Markus Kelanti

STAKEHOLDER ANALYSIS IN SOFTWARE-INTENSIVE SYSTEMS DEVELOPMENT
MARKUS KELANTI

STAKEHOLDER ANALYSIS IN SOFTWARE-INTENSIVE SYSTEMS DEVELOPMENT

Academic dissertation to be presented with the assent of the Doctoral Training Committee of Technology and Natural Sciences of the University of Oulu for public defence in the Wetteri auditorium (IT115), Linnanmaa, on 28 October 2016, at 12 noon

UNIVERSITY OF OULU, OULU 2016
Abstract

A stakeholder analysis is commonly a part of the requirements engineering process in the development of software systems. It contributes to identifying, analysing, negotiating and validating requirements from multiple stakeholder viewpoints that do not necessarily share the same views on a system under development and do not necessarily express themselves using a similar language. Stakeholder analysis is often integrated into a used development method or practice and doesn’t necessarily appear as a separate process.

The increase in software size, availability and use in different appliances, however, requires more from the stakeholder analysis than has been recognized in Software Engineering literature. The increasing scale of software systems and connections to other systems increase the number of involved stakeholders complicating the stakeholder analysis. In addition, how the actual stakeholder analysis should be implemented in large scale software development and how it supports the development effort is problematic in practice.

The purpose of this thesis is to study the role and purpose of a stakeholder analysis in a large-scale software-intensive systems development. In this thesis, an empirical approach is taken to study the large-scale software-intensive systems development as phenomena in order to observe it as a whole. This approach allows this thesis to analyse the phenomena from different perspectives in order to identify and describe the nature and purpose of a stakeholder analysis in large-scale software-intensive systems development.

The contribution of this thesis is the following. First, the thesis contributes to both the practical and scientific community by describing the role of stakeholder analysis in the software-intensive systems development process. Secondly, it demonstrates how a stakeholder analysis can be implemented in a large-scale software-intensive systems development process.

Keywords: large-scale software development, software-intensive systems, stakeholder, stakeholder analysis
Tiivistelmä

Sidosryhmäanalyysi on yleensä osa vaatimusmäärittelyprosessia ohjelmistojärjestelmien kehityksessä. Se edesauttaa vaatimusten tunnistamista, analysointia, sopimista ja vahvistamista useiden eri sidosryhmien näkökulmasta tilanteissa, missä eri sidosryhmät eivät välttämättä jaa samaa näkökulmaa kehitettävään järjestelmään ja eivät välttämättä käy sammaka kieltä ilmaistakseen itseään. Sidosryhmäanalyysi on usein integroitu suoraan käytettyyn kehitysmenetelmään tai käytäntöön ja ei välttämättä ilmene erillisenä prosessina.

Ohjelmiston koon kasvaessa ja yhteyksien lisääntymisen yhä useampiin laitteisiin on johtanut tilanteeseen, missä sidosryhmäanalyysilta vaaditaan yhä enemmän kuin kirjallisuudessa on aiemmmin tunnistettu. Ohjelmistojärjestelmien alati kasvava koko ja yhteyksien lisääntyminen muihin järjestelmiin kasvattaa sidosryhmien määrää vaikuttuen sidosryhmäanalyysin tekemistä. Lisäksi on ongelmallista, että miten sidosryhmäanalyysin tulisi tukea suuren mittakaavan ohjelmistotuotantoa ja miten se käytännössä toteutetaan tällaisessa ympäristössä.

Tämän väitöskirjan tavoitteena on tutkia sidosryhmän roolia ja tarkoituksa suuren mittakaavan ohjelmistointensiivisten järjestelmien tuotannossa. Tutkimus on toteutettu empirisellä lähestymistavalla tarkkailemalla suuren mittakaavan ohjelmisto- intensiivisten järjestelmien tuotantoa kokonaisuutena. Tämä lähestymistapa mahdollistaa kokonaisuuden analysoimista, jossa on kaikista sidosryhmän seurauksista ja tarkoitus voidaan tunnistaa ja kuvata suuren mittakaavan ohjelmistointensiivisten järjestelmien tuotannossa.

Väitöskirjan tulosten kontribuutio jakautuu kahteen osaan. Ensimmäiseksi väitöskirjan tulokset auttavat sekä tiedeyhteisöä ja käyttäjiä käyttämään käytännössä sidosryhmän suuren mittakaavan ohjelmistointensiivisten järjestelmien tuotannossa. Toiseksi tulokset havainnollistavat miten sidosryhmäanalyysi voidaan toteuttaa suuren mittakaavan ohjelmistointensiivisten järjestelmien tuotekehitysprosessissa.

Asiasanat: ohjelmistointensiiviset järjestelmät, sidosryhmä, sidosryhmäanalyysi, suuren mittakaavan ohjelmistotuotanto
Scientists discover the world that exists; Engineers create the world that never was.

Theodore von Karman
Acknowledgements

Writing of this thesis was quite a road, starting from 2011 and finally reaching its end in 2016. This work would not have started without the encouragement and support given by my supervisor professor Samuli Saukkonen. I would like to express my gratitude for the time and effort he spent to guide me through the process and the long discussions we had to create the results in this thesis. I would like also to express my gratitude for my second supervisor professor Markku Oivo for supporting my work during these years and valuable comments he provided me.

I would like to express my sincere gratitude for the research group I have been working on, especially Pasi Kuvaja. He has been tirelessly worked to create research opportunities for everyone and challenging us to try our utmost. Also, I would like to thank my co-workers Dr Jarkko Hyysalo, Sanja Aaramaa and Nebojsa Tausan who I have been working closely and exchanging ideas and feedback during these years. As a special mention, I would like to thank Dr Jouni Markkula for all the discussions and debates we had along these years. They ended up being, priceless.

In addition, a special thanks is given for Jari Lehto. He presented me the challenges from the industry and opportunities to conduct research in real environment. We spent countless of hours discussing and debating over various topics providing valuable insight and comments directly from the practice.

Finally, I would like to thank professori Kari Smolander of the Aalto University and professori Rini van Solingen of the Delft University of Technology for pre-examining my thesis and for their valuable comments and recommendations.

Oulu, October 2016

Markus Kelanti
Abbreviations and Terminology

This section presents a list of abbreviations and terminology that are used in this dissertation. Consult the References sections at the end of the thesis for further clarification.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE</td>
<td>Requirements Engineering</td>
</tr>
<tr>
<td>RM</td>
<td>Requirements Management</td>
</tr>
<tr>
<td>SE</td>
<td>Software Engineering</td>
</tr>
<tr>
<td>SIS</td>
<td>Software Intensive Systems</td>
</tr>
<tr>
<td>SSM</td>
<td>Soft Systems Methodology</td>
</tr>
<tr>
<td>S3AM</td>
<td>Soft Systems Stakeholder Analysis Methodology</td>
</tr>
</tbody>
</table>
List of Publications


# Table of Contents

Abstract ............................... 15

Tiivistelmä 9  

Acknowledgements 11  

Abbreviations and Terminology 13  

List of Publications 15  

Table of Contents 17  

1 Introduction 17  

1.1 Background ................................................................. 18  

1.2 Motivation ..................................................................... 19  

1.3 Research problem and questions ........................................... 21  

1.4 Research design and structure of the thesis ......................... 22  

2 Background and Related Work 23  

2.1 Definition of a stakeholder ............................................... 23  

2.2 Stakeholder theory .......................................................... 25  

2.3 The concept of a stakeholder in Software Engineering ........... 28  

2.4 Conclusions from the literature analysis ............................. 32  

3 Research setting 35  

3.1 The research framework and phases .................................... 36  

3.1.1 Literature analysis ....................................................... 38  

3.1.2 Phases 1 and 2 ............................................................ 40  

3.1.3 Phase 3 ..................................................................... 43  

4 Original Contributions 47  

4.1 Paper I: A Case Study of Requirements Management: Supporting Transparency in Requirements Management Tools .................. 48  

4.2 Paper II: Software development as a decision-making process ....... 51  

4.3 Paper III: Characteristics of a Stakeholder Analysis in a large-scale Software Intensive Systems Development ....................... 54  

4.4 Paper IV: Comparison of Stakeholder Identification Methods – The Effect of Practitioners Experience ..................................... 56  

4.5 Paper V: Soft Systems Stakeholder Analysis ............................ 57  

5 Discussion 61  

5.1 Main contribution and findings ............................................. 61  

5.1.1 RQ 1: What kind of characteristics do large-scale development processes require from methods and practices? .............................................. 63
5.1.2 RQ 2: What kind of characteristics does a stakeholder analysis in SIS development processes have? .............................. 65
5.1.3 RQ 3: What kind of characteristics are required from the structure and methodology of a stakeholder analysis in the SIS development process? ............................................................ 66
5.2 Study relevance and validity ................................................................. 68
  5.2.1 Validity and Reliability of the case study results ......................... 68
  5.2.2 Validity and reliability of the experiment results ...................... 69
  5.2.3 Validity and reliability of the action research results.................. 70
5.3 Study limitations and future research ................................................... 71

6 Conclusions 73
7 References 75
Original publications 79
1 Introduction

In today’s world, software systems are developed globally, with collaboration between different groups of stakeholders. These stakeholders are developers, customers, end users, subcontractors, suppliers, third-party developers, governmental organisations and other stakeholders that affect or are being affected by the software system under development. Modern systems aren’t isolated local applications; they tend to progress towards large and complex systems with increasing numbers of connections to other similar systems. Furthermore, these software systems aren’t restricted to be only software or hardware. They can contain human components, such as services, that are essential parts of the software system and its ecosystem.

In order to develop such systems, a wide variety of experience and expertise is required from the developers. Often this means that multiple persons need to be involved, each an expert in certain fields, as a single individual developer doesn’t or cannot have all the necessary information to develop the software system. To aid the development, a multitude of different approaches and methodologies have been developed, starting from original waterfall approaches to modern agile methodologies. At the heart of each methodology is a process that identifies, documents, analyses, agrees, validates and maintains software system requirements, namely the Requirements Engineering (RE) process (Alexander & Stevens 2002) (Kotonya & Sommerville 1998) (Sommerville 2004).

The RE process in the traditional sense is a process where developers, along with a customer, identify the target system and the customer's needs towards the target system and agree on what is being built and when. In addition, other stakeholders are involved in the process in different roles. There are users, managers, GUI designers, government and various other actors who might affect or be affected by the target system. The needs of these stakeholders need to be identified, their needs recorded and managed in some manner as a part of building successful new software systems. This process is commonly known as a stakeholder analysis. In RE the stakeholder analysis process ideally is used to identify and understand all relevant stakeholders that can influence the system requirements to successfully identify and document relevant system requirements (Kotonya & Sommerville 1998) (Sommerville 2004). The purpose of this thesis is to discuss the role of stakeholder analysis in a Software-intensive Systems (SIS) development environment and propose how it should be conducted to support the needs of the SIS development environment.
A modern SIS is a large and complex system which is required to communicate with other systems, and the main difference from other large-scale systems is the role of software. In SIS, both software and hardware form the complete system, but the software determines the product’s usability and functionality. Furthermore, the development tools, production methods and mechanisms are determined mainly by the software. Finally, innovations in SIS are driven by the software, further emphasising the role of software as the determining factor of the features of the final product. Hardware is essential, but SIS is designed to limit the influence of the hardware (Broy 2006) (IEEE-Std-1471-2000 2000) (Giese & Henkler 2006).

1.1 Background

A typical large scale development effort often occurs in different locations in several countries, an environment that demands knowledge workers (Robillard 1999) with a common understanding, shared goals, awareness and practices that support the work. Knowledge-intensive processes are characterised by dynamic changes of goals, information, environment and constraints as well as intensive individual ad hoc communication and collaboration patterns; thus, it is not easy to plan the work in detail beforehand (Buckingham 1998). Various stakeholders from different organisations work in collaboration, forming teams that work together via communications technology. These teams are dynamically and spontaneously assembled groups in which members can collaborate (Prinz et al. 2006). There are few who are capable of mastering entire software development processes, but even then, modern software is created by pooling the expertise of software development experts together and creating the required software in cooperation.

