“An Improved Method for Socio-Technical Process Design – the Development of Requirements in the Case of Pharmacy Systems”

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Abstract

Modeling social-technical systems' work processes as a basis for requirements engineering is a challenging issue. One of the most important requirements for enhancing a socio-technical system for an organization is that system analysts know and understand how the system supports the company's work processes. Formal approaches have a difficult time capturing the scope and complexity of diverse organizations with social and technological components. Informal techniques, on the other hand, lack the precision required to inform the software design and development process or enable automated analysis. In this research, the concept of SeeMe (a semi-structured socio-technical modeling method) is revisited. SeeMe models socio-technical systems as a representation of contingency, explicit incompleteness, and multiplicity of perspectives.

In this thesis, SeeMe is used as a well-defined semantics for representing sequences of activities. In addition, requirements analysts have investigated the practice of modeling stakeholder objectives and motivations behind systems using organizational modeling frameworks such as i* to deal with the rapidly increasing complexity of socio-technical systems. The research area of this thesis would be the optimization of requirements engineering for a socio-technical systems by applying the process modeling notations. More specifically, the thesis focuses on socio-technical, process-based requirements specification. The participating research fields and scope of this thesis examines the intersection of three of the following areas:

- socio-technical systems,
- process modeling,
- and requirements engineering.

To support this social concept, an extended SeeMe (SeeMe*) is presented that supports modeling of the agent-oriented paradigm of the i* framework, and allows us to capture agent properties such as intentionality, autonomy, sociality, contingent identity and boundaries, strategic reflectivity, and rational self-interest. Afterwards, SeeMe* is applied in a pharmacy case study to improve its work process and elicit the social and technical requirements. The application of SeeMe* enables analysts to systematically generate the specifications of requirements. An expert-workshop was also conducted to evaluate the application and usefulness of this method and validate the research findings.

Keywords: SeeMe, i* framework, social modeling, socio-technical system design, requirements analysis.

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Chapter 1
Introduction

This thesis examines how social aspects can be adequately analyzed and represented by a socio-technical process modeling notation that will be developed in this research to support requirements analysis for software-engineering and socio-technical design. In other words, a method is provided for the development and optimization of socio-technical systems to be followed in the early stages of design.

Major steps of this study are introduced in this chapter. The chapter begins with explaining the problem and the motivation behind the research. The following is how the rest of this chapter is structured: Section 1.2 contains an introduction to the study and a description of the research's scope. Section 1.3 presents research questions and explain the objectives of the study, Section 1.4 describes the proposed solution, and Section 1.5 presents the research methodology. The chapter ends with the organization of this thesis.

1.1. Motivation

If a project's requirements are not properly addressed, they can cause the failure of the project. When addressing requirements analysis of a socio-technical system, most of the researches focus on the technical requirements to develop the system. They often overlook the social concepts such as goals and intention of actors as well as parts with incomplete knowledge which are the less formal aspects of these systems. Therefore, the development of a socio-technical system may fail because it does not meet the needs of its stakeholders.

In addition, requirements documentation often fails to represent the business environment or consists only of a data model in the form of a class or entity-relationship diagram. Thus, the requirements engineering community has recognized the need of eliciting requirements based on business issues (Sommerville & Sawyer, 1997). More precisely, the importance of process modeling during requirements analysis has been acknowledged by some research studies (Bubenko & Kirikova, 1999). However, process modeling in early phases of the project development often results in vagueness and incompleteness. Therefore, these inadequacies need to be considered by requirements engineers so that the requirements are adequately analysed, elicited, and integrated into a process model. On one side, finding a process model using human and social factors is one of the main challenges. There is a need to develop a socio-technical modeling method that can be useful in the requirement elicitation process. Traditional requirements analysis takes a mechanistic view of the world, thinking that it is made up of objects and activities that are perfectly understood and predictable. However, when we embrace a social worldview, we should perceive the world as having intentionality, which indicates the existence of intentions, reasons, and motives behind behavior. Intentional actors have needs and desires, and they act to satisfy those needs and desires. The decisions made by actors needs to be taken into account in order to create and suffice requirements.

On the other side, finding a graphical notation for modeling business processes which is traceable and comprehensible for both system analyst and stakeholders can be another challenge. Business process modeling is primarily used to map a workflow in order to comprehend, analyze, and improve that workflow or process. The use of a diagram can help to visualize the process and to make better decisions. Flowcharts are probably the most popular diagram type in the world. A flowchart is a picture of the separate steps of a process in sequential order to develop understanding of how the process is performed and when better communication is needed between people involved in the same process. Since the flowchart has few standard symbols, it can be easily understood by many individuals, but it is limited by its accuracy. The flowchart's simplicity makes it a powerful and an effective tool when used correctly (Jun, Ward, Morris, & Clarkson, 2009). One of the most recent process modeling languages is the Business Process Modeling Notation (BPMN), which can be considered as an advanced version of the basic flowchart technique.

To better understand the challenges mentioned above, an example of a case study used in this research is provided below.

As will be discussed in the next chapters, the dispensing process in a pharmacy has been selected as the main focus of evaluation in this study. Different aspects of a socio-technical system were considered in thesis case study to help with a comprehensive overview of the system. There are many resources in the dispensing processes for both acute and repeat prescriptions, such as the number of professionals present at the time of observation, ranging from the counter assistant to the responsible pharmacist, which includes delivery drivers and other resources such as printers, computers, and controlled drugs. These are participants of the dispensing technical aspects– how pharmacy professionals use the technical elements to aid the dispensing process – and social elements, i.e. how pharmacy professionals interacted with each other, and patients/customers during the dispensing process.

As a result, no existing socio-technical modeling approach addresses the presented challenges as also summarizes here:

- ✓ Finding a process model using human and social factors.
- ✓ Finding a graphical notation for modeling business processes which is traceable and comprehensible for both system analyst and stakeholders.

The existing modeling methods of designing a socio-technical system that can reflect the goals and social requirements have the following inadequacies:

- ✓ The BPMN approach is primarily concerned with methods and tools, and it frequently overlooks the human element. Users are not involved in the discovery or design of business processes in this method, which is mostly based on individual interviews (Coelho, 2005). Regarding these problems, many researchers have attempted to improve the BPMN by expanding it and using other methods.
- ✓ In order to address the need of understanding the human social dimension in the design of effective socio-technical systems, the i* social-modeling framework brings together the social and intentional concepts. In this framework, actors are viewed as being intentional, i.e., they have goals, beliefs, abilities, and commitments (Yu E. , 2009). However, the research has revealed that the construction and administration of large-scale i* models might be difficult. The size of these models makes them challenging to be developed and controlled (Maiden, Jones, Ncube, & Lockerbie, 2011).

Therefore, there is a need to integrate social concepts into current processes, techniques in which businesses have spent a significant amount of time and money. Existing approaches will need to be integrated and supplemented by social-technical modeling techniques. For example, SeeMe is a modeling method for socio-technical systems with the purpose of smooth communication processes utilizing socio-technical solutions. An important difference of SeeMe in comparison with other methods is the handling of vagueness, which is emphasized in the early phase of socio-technical systems (STS) development process (Herrmann, 2006). We frequently require a deeper knowledge of the process to enhance or redesign it - an understanding that shows the “Whys” behind the “Whats" and “Hows." Typically, process performers need models that detail the “Hows”, while process managers prefer models that highlight the “Whats” and process engineers responsible for improving and redesigning processes need models that explicitly deal with the “Whys” (Yu, Giorgini, Maiden, & Mylopoulos, 2011).

New research efforts are required to offer viewpoints and approaches in the form of extending modeling notation and guidance to support system analysts. To summarize, when an organization develops a process model by systematically capturing the goals, intentions, and social aspects of participants in the work process, the organization creates the opportunity to transmit this information to other areas that can create relevant requirement specification in a comprehensive and consistent way.

Consequently, this research provides not only a new modeling method but also a proposal on how socio-technical system requirements can be derived by developing socio-technical modeling methods and analyzing them.

1.2. Research Areas

This study focuses on the requirements of a socio-technical system and strives to improve the requirements eliciting process by using a socio-technical modeling notation.

Requirements engineering (RE) is a process-based method for defining, recognizing, modeling, linking, documenting and maintaining software requirements in software life cycles that helps with better understanding of problems (Kotonya & Sommerville, 1998). In other words, requirements engineering means that requirements for a system are defined, managed, and tested systematically (Jocob, 2009). It should be mentioned that the cost of correcting a requirement's fault later in the development process is significantly higher than the cost of discovering and correcting it at early stages (Dawson, Burrell, Rahim, & Brewster, 2010). Thus, for the significant benefit of the system, its requirements need to be appropriately defined, assessed, and reviewed at early stages of the development process.

The RE process has long been recognized as the most important software development stage (Pandey & Suman, 2010). Most of the researches on the RE focuses on the requirements themselves, including how to elicit, evaluate, and manage them, as well as how to detect and resolve conflicts. However, in order to perform successful requirements engineering, other difficulties that may lead to the fulfillment of the requirements need to be considered.

Understanding how the end user will use software and improving software requirements specifications are dependent on human elements such as team skill, employee attitude, and personality. “It is widely acknowledged that adopting a socio-technical approach to system development leads to systems that are more acceptable to end users and deliver better value to stakeholders” (Baxter & Sommerville, 2011, p.4).

With the adaptation of socio-technical approaches to the system development, software engineers are able to obtain richer requirements enabling the design of better information technology to support the system. “Socio-technical systems design (STSD) methods are an approach to design that consider human, social and organisational factors, as well as technical factors in the design of organisational systems. They have a long history and are intended to ensure that the technical and organisational aspects of a system are considered together. The outcome of applying these methods is a better understanding of how human, social and organisational factors affect the ways that work is done and technical systems are used. This understanding can contribute to the design of organisational structures, business processes and technical systems” (Baxter & Sommerville, 2011, p. 4).

The rationale for adopting socio-technical approaches to systems design is that systems often meet their technical ‘requirements’ but are considered to be a ‘failure’ because they do not deliver the expected support for the real work in the organization.

After discussing the importance of considering social aspects of a socio-technical systems for success of requirements engineering, it is worth mentioning that most organizational modeling-based RE methods include business process modeling. Business process models represent an organization's activities and makes the application domain easier to comprehend. They may be used to elicit system requirements as well (Li, et al., 2012).

Organizations are increasingly using business process modeling approaches to visualize their processes and identify areas where improvements are needed. However, despite the plethora of modeling techniques available, the main focus has typically been the graphical depiction of a process. Over time, a variety of process modeling methods have been suggested, ranging from simple flowcharts to complex Petri net variants with high expressive power (Zur Muehlen, Recker, & Indulska, 2007).

Processes include individuals and/or groups working together to attain a goal – in BPM there is a need for recognizing the involvement of humans in the execution of processes to properly model them (Pflanzl & Vossen, 2013). Therefore, work processes can be seen as social constructs. As a result, when modeling processes for a comprehensive representation of organizational dynamics and the assessment of their effectiveness, the behavior of both components, people and IT systems, must be taken into consideration. Socio-technical systems can be understood as an appropriate approach to business process modeling through the investigation of complex interactions and dependencies among humans and IT systems of organizations (Gregoriades & Sutcliffe, 2008).

Considering these aspects together, the research focus of this study is the optimization of requirements engineering for a socio-technical system by applying the process modeling notations. More specifically, the thesis focuses on socio-technical, process-based requirements specification. The research fields and scope of this study examines the intersection of three of the following areas: socio-technical systems, process modeling, and requirements engineering.

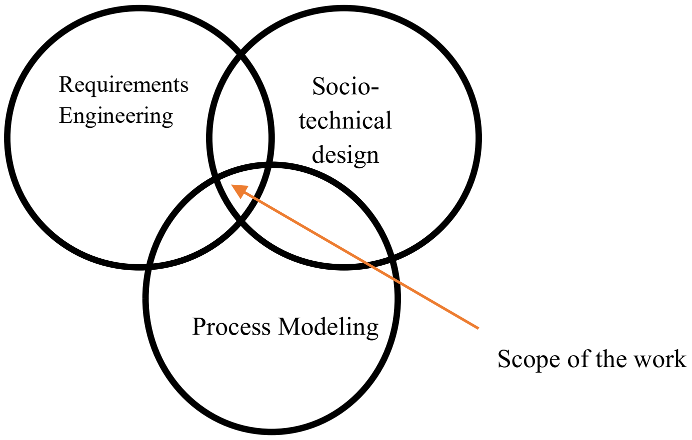


Figure 1. 1 Interdisciplinary Area from the Participated Research Fields

1.3. Thesis Objectives and Research Questions

Process-based requirements specification for socio-technical development and its relationship with social conceptual modeling might be problematic for system analysts, as mentioned in the preceding section. Focusing on work processes during the RE process is a challenge for future research on socio-technical system RE. Integrating methods and providing guidance for this purpose is also one of the main needs of the RE (Cheng & Atlee, 2007). In order to contribute the research gaps identified above, three research questions are identified:

Research question 1 (RQ1): How can the viewpoints, goals and dependencies of different actors within processes be represented and supported with a semi-structured, socio-technical modeling method?

Research question 2 (RQ2): How can socio-technical requirements be elicited from the socio-technical process modeling method?

Research question 3 (RQ3): Can the use of the new modeling method lead to a better understanding of the motivation of social actors and improve the comprehension of their requirements?

The main goal of the thesis is developing a STS-system requirement specification from a socio-technical process model that considers actors as a social factor with dependencies and motivations. This goal, as well as the involving challenges, may be achieved by fulfilling a number of objectives, all of which are connected to the three research questions mentioned above. The objectives that are related to the RQ1 are:

1. Understanding the limitation of current process modeling methods for socio-technical systems,
2. Identifying an appropriate notation for process modeling for the RE process,
3. Completing socio-technical process modeling with a new perspective aimed at describing and analyzing the social and intentional aspects of a socio-technical modeling approach, and
4. Visualizing relationships among social actors based on flowchart technique which shows the workflow steps and is used in analyzing, designing, documenting or managing a process in various fields.

The objectives that are related to the RQ2 are:

5. Finding a better method of understanding problems and motivation behind a socio-technical system that occurs during the early-phase of requirements capture to provide concepts such as softgoal and goal, and
6. Developing a specification template for extracting requirements that:
    - determine support for modeling processes; and
    - represent specifications of socio-technical requirements.

The objective that is relevant to the RQ3 is:

7. Validating the findings of our study defined in a real case study and presenting analysis, workshops and evaluations to establish transferability and credibility of the approach.

1.4. Proposed Solution

The objectives of this research are achieved by improving a method for socio-technical process-based requirements specification. The method consists of three stages:

1. **Socio-technical process modeling:** This stage aims to model and understand the behaviour of a socio-technical process. Business process (work) models are the main artifact of this stage, and these models are used to promote participation and communication with customer stakeholders.
2. **Social modeling:** The purpose of this stage is to analyze the goals and social aspects of actors such as their motivations, dependencies, and conflicts among them. Social models are used as a basis for the development of this stage and involvement of customer stakeholders is promoted.
3. **Derivation of system requirements:** In this stage, system requirements for a socio-technical system from a process model are identified. For example, how social concepts modeling in a process model support the analyst to derive non-functional requirements.

This three-stage approach is presented in detail in the next chapters and corresponds to the overall contribution of the thesis.

1.5. Research Design

The approach followed for the purposes of this research is inductive. According to this approach, the researchers begin with specific observations, which are used to produce generalized theories and conclusions drawn from the research. The formation of hypotheses is not required in the inductive method. It begins with the research questions, goals, and objectives that must be met throughout the research process (Denzin & Lincoln, 2011). The following section summarizes the overall study design, activities, and the extent of data resulting from this approach.

