2
Computer Science and Information Systems Research Projects

This book outlines a general process for carrying out thesis projects, and it embraces the following components as fundamentally important: (1) identifying the question/research problem; (2) planning time and resources; and (3) choosing a research method for studying the specific question. In this section, we consider how a thesis project relates to research and research methods. First, we discuss the different areas within computer science and information systems.

2.1 The Landscape of CS and IS

Computer science and information systems have been described and defined in many different ways in the literature. One illuminating characterisation of computer science, given by Edsger W. Dijkstra, is as follows: "Computer science is no more about computers than astronomy is about telescopes." However, to avoid being too abstract for our purposes with this text, we will avoid in-depth elaboration of the various characterisations and definitions. Instead, we give one general view, which we then illustrate with specific examples of problems. These serve to give some idea of the broad scope of computer science and information systems.

The 1975 ACM Turing Award winners Allen Newell and Herbert A. Simon (Newell and Simon, 1976) characterised computer science (CS) as an empirical discipline, in which each new artefact, e.g. a program, can be seen as an experiment, the structure and behaviour of which can be studied. In particular, the field of computer science is concerned with a number of different issues seen from a technological perspective, e.g. theoretical aspects, such as numerical analysis, data structures and algorithms; how to store and manipulate data (e.g. by means of a database system); the relationship between different pieces of software (i.e. different types of architecture, such as client-server, peer-to-peer, two-tier, three-tier); techniques and tools for developing software (i.e. software engineering, programming languages and operating systems).

The field of Information Systems (IS), as characterised by Allen S. Lee (2001), is concerned with the interaction between social and technological issues. In other

M. Berndtsson et al. (eds.), *Thesis Projects: A Guide for Students in Computer Science and Information Systems.*

words, it is a field which focuses on the actual "link" between the human and social aspects (within an organisation or other broader social setting), *and* the hardware, software and data aspects of information technology (IT). Similarly, the IFIP Working Group 8.2, which focuses on information systems, describes its scope as being concerned with:

> the generation and dissemination of descriptive and normative knowledge about the development and use of information technologies in organisational contexts, both broadly defined. By information technology (IT), we mean technologies that can be used to store, transfer, process or represent information. By organisational context, we mean the institutional arrangements in which information is used or created (IFIP WG 8.2, 1996)

The following three examples of research problems, all of which are centred around a specific IT product such as a CASE-tool, illustrate that the primary concern for each problem might be different. Research problems that focus on the human and organisational aspects of CASE-tools are naturally IS-oriented, whereas research problems that focus on technical aspects of CASE-tools are more CS-oriented. It follows, therefore, that there will be different choices of methods available for each.

The first problem is based on a human and organisational perspective on specific types of software tools (CASE tools). The second problem is illustrated by a focus on both technical and human issues in the context of CASE tools. The third problem has a technological basis, and addresses technical aspects of CASE:

1. What are the critical elements that shape the organisational changes associated with the adoption and use of CASE tools? (Orlikowski, 1993, p. 310)
2. What features do software developers want from OO-CASE tools? Related to that question is: how well do current OO-CASE tools meet these needs? (Post and Kagan, 2000, p. 384)
3. In this paper the meta-CASE system KOGGE will be described. In order to illustrate the KOGGE approach it will be shown how KOGGE was used to implement a CASE tool supporting the object-oriented method BON. (Ebert et al., 1997, p. 203)

2.2 What is Research?

The term "research" is semantically overloaded given its use in everyday language. In an academic context, research is used to refer to the activity of a diligent and systematic inquiry or investigation in an area, with the objective of discovering or revising facts, theories, applications etc. The goal is to discover and disseminate new knowledge. While you, as a student, are learning new things throughout the course of a project, it the goal is also that your results should include som elements of new scientific knowledge.

Science primarily aims to develop knowledge previously unknown in the area of concern, i.e. the outcome of the scientific research process should be an original

contribution of knowledge to mankind. Therefore, the overall goal of scientific research is to reduce, or even eliminate uncertainty in what we know. Such results are primarily disseminated via scientific journals and conferences (c.f. the journalist who is normally said to be carrying out research when collecting material for an article. This is not considered research in a scientific sense).

