to use for an EFS, the selected ODP must answer the CQs stated in Section 4.3.

We focus on applying Content ODP for designing an EFS ontology design, because it addresses a specific set of CQs, which represent the problem that it provides a solution for.

The main reason for choosing the Content ODPs is to facilitate the designing of flexible systems that can use components which can be linked to other existing ontologies in the related field. Another major reason is that the use of the Content ODP clearly identifies the domain concepts and instances and the specific relationship connecting them, which could apply to an EFS ontology design.

After studying the proposed lists of content ODPs in the www.ontologydesignpatterns.org site, we found the following types the most appropriate to use for EFS in university settings:
4.4.1 Agent role

The intent of the agent role ontology pattern is to represent the agents and the roles they play [18]. It can be applied to domains such as management, organization and scheduling.

The CQs answered by this type are:

- Which agent does play this role?
- What is the role played by this agent?

The following graphical representation in Figure 9 illustrates the characteristics of agent role design.

Figure 9: Agent role CODP [18]

This model can easily be applied to EFSs because it can define the domain of an expert and the different roles this expert plays, which directly answers our CQs.

For example, it answers the second CQ which states:

“What is the position of the expert at the university?”

Example: Paul_Davidsson hasPosition CS_Professor, as shown in Figure 10.

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Figure 10: Presents the position of Paul
This only gives an example of an expert role (teacher) in a university setting. This can be expanded to include other roles such as student, staff, guest lecturer, etc… which can be also added in the same way.

### 4.4.2 Participant role

This is another type of CPs which intends to represent participants that hold specific role in a particular event [18].

It can be applied to domains such as organization and to other general domains. The CQs answered by this type are:

- What is the role of the object in this event?
- What is the object holding this role in this event?
- In what event did this object hold this role?

The following graph shows how the objects and their properties are related to each other in participant role domain.

![Figure 11: Participant role CODP [18]](image)

While this CODP is handling the role of an object in a particular event, it can also be applied to EFS because it clearly identifies the objects and their roles in a domain.

In EFS case, we can assume that we only have one continuous event in order to apply it in a university setting, and this event can be the fall, spring, or summer semester, or any time period in which a teaching project or research was held in.

This Participant role ODP can also answer the CQs such as “What research projects did this expert participate in?” and “When did this expert participate in a certain research?” as we can see in the following example:
Example: Ghassan & Tarek are partners in EFSs ontology research during semester VT11, as shown in Figure 12.

4.4.3 Role task

The Role task ODP is very similar to agent role ODP mentioned in example one, because it represents the assignment of task to role and it can be applied in domains such as organization management and scheduling, and it can also answer similar competency question which are:

- What are these tasks of?
- What task do these roles have?

![Diagram of Role task ODP](image)

Because this CP is very similar to agent role CP it also can be applied in EFS in the same way mentioned in example one, it can answer for example the CQ “What courses does this expert teach in the university?” and “What is the position of the expert at the university?” as illustrated in the following example:

Example: Annabella_Loconsole Teaches Research_methodology
4.4.4 Object role
This is a CP that can be applied to many domains in general because it represents the objects and the role they play [18] and it answers the following CQs:

- What role does this object play?
- Which objects play this role?

![Object Role CODP](image)

Figure 15: Object Role CODP [18]

This CP is also very similar to the agent role CP and it can be applied in EFS in the same way mentioned in example one and it can answer for example the CQ “What courses does this expert teach in the university?” and “What is the position of the expert at the university?”

4.4.5 Determining the content pattern type to use
After comparing the above CPs, we can choose one of them or a combination of two or more as a base model and specialize it to suit our needs in designing the EF ontology. Specifically, we’ve used the Agent role type which is represented by the “Person” class in our ontology. We have also applied the Role task type in the “Expertise” class where the expert has the role of java teacher as an example.

Furthermore, we have used the Participation role type in the “Event” class where a teacher teaches java in the fall semester for example. For example, we can use the agent role in combination with the role task and the participation role, to define the role of the expert, the tasks and responsibilities and the participation in research, and this will answer some CQs, and we can then modify it to answer the rest of the CQs.
4.5 Validating and testing the EF ontology

The power of ontology lies primarily on its inference capabilities [41]. In fact, the ontology must be able to infer information based on some other related information that was previously fed into it regarding the description of the objects in the ontology and the relationships between them.