Figure 1.2 presents the study design which shows the logical flow of the preliminary activities that started this study and led to the construction of the conceptual model, including data collection and analysis, elicitation of requirements using a new modeling approach, and the evaluation of the modeling method. The preliminary activities include:

- Initiating the study and addressing RQ1. For this purpose, this research includes:
  - ➢ conducting an extensive literature review of process modeling in socio-technical systems and the theoretical frameworks and models that derive the requirements from the work process models. The goal was to find the best process modeling method which supports elicitation of socio-technical requirements,
  - ➢ performing some interviews with participants of a pharmacy case study to get an overall view of the processes in the pharmacy, which also allowed the observation of routine work processes, and provided insights for better understanding of pharmacy process, and
  - ➢ modeling current state of the pharmacy process (as-is) with selected modeling methods from literature review: SeeMe and i* framework (figures in chapter 3).
- Analyzing SeeMe and i*. To answer RQ1 and develop a modeling method which represents all required factors in a socio-technical process, this research consists of:
  - ➢ Utilizing the theoretical principles for using the meta-models of modeling languages to describe and compare these methods. In particular, the comparison of the SeeMe as a socio-technical process modeling tool and i* as a framework for modeling social actors was studied. The requirements to extend the model were generated in this stage.
  - ➢ Appling a meta-model-based approach to extend a process-modeling method with i* aspects (figures in Chapter 4). The purpose of this stage was to illustrate how social factors, such as goals and dependencies, can be modeled in the socio-technical modeling method.
- Elicitation of requirements from the extended model. To answer the RQ2 and application of the extended model, this research includes:
  - ➢ Conducting the second phase of (in-depth) interviews in the pharmacy to comprehend one of the problematic processes in the pharmacy,
  - ➢ Creating an as-is process model using the SeeMe*,

- Analysing the as-is process model and gathering socio-technical requirements of pharmacy managers (with conducting interviews) to improve the process,
- Creating a goal-oriented to-be SeeMe* which represents the ideal situation and develops activities to reach pharmacy manager goals,
- Creating a solution-oriented to-be SeeMe* to represent practical changes and solutions to the process which will address the pharmacy manager needs (social and technical solutions), and
- Eliciting solution requirements specification and determining whether these requirements are fulfilled with the help of technical support or by the social roles/people in the pharmacy.

- Validity check. To answer RQ3, the participants and experts are engaged to evaluate the transferability, accuracy, and credibility of our findings. More commonly, validity check refers to a broad concern that arises when researchers have studied one or a few cases. External validity of the research findings is evaluated in another case presented in a research study (González & Díaz, 2007) which is a car-sharing company. Also, an expert workshop was conducted for evaluating internal validity, which identifies if the results of this research are credible or believable from the perspective of the participants.

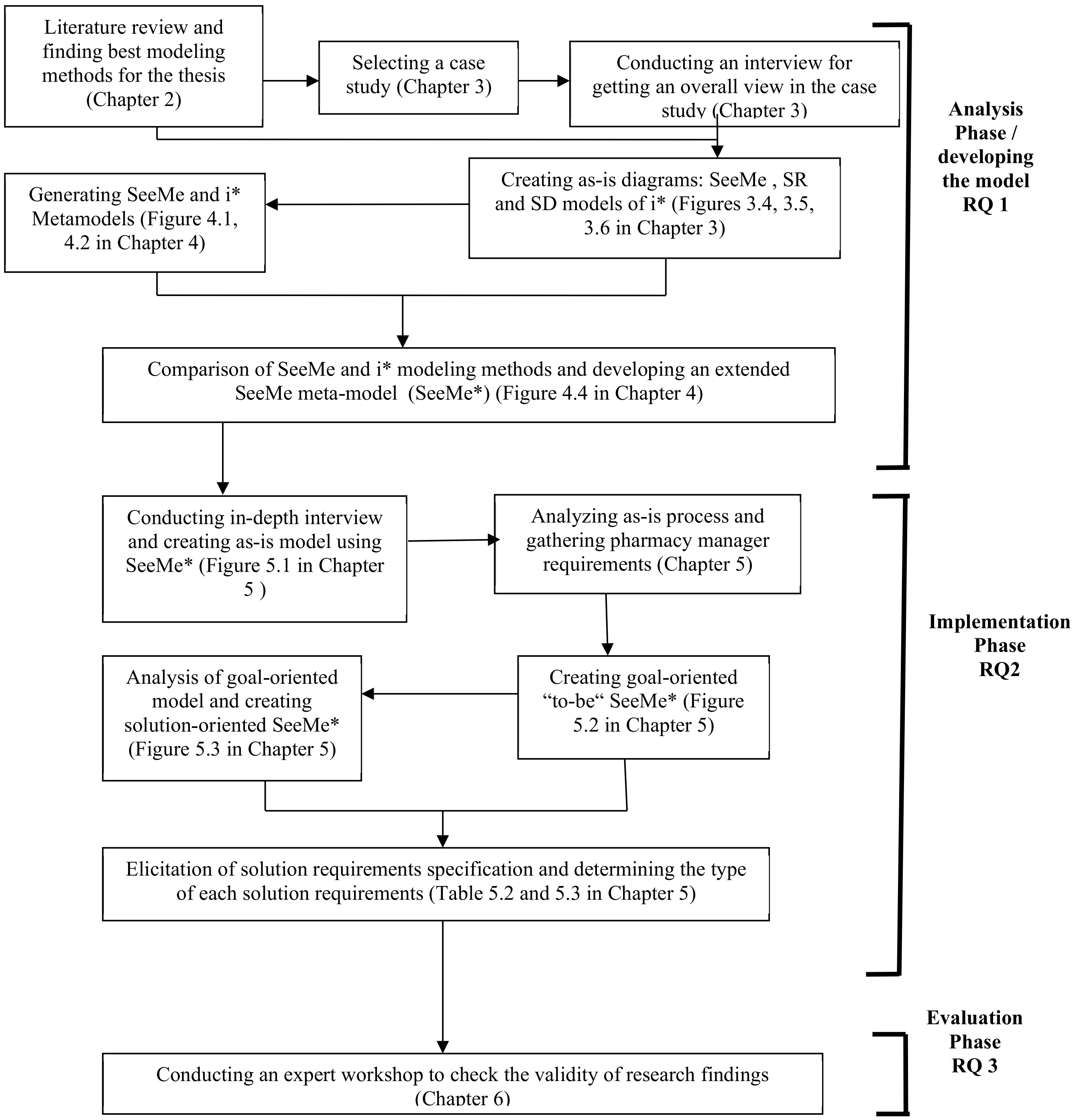


Figure 1. 2 Study Design

1.6. Thesis Outline

This thesis consists of five chapters, described as follows:

Chapter 1 provides an overview and introduction of the research. Research background, motivation, questions and objectives, and methodology are described.

Chapter 2 reviews the related research and literature analysis about business process modeling, socio-technical, and social modeling methods as well as requirement engineering and business process-based requirement specifications. It provides theoretical background to the research and identifies research gaps.

Chapter 3 describes the empirical research and background of a case study. The method of data collection and analysis to modeling “case study” processes with current modeling methods are presented in this chapter.

Chapter 4 presents the analysis of current models to find the requirements for model extension. It explains the meta-model and how it led to the development of the new model. The developed model is introduced in this chapter.

Chapter 5 presents the implementation of new models and references the outputs of these studies for answering Research Question 2. It describes how to elicit the process-based requirements of a socio-technical system from the developed model presented in Chapter 4.

Chapter 6 describes the evaluation that has been performed for the proposed solution. This evaluation considers both the internal and external validity of the proposed model with respect to its goals and elicited requirements.

Chapter 7 summarizes the main conclusions that can be drawn as a result of the development of this thesis. It describes the contributions that have been made and presents the limitations and the future works that could be performed.

Appendices explain the as-is and to-be work processes that have been represented in Chapter 5.

Chapter 2
Theoretical Background: Socio-technical Modeling Method for Requirements Engineering

The fundamental area of the social and intentional aspects of the socio-technical process modeling method for requirement engineering elicitation, as well as its relative preliminary state of study, were introduced in Chapter 1. In agreement with this, the purpose of this chapter is to review the research literature and theoretical foundation to identify the related concepts of the current research. It is important for the goal of the study to understand the current process modeling notations, which are used in practice, and their current problems facing human social environments. Moreover, it is described how process modeling is used in requirements engineering. By understanding the existing approaches, it is possible to judge how these methods can be utilized to create a model that consider social aspects of process modeling and its usage for requirements elicitation.

Section 2.1 explains the definitions of requirements engineering and its methods for goal-oriented requirement modeling. In Section 2.2 socio-technical systems and the socio-technical process modeling method of SeeMe are explained. Section 2.3 is about business process management and process modeling methods. The most popular process modeling notation is described in details within that section. Section 2.4 provides the definition of social modeling and the rational and importance of this approach currently. Furthermore, i* framework is defined in this section as one of the social modeling methods. Section 2.5 briefly explains the usage of BPM and social modeling for requirements engineering. Finally, in Section 2.6, the studies and research in field of the topic of this research is thoroughly reviewed.

2.1. Requirements Engineering (RE)

The role of Requirements Engineering (RE) grows more and more important within software engineering projects. “Hence, requirements capture has been acknowledged as a critical phase of software development, precisely because it is the phase which deals not only with technical knowledge, but also with organizational, managerial, economical and social issues” (Castro, Cysneiros, & Alencar, 2000, p. 5). Errors that are not recognized and corrected in the early phases of requirement capturing will cost a hundred times more to correct in later phases (Boehm, 1981).

The significance of studying domain knowledge and requirement analysis has also been shown in empirical software development projects. Curtis et al found in a review of 17 major software projects that the three main risk factors for project success are:

1. "The thin spread of application domain knowledge,
2. fluctuating and conflicting requirements,
3. communication and coordination breakdowns" (Curtis, Krasner, & Iscoe, 1988, p.1270).

Requirements engineering can be characterized as a systematic analysis of a particular system's requirements and as description of what a product or service should do (Paetsch, Eberlein, & Maurer, 2003). Requirements can be divided into business, user, and system requirements. Business requirements relate to the question 'why'. For instance, it could answer why something is important to the business and why something satisfies some business goals or needs. Business requirements ensure that the solution is compatible with an organization's (strategic) goals and corresponding business needs. User requirements, also known as customer requirements, refer to the "what" questions. For example, it answers what a solution must contain to satisfy the business requirements. All user requirements must be connected higher up the chain to one or more business requirements. At the bottom of the chain we find the system requirements. System requirements relate to "how" and explain what is needed to meet one or more user requirements higher up the chain. A graphical outline of the above definition is given in the following figure (Brennan, 2009).

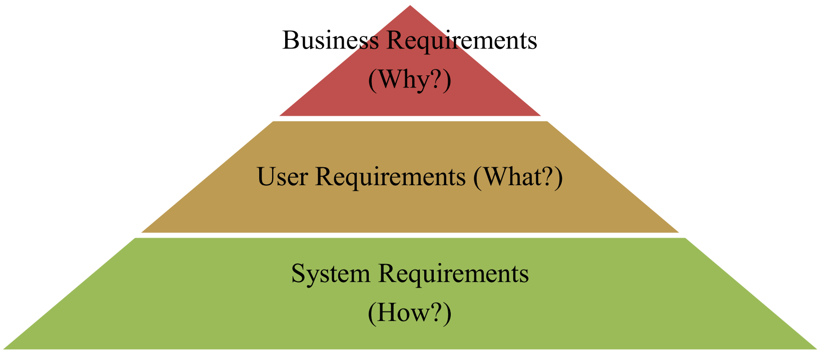


Figure 2. 1 Types of Requirements (Brennan, 2009)

The system requirements are focused on defining and analyzing the functions needed by any given solution system associated with performance and other quality measures and provide the basis for assessing candidate solutions and verifying the completed system (Cloutier, 2021).

These requirements refer to the expected features and behaviour of the system and can be defined as solution requirements that are based on the BABOK guide (A guide to the Business Analysis Body of Knowledge).

Describe the capability of a solution which meets the requirements of users. System Requirements provide the necessary level of detail to allow the solution to be developed and implemented (Brennan, 2009). Solution requirement describes specific characteristics of a solution that meet business and user requirements and come in two categories: functional and non-functional requirements. The functional requirements of the system describe the expected functionality of the system and are a kind of solution requirement that describes specific capabilities or functions that the solution must have to fully meet the user (stakeholder) requirements. The non-functional requirements do not care about what the system should do, but how it does it, and is related to the behaviour of the system. If a non-functional requirement is stated when it is deeply analyzed, it concludes into several functional requirements. So in detail's level only functional requirements are considered (Brennan, 2009).

"Requirements engineering is the process of discovering, documenting, and managing the requirements for a computer-based system. The goal of requirements engineering is to produce a set of system requirements which, as far as possible, is complete, consistent, and relevant and reflects what the customer actually wants" (Sommerville & Sawyer, 1997, p.5). Requirement engineering processes makes sure that all business, customer and system requirements are defined, described and communicated.

The process of software requirements engineering can be divided into four main phases (Sommerville, 2004):

- First is the requirements elicitation with the stakeholders. This is the process of identifying the application domain by determining the desired software system functionality. The elicitation process should include all persons directly involved in or indirectly affected by the project. Some techniques like workshops, interviews, and observations can be used to gather the requirements.

- Next is the analysis phase. Here, the collected requirements are analyzed to find out all hidden meanings. There are some problems in this phase. For example, stakeholders don't know what they really want, stakeholders express requirements in their own terms, or different stakeholders may have conflicting requirements.
- After analysis, requirements are documented. Here is the output Software Requirements Specification (SRS). The SRS organized functional and non-functional requirements and may include a collection of use cases that describe user interactions that the software must provide to the user for perfect interaction.
- Verification of SRS document is the last phase. The document as a part of the contract is verified by the customer to be sure that the designed SRS provides a real contribution for satisfying stakeholder requirements.

2.1.1. Critical Aspects of Requirements Engineering

As mentioned above, analyzing the collected requirements can be very challenging and despite the importance of an effective identification of requirements, there are a number of difficulties in doing requirements well. "Broadly speaking, doing requirements means managing complexity and communication among people" (Damian, 1999, p.2). Therefore, in this section we will discuss the methods that help requirements engineering improve.

2.1.1.1 Requirements Engineering Based on Business Process Models

Since requirements engineering involves the attempt to conciliate the stakeholders' viewpoints involved in the design process (Pouloudi, 1999) its success is directly linked to effective communication between stakeholders (Cardoso, Almeida, & Guizzardi, 2009). In the absence of this, the requirements engineering process may lead to systems whose functionalities are unnecessary, wrong, or do not represent the goals of stakeholders. Consequently, if the business environment is not correctly analyzed, the system may not meet expectations, and business/IT alignment would thereby not be achieved.

To prevent these problems, there is a growing need for methodologies or techniques that fill the distance created by poor communication. Some researchers reported which modeling of business processes was considered as a useful tool for requirements engineering. As a starting point, they used business process models to derive alternative sets of process-oriented system requirements (Cardoso, Almeida, & Guizzardi, 2009; González & Díaz, 2007; Alexander, Bider, & Regev, 2003). These researchers considered the role of business process modeling as a means to address eliciting requirements by learning about the environment and understanding stakeholders' needs. Since the current system (processes, organization, environment, and legacy systems) is one of the key sources for eliciting requirements, graphical representations such as models and diagrams are becoming increasingly common for representing current systems (Wand & Weber, 2002). Such models and diagrams help stakeholders communicate more effectively and have a deeper understanding of the domain.

The primary aim of business process modeling is to formalize business processes in an organization and capturing the context in which these processes are carried out (Sharp & McDermott, 2009). Business process models, in fact, allow analysts to consider alternative sets of requirements by varying the "level of automation" for the different processes in a business process. (Cardoso, Almeida, & Guizzardi, 2009).

Considering the above-mentioned points, a business process-driven requirement engineering approach that allows the requirements to support the operations of a business and meet the needs of stakeholders is clearly needed.

2.1.1.2 Social Context in Requirements Analysis

According to a survey of 8000 projects in 350 US companies, one-third of software development projects are never finished, while the other half are only partially successful (Clancy, 1995). In about half of the responses, managers described poor requirements as the biggest problem. Obviously, a major obstacle to system success is the difficulty of the requirement-gathering process. In a study (Reddy, Pratt, Dourish, & Shabot, 2003), they stated that one of the causes of these failures is a discrepancy between traditional requirements systems and the complexity of the settings in which computer systems are usually implemented. "Traditional "requirements analysis" is based on a set of assumptions (e.g. that the application domain is stable, that information is fully available and known and that most work is routine) that often break down in dynamic, real-world settings" (Reddy, Pratt, Dourish, & Shabot, 2003, p.437).

To design successful systems, we must investigate alternative approaches to requirements analysis that do not use traditional requirements analysis. It is recognized that requirement engineering issues cannot be solved solely by technological way; the social aspect is much more significant than in the design and programming processes (Damian, 1999). The information required for system design is found in the social worlds of users and managers and is therefore informal and dependent on its social context for understanding. On the other hand, the representations used in the system design are formal and relatively independent of social context. Combining these social and technical aspects of the system is seen as the very foundation of engineering requirements (Goguen, 1994). Jirotka and Goguen (1994) describe three approaches to social and technical analysis of requirements:

1. Integrating social processes into the existing technical requirements methodology.
2. Involving users more directly in the design process through methods such as participatory design.
3. Viewing technical requirements as embedded in the work practices of the users.

By following these steps, it is possible to move away from a completely technological view of requirements, which will assist us in designing a solution that fits the company and communicates for users. Also, „Requirements engineering roadmap of the year 2000" (Nuseibeh & Easterbrook, 2000) stated the importance of understanding the system environment and emphasized that modeling criteria must consider the organizational and social context in which a new system would function.