To solve problems that involve multiple stakeholder needs in Software Engineering (SE), a common approach in RE is to perform a stakeholder analysis (Kotonya & Sommerville 1998) (Sommerville 2004). The main goal of a stakeholder analysis is to discover relevant stakeholders for a problem faced by developers in order to help developers to capture stakeholders’ needs, analyse them to requirements, negotiate and prioritise them as requirements specification and finally verify and validate the requirements throughout the process. In SE, applying a stakeholder analysis during software development in its own part provides tools and practices to understand the problem and its environment from multiple stakeholder perspectives.

The origin of the term “stakeholder” is often credited to Freeman (1984). The original purpose of the term was to define other people, groups and organizations
that are not direct stockholders of a company. This need was recognized as companies were either affected or could affect these entities that either directly or indirectly affected company’s performance. Companies recognized that those stakeholders’ needs should be also accounted somehow, starting a new era in company management culture. While this phenomenon has existed as long as organisations themselves, Freeman’s book gave a name to this phenomenon, and stakeholder analysis in its modern form was born.

While the stakeholder concept existed mainly in management science, it eventually found its way to computer science and to software engineering and embedded systems development. It was seen as a meaningful term and method capturing those persons, groups or organisations that could potentially affect or be affected by a system under development. Generally only the customer is the most well-known stakeholder, and the needs of other potential or real stakeholders are often handled ad hoc or at least not in systematic manner depending on personal experience and company organization/culture. They were seen initially as a potential source of requirements and modern software engineering textbooks introducing stakeholders and stakeholder analysis as a means to obtain requirements, validate them and finally negotiate between stakeholders in order to generate a prioritized requirements document.

Today, most of the literature discusses potential groups of stakeholders and concentrates on methods and practices to extract information relevant to a development effort, negotiation support for RE, increasing customer and user involvement and feedback, validating requirements and formal language creation for requirement descriptions. Recent openings in the stakeholder analysis focus on formalizing analysis and stakeholder identification, such as WinWin (Boehm et al. 1995) and Stakenet (Lim et al. 2010).

1.2 Motivation

The main motivation for the research, however, surfaced when an RE process of a large-scale telecommunication company was analysed in order to develop practices to record and analyse different stakeholder requirements (Kelanti et al. 2012). This particular case identified a particular need in large-scale development environment in regard to communicating stakeholder needs over different domains, most notably between solution and problem domains. In this case, the problem appeared in situations where customer needs surfacing from a problem domain were handled as a solution domain need, understanding customer needs directly as a technical
problem. This raised a need and eventually one solution to connect the stakeholder need to the system perceived by the stakeholder. Information about the interest, value and impact of the need to the real system perceived by the stakeholder helped developers to see new technical solutions to the stakeholder’s need. These solutions were no longer the same as they initially thought, and developers perceived that they understood the problem better than they did previously. While they would have understood the problem if enough time was given, the System-Stakeholder-Request/Requirement practice allowed themselves to think about the problem from proper viewpoints, allowing them to understand the problem sooner.

This is a well-known problem in a software development process. Rosenhead & Mingers (2001), for example, point out that design problems often result from ill-defined goals and evaluation criterions. Typical characteristics of this problem are the existence of:

- Multiple actors and perspectives
- Incommensurable and/or conflicting interests
- Important intangibles
- Key uncertainties

Stakeholder analysis is typically conducted to record, analyse and understand the stakeholders relevant to the problem faced by the developers in order to get information to tackle the previously mentioned problems. Even if the information is available, large-scale developers, especially software intensive systems (SIS) developers, often find it difficult to approach, collect, analyse and structure the information they need. Furthermore, practitioners need to re-examine their own solution as they do not have a complete understanding of the solution due the sheer size of it. Development efforts require hundreds or thousands of developers, each having their own viewpoints. Combined with connections to other systems and solutions, the amount of organisation work required in communication and decision-making to keep the development from falling to chaos increases.

While there are established methods for stakeholder analysis (cf. (Lim et al. 2010), (McManus 2004), (Alexander & Robertson 2004)), none has established itself as a dominant or generally accepted way to do the stakeholder analysis in software engineering. Recently, StakeNet (Lim et al. 2010) has been developed for analysing stakeholders in Large-Scale development environments. Before that, the stakeholder analysis methods mainly either concentrated on small and medium scale development effort or used simplified examples or industrial cases to demonstrate the analysis methods.
Furthermore, a literature analysis about stakeholder analysis (presented in chapter 2) indicates that while multiple methods have been developed to address the problem of analysing different stakeholder viewpoints in SE, none of the existing methods appear in a dominant role in practice. Therefore, it becomes worthwhile to examine the nature and role of stakeholder analysis in practical software development.

1.3 Research problem and questions.

The research problem in this thesis concentrates on understanding how stakeholder analysis emerges in a software-intensive systems development.

The research design in this thesis is constructed to allow observing and identifying the factors required from stakeholder analysis to support a development process in a SIS development environment. The design is based on an empirical approach (detailed description in chapter 1.4) aiming to study the SIS development environment and stakeholder analysis in it. The main goal is to study stakeholder analysis from different viewpoints:

- The large-scale development environment
- stakeholder analysis in the SIS development process
- methodological aspects of a stakeholder analysis in SIS

The aforementioned viewpoints were selected to understand how the environment in general works, essentially what general needs the environment sets for any method or work conducted in the large-scale development environment. After analysing the environment, the last two viewpoints concentrate on the stakeholder analysis in a specific SIS environment by analysing the characteristics of stakeholder analysis and the structure of the methodology itself. These three viewpoints can be expressed as following research questions:

RQ1. What kind of characteristics do large-scale development processes require from methods and practices?

RQ2. What kind of characteristics does a stakeholder analysis in SIS development processes have?

RQ3. What kind of characteristics are required from the structure and methodology of a stakeholder analysis in the SIS development process?
The research questions are answered with five original research articles. The contribution of each original study to the research question is presented in figure 1.

**Fig. 1. Contribution of each original research paper for the research questions.**

### 1.4 Research design and structure of the thesis

The rest of the thesis is structured as following. Chapter 2 presents the related literature and work of stakeholder analysis and theory in general and in SE. The research setting of this thesis is described in detail in chapter 3. Chapter 4 presents the original work and contributions to the research questions and problem. Chapter 5 discusses the contributions of the original work along with limitations, threats to validity and future research. Finally, chapter 6 presents the conclusions.
2 Background and Related Work

Stakeholder analysis is a process where individual stakeholders or groups are identified as they are likely to affect or be affected by an action. The stakeholder analysis is commonly used in business administration and project management where the stakeholder interests are used to assess project plans, policies, strategies and other aspects and actions. A stakeholder analysis in general aims to identify all of the stakeholder demands on a firm in a selected issue in order to weight and balance them to determine a company’s obligations in that particular issue. A stakeholder analysis does not require overriding any particular stakeholder interest but rather tries to ensure all stakeholders who are affected are considered. (DeGeorge 2010)

A stakeholder analysis essentially helps to identify the key stakeholders of a project (or an organisation, a process or any other system the analysis is being conducted upon) and their interests. As these stakeholders become known, the interests can be identified and managed. Since these stakeholders are identified, they can also be informed about the progression of the project. Additionally, the stakeholder analysis helps to analyse the potential risks by identifying negative stakeholders and other negative effects affecting the project. Stakeholder analysis is used to analyse complex problems and formulate them as problems that can be solved (Bryson et al. 2002) (Savage et al. 1991).

The purpose of this chapter is to define what a stakeholder is, the theories of stakeholder management in organisation. Chapters 2.1 and 2.2 utilise the work done by Friedman and Miles (Friedman & Miles 2006) to describe the history and general idea of stakeholder and theories behind before moving to describe the concept and usage of stakeholder in SE. The chapter 2.3 presents the results of a literature analysis in which stakeholder and stakeholder analysis is defined in SE. Chapter 2.4 summarises the key findings of the literature analysis. Detailed description of the literature analysis is presented in chapter 3.1.1.

2.1 Definition of a stakeholder

The term and definition of stakeholder was popularized by Freeman (1984) in his book “Strategic Management: A Stakeholder Approach”. In his book, Freeman defines a stakeholder as:

‘any group or individual who can affect or is affected by the achievement of the organisation’s objectives’
The concept of stakeholder was introduced to provide foundations for a new way to think about the purpose of a company. Instead of operating only to maximise stockholders’ benefits, it should also consider the interests of employees, suppliers, retailers and other stakeholders. The purpose of this concept was to introduce ethics directly to the foundations of a business. The intent was that a company should not only operate to provide maximum benefits for stockholders, it should also consider the interests of other stakeholders and their benefits. The company, therefore, should also consider the interests of employees, governments, suppliers, retailers and other stakeholders (Freeman et al. 2007). The term “stakeholder” however first appeared in 1963 in a memo from the Stanford Research Institute (Donaldson & Preston 1995).

Based on the new concept, the organisation or company should be thought of as different groups of stakeholders and the company’s purpose should be to manage their interests, needs and viewpoints. Therefore, a certain group of top-level managers, as stakeholders themselves, should be charged to fulfil the role of stakeholder management (Friedman & Miles 2006). The concept can be elaborated as two principles (Evan & Freeman 1993):

1. Principle of corporate legitimacy. The corporation should be managed to benefit its stakeholders and the rights of these stakeholders must be enforced. Furthermore, if these stakeholders are substantially affected by the decisions made by the company, their participations should be ensured in some manner.

2. The stakeholder fiduciary principle. A company’s management must act in the interests of the stakeholders, and the company and ensure the survival of the company and safeguard the long-term stakes of each group of the stakeholders.

Freeman later reworked these two principles to promote the idea that that corporations should be managed based on the interests of the stakeholders and management’s duty is to direct the company in such a manner that the stakeholders’ interests are being managed.

However, the concept of stakeholder has varying definitions in both practice and literature. Friedman & Miles (2006) summarise the history and different stakeholder definitions along with the theories known in management sciences. Over 70 different definitions are given alone, some only slightly different while others drastically different. For example, starting from Stanford Research Institute’s “Those groups without whose support the organization would cease to exist” to “Parties affected by an organization” by Lampe. Further examples can be taken from the collection, but the main point is that with so many different
definitions, stakeholder is a specific set of stakeholders or it can be virtually anyone. It reveals how many different actors should be considered when managing a company or the many ways how the whole concept is understood and used. This has led to criticism against the concept of stakeholder as it is vague and abstract due the usage in literature and public:

- “A muddling of theoretical bases and objectives” (Donaldson & Preston 1995)
- “A rather vague and cryptic concept that is open to a wide variety of rather divergent political interpretations” (Hay 1996)
- “A slippery creature... used by different people to mean widely different things which happen to suit their arguments” (Weyer 1996)
- “The term stakeholdering becoming ‘content free’ meaning ‘almost anything the authors desire’ and the stakeholder debate becoming ‘confused’ and ‘often shallow’ in nature” (Stoney & Winstanley 2001)

The criticism is mostly born from the usage of the concept of stakeholder by different authors as the term itself became more popular. It became a meaningful way to describe the individuals, groups and other organisations that were influenced or being influenced by the company’s actions but law alone only provided the minimum of protection and enforcement for these stakeholders. These issues were discussed under the corporate social performance (CSP) and later as a stakeholder theory.

2.2 Stakeholder theory

The roots of stakeholder theory start from the growing need to make companies socially responsible for their actions. The view was that companies were soulless entities that lacked any form of ethics and “feelings” common to human beings as a result of their actions. These needs required an introduction of means to make corporations socially responsible and one of the earliest advances were CSP (Friedman & Miles 2006).