In other words, it is essential to use the correct description of the objects, properties and the relationships in order for the ontology to be effective. For example, in EFO, the CQs suggest that each expert has a set of information related to his/her area of expertise.

An example of a CQ can be:

- Who is expert in Ontology?
  - And the ontology should be able to answer, for example, “X, Y and Z”

Therefore, we need to evaluate if our EFO can answer the CQs, and this can be done by querying the ontology and see if it can correctly infer the required information and thereby answering the competency question accurately.

To apply this concept in the EF ontology that we have designed, we take for example the individuals Marie, Paul, and Annabella. It is sufficient to indicate that Paul is a colleague to both Marie and Annabella in the computer science department (Figure 16) and that the characteristics of this relationship is “Symmetric” in the object properties pane (Figure 17), and the ontology will infer that Marie and Annabella are Paul’s colleagues, as shown in Figure 18.
Figure 16: Paul isComputerScienceDeptColleague to Marie and Annabella as it is explicitly stated in the property assertions pane and it is shown in the usage pane.

Figure 17: The “IsComputerScienceDeptColleagueTo” object property is symmetric.
The above example illustrates that it is possible to search for Annabella’s colleagues and we will get Paul for example, although we have not explicitly stated that information in the ontology, we’ve only explicitly stated that Paul is a colleague to Annabella.

Another good example will be the use of the inverse object property as in the case of teaches and isTaughtBy object properties, see Figure 19. When we indicate that Annabella teaches the research methodology course, see Figure 20, the ontology will infer that the research methodology course isTaughtBy Annabella, so if someone is searching for “who is teaching the research methodology course”, this person will get the result Annabella, although we have not indicated that explicitly, but the ontology had inferred it automatically as shown in Figure 19.
Figure 19: The object property “teaches” and its inverse property “isTaughtBy”

Figure 20: The Property assertions indicates that Annabella “teaches” research methodology

Figure 21 shows that there is nothing indicated in the Property assertions pane for research Methodology, but the ontology has inferred that Annabella teaches research methodology as it shows in the usage pane.
The previous two examples show that the ontology has passed the validation process by correctly inferring the relationships between objects. Furthermore, the first example (Figure 16) has directly and accurately answered the competency question:

6- Who are the colleagues of this expert in the same department?

Whereas the second example shown in Figure 18 shows that the ontology answers the following CQs:

12- Who are experts in research methodology?

4.6 Towards an ontology-based expert finding system

In order for the EF ontology to be easily accessed and updated, a mechanism should be developed to facilitate the entering and retrieving of the information from the EFS ontology. When analyzing the interviews that we have made with potential users, we conclude that all the users prefer a Web interface.

4.6.1 Benefits of using a Web interface

Although the actual design of a Web interface is out of the scope of this research, we can at least discuss the benefits of using such a tool and how it can be used. A Web interface can be beneficial for the following reasons:

- A Web interface is platform independent, and it can be accessed by almost every operating system such as Windows, Mac, Linux, etc...
- A Web interface can be accessed by the user’s preferred browser.
• It is easier for the user to query for information through a Web interface rather than a text based query system.
• It will be much more effective for the system administrator or the experts to modify and update the different expertise areas and related information.
• A Web interface can include a design tool that can help the developer in designing and changing the EFS ontology.

4.6.2 Updating and modifying the EFS ontology
When considering ways to access and update the EFS ontology, the designer must take into account the types of users who are going to interact with the system. There are mainly three types of users:

• The developers who design the ontology and can greatly benefit from a Web tool to modify the ontology.
• The system administrators/experts who will be administering and populating the EFS ontology and updating the expertise information.
• The end users who will be querying for the expertise information from the EFS ontology.

Updating the information in the EFS ontology can be made manually by the system administrators and/or the experts themselves. Another way that we discuss in the future work chapter is to enable the system to update and retrieve the information from the internet.

All users (developers, system administrators/experts and end users) access the Web interface. The end users do not need to authenticate themselves because they are just querying for information and cannot make changes to the system. However, the developers and system administrators/experts need to log on to be directed to their specific areas. For instance, the developer will be directed to the design and developing area of the EFS ontology, and the system administrators/experts will be directed to the areas where they have the authority to modify and update the information.
The preceding can be represented in the following architecture:

![Architecture of EFS ontology](image)

*Figure 22: Architecture of EFS ontology*
Chapter 5: Conclusion

In this chapter we begin with summary for the whole thesis in section 5.1, and we address the contributions in section 5.2, then we introduce the discussion in section 5.3, and finally we talk about the future work and the extension for this project in section 5.4.