2.1.1.3 Early and Late Phase of Requirements Engineering

"Requirements engineering (RE) is receiving increasing attention as it is generally acknowledged that the early stages of the system development life cycle are crucial to the successful development and subsequent deployment and ongoing evolution of the system" (Yu E., 1997, p.226). The initial requirements statements have been taken as a starting point in many RE studies. The expectations of the customer on what the system should do is represented in these statements. "Initial requirements are often ambiguous, incomplete, inconsistent, and usually expressed informally…". Nonetheless, "The objective in these "late-phase" requirements engineering tasks, is to produce a requirements document to pass on ("downstream") to the developers, so that the resulting system would be adequately specified and constrained, often in a contractual setting" (Yu E., 1997, p.226).

"These "early-phase" requirements engineering activities include those that consider how the intended system would meet organizational goals, why the system is needed, what alternatives might exist, what the implications of the alternatives are for various stakeholders, and how the stakeholders' interests and concerns might be addressed. The emphasis here is on understanding the "whys" that underlie system requirements…, rather than on the precise and detailed specification of "what" the system should do. This earlier phase of the requirements process can be just as important as that of refining initial requirements to a requirements specification, at least for the following reasons" (Yu E. , 1997, p. 226):

- As discovered in empirical studies, poor understanding of the system domain is a primary cause of project failure. To have a deep understanding about a domain, it is necessary to understand the desires and goals and abilities of different actors and players, as well as to have a good understanding of the principles and facts of the domain.
- First and foremost, users need assistance in coming up with initial requirements. A formal structure is needed to assist developers in understanding what users want and to assist users in understanding what technical systems should do. Many technical systems have failed to meet real needs.
- Rather than automating well-established business processes, systems are now seen as "enablers" of creative business solutions. As a result, requirements engineers are more important than ever before in connecting systems to business and organizational goals.
- As more and more systems interconnect in organizations, understanding how systems interact (with each other and with human agents) to contribute to organizational objectives is becoming increasingly important. Early phase requirements models that deal with organizational goals and stakeholder interests can provide a view of the cooperation among systems within an organizational context.

Considering the above reasons, it can be declared that the RE methods which can model early requirement engineering and show organizational goals are highly requested and needed. Hence, the following section will describe the role of the goals of RE.

2.1.1.4 Goal oriented RE Approaches

"The main objective of requirements engineering is to understand a customer's needs, problems to be solved before system development, the delimitation of system boundaries, as well as other types of constraints imposed to the solution…" (Cardoso, Almeida, & Guizzardi, 2009, p.320).
In other words, requirements and solutions can be defined as follows (Brennan, 2009):

- Requirements are conditions or capabilities needed by a stakeholder in order to achieve an objective.
- Solutions are changes to the business which will address the business need (i.e. process changes, personnel changes, technology changes).

"Goals have long been recognized to be essential components involved in the requirements engineering (RE) process" (Lamsweerde, 2001, p.249). They can be defined as objectives that a software system should achieve in order to meet stakeholders' needs. "Goals may be formulated at different levels of abstraction, ranging from high-level, strategic concerns … to low-level, technical concerns …" (Lamsweerde, 2001, p.250). Once the business stakeholder(s) agree on a strategy for achieving that goal, the business will identify requirements for the actionable project(s) that will achieve this strategy. Valuable requirements must solve problems in the market and support the business strategy. In the following table, the difference between goals and requirements is presented.
Requirements Engineering (RE) is, simply said, concerned with the process of finding a solution for some problem. This concern can be approached from a problem-oriented view, which focuses on understanding the actual problem, and a solution-oriented view, which focuses on the design and selection of solution alternatives (Wieringa, 2004). Finally, requirement specification refers to the description of the solution in general, covering the requirements.

Goals	Requirements
Broad scope	Narrow scope
Apply to system	Apply to individual functional requirements
State desires	State constraints
Not testable	Testable
Not about design/implementation details	Provide some details

Table 2. 1 Goals vs. Requirements (Clarkson, 2016, p.15)

Goal-oriented RE techniques developed as a way to address a significant flaw in traditional RE methods. They result in systems that are technically satisfactory but incompetent to reply to user

demands. Goal-oriented RE proceeded that rather than focusing on what needs to be accomplished, requirements should first concentrate on the "why" and "how" of a software system.
More specifically, ""Traditional" analysis and design methods focused on the functionality of the system to be built and its interactions with users. Instead of asking what the system needs to do, goal-driven methods ask why a certain functionality is need and how it could be implemented" (Aljahdali, Bano, & Hundewale, 2011, p.330).
Therefore, goals provide a basis for system performance. Besides that, goal modeling and analysis in the RE process aims to: (a) get a better understanding of a system-enabling elicitation of requirements, (b) finding and evaluating alternative implementations, (c) detecting irrelevant requirements, (d) obtaining full specifications of requirements, (e) identifying and resolving conflicts of requirements, and (f) establishing consistent goals (Pohl, 2010).
The goal-oriented RE methods that can be considered the most relevant are (González J. L., 2011):

- I* framework: The i* framework is also closely related to the NFR Framework (Chung, Nixon, Yu, & Mylopoulos, 2000). Both frameworks are concerned with softgoal analyses. The NFR system, on the other hand, focuses on identifying, analyzing, and operationalizing non-functional requirements.
- Kaos (Dardenne & Lamsweerde, 1993): KAOS stands for Knowledge Acquisition in automated Specification. It was designed in 1990 by Axel van Lamsweerde and others. Its aim is to aid in the elicitation of requirements from high-level goals that system requirements must meet. The goal model, the object model, the agent responsibility model, and the operation model are the four complementary models that make up KAOS.
- The Map approach (Rolland, 2007): Its aim is understanding an organization or system's goals and defining strategies that can lead to the fulfillment of those goals. The assumption that stakeholders cannot instinctively distinguish between goals and strategies supports this focus.
- Formal Tropos: It is a specification language for early requirements. It is based on concepts from an agent-oriented early requirement model framework (i*) and extends them with a rich temporal specification language (Fuxman, Liu, Mylopoul, Pistore, & Roveri, 2003). A Tropos specification includes a "static" view of the organizational environment as well as the interdependencies between the domain's various components (Perini, Pistore, Roveri, & Susi, 2003).

2.1.2 **Analysis and Discussion**

The approaches for interpreting system requirements have been evaluated in terms of how well they help to accomplish the thesis's fifth goal:

> "To find a better method to understanding problems and motivation behind a socio-technical system that occurs during the early-phase of requirements capture to provide concepts such as softgoal and goal."

In Section 2.1, the importance of requirement engineering in software engineering process and the critical aspects of the requirements engineering have been explained. Business process models have been presented as a starting point for gathering system requirements, with the argument that process modeling will make gathering requirements easier. A business process-driven requirements engineering approach enables software requirements to help a company's operations and facilitate business / IT alignment (De laVara, Sánchez, & Pastor, 2008).

As mentioned in Section 2.1.1.2, software systems are increasingly being ingrained in daily life, affecting both organizational and social interactions. This increases the need for the social and technical perspectives for requirements engineering. In order to achieve their goals, social system, human, organizational, and software actors depend heavily on one another.

Moreover, the importance of goals in effective requirement elicitation cannot be overstated. Goals have long been accepted as critical elements in the requirements engineering process. I* social modeling optimizes the techniques developed in goal-oriented RE and allows for the operationalization of goals. Also, the i* framework is well for early-phase requirements capture, since it allows for the representation of alternatives and offers basic modeling concepts such as those of softgoal and goal.

Therefore, a lack of a systematic process, poor communication between people, lack of socio-technical perspective and goals in the context of social actors can negatively affect requirement engineering.

Considering all these critical aspects of RE, it is clear that providing a process model with social and technical perspectives which facilitates requirements elicitation and finding solutions to system challenges plays a significant part and is the focus of this research.

2.2. Socio-Technical Modeling Methods

As described in Section 2.1, social perspective plays also an important role in requirements engineering. In this section we provide some background to socio-technical systems and discuss its relevance for our research.

2.2.1. Socio-Technical System : Introducing the Concept

It is difficult to distinguish organizational or social issues from technical issues in a socio-technical viewpoint. Organisations need to promote designs that demonstrate optimum performance of both the human and technical components (Gregoriades & Sutcliffe, 2008).

In the past social and technical were seen as separate side-by-side systems which needed to interact positively. "The term socio-technical systems was originally coined by Emery and Trist (1960) to describe systems that involve a complex interaction between humans, machines and the environmental aspects of the work system—nowadays, this interaction is true of most enterprise systems" (Baxter & Sommerville, 2011, p.5). As a result of this principle, when designing these systems using STSD methods, all of these factors — humans, machines, and context — must be considered. Mumford (Mumford, 2006) states that the primary goal of socio-technical projects was to assign equal weight to technical and human aspects in the design process whenever possible. The definition most in line with the ICT field is that of Baxter and Sommerville which explains that socio-technical systems are "…systems that involve a complex interaction between humans, machines, and the environmental aspects of the work system..." (Baxter & Sommerville, 2011, p.5).

Although many complex systems are commonly referred to as socio-technical systems, open socio-technical systems have five distinct features (Badham, Clegg, & Wall, 2000):

- Parts of systems should be interdependent.
- Systems should adjust to and follow goals in external environments.
- The internal environment of systems includes different but interdependent technical and social subsystems.
- Systems goals can be achieved by more than one means. This implies that there are design choices to be made during system development
- System performance relies on the joint optimisation of the technical and social subsystems

In Chapter 3, we will see how these points are part of the characteristics of the selected case study in this research (pharmacy system).

Table 2.2 recommends four levels of computer system, which correspond to the idea of an information system as hardware, software, people, and business processes (Alter, 2001). Socio-technical systems emerge when cognitive and social interaction is influenced by information technology instead of the real world (Whitworth, 2006, p.533).

Level	**Examples**	**Discipline**
Social	Norms, Culture, Laws, Roles, Sanctions	Sociology
Cognitive	Semantics, Attitudes, Beliefs, Opinions, ideas, morals	Psychology
Information	Software programs, Data, Bandwidth, Memory, Processing	Computing
Mechanical	Hardware, Computer, Telephone, fax, Physical Space	Engineering

Table 2. 2 Information System Levels (Whitworth, 2006, p.533)

2.2.2. Socio-Technical System Design Methods

Socio-technical systems design (STSD) methods are design techniques that consider human, social, and organizational factors, along with technical factors, in designing organizational systems. They are designed to ensure that system's technical and organizational elements are taken into account simultaneously. Using these methods improves our comprehension of how organizational, social, and human aspects influence the ways that technical systems are used and work is carried out (Baxter & Sommerville, 2011).

The reason for adopting socio-technical approaches to systems design is decreasing the risks that systems will not make their expected contribution to the goals of the organisation. “Systems often meet their technical ‘requirements’ but are considered to be a ‘failure’ because they do not deliver the expected support for the real work in the organisation” (Baxter & Sommerville, 2011, p.4).

Indeed in spite of the fact that numerous managers figure it out that the importance of socio-technical issues, socio-technical design methods are seldom used. The main reason why these methods are not used more is that they are difficult to use and don't connect well with technical engineering issues and individual interactions with technical systems (Baxter & Sommerville, 2011). “…Methods that stemmed from the socio-technical school of thought such as ETHICS (Mumford, 1983), Soft Systems Methodology (Barua & Whinston, 1998), and Multi View

(Avison, 1990) incorporate the people dimension, but lack quantitative and analytic capabilities necessary for assessing business process performance" (Gregoriades & Sutcliffe, 2008, p.1018). Studies of related research in socio-technical system design methods show the disadvantages of these methods and the need to modify them. For example, "starting from the contribution made by Keen and Scott Morton (1978) regarding structured, semi-structured and non-structured decisions, Pava (1983) argued that the distinction between routine and non-routine tasks should be seriously taken into account…" (Biazzo, 2002, p.48). To look at it another way, the methodology used must be determined by the context of the work being studied, and a linear representation of workflows, which is accepted as true for all types of work but cannot always be used. Moreover, it is difficult to model the STS effectively because of the complex nature of the problem domain. "There are many different dimensions to STS such as economic, legal and regulatory, technical, security and social dimensions…" (Wu, Fookes, Pitchforth, & Mengersen, 2015, p.15).

Unified Modeling Language (UML) diagrams are one of the most popular approaches in the study of organisational STS as they provide a graphical representation of system interactions and processes with respect to function (Weck, Roos, & Magee, 2011). Independent of the modeling method, the uncertainty inherent in the system must be captured. "Herrmann and Loser (1999) provide one approach to classifying uncertainty based on whether it is deliberately introduced by the modeller (e.g. through abstraction), through vagueness (potential inaccuracy and/or incompleteness), and omission (unrecognised unknowns). This uncertainty can be represented qualitatively on a diagram, or quantified as part of an analytic or simulation model…" (Wu, Fookes, Pitchforth, & Mengersen, 2015, p.15)

2.2.3. Designing Socio-Technical Systems: Challenges

Socio-technical systems are thought to be integrated into organizational environment (Bryl, 2009). As a result, recognizing the organizational environment, work processes, and the changes that technology causes in an organization's system is required when developing an STS. The challenges and approaches to the study and design of socio-technical processes are discussed in the following.

Developing a socio-technical system is a system engineering process in which not only software but also hardware, system interactions with human users, and various constraints imposed by organizational and social policies and regulations must be considered (Sommerville, 2004).

Understanding the requirements of software modules, how technology should assist human and organizational activities, and how the structure of these activities is affected by implementing technology are all problems in the analysis and design of a socio-technical system (Gregoriades, Shin, & Sutcliffe, 2004).

"In particular, in a socio-technical system, human, organizational and software actors rely heavily on each other in order to full their respective objectives. Not surprisingly, an important element in the design of a socio-technical system is the identification of a set of dependencies among actors which, if respected by all parties, will fulfill all stakeholder goals, and then the requirements of the socio-technical system" (Bryl, 2009, p.1). Albert Cherns (1976), an Associate of the Tavistock Institute, described the socio-technical design principles in an article in Human Relations. These principles can be summarized as follows:

> The process of design must be compatible with its objectives. No more should be specified than is absolutely essential. This is often interpreted as giving employee groups clear objectives but leaving them to decide how to achieve these. For groups to be flexible and able to respond to change, they need a variety of skills. These will be more than their day-to-day activities require. All groups should learn from each other despite the existence of the boundary. Systems of social support must be designed to reinforce the desired social behavior. New demands and conditions in the work environment mean that continual rethinking of structures and objectives is required.

In Chapter 4, the modeling notation which is developed for this study will be described. In this chapter we can find out how these principals come into practice.

2.2.4. Analysis and Discussion

This section discusses the key characteristics of socio-technical systems and the problems one is faced with during their analysis and design in early phases in situations where the requirements are incomplete (Fifth objective of the thesis).

As mentioned, the need for a best match between the technological and social aspects of the interaction between jobs and the expectations of individuals is emphasized in socio-technical design. Therefore, in the early stages of the development of a socio-technical system, modeling and analytical techniques are required to help understand the organizational environment in terms of the goals, interdependencies and mutual constraints of different actors and take the mentioned design principles into account.

As described in Section 2.2.3 and 2.2.2, socio-technical methods such as UML incorporate the human dimension but lack the quantitative and analytic capabilities necessary to evaluate the success of business processes. They contain too little process orientation as well as too little consideration of social factors.

Hence, the following two sections are introducing more process-oriented modeling notations (Section 2.3) and social modeling methods (Section 2.2.4) to solve these challenges.

2.3. Business Process Management and Business Process Modeling

This section reports a history of business process modeling that is regarded as a useful tool for requirements engineering. As mentioned in 2.1.1.1, business process models are used to generate different sets of requirements for a process-oriented system.

2.3.1. Business Process Management

Before analysing details of BP Modeling literature, the definition of business process management has been given, because it covers the BP modeling as a major activity.

In its simplest definition provided by Davenport, "a process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action" (Davenport, 1993, p.5). In addition, Becker et.al explains that a business process is a particular process that is operated by company's business goals and the business environment (Becker & Kahn, 2003) Scheer and Nüttgens define business processes "…as a procedure relevant for adding value to an organization" (Scheer & Nüttgens, 2000, p.376). A business process:

- has its customers,
- is composed of activities,
- these activities are aimed at creating value for customers,
- activities are operated by actors which may be humans or machines,
- Often involves several organizational units which are responsible for a whole process (Kueng, Bichler, Kawalek, & Schrefl, 1996).

Processes in companies have to be considered from two perspectives. One is considering them as business process that focuses on value creation. On the other hand, they can be regarded as work processes involving several people working together in different roles and using resources. The work steps depend on conditions and events or states. Work processes are primarily social phenomena that are shaped by the history of the current or future changes. Most importantly, these changes affect the goals and criteria that are set for creating success measurement of a business process.