According to Carroll (1979), the CSP requires the companies to meet the economic, legal, social and discretionary expectations given by the society. Furthermore, these expectations are evolving, and they appear or change their importance as time progresses and greatly depend on the type of the industry. This led the businesses to seek more managerial approaches that are capable to response all social issues as they become important for the firm.
A stakeholder theory was one of the solutions developed as a response for previously mentioned issues. The concept of stakeholder was used mainly in strategic management literature designed to understand the interests of specific groups of stakeholders and help companies to predict the future environment and strategy based on these needs. However, the concept of stakeholder was mainly used in special situations. Freeman (1984) changed this view because companies were facing “turbulence” in the new market situations, and new management paradigms and concepts were needed. Freeman also notes that companies had been always facing “turbulence” but the internal and external changes meant that companies could not be considered as plain resource conversion units. Freeman argued that the both internal and external changes had new unknown entities or stakeholders that current theories or approaches did not yet properly understand and new generations with new ideas and values required new approaches to management meant that organisations should identify, address and adapt accordingly. This new management approach requires companies to develop expertise on understanding how stakeholder groups form and appear, the key issues they perceive, how willing they are to use resources to either help or harm the organisations on these issues, and stakeholder relations management. This new approach was known as a stakeholder approach.

After Freeman, the stakeholder approach established itself as way to manage the stakeholders’ interests constantly, not just in special situations. A stakeholder approach would essentially guide the company to determine who the stakeholders are, manage their needs and guide the company to serve these needs. However, as academics, policy makers and other interested parties adapted the concept of stakeholder, the concept itself gained popularity but also became vague and abstract. This was due the different ways how authors explained the concepts of “stakeholder”, “stakeholder model”, “stakeholder management”, and “stakeholder theory” with contra dictionary and diverse evidence and arguments (Donaldson & Preston 1995).

To provide clarity in the situation, Donaldson & Preston (1995) argue that the confusion is due to the combination of four different aspects of stakeholder aspects without acknowledging them. These are normative, instrumental, descriptive, and broadly managerial aspects:

- Descriptive aspects describe corporate characteristics, like how these corporations are managed, the nature of the firm, etc. In this aspect, the
corporation can be seen as a collection of cooperative and competitive interests who possess intrinsic value.

- Instrumental aspects concentrates more on stakeholder connections, those that can be described as “ceteris paribus.” They pay more attention to management practices, like how a corporation can achieve its goals and can be understood by the principle that if you want to achieve certain things you have to adopt certain practices and principles.

- Normative aspects define stakeholders as those who have legitimate interests in corporate activities, where the interests have intrinsic value. Theories themselves are more or less moral or philosophical guidelines for corporate management according to these aspects.

- Broadly managerial aspects represent the organisational structures, practises and attitudes that constitute stakeholder management in a company.

Reed (2002) refines normative, instrumental and descriptive categories. Normative theories are the strictest of these three; they define theories where a stakeholder has valid normative claims over the company. Normative theories are the ones that guide management to morally act correct or in a way to create “good” outcome. Instrumental theories are somewhat broader as they allow those stakeholders that management needs to take into consideration to be identified. These stakeholders can affect the achievement of company's goals, and therefore, need to be identified. The broadest definition is descriptive, which defines stakeholders as a person or group that can be affected by the company and/or can potentially affect the company itself. Figure 2 demonstrates the relationship of these theories by presenting the normative theories in the core, wrapped with instrumental and descriptive aspects.

However, it might be wrong to describe normative, instrumental and descriptive as individual categories for stakeholder theories. Donaldson and Preston (1995) and Friedman and Miles (2006) present them as the aspects of the stakeholder theory, meaning that the stakeholder theory includes all these three aspects. The actual difference between theories is that the theory usually concentrates on one of these aspects making it an instrumental, normative or descriptive theory.
To conclude, the main purpose of the concepts of a stakeholder and stakeholder theory is organise the management of the company to follow a stakeholder approach. It directs the company to identify and analyse its stakeholders constantly in an evolving environment and identify the needs of different stakeholders. Furthermore, it allows the analysis of the power of the stakeholders themselves, how willing they are to advance their needs and help or harm the company. Depending on the specific theory, it also provides morals and values that should be taken into consideration when decisions are made. For example, a theory that concentrates on environmental issues would direct the company activities based on environmental values. In practice, this could materialise with considering stakeholders who have more impact on environmental issues would for example be more important considering decision making or their requests get higher importance (Friedman & Miles 2006).

2.3 The concept of a stakeholder in Software Engineering

The concept of stakeholder in software engineering is generally used in a development process as a means to identify and manage stakeholders relevant to the system under development. In software engineering, a stakeholder can be identified as a person or a group who will be affected by the system either indirectly or directly. These stakeholders are often the most visible in RE phase of a development process but depend greatly over used development methodology. For example, typical stakeholders in SE are:

- Customers
From these stakeholders, customers and developers are the most well-known stakeholders but the previous stakeholders do not form the complete list of stakeholders. For example:

- In and Boehm (2001) introduce general public, interoperator, user, maintainer, developer, and customer as stakeholders but provide no further definition of the stakeholder itself.
- Wong (2005) introduces only users and developers as stakeholders.
- Barney et al. (2008) introduce three stakeholder groups based on literature; business, project and product.
- Fedorowicz et al. (2009) define three government agencies and several organisations as stakeholders.
- Van de Weerd et al. (2006) define internal and external stakeholders (for example company board, research & innovation, market, partners, and customers) using literature sources.

Other authors identify stakeholders by various means, often based on questionnaires, lists, templates, practices and definitions to identify stakeholders, for example:

- Finegan et al. (2006) utilise CATWOE to identify stakeholders such as government agencies, current and prospective IT employers and students. The authors, however, do not define the stakeholder but use the CATWOE to identify them.
- Singh and Woo (2009) define stakeholders as potential users of a system, such as middle managers and workers. The stakeholders are those who can affect or be affected by the system under development.
- Mannion et al. (2009) define stakeholders as systems or people having interest, influence or some special knowledge of a domain.
- Poole (2003) refers to a stakeholder as someone who holds a share, interest or a stake in a project.
- Ballejos and Montagna (2008) define stakeholder as an individual, group or organisation that can affect or be affected positively or negatively by a system under study. Furthermore, these stakeholders also have a direct or indirect influence on the system’s requirements.
Davis (2005) defines as stakeholder a person who is in some way affected by the presence of a new system. He presents users, customers, marketing, development, system testers as basic stakeholders. Also, a stakeholder known as the “lost user” is introduced originally defined by Gause (1989) implicating that the term “affect” includes both negative and positive affect.

An interesting remark is that negative values or relations aren’t considered or mentioned often. Davis (2004) presents the idea of the negative stakeholder in his book when describing some general stakeholder classes and roles. The author makes a note that also those stakeholders who might lose something should be considered as they might hinder, act against or even sabotage the development. This can be caused by, for example, fear of changes that affect their work negatively or even cause a loss of a job. Other authors, like McManus (2004), instruct to identify such stakeholders who might be affected positively or negatively by the development. This was just one guiding question originally taken from The World Bank, and the author describes the process of taking the stakeholder’s perspective into an account in a general level.

Although the previous lists of stakeholders and their definitions aren’t comprehensive a similar pattern of multiple different and varying descriptions appear to make the concept vague and abstract as it is in management literature. McManus (2004) argues that there are no clear or exact rules or instructions to identify concrete stakeholders and refers to the lack of stakeholder theory. Chung et al. (2009) argue that theories in literature do not take recent advances in technology into account. Therefore, new stakeholders, that previously weren't able to be affected or affect arise, and the need to identify them is becoming more important. Furthermore, the identification process itself is not systematic but rather done in an ad hoc manner (Ballejos & Montagna 2008).

One perspective to understand the vague or abstract nature of the definition of stakeholder can be found by the typical hands-on approach of a SE field. Often, the concept of stakeholder appears as part of the development process itself and is not identified as a separate process, embedded in a RE methodology itself. A typical approach is to either set a list of questions or examples to identify stakeholders in order to understand who there are, what are their goals, how the software affects them, what risks can be identified and so on. (cf. (Alexander & Stevens 2002), (Sommerville & Sawyer 1997), (Lauesen 2002)). In RE, the concept of stakeholder usually appears as a stakeholder analysis, where the stakeholder analysis often means (Davis 2005) (Kotonya & Sommerville 1998) (Sommerville 2004):
- Identification of relevant stakeholders or information sources that can affect or being affected by the system under development;
- Understanding the goals and need of the stakeholders to elicit requirements from identified stakeholders;
- Analysis and understanding of the requirements from different stakeholder perspectives to create requirements specification.
- Negotiation and prioritisation of requirements with stakeholders to prioritise and agree an implementation schedule;
- Validation of the requirements with stakeholders.

From the process viewpoint, stakeholders are considered essential to be involved to analyse their goals, rationale why they want to contribute or be involved, the identification of risks and how they understand the target system and its environment (cf. (Lauesen 2002)). For example, the CMMI maturity levels include the identification and involvement of stakeholders in different activities. As the maturity levels increase, the stakeholders’ involvement is planned, monitored and managed (CMMI 1.3 2016). In general, involving the stakeholder is an important part of any development activity as mentioned before.

The research in SE concerning stakeholder and stakeholder share the same practical approach on creating tools and methods to involve stakeholders, such as identifying stakeholders utilising network approaches. Sharp et al. (1999) propose a network based approach where stakeholders are identified in four baseline categories: users, developers, legislators and decision-makers. For each identified stakeholder, a satellite, support, client stakeholders are identified and this process is repeated for each identified stakeholder. Authors mention that the method is theoretical and not evaluated in practice. A similar approach is adapted by StakeNet, where stakeholders’ social networks are used to identify stakeholders (Lim et al. 2010). In this method, the stakeholders themselves are asked to identify other stakeholders they know that are relevant to a target system. From the same principle, a tool (StakeSource) was developed to automate stakeholder analysis, mainly to crowdsourcing the stakeholder identification to the stakeholders and aggregate suggestions for relevant stakeholders with network analysis (Lim et al. 2010).

Other approach is to create a list or category of stakeholders that are likely to be relevant for a target system, such as a business stakeholder analysis for a web based identification and classification of stakeholders (Chung et al. 2009). In this paper, authors design and test an automatic identification tool against several baseline identification methods. Similar to this is also an onion model where layers
around a target system are used to identify different stakeholders (Alexander & Robertson 2004).

Ballejos & Montagna (2008) designed a stakeholder identification method for interorganisational environments. The method first asks users to specify the stakeholder types and roles that are necessary for the given environment. After this, stakeholders are identified based on the stakeholder types and identified roles are assigned for them. The difference in this method compared with previous ones is the last step. The last step aims to analyse the influence and interest of each stakeholder to get an initial understanding about the stakeholders and their influence. Similar to this, a Soft Systems Methodology (SSM) can be utilised to identify relevant stakeholders and draw a rich picture of a soft system populated by the identified stakeholders and their interactions (Finegan et al. 2006). In this particular paper, the authors use the SSM principles to understand and analyse complex problems in an IT degree externalisation case. SSM has been proposed a potential methodology to understand complex problems and allow various stakeholders to reach a common understanding about the problematic situation (Neal 1995) (Green 1999).

The stakeholder identification and involvement is clearly important in SE, but the research is not completely concentrated on just stakeholder identification as seen earlier. McManus for example describes a methodology to identify, analyse and manage stakeholders in broad scale (McManus 2004). Instead of just identifying and analysing, techniques and guidance is given how to involve the stakeholders and especially how to gain stakeholder’s trust. Similar to this, while not strictly described as a stakeholder analysis method, the many models of the Win-Win Spiral Process (Theory W, Spiral Model) (Boehm et al. 1995) essentially helps developers in the negotiation process with different stakeholder interests. The Win-Win Spiral Process aids the user to capture the potential win conditions of each identified stakeholder, analyse the potential conflict points, and an approach to negotiate with the stakeholders to reach a win-win equilibrium state. This process promotes the soft aspects of stakeholder interaction, making everyone feel like they are winning and nobody feel like they losing.

2.4 Conclusions from the literature analysis

The data collected by Friedman & Miles (2006) indicate that the definition of a stakeholder is a meaningful way to describe anyone who is somehow affected by the actions of the company or can affect them. The original intent was to affect the
company’s decision making from stockholder approach. This in theory would allow other stakeholders to gain some value while not being owners of a company. Different stakeholder theories were then developed to guide the companies or organisations to how they should identify and serve the needs of their stakeholders. In essence, the concept of stakeholder and the theories developed guide companies to organise their purpose towards providing value for different stakeholders. However, the main issue with the concept of stakeholder is the vague usage of the concept and the amount of theories that has been surfacing after the term was made popular in 80s. Same issue plagues the stakeholder theory or the “stakeholder approach”, different definitions by different authors made the stakeholder approach abstract. While attempts have been made to categorise and solidify different definitions and theories, the main problem with stakeholder approach is the lack of clear definition. Furthermore, multiple different approaches how stakeholder needs should be served depended on the ethical and moral perceptions that was utilised, making the stakeholder approach situational as different theories perform better in different situations.