To contrast scientific research with research and development (R&D) activities, which are undertaken within commercial organisations, it is instructive to look at the goals. You will see that they are different in terms of motivations and activities. In a scientific research project, the primary objective is to learn and understand complex phenomena. For example, a research institute will undertake research activities which:

- Establish new knowledge which is made available to the public, often by means of publications in academic journals or conferences
- Are not driven by profit; researchers are therefore relatively free to identify and define their research questions

In a commercial setting, there is usually an expectation that the research activities will be centred on business goals, with the aim of contributing to new products or services, which are expected to generate profit for the organisation. For example, an R&D division within an organisation might perform activities such as:

- Undertaking research in areas related to the long term business goals
- Monitoring and observing research findings and trends in technology
- Undertaking pilot-projects to analyse and evaluate new technologies
- Exploring trends in technology for their potential adoption by the organisation (e.g. to analyse whether a specific research finding, such as a new software architecture, would be suitable for adoption)
- Building research prototypes and platforms for evaluating technologies, and possibly provide the foundation infrastructure for forthcoming development efforts
- Acting as experts and technology champions within the same organisation

For example, if an IS development organisation initiates a systems development activity, a primary goal will be the resulting successful system. In contrast, if a research institution has a goal of investigating a research question, which involves developing a system, then the system itself becomes a means by which the issue is explored. In other words, the developed system is, in itself, not of primary interest.

Although the term research is used in a number of ways with different meanings, in this book we take it to mean a systematic problem solving activity, undertaken with care and concern in the context of the situation at hand. In the process of fulfilling the requirements, the research activity is characterised by the researcher's trustworthiness, both with regard to the actual *process* of undertaking the research, and to the actual *phenomenon* being studied.

Research questions state what you want to learn. Hypotheses, in contrast, are statements of your tentative answers to these questions. Many researchers explicitly state their ideas about tentative answers as part of the process of theorising and analysing data. These are often called propositions rather than hypotheses, but they

have the same function, and therefore we use the term hypothesis throughout the text, to denote both meanings.

Research projects normally start with a basic question that you want to study. The question should be central to the project, thus helping to maintain the focus on the purpose of the project.

Research questions are normally, at an initial stage, more general and open. It is natural, as the project progresses, for the question to become more refined and particularised. Hence, the project is adapted to reflect an increased understanding of the problem.

2.3 Research Methods

Once you have a specific question suitable for study in a project, the next step is to choose an appropriate, systematic method. This is important for the successful completion of the project. In essence, the use of a systematic method is the soul of research.

Generally speaking, a method represents the means, procedure or technique used to carry out some process in a logical, orderly, and systematic way. In the context of a research project, a method refers to an organised approach to problem-solving that includes (1) collecting data, (2) formulating a hypothesis or proposition, (3) testing the hypothesis, (4) interpreting results, and (5) stating conclusions that can later be evaluated independently by others. This is also commonly described as the scientific method. In fact, part of the purpose of carrying out a thesis project is to get training in the use of a scientific method, which can then be applied when structuring and solving more complex problems. More importantly, you should know how, as well as why, the steps in the method are carried out. It should be pointed out that it is the nature of the problem or phenomenon itself, which guides the decision as to which method to use. Hence, you choose and use tools once you have established what you are dealing with (the nature of the problem), and when you know what you want to accomplish (hypothesis/proposition testing).

For a certain class of problems with similar characteristics (in terms of, e.g. the purpose, context, or research question) particular methods have shown to be effective in avoiding threats to validity. This is because researchers working on similar problems often interact with each other and form a community, where certain practices and norms evolve and become established.

However, given the many different methods that could be adopted within different areas of computer science and information systems, you should discuss the choice of method with your supervisor. Your supervisor has, after all, training and experience in research.

Most methods have some common characteristics, including the existence of a problem that needs to be formulated, aims and objectives to be met, and a phase where the problem will be investigated. This book does not discuss different scientific methods at length. However, related to method is methodology, which in certain

areas, e.g. information systems, is commonly referred to as method. The term methodology actually comes from an old Greek word, denoting the practice of analysing different methods, implying a set or system of methods, principles, and rules for regulating a given discipline.