In reality, work processes are more than just adding value. A work process also involves activities that are not directly in the sense of a business process contribution to the added value but are still relevant for the success of the entire process. Many working conditions and aspects which are necessary for success of co-operation between people are neglected when one focuses only on the goal of value creation (Herrmann, 2012).

Accordingly, the concept of work processes is regarded in this research as modeling the processes. BPM can be considered as a continuous cycle that includes the following stages (see Figure 2.2):

- BPM starts with process identification. In this phase, a business problem is posed, processes relevant to the problem being addressed are identified, delimited, and related to each other.
- Then, as the process discovery step, the current state of each of the relevant processes is documented, typically in the form of one or several "as-is" process models.
- In process analysis, issues associated to the "as-is" process are identified, documented and whenever possible quantified using performance measures.
- The goal of process redesign (also called process improvement) is to identify changes to the process that would help to address the issues identified in the previous phase and allow the organization to meet its performance objectives.
- In process implementation phase, the changes required to move from the "as-is" process to the "to-be" process are prepared and performed.
- Then, in process monitoring and controlling phase, relevant data are collected and analyzed once the redesigned process is running. With these data, we can determine how well the process is performing with respect to its performance measures and performance objectives (Dumas, Rosa, Mendling, & Reijers, 2013).

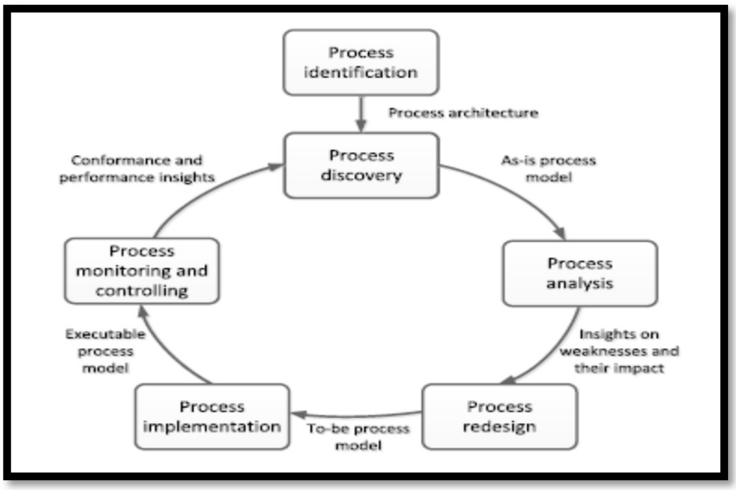


Figure 2. 2 BPM Lifecycle (Dumas, Rosa, Mendling, & Reijers, 2013, p. 23)

As we see in Figure 2.2, process discovery (also called "as-is" process modeling allowing you to get an accurate view of how the process works) is a main consequence of the BPM life cycle that has a huge impact on how it is carried out. The process discovery techniques assist organizations in identifying their real business processes. Until beginning the to-be process documentation, one must first determine how it will look like. Any inefficiencies or weaknesses in the as-is process should be investigated. By tightly coupling event data and process models, it is possible to check conformance, detect deviations, predict delays, support decision making, and recommend process redesigns (Van der Aalst, 2013).

Process models help analyze current processes and continue the lifecycle. As a consequence, BP modeling is described in the following sub-Section 2.3.2.

2.3.2. Business Process Modeling

"The increased interest in a more disciplined approach for Business process management has motivated many organizations to make significant investments in process modeling initiatives" (Recker, Indulska, Rosemann, & Green, 2006, p.1583).

As described earlier in Section 2.1.1.1, as requirements engineering tries to match the viewpoints of the various stakeholders engaged in the design process, its success is dependent on effective stakeholder communication. Without this, the development process can result in structures with unnecessary, incorrect functionalities or structures which do not represent organizational objectives of an activity. In this section, the role of business process modeling as a way of resolving the gap between those defining and performing organizational activities is considered.

"Process modeling becomes more and more an important task not only for the purpose of software engineering, but also for many other purposes besides the development of software" (Becker, Rosemann, & von Uthmann, 2000, p. 30). Being graphical in nature, it is easy for communication with stakeholders, to represent relationships among entities and to understand the overall operations. Process modeling gives everyone a clear understanding of how the process works. Business process modeling is useful for a variety of reasons. Aldin and de Cesare identified five key uses of business process models:

1. "facilitating a group to share their understanding of the process by using a common process representation…,
2. providing the advantage of reuse. if the same business process model can act as the basis for several information systems, it can be reused as the basic input for defining the requirements of each system,
3. creating suitable information systems that support the business by providing a descriptive model for learning,
4. supporting process improvement and re-engineering through business process analysis and simulation…, and
5. enabling decision support during process execution, and control" (Aldin & de Cesare, 2009, p. 10).

BPM achieves these aims by communicating operations, events, or states graphically, and by monitoring the flow logic that forms a business process that enables managers to make changes or modify decisions (Aitken, Doherty, & Coombs, 2015). "The ongoing and strengthened interest in modeling for business process management has given rise to a wide range of modeling techniques, from simple flowcharting techniques (American National Standards Institute, 1970), to techniques initially used as part of software design such as activity diagram in UML (Fowler, 2004), to dedicated business-oriented modeling approaches such as Event-driven Process Chains (Scheer A. W., ARIS - Business Process Modeling 3rd., 2000), to formalized and academically studied techniques such as Petri nets (Petri, 1962)…" (Recker, Indulska, Rosemann, & Green, 2009, p. 334).

A universal notation for business process models does not exist. As said above, each notation has been created for specific purposes. Thus, they concentrate on those aspects that have been considered as more important by their designers. In addition, each method has its own advantages and disadvantages, and each method is restricted with respect to the view of the enterprise that it can present.

Since reviewing all existing business process notations in this thesis is not possible, the next subsections present the notation that can be currently considered as the most important in academia and industry. BPMN, as a neutral notation that is adopted by many solutions providers, and SeeMe, as a socio-technical modeling method for the representation of social and semi-structured aspects of communication and cooperation relationships, have been described in the next part. Section 2.3.3 analyzes these notations and discusses their weaknesses and strengths, in order to make it possible to select one of these modeling notations for the methodological approach of this thesis.

2.3.3. Selection of the Process Modeling Notation

2.3.3.1. BPMN

"One of the most recent proposals for yet another process modeling language is the Business Process Modeling Notation (BPMN), version 1.0 of which was proposed in May 2004 and adopted by OMG (Object Management Group) for standardization purposes in February 2006" (Recker, Indulska, Rosemann, & Green, 2006, p. 1583). The need for a graphical notation to supplement the BPEL4WS standard for executable business processes led to the development of BPMN. Although this gives BPMN a technical focus, it has been the intention of the BPMN designers to develop a modeling technique that can be applied for typical business modeling activities as well (De laVara, Sánchez, & Pastor, 2008).

The popularity of BPMN has been driven by its conformance with emerging web services standards, its relatively intuitive notation, and the prospect of being an official process modeling industry standard (Recker, Indulska, Rosemann, & Green, 2006). "With regard to the choice of BPMN, several surveys have evaluated its adequacy for business process modeling and have

compared it with other notations. These surveys are based on different criteria, such as workflow patterns (Wohed, van der Aalst, Dumas, Hofstede, & A. H., 2006), quality principles (Nysetvold & Krogstie, 2005), or the BWW representation model (Rosemann M. , Recker, Indulska, & Green, 2006). From the result of these studies and our experience, BPMN has three main advantages: it is probably the most expressive notation, it is easy to use and understand, and it is receiving strong support from practitioners and vendors" (De laVara, Sánchez, & Pastor, 2008, p.215).
To summarize, BPMN notation is a language specially developed to integrate all levels in the organization, making it a very easy process to manage. It offers an easy way for non-experts to understand the semantics of complex processes, and it reduces the noise that can occur during communication between process design, execution and management (Gitbook, 2017).

"The main goal of BPMN has always been to provide a notation that is easy to understand by all business process users. It also aims to provide a standard that fills the gap between business models and their implementation and is closely related to WS-BPEL (Web Service Business Process Execution Language)....BPMN can help organizations to understand their procedures by means of a graphical notation. The notation allows these procedures to be communicated in a standard way by means business process diagrams (BPD, i.e., business process models in BPMN terminology), which consists of different types of graphical objects:

- Flow objects, which are the main graphical objects for business process modeling; they are events (start, intermediate and end events), activities (sub-processes and tasks) and gateways (exclusive, inclusive, complex and parallel gateways).
- Connecting objects, which allow other graphical objects to be connected….
- Swim lanes, which allow participants of a business process to be represented; they are pools and lanes.
- Artifacts, which provide additional information about a business process model; they are data objects, groups and annotations" (González, 2011, p.19).

In the following figure, these graphical objects are shown:

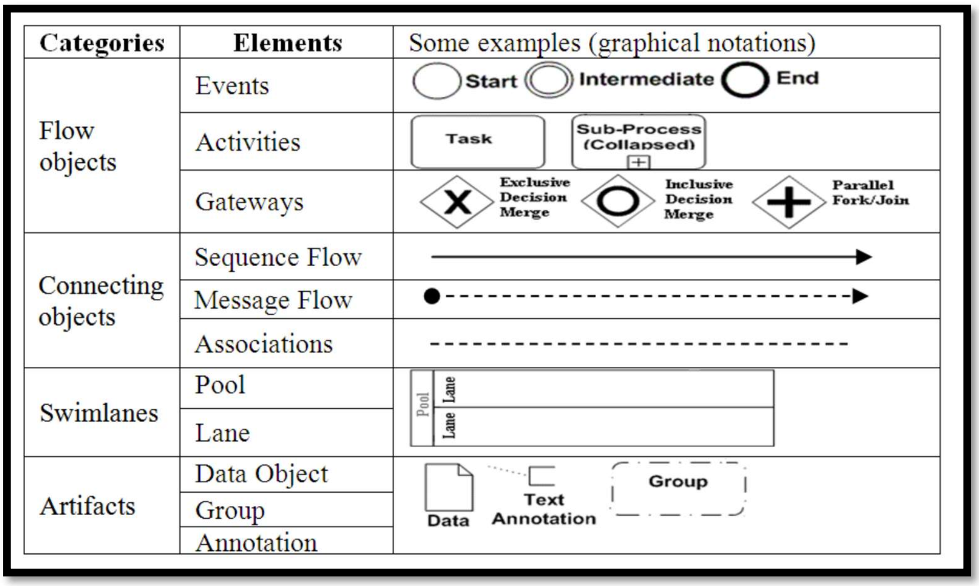


Figure 2. 3 BPMN Elements (Cotofrei & Stoffel, 2012, p. 19)

2.3.3.2. Limitations of Current Process Modeling Methods

As mentioned above, in general, a BP model is seen as a set of activities aimed at achieving a certain business goal or objective, such as creating value for customers. So, business processes define how to meet business goals. Thus, it is normal that business process modeling methods provide support for modeling these goals. Just a few methods, on the other hand, directly record, optimize, and analyze business goals.

Most major BP modeling approaches capture processes at a workflow level in terms of activities, flows, etc. (Lapouchnian, Yu, & Mylopoulos, 2007).

Furthermore, from the point of view of BPM practitioners, the limitations that BP modeling methods might be summarized as follows:

- “Process improvement is focused on methods and tools, often forgetting sometimes the people dimension,
- BPM approach begins with a lengthy and monolithic “As Is” analysis,
- The role of the business people is focused in the transfer of information for the team project and not in provoking a rethinking of the organization,
- The approach is only based on individual interviews,

- The task of documenting methods and procedures is too heavy, making it difficult to run the workshops and interviews with enthusiasm on the part of business people" (Coelho, 2005, p. 122).

"The number of BP Modeling implementation failures has been substantial (60% to 80%, according to Lockamy III & Smith (1997); and 50% to 70%, according to Hammer & Champy (1993) and Cameron & Braiden (2004). Chan & Choi (1997) summarized these failures into two broader categories:

1. lack of understanding of the actual goals and expectations; and
2. lack of ability to implement the methodologies" (Meloa, Nettob, Filho, & Fernandes, 2010, p.310).

As we said in Section 2.3.3.1, BPMN is evaluated to be the most comprehensive notation. However, we'll go through a few issues with BPMN use. "For example, knowing that BPMN exhibits a limitation in the modeling of business rules, an organization may put in place additional tools together with a set of business rule modeling conventions, or it may even adopt a business rule modeling technique…. The reported usage of extended tool functionality implies that BPM practitioners seek additional support in their process modeling that BPMN cannot provide. This could be a motivating sign for extensions or future revisions to BPMN to provide additional support for application…" (Recker, 2010, p.196). Regarding these problems, many researchers have been carried out to overcome the shortcomings and improve BPMN by extending it. In a more general study, Rosemann et al. (Rosemann, Recker, & Flender, 2008) point out that all participants extended BPMN with other tools, allowing business process restrictions to be adjusted by other methods.

For instance, in a study BPMN is extended with a goal-oriented approach to obtain a model that reflects the continuous changes checking between model and reality. They tried to represent variability at the business process level. To attain this goal, they had used a goal graph model which is characterized by the hierarchical decomposition of goals in sub-goals using logical operators such as And, Or and XOR decomposition (Santos, Castro, Sanchez, & Pastor, 2010); or in another one, a BPMN extension is defined, in order to model non-functional properties of Business. They mentioned that BPMN does not support describing a business process in terms of non-functional properties like performance and efficiency. These papers propose a BPMN

extension for the definition of properties that cover both efficiency and reliability to resolve these limitations (Pavlovski & Zou, 2008; Bocciarelli & D'Ambro, 2011).
Moreover, in another work, Koliadis et al. (2006) argue that managing change through the business process model requires more conceptual support, which can be accomplished by a combination of complementary notations and that BPMN is primarily a technically-oriented business process modeling notation which is not sufficient for their work. Therefore, the focus in mentioned paper is on the co-evolution of operational (BPMN) and organizational (i*) models to elicit the business constraints from BPMN (Koliadis, Vranesevic, Bhuiyan, Krishna, & Ghose, 2006). However, in this work, the mapping of specific constraints and softgoals to BPMN is preliminary and not well defined. For instance, they provide systematic guidance for developing an i* model given an already existing process model. Similarly, operational improvements should be linked to organizational goals to make analysis easier and ensuring there are no inconsistencies with current goals. It is a time-consuming approach that needs a software tool, along with further refinement of the approach.

2.3.3.3. SeeMe

"SeeMe was developed in 1997 after it had revealed that the available diagrammatic modeling methods were not feasible for socio-technical systems and for the purpose of smooth communication processes about socio-technical solutions" (Herrmann, 2006, p.1). "The development of SeeMe was triggered by the experience that available methods were not suitable to represent a combination of imprecisely as well as formally specified structures…. SeeMe is inspired by the extended-event-process-chain (eEPC) developed by Scheer (1992), by use-case diagrams (RationalSoftwareCrop., 1997) and by State-Charts (Harel, 1987). We have combined aspects of these methods and extended with possibilities to express vagueness which includes incompleteness and uncertainty. Vagueness in SeeMe is related to a qualitative lack of information and not to a quantitative measurement of the probability of the occurrence or correctness of a certain modeling element" (Goedicke & Herrmann, 2008, p.66).

The semi-structured, socio-technical modeling method, SeeMe, was established based on the concepts of uncertainly, explicit incompleteness, multiplicity of perspectives, and self-referential meta-relations and it is especially designed for representing socio-technical work processes and structures and can help people to understand the specific features and requirements of 'their' socio-technical systems (Herrmann, Hoffmann, Kunau, & Loser, 2004).

> "SeeMe is constructed in a way that it is flexible in both directions: it can be used to express vague, informal structures and it can support formal specifications which are similar to UML-activity diagrams, flow charts, EPC (Scheer, 1992) or entity-relation-diagrams (Moody, 1996). The strength of SeeMe -if it is compared with other methods- is the possibility to express and indicate vagueness. Furthermore, it is not exclusively focused on the interaction with the technical system, as is the case with use-case diagrams in UML which can also be considered as a means to support informal drafts. By contrast, SeeMe supports the presentation of entire processes and work settings. Compared with methods which are similar to flowcharts, SeeMe has been extended by adding the possibilities for embedding sub-elements. Furthermore, SeeMe is not restricted to only presenting a view on selected aspects such as functionality, data, organization or flows, but can also integrate these views. SeeMe is compatible with other, more formal methods, since it can mimic structures as they can be found in activity diagrams, eEPCs or in flow charts; it can represent many structures which are needed for programming" (Herrmann, 2009, p.343).

As we mentioned above, the handling of vagueness was a significant difference between SeeMe and other methods. As the concepts become clearer, vagueness can be eliminated during the socio-technical design process. The parts of the diagrams where all stakeholders know what needs to be done can remain incomplete (Herrmann, 2009).