In SE, the definition of stakeholder has similarities to the original usage of the stakeholder. However, it primary serves the RE phase in software development where stakeholder requirements are defined for a system under development. The same problem is present regarding SE as the different definitions or lack of clear definition allows anyone who is affected or can be affected, in some manner, to be a valid stakeholder. General approach in SE is to ask a set of questions or utilise pre-defined categories to identify stakeholders and then determine if they are relevant. Generally anyone who can affect or be affected can be considered to be a stakeholder until it is determined whether the stakeholder is important enough to be considered or not. In addition, the lack of connection to proper stakeholder theories have been criticised. Most of the stakeholder analysis methodologies aim to identify, analyse, negotiate and validate stakeholder’s needs and concerns towards a software product and managing the stakeholders varies from case to case. Based on the literature analysis, the first finding is that the stakeholder definition in SE appears to be abstract and vague and the main use of the stakeholder analysis is in RE process to generate a requirements specification.

The second finding from the literature analysis is the small amount of research about stakeholder analysis methods or approaches in a large-scale development environment, including SIS development. The majority of studies and textbooks do not specifically identify the scale of the development effort or provide examples of small or medium scale programs or projects as a means to practice or demonstrate
the development methodology. A few studies claim and demonstrate stakeholder analysis in large development environment but do not specifically identify SIS as target environment.

The third finding is that the identified literature provides methods to conduct stakeholder analysis but the proposed methods vary, and there is a lack of evidence that one or few of them are consistently or generally used in practice. It should be noted that the way stakeholders are identified and analysed in traditional textbooks is fairly similar and is based on asking questions in order to identify relevant stakeholders. This, however, has been criticised as it is not a systematic approach.

In conclusion, the research about the concept of stakeholder is mainly concentrated on tools and methods that essentially support the practical work, especially how to identify stakeholders that are relevant. Some studies criticise the lack of a connection to stakeholder theory in order to establish systematic and clear stakeholder analysis in SE. Studies and practices clearly make stakeholders essentially a part of a project that aims to modify or create a new system. This presents a research opportunity to study what the concept of stakeholder actually is in SE and how the stakeholder analysis should be understood and used, especially in large-scale development environments such a SIS.
3 Research setting

As the research problem of this thesis requires studying the nature of a SIS development environment and stakeholder analysis, the research approach is empirical where the subject of study can be observed directly or indirectly allowing the use of different empirical research methods is emphasised in order to accumulate knowledge about the real world phenomena under study (Wohlin et al. 2000) (Runeson & Höst 2009). The empirical approach was motivated by the initial literature analysis over stakeholder analysis in chapter to and previous research over practices how to record and analyse requests and requirements from different perspectives (RE practices in large-scale development (Kelanti et al. 2012)), as better understanding was needed based on literature analysis over following viewpoints:

- what is a stakeholder analysis in a large-scale software development process, such as SIS,
- what restrictions and features the large-scale development environment causes, and
- what shape of form a stakeholder analysis appears in SIS and what methodological and tool support it requires.

The research approach in this thesis therefore aims to let the real world to describe the phenomena itself (stakeholder analysis) and its environment (large-scale software development) and understand how the phenomena can be supported in its environment (methodology and tools). These represent each of the research question presented in chapter 1:

RQ1: What kind of characteristics do large-scale development processes require from methods and practices?

RQ2: What kind of characteristics does a stakeholder analysis in SIS development processes have?

RQ3: What kind of characteristics are required from the structure and methodology of a stakeholder analysis in the SIS development process?

The generalisation of the research results greatly depends on what kind of data was available and how many different representative cases of large-scale development environments are available. In this research, two different case companies were available to study the restrictions and features of a large-scale development
environment but only one for analysing the stakeholder analysis phenomena. Therefore, the overall results of this thesis are restricted to SIS development as the participating company was conducting the software development process in this specific manner.

The rest of this chapter will further elaborate the research framework and its phases, including the specific details of each original contribution in their respective phases.

### 3.1 The research framework and phases

The overall research framework consists a literature review using the principles of a systematic literature review and three research phases. These phases are organised around the research questions presented in the chapter 1:

- **Phase 1** – Characteristics of a large-scale development process. (RQ1)
- **Phase 2** – Characteristics of a stakeholder analysis in a SIS specific large-scale development process. (RQ2)
- **Phase 3** – Characteristics of a structure, methodologies and tools supporting stakeholder analysis in a SIS specific large-scale development process. (RQ3)

Selection of actual methodologies were decided based on the data that was made available during the research process. As the overall goal was identification of attributes that describe stakeholder analysis in SIS development, methods were selected case-by-case. Figure 3 elaborates on the overall research framework.

The research framework was motivated by identified real world problem in previous research (Kelanti et al. 2012), and it was designed to address the problem of organising stakeholder analysis in a SIS development where the past experience indicated problems with properly communicating different stakeholder viewpoints. The main research approach selected was an empirical approach to study the phenomena of stakeholder analysis in its own environment, large-scale software development.

The first step of the research approach was to establish the research problem and identify whether already existing solutions exist in literature. In this thesis, the first step is to establish an understanding of the concept of a stakeholder and stakeholder approach. The viewpoint adapted in this thesis originates from the work done by Friedman and Miles (Friedman & Miles 2006) where authors describe the origins and purpose of the stakeholder approach. After establishing the definition and purpose of stakeholder analysis in its original meaning, the next step was to
conduct a literature analysis to gain a proper understanding of stakeholder analysis and the current approaches in SE. Based on the findings in literature analysis, it became relevant to study what a stakeholder analysis is in a large-scale software development and the nature of the environment itself in phase 1 with RQ1.

Fig. 3. Research framework.
Phase 2 and 3 were designed to analyse the stakeholder analysis especially in a large-scale SIS development. Phase 2 concentrated on analysing the purpose and form of stakeholder analysis in SIS development represented by RQ2. Phase 3 is focusing in to the methodological aspects and required tool support of a stakeholder analysis represented by RQ3.

The rest of this chapter describes the details of the applied research approach of the literature review and each individual phase.

### 3.1.1 Literature analysis

The literature review was designed to analyse how the concept of stakeholder and stakeholder analysis is defined in a SE literature and what is its intended purpose in a development process. Furthermore, the literature analysis concentrated on identifying stakeholder analysis methods from SE literature in order to identify methodologies that are capable or were designed for large-scale development processes.

The papers for the literature analysis were obtained by utilising the principles of a systematic literature review. A systematic literature review is a rigorous search strategy where selected sources are reviewed systematically using a pre-defined search strategy (Kitchenham & Charters 2007). The systematic literature review originates from medical science and was designed to collect all relevant material from large collection of material and studies. The method has been applied outside the medical domain (Higgins & Green 2009). Systematic review is often divided into three main phases: planning the review, conducting the review, and reporting the review. The way the systematic literature review was adapted based on Kitchenham and Charter’s (2007) framework and is illustrated in figure 4.
Fig. 4. Process for obtaining the literature analysis papers.

The literature review was conducted by the author of this thesis supported by a supervisor. In the first phase, databases were chosen using the recommendations provided by Kitchenham and Charters (2007), Dybå (2007), consulting other professors and professionals who gave their opinion about the relevance of databases:

- IEEE
- ACM Digital Library
- Springer Link
- Science Direct (Elsevier)
- Wiley Online Library

These databases were searched using terms “Stakeholder” and “Stakeholder Analysis”.

39
The results from this phase were extracted into an Excel file for sorting and listing. No limits were imposed to the publication year, and English was used as a language to search papers. Only papers in English were accepted. Obtaining the studies were done by one researcher.

In the second phase, the main objective is to evaluate whether the study’s context is in SE process. Paper titles were analysed and the principle for including the study in this phase was that if the study is clearly not about SE, it will be excluded and otherwise included.

In the third phase, the introduction and conclusion from each study was analysed in order to determine whether the paper includes, identifies or analyses stakeholders in any way.

In the fourth phase, each study’s quality was analysed. A simple approach was used and only those papers were included that had been peer-reviewed and published in a conference proceedings or in a journal. In addition, the whole paper was read and analysed to include only papers where stakeholders were analysed.

The fifth phase concentrated on analysing and collecting data about stakeholder analysis in SE. This was done in thematic manner by one researcher where themes were identified based on the themes and topics identified in the original stakeholder approach. In addition, further information was extracted and analysed if it had any relation to the concept of stakeholder. The results of the analysis are presented in the chapter 2.

After the first literature analysis and research question formulation, the literature analysis has been updated as a part of the literature analysis of each original study.

### 3.1.2 Phases 1 and 2.

The research approach and method used in phases 1 and 2 was designed to utilise qualitative case studies with expert interviews. In both phases, semi-structured interviews were used to provide a direct access and communication channel directly to the practitioners allowing researchers to collect rich information. Furthermore, the research method was selected to allow the collection of any information in any format. This phase produced three case studies; A Case Study of Requirements Management: Supporting Transparency in Requirements Management Tools (Paper 1), Software development as a decision-making process (Paper 2) and Organising Stakeholder Analysis to Support Software Intensive Systems Development (Paper 3).
The case studies follow the guidelines presented by (Runeson & Höst 2009), and figure 5 presents the general approach adapted. The case studies utilised semi-structured expert interviews in companies doing SIS development. Utilising semi-structured interviews and a qualitative approach, the researcher can encourage the interviewee to express their viewpoints, opinions and experiences freely providing a rich picture about the large-scale systems development phenomena. Here the goal is to understand the environment itself before moving to specific system development.

![Fig. 5. The research approach for case studies.](image)

The interviews in both phases were done during the AMALTEHA project, between 2011 and 2014, details are presented in each original study. In these three case studies, the problem was first identified with company representatives and researchers supported with study specific literature reviews and material provided by the company representatives. After identifying the problem, questionnaire templates were created and improved in iterative manner between researchers and company representatives. When the iterations produced a version all parties were satisfied, a pilot interview was organised in each case company to determine the quality and validity of the questions. The pilot interviews were mainly used to fine tune the questions and determine whether the terminology used in the interviews was understandable and suitable for the context.

After the pilot interview, the actual interviews started. The questionnaire was delivered to each interviewee in advance, at least one week before, allowing the interviewees to prepare themselves and be familiar with the questionnaire. In each interview, at least two researches were present, one talking with the interviewee and another making notes. The roles could change during the interview. Duration of each interview was approximately 1.5 hours. The interview was recorded and transcribed and summarized and sent back to the interviewee to be checked and corrected. Each interviewee were given at least two weeks to respond.

After the checking process, each transcription and summary was analysed using an analysis software such as Nvivo 10 to help the analysis process. The material obtained from the case studies was analysed using thematic analysis. Thematic analysis is a method where data is organised into themes, allowing researchers interpret the results with different theoretical frameworks. It allows
reporting the experiences, meanings and realities of the participants in rich detail. Analysing the results with a thematic analysis, an overview and general characteristics can be identified from real life phenomena (Braun & Clarke 2006) (Cruzes & Dybå 2011). In practice, each identified theme based on topics presented in research questions and any new theme surfacing from the data was coded and analysed. After the coding and first analysis, the results were compared with existing literature and presented to the case companies in workshops where findings were presented for each interviewee and they had an opportunity to comment and discuss the findings. Feedback from each workshop was recorded and used in a second analysis of the data.

In the first case study (Paper 1) 11 interviewees were interviewed, seven designers and engineers and four managers in the case company developing automation platforms for industrial automation purposes. The interviewees were selected to cover the whole development process in the case company. The questionnaire in this study was designed to cover the company’s existing development process and practices. In addition, questions also inquired the pros and cons the interviewees perceived along with possible improvement proposals or other topics the interviewees wanted to discuss.