5.1 Summary
EFS can be useful in facilitating the search for expertise in a university setting. However, given the large amount of data contained in legacy EFSs, it is often difficult to seek the required information on a particular expert, if we are to consider comparing and ranking the expertise of different experts who might have similar fields of expertise. That is why the SW approach can be beneficial by making the information machine-readable and thus increasing the quality of the search results.

Additionally we have study different type of ODP which can simplify modeling of ontology and reduce time and effort in generating ontology and decide from several type of ODPs the pattern that are most appropriate to generate ontology for EFS.

During the course of this research, we have gathered information from different resources and related work in this field. We have also made interviews with the different types of potential users with different backgrounds that were chosen in order to determine the needs for EFS from a user’s perspective.

5.2 Contribution
Although the topic of EFS and ontologies have been discussed in previous work, we focus on the user perspective in deciding whether an EFS in a university setting can help in finding related information on a particular expert.

We made interviews with different users of different backgrounds to help in identifying with their needs for finding experts in a university setting. And, by analyzing the different types of commonly used ODPs, we suggested the most suitable ODP to use in designing an EFO.

5.3 Discussion
Expert finding ontologies is a topic that was widely addressed by many researchers for a long time. The subject of information reuse and ontologies has been addressed by [7] but the users’ needs were neglected. Furthermore, they did not use existing ODPs and they suggested designing a new pattern, which contradicts the idea of reusability. A researcher expertise search system was also
introduced by [22], but again, they did not focus on the satisfaction of the user but rather on the accuracy of the search system.

EFS can improve the efficiency of the organization by placing the most appropriate expert in the desired position, but in other hand the expert finding have some challenges because the expert knowledge is dynamic and difficult to qualify, in order to make the EFS locate the experts for appropriate tasks it should follow the steps below to achieve that goal [2]:
Maybury [2] gives some steps to achieve that goal:

- Identify experts via communications, publications, and activities
- Classify the type and level of expertise of individuals and communities.
- Validate the breadth and depth of expertise of an individual.
- Recommend experts including the ability to rank order experts on multiple dimensions including skills, experience, certification and reputation.

In our view, addressing the users views and needs is very important to take into account, and that’s why we made several interviews to help us gather enough information from different types of users in order to formulate the competency question that led us to the ODP that is most suitable to use in EFS, and thus applying the concept of reusability.

However the drawback is that not all the users were familiar with EFS, despite the fact that we have explained the purpose and benefits of expert find systems to the interviewees before conducting the questionnaire, but the answers reflected that some of them were still not clear about the purpose of such a system in university setting.

Although ODPs provide models or templates for the designer to use in designing similar ontologies to solve recurrent problems, there are some drawbacks that must be taken into consideration. A major drawback of using a predefined ODP is that it can constrain and limit the developer from inventing and developing new solutions or designs for customized ontologies based on the requirements of each specific case. Furthermore, selecting between many ODPs that have many similarities confuses the developer and complicates his/her task even more.

The Content pattern that was chosen has many benefits such as:
- Applicable to a lot of domains in general.
- Reusable
- Expandable
- Can be linked to other existing ontologies.

However, there exists some drawbacks of using CPs, e.g., in the agent role CP the drawback is it does not allow to model time-indexed task assignments [18].
The participant role CP has the drawback of not taking into account the time aspects of the participation. While the Role task CP allows putting roles in the domain of discourse, it does not allow to model time indexed task assignments [18]. The Object role CP does not allow for classifications of different dimensions such as time and space.

5.4 Future work

Future research can make use of our EFO and include all of its aspects and principles, and build on it to do more work such as designing a Web interface or a mobile application.

The ontology that we have designed in this research can be adapted to suite the existing, or future, EFSs, and develop expert finding ontologies that are specific to each educational organization or a business enterprise and benefit from the ontology’s inference capability.