Furthermore, the goal of SeeMe is to support and document the early phases of developing concepts for socio-technical solutions. "An early-phases notation must not enforce the depicting of all details as they are needed for context-free tasks of programming, configuration or formulation of regulations. It must be possible to represent incomplete or uncertain information and to indicate those aspects of a model which are only incompletely specified" (Herrmann, 2006, p.2).

"SeeMe is based on the concepts of role, activity, entity and relation. They reflect the conception of socio-technical systems from the point of view of contemporary activity theory. Activity is seen as mediating the transformation or the creation of material objects or immaterial cognitive entities by social subjects” (Herrmann, Hoffmann, Kunau, & Loser, 2004, p.122).

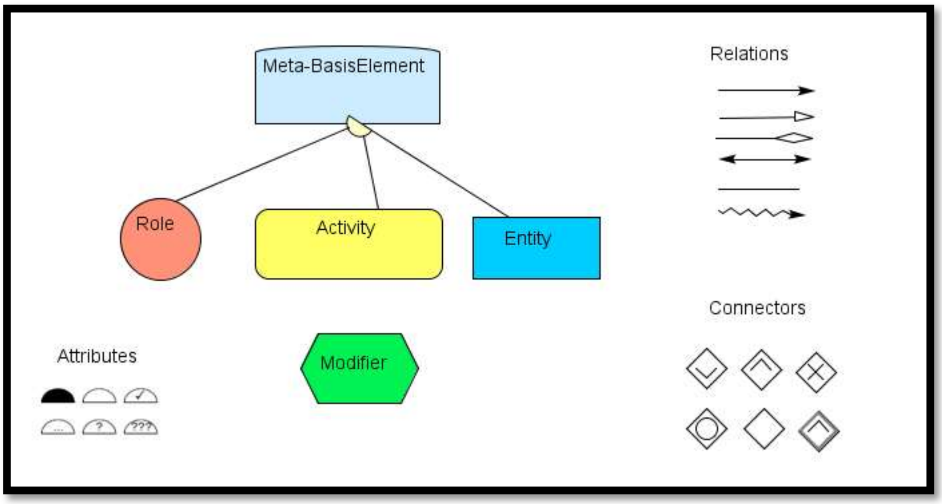


Figure 2. 4 Element of SeeMe Notation; Own Presentation Referring to (Herrmann, 2006)

1. Roles are a collection of rights and responsibilities that may be assigned to persons, teams, or organizations. Here, only human actors, groups of human actors or organizations are representable. Lastly, a role's characteristics are determined by the expectations of other roles. These relationships described above are common in social systems.
2. Activities that are (usually) carried out by roles and reflect the dynamic aspects of change, such as task completion, function completion, and so on.
3. In contrast to roles, entities represent passive phenomena; documents, tools, programs are examples of resources that are utilized or changed for activities. They may be used to represent containers (such as a box or a warehouse) or ephemeral phenomena (Herrmann, 2006).

Elements can be embedded into other elements: It means, a sub-element is part of a super-element. It can be useful to distinguish between whether a super-element is completely described by its sub-elements or only partially. In the latter case, incompleteness is indicated by a semi-circle. If the incompleteness is intentional, then the symbol is empty. If the incompleteness is not intentional, then the symbol has three dots next to it, signaling that more research is needed to determine its meaning. A question mark shows doubts about the accuracy of the used sub-elements (Herrmann, 2006).

SeeMe offers nine standard relations represented by arrows. The meaning of the arrows is determined by the types of elements associated and the direction of the arrow. The most used relations are:

- The role carries out the activity.
- The activity influences the role.
- An activity produces or modifies an entity (diagram).
- An entity (editor) is used by the activity.
- An activity is followed by another one (Herrmann, 2006).

Relations can be connected to super-elements or to one of its sub-elements. They can also be incompletely attached to elements: Relations may be omitted where it is unclear if they belong to the whole super-element or only a subset of its sub-elements. Relationships between sub-activities, for example, could be excluded if the order in which they occur is unclear.

Different perspectives of views of a phenomenon within the same element can be shown in perspectives which are separated by a segment line.

Relations can be combined with logical connectors. Typical logical constellations are "or", "xor", or "and". However, if the definition of a connector is obvious from the context of a diagram, or if it is not reasonable to be more precise, the logical form of the connector can be left unspecified (Herrmann, 2006).

Considering all these details about SeeMe notation, it is clear that SeeMe has many benefits to modeling a socio-technical system in the early phase of the development of requirement engineering.

2.3.4. Analysis and Discussion

In Section 2.3, the notations for process modeling have been analysed on the basis of the support that they provide to achieve the first objective of the thesis, which is related to (1) the limitations of the current process modeling notations and (2) finding the best process modeling notation for our work.

As discussed above, the cause of the problem is that techno-centric approaches to systems design fail to take into account the dynamic interactions that exist between the organization, the people who carry out business processes, and the system that facilitates those processes (Baxter & Sommerville, 2011).

The psychological and social factors that affect process efficiency are ignored in traditional process redesign attempts. Organisations are made up of people who work with IT systems in order to achieve goals. Consequently, the action of both components needs to be considered during simulation processes (Gregoriades & Sutcliffe, 2008).

Therefore, it is appropriate to use a modeling notation to build diagrams that consider incompleteness and vagueness when some detail for modeling the method is not yet clear during the early phases of developing socio-technical systems or processes. Furthermore, this modeling notation should be able to simulate the dynamic interconnections between humans, people, and technical components, while also integrating both formal and informal processes and considering technical and social aspects.

According to these criteria mentioned above and the comparison represented in the following table, the SeeMe model is the better process notation choice for modeling the systems which are the interaction of humans and technical aspects and include incompleteness in early phases of the modeling process. SeeMe is a modeling notation that improves the functionality of other notations by adding many features for communication and presentation of vague content. However, this modeling method cannot represent the goals and interests of stakeholders. In social environments, the intentional dimension of actors and dependencies among them should not be underestimated. Therefore, we need to extend SeeMe with social actors in order to find all kinds of system requirements.

BPMN	SeeMe
It's a graphical representation of business processes in a business process model with the primary purpose of offering a notation that all business users can understand.	It is a method which is especially designed for representing socio-technical work processes and structures.
The BPMN notation is focused on modeling business processes.	The SeeMe is focused on supporting the early phases of developing concepts for socio-technical solutions and documenting them.
It takes a process oriented approaches to modeling of systems.	It reflects socio-technical concepts with diagrams that can be created, analyzed, and changed during the socio-technical walkthrough. It is possible to represent missing or unknown data, as well as aspects of a model that are only incompletely defined..
It only presents two views and is not able to capture all views.	It does not rely on specific views of objects, such as processes, functions, or tasks, but rather helps modellers to merge them.

Table 2. 3 BPMN vs. SeeMe

2.4. Social Modeling

In this section we will describe the social modeling for requirement engineering. In the previous section, SeeMe was chosen as an appropriate method for modeling socio-technical systems. We have seen the role's attributes are influenced by the expectations of other roles. This type of mutual relationship is common in social systems.

2.4.1 Social factors

According to Section 2.1.1.2, social context is regarded as an important point for the Requirements Analysis.

"Traditional requirements analysis adopts a mechanistic view of the world: the world consists of entities and activities that are fully knowable and predictable. In adopting a social worldview, we see the world as having intentionality, that is, there are intents and reasons and motivations behind behaviour" (Yu, Giorgini, Maiden, & Mylopoulos, 2011. p.4).

We need modeling techniques that can reflect human-related issues as required by the system to better accept the social factors that can make or break the implementation of a process. These models can help organizations determine the social consistency of a method with their philosophy and its inherent structures. “For instance, when adopting an agile method, the organization and the team members participating in the new development process will have concerns such as:

- Which other actors will I depend on in order to succeed in my goals? What do I depend on them for?
- What are the process objectives that I have to fulfill?
- What are the skills required to perform each role?
- Which are the most critical roles? What are the consequences if these roles do not successfully fulfill their tasks?
- What are the rationales of performing certain development activities?” (Chiniforooshan Esfahani, Cabot, & Yu, 2010, p. 224)

These questions (and many others that appear frequently in process modeling) are difficult to address using socio-technical process models. To complement it, the following sections add a social modeling perspective for modeling systems.

2.4.2 i* Modeling Approach

In Section 2.1.1.4, i* framework has been introduced as a goal-oriented RE methods that can be considered as one of the most relevant. “The i* modeling approach is an attempt to bring social understanding into the system engineering process by putting selected social concepts into the core of the daily activity of system analysts and designers…” (Yu E. , 2009, p.100). “To overcome the limitations of the mechanistic worldview, we shift our attention away from the usual focus on activities and information flows. Instead, we ask: What does each actor want? How do they achieve what they want? And who do they depend on to achieve what they want? ” (Yu E. , 2009, p.100).

In addition, the i* modeling framework integrates some aspects of social modeling into information system engineering techniques, particularly at the level of requirements. I* emphasizes the primacy of social actors, in contrast to traditional systems analysis, which tries to abstract away from the social aspects of systems. Actors are seen as intentional since they have commitments, goals, and beliefs (Yu E. , 2009). In the following, we go through each of i* properties one by one (Yu E. , 2009):

- **Actor autonomy:** In i*, the actor is the primary conceptual modeling construct. It is a term used to describe an active entity capable of acting independently. Actors can be humans, hardware and software, or combinations thereof. Actors are seen as primarily independent-their actions are neither completely controllable nor absolutely knowable.
- **Intentionality:** Actor behavior isn't entirely predictable or controllable, but it isn't completely unpredictable either. We assign motivation and intent to the actors to justify and describe their behaviour. It can be expressed by attributing intentionality why an actor undertakes such acts, or chooses one option over another. These intentional concept allows analysis of means-ends relationships to find space of alternatives for each actor.

  Some unintentional modeling frameworks and languages, such as UML usage case diagrams and BPMN swim lanes, include various notions of actor. Such actors are inadequate for social modeling because they are neither intentional nor autonomous.
- **Sociality:** i* chooses to focus on one aspect of being social – that the well-being of an actor depends on other actors. Actors depend on one another to achieve their goals, complete tasks, and provide resources.
- **Rationality:** In the Strategic Rationale (SR) model, they attribute goals, tasks, resources, and softgoals to each actor, this time as internal intentional elements that the actor wants to achieve. A means-ends connection connects a task to a goal, suggesting a specific way to the goal's completion. Since there are usually several ways to accomplish a task, a goal in an SR model leads to the question, "How else can this goal be accomplished?"
- **Contingent boundaries and identities:** The actor is considered as a modeling abstraction, its identity and scope are determined by the modeller. It is up to the modeler to represent each member of a team as an actor, the team as a whole, or each individual supported by software tools as an actor. These would each present various chances for analysis. Actors can have selfish as well as altruistic goals. In i*, the relationship/dependencies between an actor and other actors helps to demarcate the actor's boundaries at an expected level.
- **Strategic reflectivity:** The models usually provide a description of the system at the operational level in traditional systems analysis. The tasks and reasons for improving system operation, such as how to improve efficiency, reliability, cost, and security, are usually carried out outside of the models. An intentional ontology, such as the use of goal

models would make the intentional dimension explicit and allow reflection by each actor upon its relationships with other actors.

- **Understanding why:** The majority of existing models attempt to represent the steps that make up a process or how they should be carried out. However, in order to improve or redesign a process, a deeper understanding of the process is usually needed — an understanding that demonstrates the "why" behind the "whats" and "hows."
  "Typically, process performers need models that detail the "hows", process managers prefer models that highlight the "whats", while process engineers charged with improving and redesigning processes need models that explicitly deal with the "whys"" (Yu & Mylopoulos, 1994b, p.159).

2.4.3. Elements of i* Modeling Method

The i* framework offers modeling systems using two types of models, each one corresponding to a different level of abstraction: the Strategic Dependency (SD) model represents the intentional level and the Strategic Rationale (SR) model represents the rationale behind it (Yu, Giorgini, Maiden, & Mylopoulos, 2011). In what follows I mostly directly take passages from (Yu E. , 2011) to describe the i*-notation elements:

1. A SD model consists of a set of nodes that represent actors and a set of dependencies that represent the relationships among them. Dependencies express that an actor (depender) depends on some other (dependee) in order to obtain some objective (dependum). Thus, the depender depends on the dependee to bring about a certain state in the world, to attain a goal in a particular way (goal dependency), to carry out an activity (task dependency), for the availability of a physical or informational entity (resource dependency) or to meet some non-functional requirement (softgoal dependency). A softgoal is typically a quality (or non-functional) property and the other intentional elements in a routine (Yu & Mylopoulos, 1994a).
   As mentioned above, Yu distinguishes four types of dependencies, based on the type of the dependum (Yu E. , 2011, p.26 and p.27):
   - "In a goal dependency, the depender depends on the dependee to bring about a certain state in the world. The dependee is given the freedom to choose how to do

it. With a goal dependency, the depender gains the ability to assume that the condition of the world will hold…

- In a task dependency, the depender depends on the dependee to carry out an activity. A task dependency specifies "how" the task is to be performed, but not why…
- In a resource dependency, one actor (the depender) depends on the other (the dependee) for the availability of an entity (physical or informational). By establishing this dependency, the depender gains the ability to use this entity as a resource…
- In a softgoal dependency: a depender depends on the dependee to perform some task that meets a softgoal."

A sample of SD model is shown in Figure 2.4. For example, a seller depends on the customer to be loyal or the customer depends on the seller to offer good quality services.

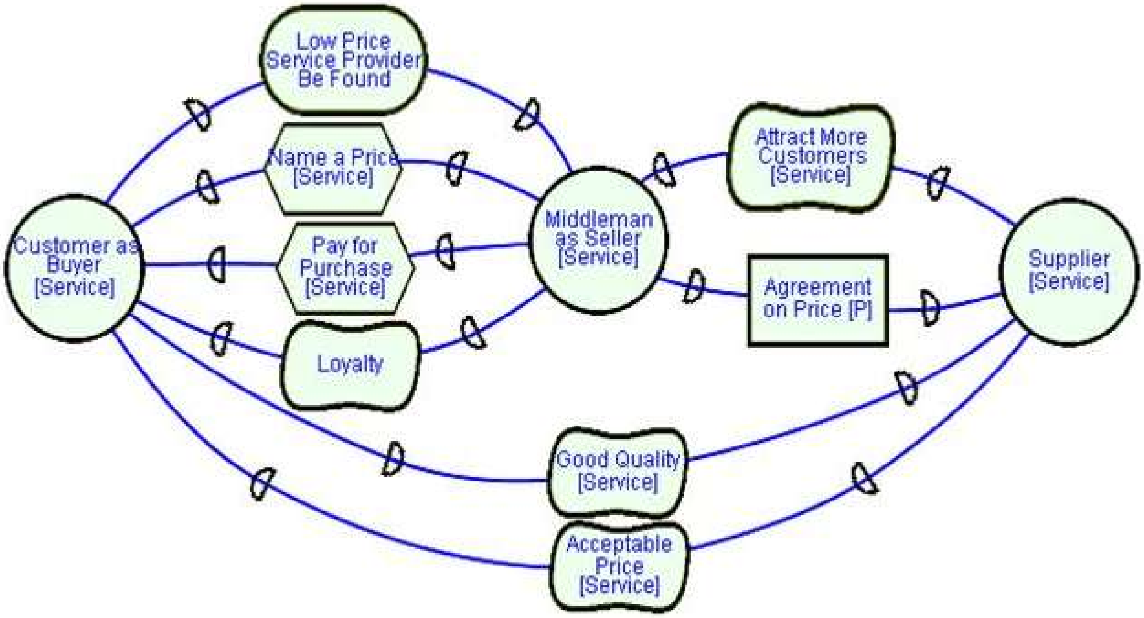


Figure 2. 5 Strategic Dependency Example Model: Buyer Drive E-Commerce (Yu, Liu, & Li, 2001, p.167)

2. "An SR diagram allows the intentional elements to be visualized within the boundary of an actor in order to refine the SD diagram with reasoning capabilities. The dependencies of the SD diagram are linked to intentional elements inside the actor boundary" (Cares, Franch, Mayol, & Quer, 2011, p. 578). The Strategic Rationale model examines "inside"

actors to model internal intentional relationships at a more detailed level (Castro, Cysneiros, & Alencar, 2000).

Goals, tasks, resources, and softgoals can also be the intentional elements of the SR model; and are decomposed according to these types of links (Grau, Franch, & Maiden, 2008, p. 77):

- "Means-end links establish that one or more intentional elements are the means that contribute to the achievement of an end. The end is usually a goal, whereas the means is usually a task. There is a relation OR when there are many means linked to the end, which indicates that there are different ways to obtain that end.
- Contribution links are Means-end links with a softgoal as an end. They allow to state explicitly if the contribution of the means towards the end is negative or positive.
- Task-decomposition links represent the decomposition of a task into different intentional elements. There is a relation AND when a task is decomposed into more than one intentional element".