In the second case (Paper 2) two case companies participated to the study where company A was information and communication technology provider and company B which developed automation platforms for industrial automation purposes. A total of 35 interviews were completed in company A and 11 in company B. In both companies, interviewees were selected to represent the whole development process in both companies. The interview templates in both companies were structured in similar manner, covering their development process and practices but tailored each company to have a terminology interviewees were familiar with. In each questionnaire, interviewees were allowed to discuss any topic they wanted after the questionnaire was finished.

In the third case (Paper 3), two case companies from two different domains participated the study. These two companies were same as in second case and use same interview material as in the first case with 7 additional interviews from company A. In this case, the interviewees concentrated on companies’ development, management and business processes and total of 18 interviews and 4 workshops were organised. The questionnaire in this case was same as in case study 2 but the study concentrated on analysing the stakeholder analysis itself.
3.1.3 Phase 3.

The research approach to phase 3 was different as the methodological viewpoint was explored. The aim was to gain the insight of what methodological support is required in SIS development environment. Two approaches were selected to answer the RQ3 and they were experimentation with existing stakeholder identification methods and action research to analyse how the stakeholder analysis shapes out in SIS development.

The first study was an experiment (Paper 4). The used experiment method was a software experiment method described by Juristo & Moreno (2010) that can be used to experiment different scenarios in a controlled environment. The purpose is to collect data by manipulating the parameters of the controlled environment that can be used to validate theories (Wohlin et al. 2000). In this thesis, the experiment was conducted to compare different existing stakeholder analysis strategies exploring different structures for a stakeholder analysis.

The actual experiment concentrated to analyse three different approaches to stakeholder analysis, one who was taught in general software engineering textbook (baseline method), one that resembles common approach by presenting a list of questions to help identify stakeholder (questionnaire method) and a method that guides the user to identify groups of stakeholders and then systematically identify new stakeholders inside the group to specify the stakeholders (systematic method).

The experiment was conducted as a part of a RE course in University of Oulu and it was mainly aimed for 3rd year bachelor’s degree students. Students were mainly from information systems and software engineering. In total 51 students participated in the experiment.

The experimental setup was designed to compare the previously mentioned stakeholder identification methods against student’s work experience. Before the experiment, students were asked to evaluate their work experience in two categories, how many years they had SE work experience and how many years they had experience from work that wasn’t related to SE. This information was used to split the students into three different groups:

- Those with at least one year of experience with SE
- Those with at least one year of experience not related to SE
- Those with no experience at all

The purpose of this experiment was to determine what kind of stakeholder analysis methodology or structure is preferable for different experience group or does the
different methods change the result at all. All enrolled students were required to participate a 2 hour session part of the course exercise work. Each student randomly received one of the analysis methods along with guidance and paper to create a list of stakeholders using the provided method. Students worked alone and no other time limit was imposed other than the maximum 2 hours reserved for the exercise. Two researchers were constantly present during the session to answer questions and ensure that the rules and instructions were followed. The data was analysed by two researchers.

The second study in this phase was designed to be an action research study where a stakeholder analysis methodology is constructed in a practical working environment. Due to the nature of the research problem in this thesis and companies involved in the research effort, action research was used to develop a stakeholder analysis methodology. This approach offered exclusive access to experts and experienced stakeholders allowing researcher to access detailed information on SIS development process. Action research is an iterative and systematic process that allows theories to be used in practice to solve concrete problems for an organisation. It allows both researchers and practitioners to gradually create a satisfactory solution for the problem of the organisation while adding to the scientific knowledge on the topic (McTaggart 1997) (Baskerville & Wood-Harper 1996). The action research cycles can be generalised as following phases:

- diagnosis, where the problem is identified, analysed and defined;
- action planning, where the actions to address the defined problem are decided based on the available solutions and theories;
- action taking, where the desired actions are implemented;
- evaluation, where the impact of the action is studied; and
- specify learning, where the results and findings of the evaluation are documented and published, and then this information is used in a new cycle.

The actual study was implemented by analysing the problem first with company representatives and with literature analysis to select a suitable approach for the problem. After selecting the suitable approach, the iterations were run according to the five phases presented earlier. Each iteration began with a diagnosis meeting between at least two company representatives and one researcher, who analysed the results of the pre-study or a previous iteration. Based on the results, they determined the desired actions for the iteration and how long the iteration would last. After the meeting, the actions were implemented; this was done primarily by the researcher, who was assisted by the company representatives. When this phase ended, the
researcher evaluated the results and presented them in a retrospective meeting. The purpose of the retrospective meeting was to specify what was learned. This meeting was open to the company representatives and other company personnel, especially those who were involved in the research.

A total of five iterations were completed during 2014, and a total of 30 modelling sessions during action taking were completed with 20 engineers and managers relevant for the case. Five meetings and five workshops were held at the beginning and end of each iteration, respectively.
4 **Original Contributions**

This chapter presents the publications included in this thesis and how they contribute to the thesis’ research problem. A total of five peer-reviewed articles published in international conferences are included. Table 1 summarises each paper’s contribution and author’s role in the publication.

<table>
<thead>
<tr>
<th>Publication</th>
<th>Purpose of the study</th>
<th>Author’s contribution</th>
</tr>
</thead>
</table>
4.1 Paper I: A Case Study of Requirements Management:  
Supporting Transparency in Requirements Management Tools

The first publication concentrates on analysing the development process of a large company developing automation platforms in industrial automation domain. A total of 20 requirements were identified, all presented in table 2.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Support</td>
<td>RM tool shall provide information about the state of the process and tasks</td>
</tr>
<tr>
<td></td>
<td>RM tool shall only show the task relevant information</td>
</tr>
<tr>
<td></td>
<td>RM tool shall have task views that match the actual development tasks</td>
</tr>
<tr>
<td></td>
<td>RM tool shall provide task guidance</td>
</tr>
<tr>
<td></td>
<td>RM tool shall provide process guidance</td>
</tr>
<tr>
<td>Tooling &amp; Work Items</td>
<td>RM tool shall provide information about development artifacts</td>
</tr>
<tr>
<td></td>
<td>RM tool shall provide standard information templates for RE items</td>
</tr>
<tr>
<td></td>
<td>RM tool shall support linking</td>
</tr>
<tr>
<td></td>
<td>RM tool shall maintain link validity</td>
</tr>
<tr>
<td></td>
<td>RM tool shall enforce linking rules between items</td>
</tr>
<tr>
<td></td>
<td>RM tool shall support traceability</td>
</tr>
<tr>
<td></td>
<td>RM tool shall support version control</td>
</tr>
<tr>
<td>Decision-making</td>
<td>RM tool shall provide the rationale and reasoning for decisions</td>
</tr>
<tr>
<td></td>
<td>RM tool shall provide visibility of decisions &amp; their documentation</td>
</tr>
<tr>
<td></td>
<td>RM tool shall be able to generate status reports from processes</td>
</tr>
<tr>
<td>Collaboration &amp; Communication</td>
<td>RM tool shall provide awareness of others' actions</td>
</tr>
<tr>
<td></td>
<td>RM tool shall provide support for information sharing between management and developers</td>
</tr>
<tr>
<td></td>
<td>RM tool shall enforce a coherent terminology for RE items</td>
</tr>
<tr>
<td>Organization &amp; Strategy</td>
<td>RM tool shall support breaking down the strategy, vision, goals and motives into work tasks</td>
</tr>
<tr>
<td></td>
<td>RM tool shall provide information about available resources, skill and competences</td>
</tr>
</tbody>
</table>

The identified requirements are combined under the umbrella of transparency, indicating that information transparency has an important role in requirements management.
Process Support. The requirements for process support show that due the scale of the development effort, guidance is needed all the way to individual tasks. Furthermore, the requirements indicate that the guidance should be only directly related to the task in hand. Practitioners also require status information about the tasks that are under work by someone. Workers need to understand the context of their work in order to understand their own goals properly and relate them to others’ goals and work. From development environment perspective, following support is required:

- Only task relevant information should be available when the task itself is being worked upon. Unnecessary information should be hidden.
- Practitioners should be aware of the status of the task and process.
- Guidance for tasks and processes to give a context and goal for the work.
  Especially on aligning one’s own work with others.

Tooling & Work Items. The requirements identified in this topic give specific restrictions and needs. The first two requirements mainly concentrate on information given from software artefacts and standard templates to support work. The rest of the requirements concentrate on links between data items and providing history data. The tool support comes down to the following main points:

- Information about the development artefacts to allow practitioners not working or otherwise familiar with a single artefact to understand what it is.
- Data items should contain a structure or a template to allow practitioners to structure their information in a similar format with others.
- The ability to link between data elements in order to show dependencies and relationships is important. These links need to be valid and formed with rules to keep the overall structure coherent and understandable.

Decision-making. Awareness about the decision-making process is required for practitioners to keep track the progress of the development process. In this particular case, for example, the practitioners need to know the status and decision for customer’s requirement in order to inform them. Rationale for the decision is also needed as it affects the work of the practitioners and their communication with other stakeholders. Finally, a decision-making process needs status reports from the process. The needs of the decision-making can be summarised as following:

- Visibility of decisions and a rationale for a decision is needed as it affects the work and communication between different stakeholders.
The information should be structured in such a format that reports can be generated to summarise status of any software artefact or data item.

**Collaboration & Communication.** The work is often distributed between different stakeholders and possibly in different physical locations. The roles and responsibilities of an individual stakeholder should be visible along with information about their current tasks in order to coordinate the work. The information sharing aspect is an important part of a large-scale development process but a coherent terminology should be enforced to avoid confusion and misunderstanding. The main needs can be summarised as following:

- Information about other stakeholder activities are required to organise work in a process.
- Transparency of information, it shouldn’t be hidden but available between stakeholders.
- Shared or coherent terminology between all stakeholders.

**Organization & Strategy.** Information about the overall strategy and goals are needed to plan and prioritise work in the process. Furthermore, this information should be broken down and related to actual tasks to understand how the completion of the task affects the overall goals and strategies of the company. As in collaboration & communication, information about resources, skills and competencies are needed for planning purposes and as identified sources of information. The needs can be summarised as:

- Organisations own goals need to be communicated and broken up to the level of tasks to provide context and understanding how stakeholder’s own work affects them.
- Information about the stakeholders in the organisation is needed to plan what the organisations does and with what time schedule.

This study contributes to the RQ1 by showing the importance of information transparency in large-scale development environment. Furthermore, the transparency requirements further define the environmental needs of a large-scale development environment. Firstly, the tasks and processes are translated to stakeholders’ viewpoint(s) supported with process support and guidance. Secondly, information overload becomes an issue if too much information is available and should be tackled with proper support within tools and practices how information is structured. Thirdly, decision-making guides the work done by stakeholders in the
process and is essential in communication. Fourthly, awareness of other stakeholders’ work was seen important to properly align work and results with others. Fifthly, rationales and goals should be understood and communicated all the way to task level to align stakeholders’ work with company goals and strategy.

4.2 Paper II: Software development as a decision-making process

The second article continues to analyse further the development process of a large-scale development. The goal of the study was to identify the drivers that guide the development process and use this information to provide a structure for the development process.

Table 3. Drivers for decision-oriented process.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Drivers for decision-oriented process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Flow</td>
<td>Provide clear goals and objectives</td>
</tr>
<tr>
<td></td>
<td>Provide up-to-date information about process and tasks</td>
</tr>
<tr>
<td></td>
<td>Provide sufficient information for decision-making</td>
</tr>
<tr>
<td>Development Process</td>
<td>Provide an awareness of the development process</td>
</tr>
<tr>
<td></td>
<td>Recognize the context of activities and tasks</td>
</tr>
<tr>
<td>Tooling &amp; Work Items</td>
<td>The development process must be flexible</td>
</tr>
<tr>
<td></td>
<td>The process must support and guide the work</td>
</tr>
<tr>
<td></td>
<td>Regular checkpoints to obtain feedback and status, and to synchronize the work</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Provide decision-making awareness</td>
</tr>
<tr>
<td></td>
<td>Provide acceptance criteria</td>
</tr>
<tr>
<td></td>
<td>The process should have regular reviews</td>
</tr>
<tr>
<td></td>
<td>Clearly define decision points to control the work</td>
</tr>
</tbody>
</table>

Table 3 presents the results from the analysis. Based on the findings, a new structure for a process was presented using a decision point as main defining element. Figure 6 presents an overall process picture where the software development process is modelled as a decision-making process.
Fig. 6. Example of how elements are related and are structured as a network.