These applications should consider the user friendliness aspect in retrieving the information and populating the ontology. Another important way to consider is to enable the system to update and retrieve the experts’ information from the internet through an external import system. For instance, this can be beneficial in retrieving latest research or tasks achieved by a certain expert and other related work. However, this will require larger research teams and more time to be allocated to such a large project, supported with enough resources to reach the required goals and objectives. Furthermore, to avoid the drawbacks of current ODPs, it is may be necessary to customize or adapt these existing ODPs, or even design new ones.
References


47. The SAGE People Finder. Available at: http://sage.fiu.edu/Mega-Source.htm. [Accessed 12 november 2011].

Appendix A

Interview questions
Many of us find it somehow difficult to search for persons who are experts in a specific field, and get quick and reliable results. As an example, how would you do to find an expert on java programming, economy, or algebra at Malmö University?

That is why we, Ghassan Kafafi and Tarek Hammou, master’s students at the computer science department at Malmö University, are thinking about making an EFS, which is a tool to help people find persons with specific expertise, may be as an information source or to perform a specific task.

The preliminary system design is where you specify the expertise you want to find and the system will search for it and quickly present you with the most suitable results. We’d like to ask a few questions in order to get an idea about what is needed and what can be improved in the expert finding search process in general, and we appreciate your feedback:

1. Can you please tell us a little about your background?
2. In your view, is there a need for an expert finding system at Malmö University?
3. Why do you feel that such an expert finding system will be useful?
4. Who would benefit from this expert finding system?
5. Have you ever been in a situation where you found it difficult to find the expert you want?
6. What kind of expertise are you most interested in?
7. What are the most interesting types of information about a certain expert that you would search for?
8. Do you prefer free text search or would you like to select the expertise from a list, or both?
9. What kind of user interface is preferred, a dedicated software or a Web interface?
10. Do you have any suggestion to improve the search?

Please provide your answers by simply replying to this e-mail, or if you prefer, write your answers in a word document and attach it to your e-mail reply.

Finally, we would like to thank you for your time and your valuable answers.

Best Regards;
Ghassan Kafafi & Tarek Hammou
Department of Computer Science, Malmö University, Sweden
Appendix B

Answers to the interview questions
The following are the questions asked and selected samples of the answers we’ve received. We have received 12 answers but we list 7 of the answers to avoid repetitiveness and present only different answers that reflect a summary of the users’ feedback.

1. Can you please tell us a little about your background?

- Lecturer focusing on user-driven Web based information systems. BSc. comp Sci. Worked as a Web developer.

- I am computer systems engineer since 2001. I was working as programming teacher for several years in high school and universities. I am planning to continue working as a professor, but changing my profile and teach in other areas such as software engineering or research methodologies.

- I’m a computer science’ master student in Malmö University.

- I am master student at Malmö University.

- I am a student.

- Student at Malmö University.

- I am studying at Malmö University.

- I am an employee in hospital

- I work as salesman at a department store for 3 years; I have high school education, business section.

- House wife now, but I have works as an accountant for five years.

- Architect, 3 years’ experience, Copenhagen municipality.

- I am an employee in hospital.
2. In your view, is there a need for an expert finding system at a University?

- Somewhat. Malmö U has quite an active Yammer community, which helps when trying to find people with specific expertise. However, answers require time and attention from other members of the faculty/staff.

- Well, I am not sure if we need it. I mean, we can find several sources of information on internet and with this; it is possible to manage any issue or almost any issue. Nevertheless, a system like that could be making our specific problems in Malmö University easiest to solve in our context. You know, I could not evaluate the necessity of a thing like this, because in my case, I never have used one before.

- Yes.

- I think it’s needed and will be useful for all students and lectures also.

- Yes, to make it easy to get the correct guidance.

- I’m not sure.

- This can help in solving problems for finding the right people to consult.

- Yes

- I think somewhat it will be helpful.

- If I need some feedback in certain research it could be useful.

- Well I think searching for expertise in certain filed will help the researcher.

- Maybe am not sure.
3. Why do you feel that such an expert finding system will be useful?

- An automated system would be faster than asking on Yammer.

- Because students could find specific information that would be very useful in their specific context that means Malmö University. It is useful too, because students could make contacts in an easy way.

- Because it’s not easy to find a specific expert at the present system in Malmö University.

- If I need a professor for a particular subject, I can just go in to expert finding system and can see whether this professor is present at Malmö university or not. Instead of asking someone in the university.

- It can be useful when I decide to continue my studies.

- I’m not sure, may be if I want to register for a course.