To better understand all elements of the SR model, an example is presented in Figure 2.6.

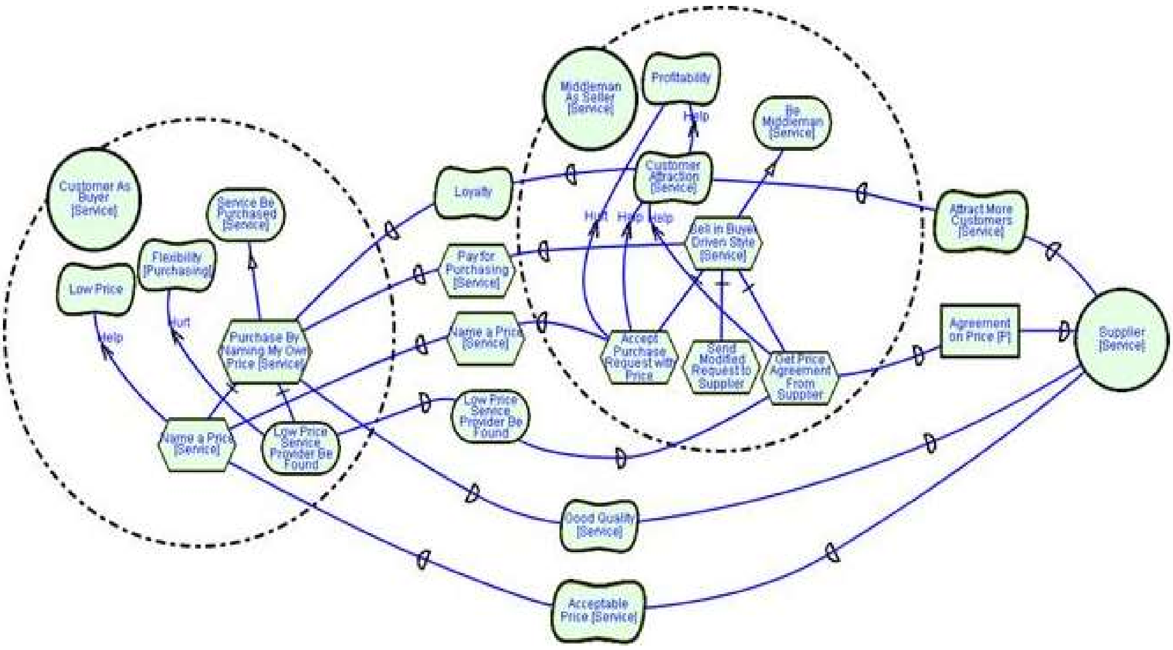


Figure 2. 6 Strategic Rationale Example Model: Buyer Drive E-Commerce (Yu, Liu, & Li, 2001, p. 168)

Table 2.4 provides all the graphical notation of i* syntax. As mentioned, the meta-model specifies the structure, semantics, and restrictions of a model family. In Chapter 3, we represent the i* meta-model.

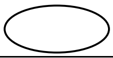
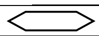
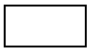
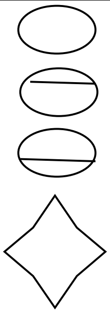
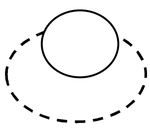
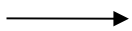
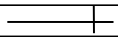
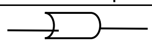
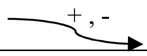
i* notation		**Process Interpretation**
Goal		Process functional objective (state that should be reached during process enactment) with clear-cut achievement criteria
Softgoal		Process qualitative objective, including expected quality attributes of activities or products (e.g. meetings be Effective), as well as needed skills and objectives with no clear-cut satisfiability
Task		Activities and practices prescribed by the process
Resource		Resources needed for, and artifacts developed during the enactment of process
Actor Agent Role Position		Actor: refer generically to any unit to which intentional dependencies can be ascribed. Agents, roles and positions are sub-units of a complex social actor. Agent: Actor with concrete, physical manifestations, such as a human individual. Agent is applied instead of person for generality, so that it can be used to refer to human as well as artificial (hardware/software) agents. Role: Abstract characterization of the behavior of a social actor within some specialized context or domain of endeavor. Dependencies are associated with a role when these dependencies apply regardless of who plays the role. Position: Intermediate abstraction that can be used between a role and an agent. It is a set of roles typically played by one agent. For example, the position of project manager covers the two roles of "Scheduling And Assigning Tasks", and "Monitoring Progress". An agent occupies a position.
Actor boundry		Actor boundaries indicate intentional boundaries of a particular actor. All of the elements within a boundary for an actor are explicitly desired by that actor.
Means-Ends Link		Alternating tasks for achieving a goal. Means-ends links are the relationships that end with a hard-goal.
Decomposition Link		Constituting elements of a task
Dependency Link		Dependency relations between process actors
Contribution Link		Effect of different elements on a softgoal

Table 2. 4 The i* notations; Own Presentation Referring to (Chiniforooshan Esfahani, Cabot, & Yu, 2010)

2.4.4. Experience of Applying i* Framework in Requirements Projects

For more than a decade, the i* approach has been accessible in research groups, but it has not been applied broadly in commercial requirements projects. Thus, between 2001 and 2005 the i* has been applied in three major industrial projects (air traffic management projects) to discover their requirements and the results of the applying is reported in one research (Maiden, Jones, Ncube, &

Lockerbie, 2011). This section reports lessons learned from previous projects in which i* was applied to model and analyze new socio-technical system requirements:

They report that the application of i* and starting the production of i* models, in their experience, is more difficult than it might at first appear. It's hard to say where to start i* modeling, a priority. In addition, the i* semantics emphasize on modeling objectivity and it makes difficult to identify the most important actors and dependencies from which to create a first-cut SD model. Their idea was to create context models beforehand and then utilize those models to drive the development of the first-cut SD model.

Furthermore, it is mentioned in this report that the i* approach is significantly different from most other modeling approaches to which analysts and stakeholders have been exposed. The emphasis on actors and dependencies in a socio-technical context in SD models contrasts with current approaches for modeling a mostly software-oriented system, such as the UML and its basic notations, such as use case and class diagrams. Whereas UML specifications state what a system should do, I models include cross-references to goals and softgoals that explain why it should do so.

This report stated that the resulting SR models were large and challenging to handle, especially with the limited tool support available. In addition, the benefits obtained from SR modeling within RESCUE (An Integrated Method for Specifying Requirements for Complex Sociotechnical Systems) were minimal, mainly as a result of the parallel development of use case specifications based on notions similar to those found in SR models. Their findings suggest that SR modeling should be applied more selectively in future projects only to investigate significant system actors, goals, and tasks that may be utilized to find and organize use case specifications.

Important semantics that are not reflected in use case specifications should be modeled via SR modeling. In particular, task/action contributions to softgoals are not explicitly represented in use cases. Modeling such contributions is necessary for analysts to understand how behavior defined in use cases meets various softgoals, as well as to inform trade-off analysis and other types of goal-related decision-making.
Experiences from the research reveal that supporting the development and management of large-scale i* models can be challenging. In particular, SR models are large and difficult to develop, and

as a result, hard to manage. Therefore, to support the development of integrated SR models, new flowcharting characteristics are required. Even simple forms of support can be the difference between the success and failure of i* in a requirements project.

2.4.5. Analysis and Discussion

In this section, the social modeling approach for requirement engineering is analyzed on the basis of the support for achievement of the third and fourth objective of the thesis.

> "To visualize relationships among social actors based on the flowchart technique, which shows the workflow steps and is used in analyzing, designing, documenting or managing a process or program in various fields."
>
> And "To complementing socio-technical process modeling with a new perspective aimed at describing and analyzing the social and intentional aspects of a socio-technical modeling approach."

The interdisciplinary aspect of STS is one of the challenges of STS modeling. An integrated model that covers all elements in one framework is one of the most common approaches to STS modeling, which is especially effective for infrastructure. Integrated models tend to be high level models.

As we mentioned in Section 2.3.4, SeeMe is the best modeling method for showing incompleteness and vagueness in early phases of modeling, since it allows the modeller to leave parts of the modeled reality intentionally unconsidered and to indicate this decision in the model itself. Also, SeeMe modeling covers aspects of workers' actions that aren't totally planned, as well as planned and predictable behavior in technically established process.

On the other hand, other approaches such as i* may be used to build dependency diagrams, which allow you to represent dependencies between goals, conditions, tasks, etc. I* differentiates between goals and softgoals. Dependency diagrams, on the other hand, are not process-oriented and cannot be used to enable a step-by-step improvement of functionality and forms of interaction with the technical system. Hence, developing and managing the i* models is difficult and challenging for stakeholders.

According to these factors, we argue that integration of SeeMe and i* framework can alleviate the weaknesses of each model and help organizations to understand their requirements from different perspectives.

2.5. Requirements Specification Based on a Socio-Technical Process Modeling Notation

2.5.1 Necessity of Integrating i* within SeeMe for Requirements Elicitation

"Before one can properly understand requirements, one needs to ask why the proposed system is needed, who is involved, and what relationships exist among various actors. One needs to understand how things are done under current conditions, why they work or do not work, from whose perspective and according to what criteria. In specifying a new system, that is, the requirements, one is in effect rearranging relationships among the social actors" (Yu, Giorgini, Maiden, & Mylopoulos, 2011, p. 4). Multiple social actors with various interests, a number of roles, and complicated connection networks are involved in each of the environments. Intentional relationship modeling provides a higher level of abstraction for analysis.

According to the literature, early requirements engineering needs to focus on the social dimension of systems and their environments. Many existing requirements techniques and frameworks are oriented toward the later phases of requirements engineering, which are concerned with completeness, consistency, and automated verification (Yu E. , 1997). The early phase, on the other hand, tries to model and evaluate stakeholder interests, as well as how they may be addressed (or compromised) by various system-and-environment options. Because early-phase RE activities have objectives and presuppositions that are different from those of the late phase, it would be appropriate to provide different modeling and reasoning support for the two phases (Yu E. , 1997). "What is required to capture such concerns is a framework that focuses on the description and evaluation of alternatives and their relationship to the organizational objectives behind the software development project …" (Castro, Cysneiros, & Alencar, 2000, p. 6). Several recently created RE approaches, such as agent- and goal-oriented methods, are appropriate and might be applied for early phase RE.

"The i* technique … provides understanding of the "why" by modeling organizational relationships that underlie systems requirements" (Castro, Cysneiros, & Alencar, 2000, p.6). Because some of these more advanced concepts are supported by the ontology of i*, I selected it from among the modeling languages available for eliciting requirements. For example, it can be used for:

- obtaining a better understanding of the organizational relationships among the various organizational agents,

- understanding the rationale of the decisions taken,
- illustrating the various characteristics found in the early phases of requirements specification,
- The representation of functional and non-functional requirements as well as business goals at the same level, thus bridging the gap that is usually found between requirements and organizational needs,
- Providing a better view of the intentionality of the actors involved in the process.
- Successfully use for the generation and evaluation of alternatives.

On the other hand, we cannot ignore the role of business process models to understand requirements. The identification of high-level business limitations or softgoals is the emphasis for business users in the context of business process modeling. Constraints, softgoals, and system quality attributes are also all terms used to describe non-functional requirements (Mylopoulos, Chung, & Nixon, 1992). "…Business process modeling is an initial step in the requirements engineering process, the opportunity to capture some detail regarding the non-functional requirements is available to the analyst" (Pavlovski & Zou, 2008, p.103).

In a study from Middle East Technical University, their requirements elicitation experience showed that creation and transformation of the need from concept to system requirements can be supported by means of notations and tools developed for business processes reengineering. When it came to identifying requirements, a process-oriented approach enables the organization to see the big picture and focus on the enhancements that were needed to be able to use the acquired system (Demirörs, Gencel, & Tarhan, 2003). The developed approach is based on the assumption that defining business processes should be the primary step in eliciting requirements. The activity sequence for their technical implementation had been defined as follows:

1. "Concept exploration and orientation
2. Analysis and modeling of current business processes
3. Modeling of target business processes
4. Requirements generation for the target system" (Demirörs, Gencel, & Tarhan, 2003, p. 410).

To provide requirements traceability, the requirements and process specifications must be fully integrated. In the importance of relating between Business Process Models and Requirement Engineering, a study with the title “A Framework for Integrating Business Processes and Business Requirements” (Kazhamiakin & Pistore, 2004) proposed a methodology based on an extension of Tropos for modeling business requirements, starting from strategic goals and constraints that are further refined and operationalized into business processes to achieve these goals and to satisfy the constraints. The methodology is also supported by a formal representation of the business requirements and business processes.

2.5.2 Approaches for Specification of System Requirements

As described in Section 2.1, the activity of the RE process that is connected to the documenting of the requirements of a software system that belongs to the system domain is specification of system requirements. A SyRS is the result of this activity. “Specification of system requirements can be considered the main activity of the RE process because all the others are influenced by or are targeted at it” (González J. L., 2011, p.37).

There exist many and very different styles and approaches for specification of system requirements (Davis, 1993; Kotonya, Sommerville, 1998; Lauesen, 2002). As notations for business process modeling, each style for specification of system requirements has specific purposes and different strong points and weaknesses. Therefore, their use will depend on the purpose of specification of system requirements. For example, a purpose can be specification of user requirements (González J. L., 2011).

1. Scenario-Based Approaches (Alexander & Maiden, 2004): These are based on the concept of a sequence of action which a user and a software system must carry out. Different techniques exist within scenario-based approaches. Use cases are perhaps the most well-known. User stories, misuse cases, and storyboards are other famous forms. “A typical template contains this information:
    - Name of the scenario
    - Actors that participate
    - Goal(s) that should be achieved by executing the scenario
    - Main story
    - Variations of the main story

- Exceptions of the main story
- Preconditions for execution of the scenario
- Post conditions after execution
- Non-functional requirements that constrain or affect the scenario" (González J. L., 2011, p.38).

2. Task and Task & Support Descriptions (Lauesen, 2002) are based on a basic but significant concept: user tasks must be supported by a software system. They concentrate on domain (business) requirements, attempting to define acceptable support for business activities as well as what people and software systems may accomplish when working together. The information in specification are:
    - "Name of the task
    - Purpose of the task
    - Trigger/Precondition for execution
    - Frequency and critical situations of execution of the task
    - Sub-tasks and their sequence
    - Variants during execution of the task" (González J. L., 2011, p.39).
3. Business Transactions-Based Approaches (Chalin, Sinnig, & Torkzadeh, 2008) focus on specification of business transactions for software systems. According to its authors, rather than approaching business transactions from a requirements aspect, the majority of efforts are focused on design. But two domain activities that should be investigated as part of the RE process are business transaction modeling and concurrency management. "The information that is included in business transactions-based use cases is:
    - Business transactions to be supported by the use case
    - Input for the use case
    - Expected results
    - Main scenario for execution of the use case
    - Scenarios for abortion situations on the basis of actor's decision
    - Scenarios for detection of accesses to transactional resources by a software system
    - Scenarios for failures in access to transactional resources

- Response time out for a system
- Policies for management of failures in data storage" (González J. L., 2011, p.40)

2.5.3 Analysis and Discussion

The approaches for specification of system requirements have been analysed on the basis of the support that they provide to achieve the sixth objective of the thesis:

To develop a specification template for extracting requirement that:

- Determines support for modeling processes;
- Represent specification of socio-technical requirements.

Firstly, in Section 2.5.1, I have analyzed the necessity of developing a new process model notation that can consider problems of a socio-technical system that occurs during the early-phase of requirements capture to provide primitive concepts such as softgoals and goals. In Section 2.5.2, the different business approaches for specification of requirements is represented.

Between these approaches, the Scenario-based approach is the ideal one for socio-technical systems, because scenarios often deal with three aspects of a software system. The term "system context" refers to descriptions of the system's surrounding environment (e.g., an organization in the case of an IS). The term "system interaction" refers to how a system interacts with its environment (e.g., users). Finally, internal system refers to internal interactions among system components.

Therefore, I have used the Scenario-based approach as a basis for documenting requirement specification in our research (Section 5.4) and enhance it with the other collected information from the new developed SeeMe model.

2.6. Summary

This chapter has summarized the literature review of the thesis. Five categories of works have been examined, and the appropriateness of each category's works for achieving the thesis's aims has been analysed and discussed. The main conclusions of this review are that:

- Most popular BP modeling approaches such as BPMN are workflow- level notations. They don't allow the study of process alternatives in terms of high-level quality attributes or business goals, and hence don't enable BP options to be traced back to requirements.