The results of the study indicate that the process needs to be flexible. The interviews indicated that not all development projects are similar and adaptation is needed. Furthermore, a strict process hinders innovation. The resulting model (figures 6 and 7) take this into account by allowing changes to the elements without breaking the overall structure and integrity of the model. In this model, a single process element is formed to allow process to be described flexible. The process elements are structured as a network of tasks defined by decision point’s decision criterions. Information transfer between these items informs the dependencies between the tasks, i.e. what are the tasks that provide information for the current task or what tasks need the information provided by the current task (see fig. 4). These dependencies form the information flow between tasks describing the process.
Furthermore, the study also demonstrates that the decision point and decisions itself are used to guide activities and tasks in a process element. The information need in the decision point is defined by stakeholders themselves and the process element is therefore defined by the decision point. There is no limitation how many activities or tasks are in a single process element as long as the information flow formed from connecting these elements provide information at least to a single decision criterion. The process model, therefore, in theory should be an accurate description of the process as its elements represent work done by stakeholders.

![Diagram of process element with decision criteria.](image)

**Fig. 7. Example of how process element is formed with decision criterions.**

Finally, the study in general found the awareness of others’ actions to be important in a large scale development environment. This was mainly due to the need to know what other stakeholders are doing in the process but most importantly, to align the work done with others. If the work and the results weren’t aligned, it resulted in more work that had to be done in order to align them in order to be utilizable by other stakeholder later in the development process.

This study contributes to the RQ1 by demonstrating the importance of flexible and dynamic approach to activities and tasks in a large-scale development process. Similar activities can be conducted in different manner, depending on what practices are used or experience the stakeholder possesses. Secondly, it is important that each activity and task needs to support the decision criteria in some manner. Thirdly, awareness was an important factor in the development process to understand and align ones work with others. In other words, the outcome needs to be the same regardless of what tasks and activities are conducted and in what order.
4.3 Paper III: Characteristics of a Stakeholder Analysis in a large-scale Software Intensive Systems Development

This paper analyses the role of a stakeholder analysis in a SIS development environment. The main goal of this paper is to identify how stakeholder analysis should be organised to support SIS development.

The resulting characteristics are in table 4.

<table>
<thead>
<tr>
<th>#</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identification of stakeholders and the concept of a stakeholder</td>
</tr>
<tr>
<td>2</td>
<td>A systematic approach to stakeholder analysis</td>
</tr>
<tr>
<td>3</td>
<td>Capture of stakeholders’ viewpoint</td>
</tr>
<tr>
<td>4</td>
<td>Information verification and validation</td>
</tr>
<tr>
<td>5</td>
<td>Continuous information elicitation and analysis</td>
</tr>
<tr>
<td>6</td>
<td>Distribution of analysis work</td>
</tr>
<tr>
<td>7</td>
<td>Information need is defined by decision-making</td>
</tr>
<tr>
<td>8</td>
<td>Actual analysis methods and tasks depend on the development process</td>
</tr>
<tr>
<td>9</td>
<td>Stakeholder’s viewpoint data synthesis</td>
</tr>
<tr>
<td>10</td>
<td>Stakeholder analysis data visualisation with models</td>
</tr>
<tr>
<td>11</td>
<td>Usability of the stakeholder analysis</td>
</tr>
</tbody>
</table>

The first four characteristics in table 4 align with the traditional stakeholder analysis used in RE. These characteristics demonstrate the general use of stakeholder analysis:

– Identify and understand who is the stakeholder (characteristic 1)
– Systematic approach to identify and analyse the needs of each stakeholder (characteristic 2)
– Stakeholder’s viewpoint needs to be captured in order to understand and evaluate stakeholder’s need (characteristic 3)
– Information that has been obtained from stakeholders and analysed needs to be validated and verified (characteristic 4)

Characteristics 5-11 describe the characteristics of a stakeholder analysis in a SIS environment. Characteristics 5-6 underline the need to constantly collect and analyse information. Often something is not immediately available, and the process is essentially forms up as a continuous analysis to support the development effort. The sheer scale of SIS development and the constant releases make the process iterative where understanding continually develops and changes during the
lifecycle. Furthermore, multiple persons are involved on the analysis work that is distributed and conducted simultaneously. This both restricts and determines how the stakeholder analysis needs to be formed.

Information should be collected and analysed in the SIS process depends greatly on the decision making process as described by characteristics 7-8. According to the interviews, multiple analyses are used that essentially analyse the same stakeholders but serve different information needs. In this particular study, the analysis methods in the companies differed but they always aimed to satisfy a certain decision or decisions. In addition, the information in the decisions should be described in such a format so that it can be understood by the stakeholder who uses it, as stated in characteristic 9. While the information can be in any format, results indicate that additional work is required to transform that information in to a format stakeholder understands.

Characteristic 10 is directly affected by the nature of SIS development due to the amount of information and the need to quickly access different sets of information strongly indicating that a modelling approach should be adapted. In order to fulfil these needs, it requires a common shared data format that allows practitioners to select any data set for analysis. In addition, modelling the information is a viable way to visualise the “big picture” from any collection of stakeholders in a certain system.

Characteristic 11 describes the importance of usability of the analysis method, how easy it is to use and whether it is capable of using less resources to the same amount of information or more than the old method or approach. If these conditions are not fulfilled, the method becomes meaningless, as it is not used.

Finally, if the characteristics are examined together, they indicate that there is a large and growing group of stakeholders that changes as the time progresses. SIS alone introduces new stakeholders and domains that have to be analysed, especially inside the development process itself. The stakeholder analysis has to tell who is a stakeholder and why. In addition, it has to inform how the stakeholders’ needs should be analysed and that information and stakeholders should be handled with.

This study contributes to RQ2 by identifying the characteristics of a stakeholder analysis. The article also points out the importance of information structuring as all of the relevant information is not available when a decision is made. While this applies to any development effort in general, the scale of the SIS development effort amplifies the impact of false information or assumptions. Furthermore, the nature of the information gathering activities indicates that every analysis is done piece-by-piece involving multiple persons utilising existing data.
4.4 Paper IV: Comparison of Stakeholder Identification Methods – The Effect of Practitioners Experience

This paper analyses the effect of practitioners experience when a stakeholder identification is being conducted. The comparison was executed as an experiment over three different stakeholder identification methods. The main goal was to analyse how the structure of the stakeholder identification methods affects the outcome and what role experience has in it. Table 5 summarises the results from the experiment and table 6 provides the averages for each method separated by experience groups.

Table 5. Overall results of the experiment.

<table>
<thead>
<tr>
<th></th>
<th>Control method</th>
<th>Questionnaire method</th>
<th>Systematic method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students:</td>
<td>16</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Total identified stakeholders:</td>
<td>128</td>
<td>165</td>
<td>156</td>
</tr>
<tr>
<td>Average per student:</td>
<td>8.0</td>
<td>8.7</td>
<td>9.8</td>
</tr>
<tr>
<td>Average time per stakeholder</td>
<td>4 min, 44 sec</td>
<td>5 min, 18 sec</td>
<td>4 min, 52 sec</td>
</tr>
<tr>
<td>Total unique stakeholders:</td>
<td>54</td>
<td>74</td>
<td>84</td>
</tr>
<tr>
<td>Unique stakeholders per student:</td>
<td>3.4</td>
<td>3.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Students:</td>
<td>No experience</td>
<td>Experience but not SE</td>
<td>Experience from SE</td>
</tr>
<tr>
<td>Total identified stakeholders:</td>
<td>223</td>
<td>72</td>
<td>141</td>
</tr>
<tr>
<td>Average per student:</td>
<td>8.3</td>
<td>7.4</td>
<td>10.8</td>
</tr>
<tr>
<td>Average time per stakeholder</td>
<td>5 min, 29 sec</td>
<td>5 min, 19 sec</td>
<td>4 min, 1 sec</td>
</tr>
<tr>
<td>Total unique stakeholders:</td>
<td>87</td>
<td>39</td>
<td>81</td>
</tr>
<tr>
<td>Unique stakeholders per student:</td>
<td>3.1</td>
<td>3.9</td>
<td>6.2</td>
</tr>
</tbody>
</table>

When the results from groups using either systematic or question-based stakeholder identification methods were compared with a control group, both groups were able to identify more stakeholders than the control group. The results also indicate that the systematic identification method performed slightly better than the questionnaire. Based on this finding, a systematic stakeholder identification method provided more identified stakeholders, although a defined method, like a questionnaire, was found to be better than just a list of possible stakeholders.

The results show that experience is an important factor in stakeholder identification. The main finding was that experienced participants were able to identify more stakeholders than those without relevant experience or with no experience at all, regardless of what identification method was used. In addition,
those without relevant experience actually performed slightly worse compared with others, indicating that the type of experience is also relevant.

The results from this paper contribute to the RQ 3 by identifying the importance of practitioners’ experience and how it affects the efficiency of a stakeholder identification method. Regardless of the experience, identifying roles and sub-roles in a systematic manner provided to be the most effective. This indicates that the stakeholder analysis needs to approach the identification of stakeholders in systematic manner analyzing their roles.

Table 6. Averages of identified stakeholders.

<table>
<thead>
<tr>
<th></th>
<th>Control method</th>
<th>Questionnaire method</th>
<th>Systematic method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced</td>
<td>8.8</td>
<td>9.4</td>
<td>14.6</td>
</tr>
<tr>
<td>No relevant experience</td>
<td>7.3</td>
<td>6.8</td>
<td>7.7</td>
</tr>
<tr>
<td>No experience</td>
<td>7.1</td>
<td>8.3</td>
<td>8.4</td>
</tr>
</tbody>
</table>

4.5 Paper V: Soft Systems Stakeholder Analysis

The fifth paper concentrates on building a stakeholder analysis that can be used in a SIS development environment. The contribution of this paper is two-fold; first, the results describe the role of a stakeholder analysis and structure in a SIS development environment, and second, an implementation of the findings as a Soft System Stakeholder Analysis Methodology (S3AM).

S3AM adapted the systems thinking part from Soft System Methodology, where the root definitions of the soft system in question are determined and modelled using semi-formal language. It allows highly abstract, conflicting, highly structured schematics or any other forms of system descriptions to exist in a single soft system model. In S3AM, this was done by utilising stakeholder viewpoints as layers and the boundaries of these viewpoints as connection points to other viewpoints. While this model itself was not coherent, the main idea was to analyse and connect models to form a coherent and a structured soft system model. This allows the bringing together different worldviews to facilitate consensus building between stakeholders. At the same time, the method gradually removes differences in the concepts and terms between stakeholders, who are able to see them through the viewpoint of others and obtain a crucial glimpse into how others think. Workshop discussions indicated problems in communication between management and engineering. From a stakeholder analysis viewpoint, the ability to have both
viewpoints in the same model helped stakeholders from both groups communicate more efficiently, allowing them to understand each other’s concerns and viewpoints.

Furthermore, S3AM fulfilled the role of stakeholder analysis by allowing participants to identify relevant stakeholders, elicit and analyse their needs and have the means to verify and validate the problem system. In the end, S3AM was designed to be simplistic and direct the user to structure any problem as a soft system model, utilising stakeholder viewpoints to describe it as accurately as possible. It also provides information in the form of impact and value to facilitate understanding of the requirements, negotiation and agreement on a solution. It allows a systematic construction of a soft system model explaining how different stakeholders perceive the real world.

The main finding of S3AM was the ability to discover and analyse impacts and values outside the original problem description. In such a situation, the original requirement only presented a situational or tactical problem. Analysing it systematically from different stakeholder viewpoints revealed ‘strategical’ problems that were previously unknown. As local and strategical perspectives were visible, S3AM had a clear impact on removing uncertainty within the participants. It effectively increased the quality of the information that described the soft system. Essentially, this helped the stakeholders evaluate how much information they had and what information was potentially missing. Furthermore, as more stakeholders shared a viewpoint, the quality of the information increased. As the stakeholders’ perspectives were visualised. In addition, visualisation was seen as a needed feature by the participants. Participants often talked about the same system but tried to explain the differences they perceived. They lacked either the words or expressions to describe this effectively for other stakeholders. However, when each viewpoint was modelled and the whole soft system was visible in a single model, the differences were communicated to each stakeholder more easily.