When we study a problem, as investigators as well as participants in a study, we approach it, for better or for worse, with certain a priori conceptions, values and experiences. These affect the way we perceive the research question. It is always the primary goal for any outcome of a project to be trustworthy, i.e. the results should be valid, independently of our personal experiences. Research methods help us to ensure validity. There are a number of potential threats to validity that have to be taken into account. It is important, therefore, that you are aware of the variety of the different types of threats to validity, which can occur in the actual application of the chosen research method. It is also important to be aware that there are slight variations in the way you can deal with different threats, even though it is partly dependent on the type of method being used in your specific project. Later in this book, we discuss the different kinds of threats to validity in more detail.

Quantitative methods have their origin in the natural sciences, where the scientific concern is with attaining an understanding of how something is constructed, how it is built, or how it works. In the natural sciences, the attempt to express this understanding by means of simple laws or principles of general importance. The research is generally driven by hypotheses, which are formulated and tested rigorously, with the goal of showing that the hypothesis is wrong. Hence, one attempts to falsify the hypothesis, and if the hypothesis withstands the test, it is considered to be correct until proven otherwise. Repeatability of the experiments and testing of hypotheses are vital to the reliability of the results, since they offer multiple opportunities for scrutinising the findings. The goal of quantitative research and methods is develop models, theories, and hypotheses pertaining to natural phenomena. The quantitative aspect is to emphasize that measurement is fundamental since it gives the connection between observation and the formalization of the model, theory and hypothesis.

Qualitative methods have their roots in the social sciences, and are primarily concerned with increasing our understanding of an area, rather than producing an explanation for it. Qualitative research is typically used in specific social contexts. Over the years, many different styles and variations of qualitative research methods have been proposed in the literature.

Qualitative research is often associated with fieldwork and analysis in a limited number of organisational settings. For example, a problem is often studied in a unique setting, and the researcher undertakes the analysis from a position close to the subject under study. He or she takes an insider's perspective, and is thereby part of the problem situation. As such, problems are often analysed by means of investigating and interpreting human or organisational aspects in relation to technology. In undertaking such research, the organisational context itself changes. As humans and organisational conditions change over time, the pre-condition for the study and the analysis of the problem change. Hence, repeatability of experiments may not be possible.

Even though there is much in common between different kinds of validity threats independently of the type of research, there are specific research methods and styles of research which are associated with certain strategies for addressing potential threats to validity. Later in this book, we review a few of the most likely in qualitative research.

By observing and reflecting on your own and others' experiences of research projects, you will develop an increased sensitivity to potential traps. This is important, since your success depends on how well potential threats are taken into account. It has a direct bearing on what can be claimed in your findings. In other words, addressing validity is closely related to minimising the limitations of the findings in the project. When discussing methods later in this book (Chap. 8), we shall make additional comments on validity threats, and in particular, how they can be identified and dealt with.

2.4 Linkage Between Research and Thesis Projects

Up to now, we have elaborated on research and its relationship with development activities in different environments, ranging from scientific research carried out at research institutes, via research and development, to product development in industrial and organisational settings. While the notion of research and the outcome may differ in these environments, a core aspect is the systematic process by which such activities are undertaken. It is our view that thesis projects share this core aspect, even if the outcome is not necessarily intended as a scientific contribution. It is also our view that thesis projects should have a stronger emphasis on developing your own learning. This concerns your ability to carry out a bigger project systematically and independently, to apply previously acquired knowledge, and to acquire new in-depth knowledge in the project area. Our notion of research, in the context of thesis projects, simply denotes a structured process for solving complex problems, formulated as research questions.

During your project, you interact with examiners and supervisors who are trained in carrying out research. You will be inspired and influenced by the strategies they use when approaching and tackling problems. The nature of the problem, which will be the topic of your thesis, might be of a scientific nature, or it might originate in a purely industrial setting. In either case, you will benefit from using this systematic way of identifying and addressing a suitable research problem.

http://www.springer.com/978-1-84800-008-7

Thesis Projects
A Guide for Students in Computer Science and Information Systems
Berndtsson, M.; Hansson, J.; Olsson, B.; Lundell, B.
2008, XIV, 162 p. 25 illus., Softcover
ISBN: 978-1-84800-008-7