- The concept of work process is regarded as the appropriate concept in this research, since it is not only for creating value in an organization but also for considering social aspects (Concept of business process).
- It is generally understood that the business process modeling notation (BPMN) does not accept that the role of social behavior in organizational system is not predictable and thereby needs to represent not completely planned action of actors as well as predictable and planned behavior in socio-technical processes. Besides, BPMN does not support expression of non-functional business requirements.
- An appropriate method to model socio-technical system depends on appropriate understanding of the dynamics of socio-technical concepts. SeeMe is the best notation for socio-technical process modeling that presenting incompleteness and vagueness for early requirement engineering. The advantage for SeeMe is that the notation can describe weakly structured work procedures and help to balance contingent and controllable structure of a socio-technical process.
- i* is the selected framework for this research to goal-oriented RE approach and is the best fit to meet the challenges, needs, and objectives of the thesis for enhancing SeeMe model with social aspects.
- There are no current RE methodologies or studies that allow all of the thesis's objectives to be met, i.e., no strategy that adequately addresses all of the thesis's challenges (research problems).

  Although some objectives could be achieved by utilizing some approaches, other objectives would require changes to the approaches or combination with other approaches. In fact, this is the line that has been followed in this thesis for development of the proposed solution. Instead of proposing a completely new approach, we argue that semi-structured socio technical process modeling (SeeMe) is an appropriate method to combine with i* framework to capture and elicit early requirements and then transform derived requirements into a formal requirements specification.

Chapter 3

Empirical Methods: A Case Study in a Pharmacy

This chapter presents the initial empirical research. The empirical study will start with a general overview on research methods. In Section 3.2, the steps in the empirical study are presented. Then a background of the case study and the rationale behind the selection of this case are presented in Section 3.3. Section 3.4.1 identifies the methods of collecting data including interview questions. Analysis of the data and created "as-is" models are represented also in Section 3.4.2.

3.1. General Overview on Research Methods

One way of viewing research methods is by classifying them into different research strategies (Singleton, Straits, Straits, & McAllister, 1999): experimental research, survey research, field research, action research and case study research. These research strategies are described in Table 3.1.

Research Strategy	Description
Experimental research	Experimental research offers the best approach for investigating the causes of phenomena. An experiment will involve the systematic manipulation of an environment and then observing whether a systematic change occurs.
Survey research	This research approach is suitable for identifying the frequency of certain characteristics amongst groups or populations. It allows a researcher to relate various characteristics to explain a phenomenon. The aim is often to generalise the data to the whole group but this can be very difficult to prove with confidence.
Field research	The researcher immerses themselves into a naturally occurring set of events to gain firsthand knowledge. The aim here is to gather information without influencing the environment. The difficulty with this is determining when and what observations to record.
Action research	Action research is often identified by its dual goal of improving the organisation participating in the research, and at the same time rigorously generating valid and consistent knowledge. The action research practitioner is expected to apply positive intervention to this environment and observe the changes in the environment and the researcher themselves.

Case study research	This research investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. Case study research design has evolved over the past few years as a useful tool for investigating trends and specific situations in many scientific disciplines e.g. social science, psychology, anthropology and ecology.

Table 3. 1. Research Strategies (Singleton, Straits, Straits, & McAllister, 1999)

Research strategy is a methodology that helps the researcher to investigate the research issue. According to Saunders et al. (Saunders, Lewis, & Thornhill., 2009), research strategy is a general plan that helps researcher in answering the research questions in a systematic way (Saunders, Lewis, & Thornhill., 2009). In addition to deciding on the appropriate sort of research strategy, the researcher must also decide on the types of studies that will be conducted in connection with each of these options. Three research strategies are used to describe the strategies of research. They are also known as approaches to inquiry (Creswell J. W., 2007) or research methodologies (Mertens, 1998). An overview of these strategies is presented in Table 3.2.

Quantitative	Qualitative	Mixed Methods
• Experimental designs • Non-experimental designs, such as surveys	• Narrative research • Phenomenology • Ethnographies • Grounded theory studies • Case study	• Sequential • Concurrent • Transformative

Table 3. 2. Alternative Strategies of Inquiry (Creswell J. W., 2008, p.12)

Different research problems require different research approaches. To satisfy the objectives of my research, a qualitative research methodology with a case study strategy of inquiry is chosen.

A qualitative approach tries to look at the issue from an open-ended viewpoint and could use interviews, focus groups or other methods to gather information from the experimental subject (Singleton, Straits, Straits, & McAllister, 1999).

Case study research is the “most common qualitative method used in information systems” (Creswell & Plano Clark, 2007). It is appropriate in many ways to answer the research questions and propose a solution relevant to the purpose of this study. The researcher(s) can also use case study research to understand the nature and complexity of processes by addressing "how" and "why" questions (Benbasat, Goldstein, & Mead, 1987). Additionally, in case studies, one or few entities are examined; no experimental controls are involved and complexity of unit is studied intensively (Benbasat, Goldstein, & Mead, 1987). A case study approach provides a mode of inquiry for an in-depth examination of a phenomenon and provides the means for understanding a complex social environment. Stake describes three types of case studies (Stake, 1995):

1. Intrinsic: One explores a particular case to better understand it.
2. Instrumental: A particular case is examined to provide information or insights on issues or the refinements of theory.
3. Collective: A number of studies are conducted jointly in order to inquire into the phenomenon.

This study serves the instrumental purpose that sheds light on the problems and issues that are common to all socio-technical systems. In this case, there is likely to be a question or a set of predetermined questions which are being explored and tested through the case study. Instrumental case study involves using a case study of one scenario to gain insights into a particular phenomenon; where there is also an explicit expectation that learning can be used to generalise or to develop theory (Stake, 1995).

I use a case study as a tool to answer the empirical part of the research questions. The goal is to understand how the social factors such as goals, dependencies, and motivation of actors can influence the process modeling of a socio-technical system and support the elicitation of socio-technical requirements.

A fundamental question concerning the results and conclusions of an evaluation is how valid they are (Wohlin, et al., 2012). Qualitative research is based on subjective, interpretive, and contextual data, making the findings are more likely to be scrutinized and questioned. As a result, it is important that researchers take efforts to ensure that their study findings are accurate. According to Lincoln and Guba (1985), credibility and transferability are two criteria for establishing trustworthiness in a qualitative research (Lincoln & Guba, 1985):

- Credibility - confidence in the 'truth' of the findings. Often called internal validity, refers to the believability and trustworthiness of the findings. Participants in the research are the only ones who can determine if the findings accurately reflect the phenomena being examined, therefore it is critical that they believe the findings are credible and accurate.

- Transferability - Often called external validity, refers to the degree that the findings of the research can be transferred to other contexts by the readers. This means that the results are generalizable and can be applied to other similar settings, populations, situations and so forth. It is hard to demonstrate that the results and conclusions of a qualitative study are relevant to other situations since the findings are specific to a small number of specific environments and populations

As you will see in Chapter 6, external validity of my research findings is evaluated in a car-sharing context. Also, an expert workshop was conducted for evaluating internal validity and with the focus of validating the correctness and usefulness of the SeeMe* implementation and its containing elements. I have selected three pharmacists and one pharmacy technician with practical experience of working in public pharmacies. Four modeling method experts of the SeeMe were also selected. I have used questions activities to provoke participants to find the contra and pro aspects of the new elements of SeeMe*.

3.2. Plan of the Empirical Work

The methodological design of the thesis has been introduced in Chapter 1. In this chapter, the procedure of the empirical study will be described in detail. Figure 3.1 shows the stages of our empirical work in the pharmacy. In the empirical work, I conducted two main series of interviews and three meetings with participants in the pharmacy. The results of the interviews and meetings were documented in written notes and sometimes in recorded voices. The data may be presented and grouped in a systematic and user-friendly style thanks to the transcription of the interviews (Seale, Gobo, Gubrium, & Silverman, 2004).

The meetings were held to validate the diagrams and collect feedback from the pharmacy team. The first series of interviews were conducted to generally understand current processes in the pharmacy. Its results have been used as a starting point to compare SeeMe and i* models. The second series of interviews provides an in-depth view of a selected process in the pharmacy and the meetings for elicitation of requirements has been described in Chapter 5.

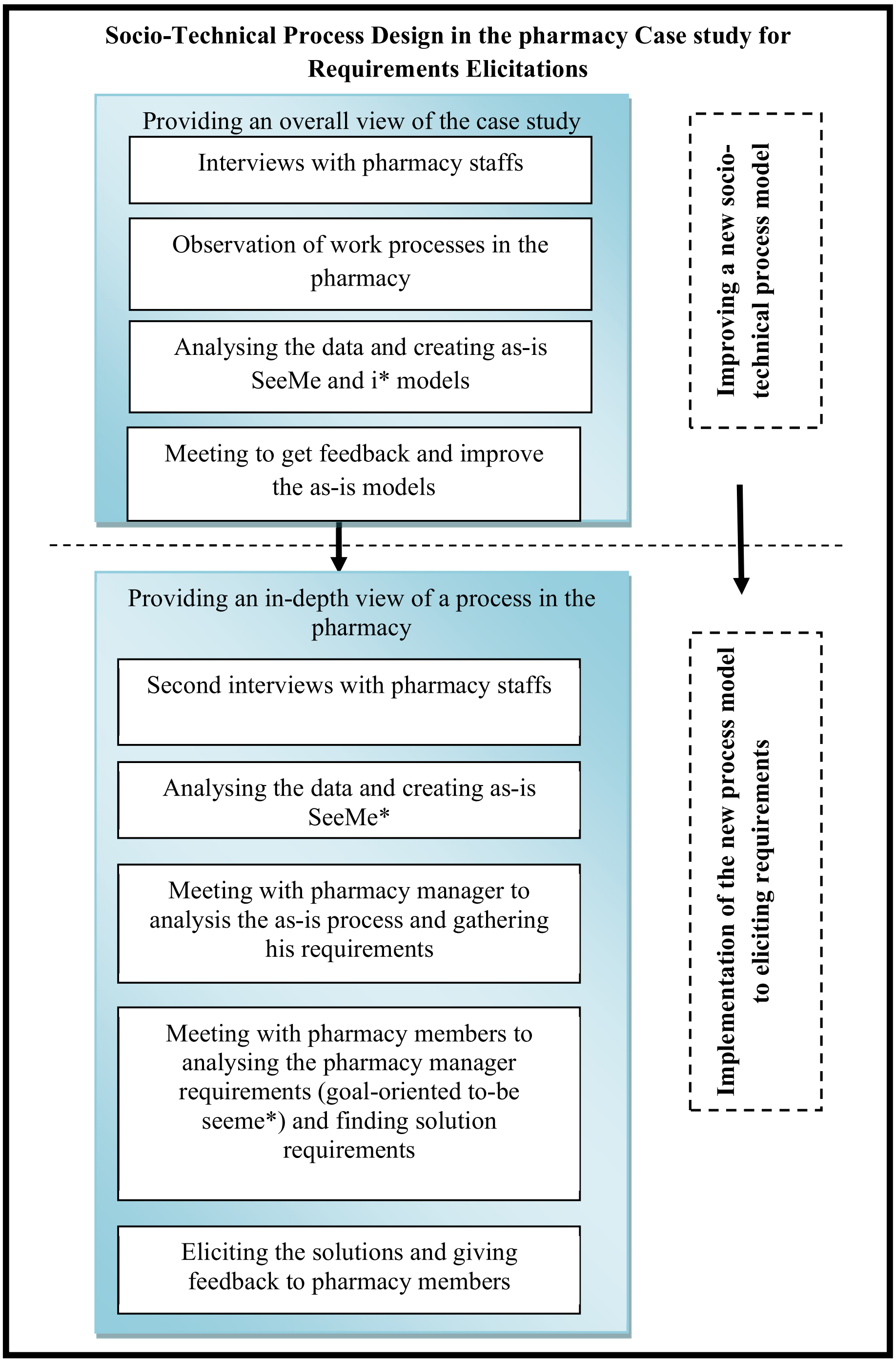


Figure 3. 1. Steps of the Empirical Work

Table 3.3 summarizes the different methods which have been used for data collection in detail. This table indicates with whom I have spoken to, for how long, and the role of my interview partner.

Methods used to obtain the data	Goal	Participants	Description	Duration
Observation	Providing a high level understanding of what the pharmacy process is about and develop a starting point for the practical part of the research	The direct questions during observation from pharmacist, pharmacy technician and pharmacy assistant	Observation of the procedures and speaking to pharmacy team who are involved with the process	10 hours
Semi-structured interview	First series- Providing the overall view of existing processes	The Pharmacist	Asking questions (described in Section 3.3.1) to comprehend the current Process	1,5 hour
Semi-structured interview	First series- Providing the overall view of existing processes	One of the pharmacy technicians	Asking questions (described in Section 3.3.1) to comprehend the current Process	1,5 hour
Semi-structured interview	First series- Providing the overall view of existing processes	The other pharmacy technician	Asking questions (described in Section 3.3.1) to comprehend the current Process	1,5 hour
Semi-structured interview	First series- Providing the overall view of existing processes	The pharmacy assistant	Asking questions (described in Section 3.3.1) to comprehend the current Process	1,5 hour
Meeting	To walk through the prepared as-is models of the SeeMe and i*.	The pharmacy team	Collecting their feedbacks to improve the models and correct the existing errors.	3 hours
Semi-structured interview	The second series- providing an in-depth view of a selected process in the pharmacy	The pharmacy technician	Asking several questions (Section 3.3.1) and some supplementary questions (Section 5.1.1) to exactly comprehend the selected Process	2 hours
Semi-structured interview	The second series- providing an in-depth view of a selected process in the pharmacy	The pharmacist	Asking several questions (section 3.3.1) and some supplementary questions (Section 5.1.1) to exactly comprehend the selected Process	2 hours
Semi-structured interview	The second series- providing an in-depth view of a selected process in the pharmacy	The pharmacy Assistant	Asking several questions (Section 3.3.1) and some supplementary questions (section 5.1.1) to exactly comprehend the selected Process	1 hour
Meeting	To analyze the as-is (SeeMe*) process and gathering his requirements	The pharmacist/ pharmacy manager	Gathering social and technical requirements which reveal the opportunities of improving the selected process.	3 hours
Brainstorming Meeting	To analyze the pharmacy manager requirements (goal-oriented to-be See	The pharmacy team	To analyse the requirements in detail and gather a list of solutions. (assuming ourselves as a	3 hours

	Me*) and finding solution requirements		patient and investigate what s/he needs s in order to be more satisfied during pharmacy visit)	

Table 3. 3. Summary of Applied Methods to Collect Data

3.3. Describing the Case Study

As explained in Chapter 1, the overall purpose of this research is to develop and optimize socio-technical systems by using the modeling of work processes to elicit socio-technical requirements in the early stages of the system engineering.

A case study in the field of pharmacy is considered in this chapter to attain this goal. The participants of this study are comprised of three pharmacists, seven pharmacy technicians, and one pharmacy assistant from a modern pharmacy which is located in a small city of North Rhine Westphalia state. The ages of participants range from 24 to 60 years old; two are male, and nine are female. On average, the participants have over 15 years of work experience.

The pharmacy uses two main software packages. One of them is pharmacy management software which is responsible for ordering medicines, selling medicines, payment management, inventory management, and customer relationship management. The other software is a prescription management system used for final inspection of prescriptions prior to shipping them to the health insurance institute. This scan_adhoc system automatically checks all prescription-relevant information and rejects incorrect ones for correction. Another complementary software that is used in the pharmacy are out of scope of this research and they are not considered here. Furthermore, the pharmacy uses a robotic system to dispense and administer the stocked medicine, which increases productivity, reduces waste, and enhances safety (automated dispensing systems). They use four computers in the front office (Point Of Sale systems) and three computers in the back office for supporting and ordering the medicine.

3.3.1. General Description of Work Procedures in the Pharmacy

The main data collection techniques used in this section were observation, direct questions from pharmacy members, and also analysis of Quality management system (QMS) documents or technical documentations of the pharmacy software.

Pharmacy management software in the case study offers a wide range of options of support for all areas of over-the-counter sales: advice thanks to access to drug information and directions for use, convenient checks for the availability of products and warehouse management, customer management, and prescription management (ADG). The four POS systems in front-office include the prescription scanner that makes transactions at the counter faster and make checking of prescriptions considerably easier. Prescriptions can be also immediately accessed digitally in case of customer complaints or inquiries. The scan-adhoc interface enables transmission of the pharmacy scanned prescriptions in order to check their plausibility and accountability. Figure 3.2 shows the cycle of prescription check in the pharmacy case study.