The action research also revealed the needs and limitations of the SIS development process. The need to make decisions in quick intervals was also apparent, and some kind of result was always necessary to either satisfy the information need to make a decision or to continue the analysis, as the risk of the unknown was too great. In this sense, stakeholder analysis also needs to inform the practitioners whether they know enough or whether there is missing information that still must be analysed. For the SIS development, gradual expansion, refinement and correction of the whole soft system model was a practical approach. The complexity and uncertainty in the beginning required that the problem should first be structured and the data refined to validate it. The ability to modify any part at
any given time was seen as an important aspect of the method. Since the information was never complete in the beginning (or it could not be properly comprehended), validation from multiple viewpoints was also essential.

The results of this paper contribute to the RQ3 by analysing the methodology that is required to describe, comprehend and communicate problems with a human component. Understanding and structuring such a problem requires human understanding. The results further demonstrate how the same phenomenon, the MRS and data used by the system, is perceived and understood in a different manner by each stakeholder and how stakeholder analysis can be used to structure the problem as a model. Furthermore, the stakeholder viewpoints should be placed into a single system model to provide a needed big picture to analyse impact past local issues in at a strategic level. Transformation from local issues to strategic level revealed values that have more weight or are more important. Finally, the semi-structured and abstract description language provided the needed flexibility to allow multiple stakeholders to express the way they saw the system worked and connect it to other stakeholder viewpoints.
5 Discussion

In this chapter, the main findings and results are discussed per each research question with the implications to practice and research. The main threats to validity and limitations are also presented and discussed with potential future research directions.

5.1 Main contribution and findings

This thesis had the following main research problem:

*How stakeholder analysis emerges in a software-intensive systems development?*

The original contributions presented in chapter 3 address the problem with three research questions:

RQ1. What kind of characteristics do large-scale development processes require from methods and practices?

RQ2. What kind of characteristics does a stakeholder analysis in SIS development processes have?

RQ3. What kind of characteristics are required from the structure and methodology of a stakeholder analysis in the SIS development process?

These characteristics identified in RQ 1 provide insight on what kind of an environment a large-scale development environment is and contribute to the second finding discovered from the literature. In order to implement any method or practice in a real environment, these characteristics provide guidelines, highlighting that different stakeholders perceive the process from a different viewpoint requiring guidance and support translated to that viewpoint in order for the stakeholder to do a proper work. The findings confirm the needs of development process identified in literature (cf. (Herbsleb 2007) (Berggren & Bernshteyn 2007)) and these characteristics bring more insight about how to structure a stakeholder analysis in a large-scale development environment. The main contribution to research and practice is the how the actual methodology should be formed and aligns the stakeholder analysis to support the decision-making process by providing information. This allows to refine the purpose of the stakeholder analysis as the information the stakeholder analysis needs to produce is determined by the used development process and stakeholders working in it.
These characteristics identified in RQ 2 provide further information about the purpose and role of stakeholder analysis in a large-scale SIS development, contributing mainly to first and third finding identified in literature analysis. Essentially, these characteristics expand the role of stakeholder analysis out of identification, analysis, negotiation and validation of stakeholder needs to understanding different stakeholder viewpoints and transferring that information in understandable format. Furthermore, supplemented with characteristics from RQ1, the flexibility, usability and continuous nature of the stakeholder analysis indicate that stakeholder analysis is not a strict process that is done during specific project phase. Instead, practitioners should be able to adapt it to their context, change it if situation requires, continuously add and analyse new information and help practitioners to understand the system and its environment from multiple different perspectives. The findings support stakeholder analysis more as a problem solving approach (Bryson et al. 2002) (Savage et al. 1991), similar to SSM approach of structuring problems (Checkland 1981).

The contribution of the characteristics discovered in RQ 3 help to describe the methodological aspect of the stakeholder analysis in a large-scale SIS development, contributing to all three identified topics in literature. The findings support the arguments of McManus (2004) and Chung et al. (2009) as similar to characteristics identified in RQ1 and RQ2, the stakeholder analysis formed up as a systematic method where main purpose was to allow practitioners to analyse and understand a target system from multiple perspectives and crucially, identify perspectives that are yet unknown. The key finding in RQ3 was that the requirements weren’t the main benefit produced by stakeholder analysis but rather the ability to see, analyse and compare different impacts from different viewpoints. Especially useful was the ability to see impacts caused by a change in the target system outside the stakeholder’s own viewpoint. This allowed practitioners to discover other benefits and values that were different than their original intentions or estimates. This ability was perceived to be useful to determine what changes should be introduced and what are the requirements that bring most of the value for stakeholders of the system under development. Finally, while the experiment itself wasn’t tested in the real development environment, student experiment indicates that both experience of the practitioner has an effect on a performance on stakeholder identification method. The findings support using systematic methods where stakeholders are identified based on categories and relations towards the target system as proposed by Sharp et al. (1999).
The contributions and findings are summarised in a table 7 and presented individually in following sub-chapters.

Table 7. Summary of findings.

<table>
<thead>
<tr>
<th>RQ1: Characteristics of the large-scale development environment</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information transparency</td>
<td>I</td>
</tr>
<tr>
<td>Tasks and processes are translated to stakeholders' viewpoint(s)</td>
<td>I</td>
</tr>
<tr>
<td>Information overload, only task relevant information is needed</td>
<td>I</td>
</tr>
<tr>
<td>Rationale and goal is required for work in process</td>
<td>I</td>
</tr>
<tr>
<td>Process and work awareness</td>
<td>I &amp; II</td>
</tr>
<tr>
<td>Flexibility of methods and processes</td>
<td>II</td>
</tr>
<tr>
<td>Decision-making needs determine the structure of process and tasks</td>
<td>I &amp; II</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RQ2: Characteristics of a stakeholder analysis in SIS process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification and understanding of who is the stakeholder</td>
</tr>
<tr>
<td>Systematic approach to identify and analyse the needs of each stakeholder</td>
</tr>
<tr>
<td>Stakeholder's viewpoint captured in order to understand and evaluate stakeholder's need</td>
</tr>
<tr>
<td>Information that has been obtained from stakeholders and analysed needs to be validated and verified</td>
</tr>
<tr>
<td>Continuous information elicitation and analysis and distribution of work</td>
</tr>
<tr>
<td>Information is defined by the decision-making and tasks to create information are defined by the development process.</td>
</tr>
<tr>
<td>Synthesis of multiple stakeholder viewpoints.</td>
</tr>
<tr>
<td>Data visualisation.</td>
</tr>
<tr>
<td>Method usability.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RQ3: Structure and methodology of stakeholder analysis in SIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practitioners’ experience.</td>
</tr>
<tr>
<td>Structure of a methodology.</td>
</tr>
<tr>
<td>Stakeholder analysis supports problem structuring.</td>
</tr>
<tr>
<td>Stakeholder viewpoints in a single model.</td>
</tr>
<tr>
<td>Semi-structured and abstract description language.</td>
</tr>
<tr>
<td>Overview of the target system.</td>
</tr>
<tr>
<td>Gradual collection, refinement and correction of information.</td>
</tr>
</tbody>
</table>

5.1.1 RQ 1: What kind of characteristics do large-scale development processes require from methods and practices?

This research question approaches the large-scale development environment from the general perspective. It aims to understand what restrictions and needs the
environment itself sets for work and processes, essential if stakeholder analysis is implemented into the process.

The common theme in study I was *information transparency*. Interviewees saw that the information need concentrated on understanding what is happening in the process, what others are doing and obtaining the information easily. From the stakeholder analysis perspective, to support the work on a large-scale development environment, information made available by the stakeholder analysis should be transparent.

*Tasks and processes are translated to stakeholders’ viewpoint(s).* From the practitioners’ perspective, each task is being translated to his or her viewpoint. Considering stakeholder analysis, the tasks, methods and purpose of the stakeholder analysis will be different for different practitioners. While one purpose of the stakeholder analysis is to do exactly this for a large group of stakeholders, the actual implementation of the analysis needs to be translated to the viewpoint of the actual user and practitioner.

*Information overload, only task relevant information is needed.* The work is often distributed between different stakeholders and possibly in different physical locations. The need to remove unnecessary information is pronounced and this is clearly attributed to the sheer amount of information.

*Rationale and goal is required for work in process.* Both studies identify the need to inform practitioners about the goal and objective of their work, including the strategy, visions and motives of the organisation. This allows the practitioners to understand what they are required to do and provide information that benefits the management. Therefore, a stakeholder analysis needs to have a rationale and goal so the analysis provides correct information. The findings also point out that there is an issue with a time spent on tasks that increase if guidance or the context is not supplied for the task. A large-scale development effort involves hundreds or thousands of people and extra time spent on understanding, asking and meeting with other people to gain necessary guidance and context easily multiplies in such an environment.

*Process and work awareness* supports stakeholders’ need to understand how the process works and how others work within it, both seen important to do work correctly and avoid unnecessary or biased work. It helped stakeholders to align their work and results with others and company’s goals.

*Flexibility of methods and processes.* The tasks employed in a process need to adapt and change as the actual implementation or ways of work require it. The study II concentrates on developing a new approach to model and construct a process.
where all process elements are same in an abstract level but can be implemented differently in practice. From stakeholder analysis perspective, the goal of the analysis process is the same for all but the implementation of actual tasks can differ and should be allowed.

**Decision-making needs determine the structure of process and tasks.** Information provided in process should be clearly linked to a decision making. In study I and II, any information created in the process eventually serve a decision criterion in a decision point by providing information needed in the decision-making. If such a link does not exist, the activities related to creating such information are not needed or there are missing activities that are required. In similar manner, the activities in stakeholder analysis should support the decision-making and the information stakeholder analysis should provide is decided by the need in decisions.

### 5.1.2 RQ 2: What kind of characteristics does a stakeholder analysis in SIS development processes have?

The study III directly supports the RQ2 by identifying the key characteristics of a stakeholder analysis in a SIS development process. This study identified four traditional roles a stakeholder analysis has:

- Identification and understanding of who is the stakeholder
- Systematic approach to identify and analyse the needs of each stakeholder
- Stakeholder’s viewpoint needs to be captured in order to understand and evaluate stakeholders needs
- Information that has been obtained from stakeholders and analysed needs to be validated and verified

In addition to the traditional roles, SIS specific characteristics were also identified.

**Continuous information elicitation and analysis and distribution of work.** The development environment sets specific needs due the amount of persons involved into the development effort. Stakeholder analysis therefore has to be designed in a way that the elicitation and analysis tasks are continuous and can be distributed to different locations.

**Information is defined by the decision-making and tasks to create information are defined by the development process.** Study III indicates that any piece of information created by a stakeholder analysis needs to support either directly or indirectly the decision-making process. Furthermore, the development process
itself restricts how the actual work and tasks appear and are implemented. Therefore, it is important to understand first what information stakeholder analysis should provide for the organisation while allowing variation in the applied methods and techniques.

*Synthesis of multiple stakeholder viewpoints.* Multiple stakeholder viewpoints should be synthesised into a single overall view or viewpoint. In SIS development process, it is important to understand the overall system and the stakeholder’s viewpoint to gain proper understanding and validate information.

*Data visualisation.* Study III underlines the importance of applying modelling approaches to visualise the stakeholder analysis data. The main rationale behind this requirement is the sheer amount of available data and the ability to identify and understand the target system. Visualisation was determined to be a preferred approach as it generally allowed the practitioners to understand and initiate discussions faster written text.

*Method usability.* The results of the study III indicate that method usability has a key role in the adaptation of methodologies. From stakeholder analysis perspective, the usability of the methodology must be addressed in order to be implemented and used.

Finally, the study results indicate that a theory of stakeholder analysis should also be studied. This finding is related to the needs that surfaced from the study, namely the need to determine whether a new stakeholder has surfaced and should be understood as a new one and not just a refinement or extension of an old stakeholder. Furthermore, practitioners needed to information and guidance how to address the stakeholders from the perspective of the organisation. They weren’t just a source of requirements but any action done towards the stakeholders had either a positive or negative effect.