- I think it will simplify the finding of the expert needed, to give a certain feedback on a topic that requires an expert opinion.

- I think to get better feedback in related subject.

- Maybe to simplify the way to look after the expertise.

- It could be useful in advanced study.

- In some certain filed.

- I do not know.
4. Who would benefit from this expert finding system?

- * Malmö U staff/faculty who are not Yammer members (roughly 65-70%).
  * Media and other external organizations looking for contacts.
  * Students, working on projects or their thesis.

- Malmö University community (Students, teachers, workers...)

- Students, teachers and any expert seeker.

- Students, researchers, outside educational organizations.

- Anyone who wants to continue studies in the future.

- Students.

- Industries, researchers, and students.

- Students.

- Students and researcher.

- Students and big organization.

- For student and university staff.

- Most for students.
5. **Have you ever been in a situation where you found it difficult to find the expert you want?**

- Not really - though it has taken some asking around. (I'm assuming the question is about people internal to Malmö U.)

- Yes, I have been in hard academics situations in which information is widely necessary but anybody seems to have it. Also, personal situations could be solve with this kind of system if it help to make contacts with expert people, like psychologists or any kind of medical assistance.

- Yes, one time I was looking for an expert in network security, it was hard to find.

- Yes.

- Yes, when I needed guidance in choosing whether to continue my education or go directly to find work.

- When searching for the right course to help in my work.

- Yes, when I studied at my university, and even in my work to find an expert for certain projects in Copenhagen municipality when we needed more specialized services.

- Yes, I have been in situation that required some feedback and I do not find it.

- Yes, because am student and I always need to have contact with some appropriate skills.

- Yes, some time when I need to make some search in certain filed.

- Not really.

- No.
6. What kind of expertise are you most interested in?

- I cannot give a general answer; it would depend on the project or course I'm working on.

- Academic and Cultural (for exchange students is important to know how must behave in this kind of society)

- All expertise in IT.

- It depends upon my need at that time. Like professor.

- Teachers at the university.

- In the meantime I’m not interested, but may be in the future if I decide to enroll in a certain course, I’d like some help from a professor.

- Qualified architects who can help using solving certain problems with projects that require certain expertise.

- Teachers.

- Teachers and researchers.

- Academic staff.

- Some expert in my field of study.

- Maybe for doctors and Nurse.
7. What are the most interesting types of information about a certain expert that you would search for?

- Name, title, department, etc. High level description of areas of focus.

- Well, the background of the expert is important in order to gain reliability in this expert.

- Expert’s name and contact information.

- Depend on subject, name of the expert, normal text, etc.

- What kind of courses does the professor teach?

- If the person asked has good knowledge of the courses that can be suitable for me.

- Background experience, education, previous projects and contact information.

- Expert name and expert education.

- Contact information.

- Background for this expert.

- Type of research that done by this expert.

- Name and general contact information.
8. Do you prefer free text search or would you like to select the expertise from a list, or both?

- I generally prefer browsing to searching, though the most important aspect would be that the interface makes it clear how people are organized. I've seen too many bad database UIs.

- I prefer select the expertise form a list. It makes the search easy.

- Both it would be better because sometimes I do not know the right spelling of the expert’s name.

- It depends, if I will not find in the list I may go for free text search.

- Select from a list will be easier.

- Both, because sometimes you do not find what you’re looking for in the list.

- It will be very useful to have both possibilities in case that the required expertise information is not included in the list.

- Select from List.

- I think to provide both possibility it will be advantage in this searching system.
- To select from the list.
- Selecting from list.
- Select from list.
9. **What kind of user interface is preferred, a dedicated software or a Web interface?**

- Defiantly Web, preferably with good mobile support.
- Web interface
- A Web interface.
10. Do you have any suggestion to improve the search?

- Not really. It seems that different people would have very different needs from the system - the challenge might be finding and support the most important use cases.

- No.

- I think it is better to have many search keys that offered on the search interface which works as a filter in the database, you can give the seeker many search options like search by name, expertise area and expert’s sex. This filter may help the seeker to find his/her result faster.

- Name, working title of particular expert.

- No.

- Not really.

- Try to make the search criteria simple enough so the public user (not an expert) can understand and use easily.

- Not really.

- No

- No

- I think to simplify the uses for this system.

- No
Appendix C

The OWL file for the EF ontology

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