5.1.3 **RQ 3: What kind of characteristics are required from the structure and methodology of a stakeholder analysis in the SIS development process?**

The studies IV and V support mainly the RQ3 by analysing the stakeholder analysis method itself by determining suitable structure and implementation in SIS.

*Practitioners’ experience.* Study IV shows the importance of practitioners’ experience and how it affects the results of stakeholder identification. While the actual results were obtained only from a stakeholder identification process, the amount of relevant experience affects directly the performance of the practitioner.
In this sense, practitioners with relevant experience perform better than those without relevant experience.

**Structure of a methodology.** Study IV results indicate that the structure of the methodology has an important effect on stakeholder identification performance. The results indicate that systematic methodology where practitioners are asked to gradually identify groups of stakeholders and then continue by identifying further stakeholders from already established groups performed better than questionnaire or a list of potential stakeholders.

In study V, a stakeholder analysis methodology was developed in a case company in SIS development environment. The impact of the stakeholder analysis methodology demonstrated following key components:

**Stakeholder analysis supports problem structuring.** The results show that problems in which humans are an integral part are hard to describe, comprehend and communicate. Understanding and structuring such a problem requires human understanding. The systems that are being described are not hard systems but soft systems where humans are integral part of it. Multiple stakeholder viewpoints need to be connected and described to understand and structure the problem to gain an overview and deeper understanding.

**Stakeholder viewpoints in a single model.** Collecting and describing all stakeholder viewpoints about the same system into a single model helps other stakeholders to understand the system and evaluate their own viewpoints as they see how other stakeholders understand the system. This helps them to identify conflicts and refine their own viewpoints as others serve as examples. Furthermore, it helps stakeholders to resolve conflicts and adjust their own understanding.

**Semi-structured and abstract description language.** The key principle is to allow highly abstract, conflicting, very structured schematics or any other forms of system descriptions to exist in a single soft system model. The goal is to allow stakeholders to express their view on the target system and while the resulting model might not be coherent, the main goal is to get all the viewpoints in to the same system model where they can be analysed and further refined.

**Overview of the target system.** In together, the ability to create a “big picture” of the target system is an important factor of stakeholder analysis. This is further pronounced as the scale and complexity of the development effort and target system grows. It essentially helps the practitioners to “elevate” their thinking, be able to see the target system in new perspective that was unattainable before for them. It drives the innovation and problem-solving abilities as new possibilities, values and
relations are revealed, often rendering old possibilities, values and relations insignificant in the light of the new ones.

**Gradual collection, refinement and correction of information.** The results of study V show that an important factor in the developed stakeholder analysis methodology was the ability to add, correct and refine information at any time and any amount. This was necessary as some information was made available at certain time and further at some other point in future, especially as new information became available sporadically and in pieces.

## 5.2 Study relevance and validity

The rationale to conduct this study originates from practice where a problem to understand different customer needs from different stakeholder viewpoints surfaced. In the beginning, the problems were more practical in nature but as the gaps in previous research become obvious, further research was justified to understand the stakeholder analysis and how it is expected to function in a SIS environment.

Each article in this thesis went a throughout review process by the scientific community. Furthermore, each paper involving companies were subjected to expert reviews within the companies and results were discussed with the interviewees either separately or utilising workshops. Participants who provided data or who participated in the research were given an option to correct the data provided by them.

Since this thesis utilised three research methodologies to obtain the results presented earlier and, therefore, it is necessary to examine the validity and reliability of each method employed. The rest of this chapter will examine the validity and reliability of the results based on the research methodology used.

### 5.2.1 Validity and Reliability of the case study results

In order to assess the validity and reliability of an empirical research in software engineering, internal and external validity, construct validity and reliability of the study should be examined (Yin 2009, Wohlin *et al.* 2012).

**Construct validity.** Construct validity examines the relationship between theory and observation and is used to determine whether the operational measures studied represent what the researcher has in mind. In the case study articles, construct validity was addressed through extensive literature review and comparing previous
findings with current research using multiple sources of evidence. Each case study had an extensive analysis of existing company material and further supported by reviews conducted by company experts and other researchers. A standard practice of organising workshops where the results were reviewed by multiple experts further ensured that the research questions, questionnaires, analysis and results were valid and correct.

**Internal validity.** Internal validity was examined in the case studies but is not relevant as it relates to conclusions made of causal relations (Yin 2009). The research in all three case studies were explorative in nature and were not aimed to establish causal relationships.

**External validity.** External validity addresses the extent of results generalisation. Essentially, results generalisation aims to extend the findings outside their original domains to be utilised and examined in other domains that share similar qualities. External validity regarding the generalization of the results was addressed, to an extent, by examining two different companies working in the same development environment. Inside companies, tens of different stakeholders were involved to provide multiple viewpoints in order to identify shared general themes.

**Reliability.** Study reliability measures the quality of the research and analysis ability to draw correct conclusions unbiased by a researcher’s viewpoints. The reliability of the results was addressed by establishing research protocol with data collection and analysis procedures. Each item in the research protocol was documented and peer-reviewed by company experts and other researchers before application. Furthermore, results were always validated by the interviewees themselves after each interview and analysis results in workshops with all participants.

### 5.2.2 Validity and reliability of the experiment results

Students were expected to do the work individually in order to test whether the method helps individual students to identify stakeholders. Communication between students and data searches was deliberately denied to control the experiment. In real life, however, work is often done in teams, and several people can work on the same task. In addition, access to company resources and the Internet also provide resources to help the identification process. Therefore, this study cannot be directly compared with a real environment as such.
The study did not consider how valid and important each stakeholder was for the system. This was intentionally excluded because determining validity and importance was beyond the scope of this study. The study concentrated only on determining which identification method is more likely to produce a larger and more refined set of stakeholders, compared to working without any specific method at all.

No quantitative analysis was performed on the results due to the nature of the study. The rationale behind the decision to use only a qualitative analysis was that the study was designed to be more explorative to see whether the methods provided clearly different results. Each answer provided by the students was therefore analysed separately to understand whether the stakeholders were the same, whether the stakeholder had a rationale to be a stakeholder for the target system and what kind of stakeholder groups were formed by the different methods. Therefore, the quantitative analysis was used to gain an insight into whether experience and method had any effect. However, quantitative analysis could provide more insight about the results of this study. Based on the results of this study, a longer study with a larger audience should be conducted.

The experiment was limited only to students, which affects the generalisation of the results. However, this shortcoming was addressed by pinpointing students with relevant experience in software engineering and classifying them as a separate group for analysis. Experimenting in a real development situation should be the next step after this experiment to confirm the SIS effect of experience.

5.2.3 Validity and reliability of the action research results

The reliability of the data and results was ensured via a rigorous research protocol with peer reviews by researchers and company representatives. The action research cycles were described and followed throughout the research. The modelling sessions were recorded and transcribed by the researchers.

This study is limited only to the telecommunication domain. Furthermore, only one company was involved in this research, limiting the generalisability of the results. However, the study uses a well-established problem structuring method that has been used in multiple domains. In order to make definitive conclusions, more domains and companies should be involved in future research.

The way the action research was implemented in this study also introduces a danger of positive bias within researchers and company participants. Due to the constant communication and interventions in the company, participants could be
positively biased, producing only positive results. This issue was addressed by having multiple viewpoints presented in the meetings. In addition, agreement over clear roles and rigorous research methods helped participants remain observers.

5.3 Study limitations and future research

The main limiting factor for results generalisation in this study is that the results are mainly obtained from two case companies working in a SIS development environment. These case companies only represent industrial automation and telecommunication domains.

However, the main goal of this thesis was to analyse and identify how stakeholder analysis manifests a SIS environment and what kind of a role it is expected to take limiting the study to be explorative. While the results come from two different SIS domains, further research would be required to analyse other SIS domains to determine how much the results can be generalised.

As the general theme of the research was to explore and identify the characteristics of the concept of stakeholder and stakeholder analysis in SIS, the research gave only an overall view from practitioners’ perspective. The research did not focus on any specific topic like project management, testing or any other topic in a development process. Further research would be needed to draw conclusions in specific topics.

A clear future research topic is the stakeholder theory itself in the context of SIS development. It helps practitioners to identify potential stakeholders, analyse different needs and demands, and decide what stakeholder interests are the most valuable for the organisation. It was identified during this research that persons working in case companies were concerned on how they should be managing the stakeholders they were directly in contact with. Furthermore, the question about stakeholder value, what is value and how it should be measured was discovered to be an important topic in the original study 5, further indicating that a theory or an approach should be developed in order to guide the company and individual workers how they should approach and deal with stakeholders.
6 Conclusions

While this thesis analysed mainly stakeholder analysis in a SIS development environment, it raises the importance to properly understand the environment and the decision-making process the stakeholder analysis works and feeds information to. The critical finding in this thesis is that the large amount of stakeholders involved to a development effort require a systematic methodology capable of constantly obtaining information and making it available to other stakeholders.

This study contributes to both research and practice in software engineering by examining and explaining the purpose, the role and the practices of how to use stakeholder analysis in a large-scale development environment. The main contribution of this thesis is the identification of different aspects of stakeholder analysis that change and become more important as the system under development becomes larger. These results were found by studying how stakeholder analysis should emerge in a software-intensive systems development by exploring the environment, characteristics and methodology of a stakeholder analysis in SIS.

The results of this thesis indicate that a stakeholder analysis in a large-scale development environment, such as SIS, is to allow practitioners to see and understand information from other stakeholder perspectives. The important issue is to communicate different viewpoints to analyse and discover the reality behind different concepts and understanding caused by the stakeholders’ own viewpoints. This process both verifies and validates information as every piece of information whether it is a model or textual is subject to constant verification and validation by adding more stakeholder viewpoints to it. The purpose of the stakeholder analysis is more of providing a means to understand a target system from multiple perspectives and transfer that information to other stakeholders.

Furthermore, the stakeholder analysis itself is part of the process. Based on the results, the practitioners merged the stakeholder analysis methodology as a part of their own working process. The consequences indicate that there is no need to separate the stakeholder analysis process but rather merge it with the existing process. While it is invisible, the way it works in a day-to-day work enables a constant information collection and analysis from multiple stakeholder perspectives. Practitioners both identify and analyse stakeholders as it becomes necessary and the methodology only provides the necessary guidance and instructions what to do.
7 References

Original publications


Reprinted with permission from Springer (II) and IARIA XPS Press (I, IV and V).

Original publications are not included in the electronic version of the dissertation.
667. Tolkkinen, Mari (2016) Multi-stressor effects in boreal streams: disentangling the roles of natural and land use disturbance to stream communities
668. Kaakinen, Juhani (2016) Öljiä ja raskasmetalleilla pilaituneita maaita koskevan ympäristöläävissä säännön ja lupameneteljen edistäminen kemiallisella tutkimuksella
670. Rönkä, Nelli (2016) Phylogeography and conservation genetics of waders
671. Fucci, Davide (2016) The role of process conformance and developers' skills in the context of test-driven development
672. Manninen, Outi (2016) The resilience of understorey vegetation and soil to increasing nitrogen and disturbances in boreal forests and the subarctic ecosystem
673. Penttasaari, Mikko (2016) Utility of DNA barcodes in identification and delimitation of beetle species, with insights into COI protein structure across the animal kingdom
674. Lassila, Toni (2016) In vitro methods in the study of reactive drug metabolites with liquid chromatography / mass spectrometry
675. Koskimäki, Janne (2016) The interaction between the intracellular endophytic bacterium, Methylobacterium extorquens DSM13060, and Scots pine (Pinus sylvestris L.)
676. Ronkainen, Katri (2016) Polyandry, multiple mating and sexual conflict in a water strider, Aquarius paludum
679. Suoranta, Terhi (2016) Advanced analytical methods for platinum group elements: applications in the research of catalyst materials, recycling and environmental issues
680. Pesonen, Janne (2016) Physicochemical studies regarding the utilization of wood- and peat-based fly ash
Markus Kelanti

STAKEHOLDER ANALYSIS
IN SOFTWARE-INTENSIVE SYSTEMS DEVELOPMENT