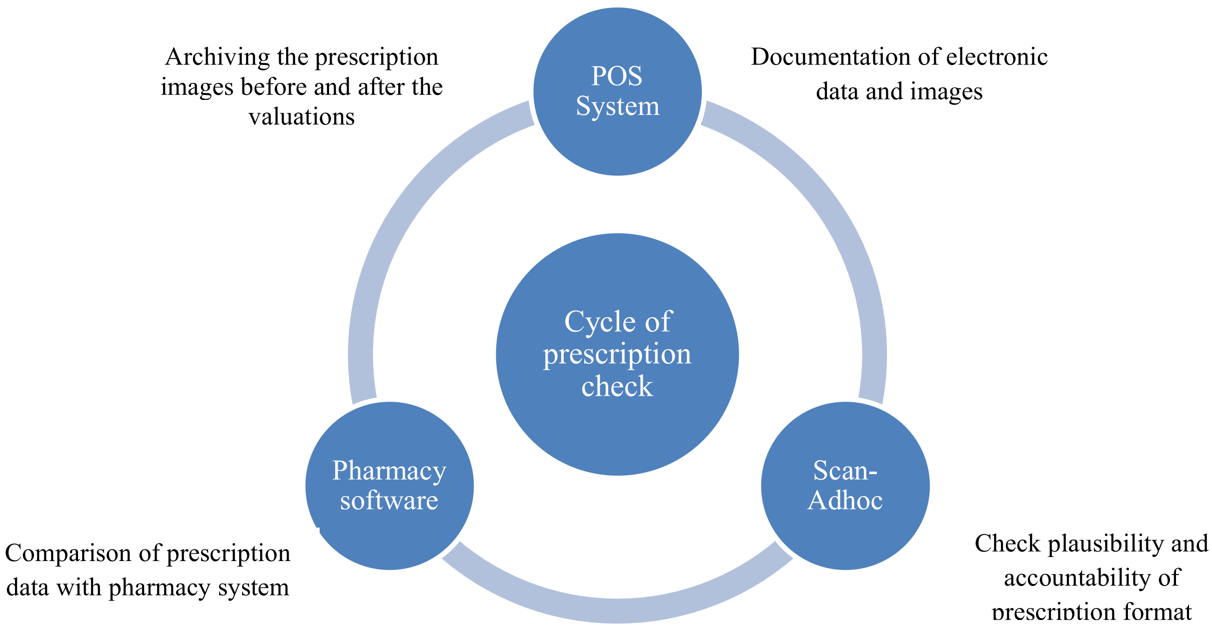


Figure 3. 2 Connection between Systems to Check a Prescription (ADG)

Also, the pharmacy management system enables pharmacy to being closely networked with pharmaceutical wholesale companies to order the drugs and manage stocks of robotic system.

In the following, it will be explained more about the roles in the pharmacy. Pharmacy technicians are health care providers who performs pharmacy-related functions under the direct supervision of a licensed pharmacist. The pharmacy technician (PTA in German) supports the pharmacist; she helps him with advice and sales, while the Pharmacy assistant (PKA in German) usually works in the back-office. Supplying medicines to patients (whether on prescription or over the counter), assembling medicines for prescriptions, and providing information to patients are some duties of a PTA. Taking inventory of drug stocks, executing the orders, checking the goods receipt, dealing with commercial work such as checking delivery notes and invoices are some responsibilities of a PKA. Drugs may not be delivered by the pharmacy assistant in the pharmacy.

Figure 3. 3 Workplace in the Pharmacy under Study

3.3.2. Why was a Pharmacy as a Socio-Technical System Selected?

The healthcare industry is very different from other industries because of the intensity of the personal interactions. Health care is all about people: patients and their families and friends, and the various healthcare professionals and workers. Therefore, when analyzing, designing, implementing and improving healthcare systems, the people dimension should be at the forefront.

This clearly underlines the need for socio-technical systems analysis and the consideration of human factors and organizational issues related to healthcare quality and patient safety. "The socio-technical systems of health care involve increasingly complex social arrangements, and in turn, the social arrangements for patients' health care and clinicians' work are more and more influential in creating increasingly complex socio-technical systems" (Herrmann, Ackerman, Goggins, & Stary, 2017, p.187).

A truly patient-centred approach would begin with considering the patient's needs. The pharmacist is responsible for ensuring that the right patient is receiving the right medicine in the right dose for the right condition in the right dosage form and the right frequency, hence, he is considered as an integral part of the health care system.

"Community pharmacists are the health professionals most accessible to the public. They supply medicines in accordance with a prescription or, when legally permitted, sell them without a prescription. In addition to ensuring an accurate supply of appropriate products, their professional activities also cover counselling of patients at the time of dispensing of prescription and non-prescription drugs, drug information to health professionals, patients and the general public, and participation in health-promotion programmes…" (WorldHealthOrganization, 2019, p.3).

These facts are the good reasons to choose a pharmacy as a socio-technical system. I will analyse how the social and technical elements come together in my case study. As mentioned in Section 2.2.1., the key characteristics of socio-technical systems such as having interdependent social and technical sub-systems or pursuing goals in external environments can be seen here in a pharmacy system. The purpose of analyzing this case study is to identify how each data collection reflected socio-technical interdependency.

As mentioned in Chapter 1, the instrumental case study is selected for this research. It means, the examination of one particular case is necessary to provide information or insights on issues or the refinements of theory. Therefore, one pharmacy is deeply analyzed to answer the research questions.

Managing a pharmacy workflow needs both people and technical elements; however, within this issue, advising a patient in store may require less use of a technical element than when checking the information from prescriptions.

For instance, several functions of the pharmacist are outlined below to show how socio-technical aspects (Socio-technical systems: systems that involve communities of people and technology) are collectively used.

- the pharmacist initiates dialogue with the patient (and the patient's physician, when necessary) to obtain a sufficiently detailed medication history;
- in order to address the condition of the patient appropriately, the pharmacist asks the patient key questions and provides further instruction (e.g. how to take the medicines and how to deal with safety issues);
- the pharmacist uses and interprets additional sources of information to satisfy the needs of the patient;
- the pharmacist helps the patient undertake appropriate and responsible self-medication or, when necessary, refer the patient to additional medical advice;

In relation to involvement of technical systems of the work, the use of the software by the staff and their interaction with the technical system influence how work is practiced. In some pharmacies, technical systems such as assigning staff to specific dispensing terminals or using a robot to dispense play a major part in how work, is organized and approached; however, other pharmacies are less integrated with such technologies. As mentioned above, the pharmacy which is considered in this study uses the technical system as much as human resources. The task of the pharmacy team depends intensively on the technical system which they routinely use. Therefore, these collective uses of social and technical resources under one heading turn the pharmacy into a socio-technical system.

3.4. Building the "as-is" SeeMe and i* Models of the Current Process

As described in the literature, the SeeMe modeling method is chosen to represent the process of a socio-technical system. Moreover, the i* framework is the selected model for this research to show the social aspects. This means that to start the process model of the case study, SeeMe and i* framework diagrams should have built to clearly understand the social factors of both models.

3.4.1. Data Collection

To provide a detailed and rich understanding of the current state of the case study, the following pieces of data have been collected:

In the first step, observation of the procedures and speaking to pharmacy teams who are involved with the process have been used to fully understand the process that would be documented as a process model and to develop a starting point for the practical part of the research. The goal was to obtain a comprehensive understanding of what the pharmacy process is about.

Data was collected over a one-week period. I observed the work processes in the pharmacy five days during their work times. In total, I spent about ten hours observing the pharmacy process and six hours collecting interview data. The primary data has been collected form the first semi-structured interview to understand existing processes used by the participants of the case study. As this type of study is concerned with finding out what's happening and to seek new insights is ideal for the purpose of this research (Saunders, Lewis, & Thornhill., 2009). Moreover, interviews, in comparison with surveys or questionnaires, provide an opportunity to probe more deeply into expert insights and a practical balance between resource-intensive ethnographic/participatory observation and the depth of understanding, which makes them the most time-effective approach for the purpose of this PhD research (Creswell & Plano Clark, 2007).

In terms of data collection methods, the study was conducted using a semi-structured questionnaire that served as an interview guide for the researcher. Certain questions were planned ahead of time to guide the interviewer in leading the interview toward the study goals, while additional questions were asked during the interviews. More openended questions were asked, allowing for a discussion with the pharmacist rather than a straightforward 'question and answer' format. In order to facilitate this interview and make sure that I fully understood every decision point, activity, manual or automated step, data source, and message, a list of questions was prepared to guide the conversation. Some sample questions that were included in the semi-structured interviews are as follows:

1. Questions to comprehend the current Process:
    - What is the name of the process?
    - What does it achieve? What are the business objectives?
    - Who are the participants in the process and what are their roles?

- What must be true before the work is performed?
- What will be true when the work is complete?
- How does the process start?
- Is there more than one way to start the process?
- How do you know when the process is complete? (What are the determining factors?)
- What existing forms/reports and documents do you have?
- Who ends the task?
- Which steps of the process is not clear enough? Is there incompleteness or inappropriateness for performing the process? (For example: if it is not clear which sub-activities are part of a task or under which conditions these sub-activities are carried out.)

2. Questions to Comprehend the Social Factors (based on i* framework):
    - What are the goals of doing this activity? Why do you do it?
    - Which other actors will you depend on in order to succeed in your goals? What do you depend on them for achieving your goals?
    - What are the process objectives that you have to fulfill?
    - What are the skills required to perform each role? (Abilities and skills of roles are types of resources in i* framework)
    - Which are the most critical roles? What are the consequences if these roles do not successfully fulfill their tasks?
3. Complementary questions for second series of interviews (chapter 5)
    - What are the biggest challenges in this activity?
    - How will you know you have been successful?
    - What problems are there for performing this activity?
    - Do you need any assistance to do your work better?

I recorded some interviews with the participants' permission to ensure accurate transcription. During the interview, handwritten notes were also taken, allowing us to track key points to return to later in the interview.

3.4.2. Analysing Data: “as-is” Process Models

Qualitative research studies involve a continuous interplay between data collection and data analysis (Strauss & Corbin, 1998). As a result, after the interview, I evaluated the data to begin the identification processes. The results of the first analysis and interview were documented in written notes. The data was then interpreted and a "study" was carried out, which included "making sense of what people have said and putting what is said in one place with what is said in another place”. At this point, I had enough information to build the “as-is” pharmacy process model. The data from the first interviews included business events, roles and business tasks, and were analyzed and the first development of the SeeMe model was represented in the SeeMe notation tool (semi-structured, socio-technical modeling method), which reflects the conception of socio-technical systems from the point of view of activity theory. Determining the scope of the pharmacy process at the beginning was not easy and I decided to model the general procedures which had been done daily in the pharmacy. Hence, this first process model did not include the details and sub-process of every super activity.

In the next step, the captured information about the social aspects of the current work processes was used to build the i* models. The second part of the first interview questions helped me to model i*. As mentioned in the literature review, the i* framework suggests the use of two types of models for modeling systems, each corresponding to a different level of abstraction: the Strategic Dependency (SD) model represents the intentionality of the process, while the Strategic Rationale (SR) model represents the rationale behind it.

The obtained diagrams must have been validated by the end-users in order to ensure that the organization has been correctly modeled and understood. One meeting had been set with the pharmacy team to walk through the prepared models of the SeeMe and i*. Collecting their feedback helped me to improve the model and correct the existing errors. The final version of the “as-is” pharmacy process model (request with prescription) is shown in Figure 3.4. The sub-diagram of request without prescription and laboratory tasks are shown in Figure 3.4 as a link which are represented as Figure 3.4.1 and Figure 3.4.2.

To better comprehend how the elements of SeeMe and i* diagrams have been extracted, the following table is represented as an example showing how the super-tasks of SeeMe and their related elements came from interviews or observations.

Elements of the models (super-tasks in SeeMe- roles in i*)	Sample quotes or observation findings	Derived Roles (or positions in i*)	Derived resources	Derived dependencies /goals/ skills
Requesting	Patient comes in and requests something. The requests of the patient can be with or without prescriptions. Here the patient should feel comfort to talk about the illness at his/her request.	Patient , Sales team	Prescription	Friendly team to make the patient feel comfortable,
Controlling/ Screening the prescription	When you get a prescription, make sure it's screened and validated to make sure it's for the right patient. The prescription should be written legibly or printed. The prescription should have the valid date.	Sales team	Pharmacy system, prescription	
Preparing the prescription	When selecting the medicine to be dispensed, the sales team checks in system if there is a discount agreement with the social insurance and also if there is generic or reimported medicine. Here the sales team should suggest the patient the alternative medicine. Extemporaneous preparations can only be made if there is no commercially available alternative product and the product must be compounded according to the patient's needs.. (the detailed information in Figure 3.1).Sales team should ensure that the correct medicine is selected, especially if there are medicines with similar names and packaging	Sales team	Pharmacy system	Careful team to issue/sell the right medicine,
Checking the availability	If the prescribed drug is not present at the pharmacy when a prescription is being filled, it is referred to as a stock-out. These medicines will be ordered in system and the patient will be informed about the arriving time.	Sales team	Pharmacy system, pick up paper	
Ordering the medicine	The pharmacy assistant must collect all of the gathered orders from system and order them to wholesale. If the patient doesn't agree to pick-up the medicine himself, the delivery person will deliver it to the patient. Before issuing the medicine, the pharmacy technician must match the ordered medicine with the prescription to ensure that the right medicine will be delivered.	Pharmacy assistant, delivery person, pharmacy technician	Pharmacy system	This activity depends on a careful pharmacy assistant to order the required medicine on time. Sometimes she forgets to order in the morning and we can not deliver

				the medicine at the same day.
Consulting	Provide medication counseling to patients if needed to ensure proper utilization of dispensed medications. If the patient has the member card, it is encouraged to counsel patients with chronic diseases on multiple medications. Maintain records of the counselling done.	Sales team	Member card, pharmacy system	Appropriate consulting is very important to make a good relationship with customers. Also, the sales team with a good skill can try to sell the supplementary products to customer.
Selling / Issuing	Issuing the medicine to the patient and receive the money based on the insurance.	Patient, sales team	Prescription	
Controlling the dispensed prescription	Check the prescription and the filled medications to make sure the prescription and the filled medicines are the same.	Pharmacist, Payment center of prescription	Prescription, scan-adhoc system	Here we need a periodic meeting to analyse and reduce the pharmacy staff errors.

Table 3. 4. An Example to Show How the Elements of the Diagrams are Determined from Collected Data

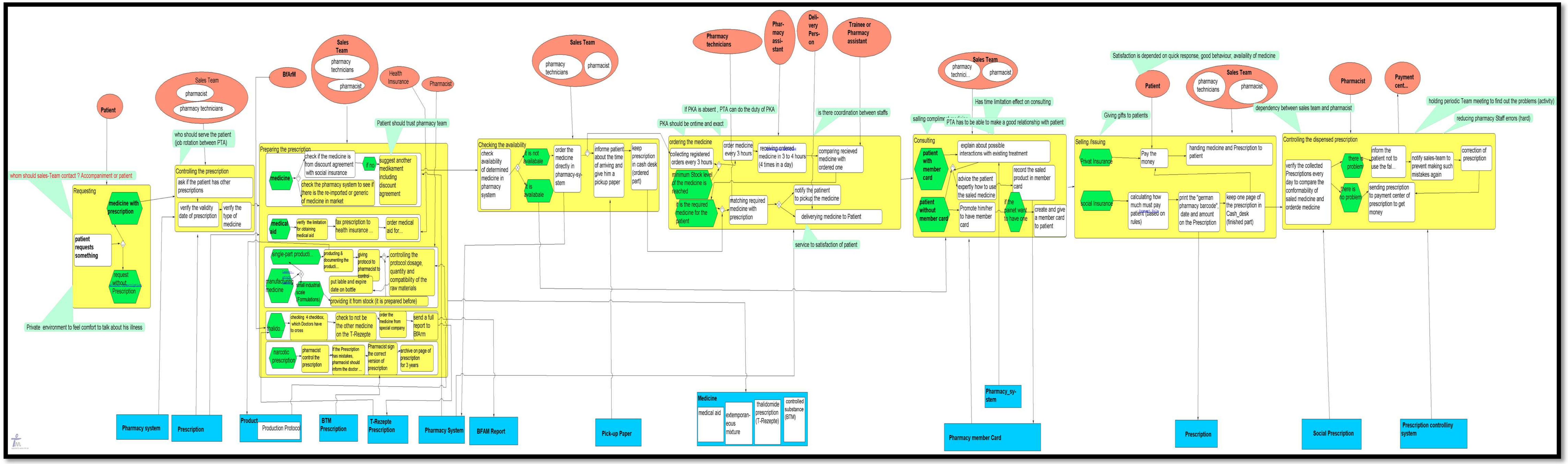


Figure 3. 4. "As-is" SeeMe model of the pharmacy (with prescription)

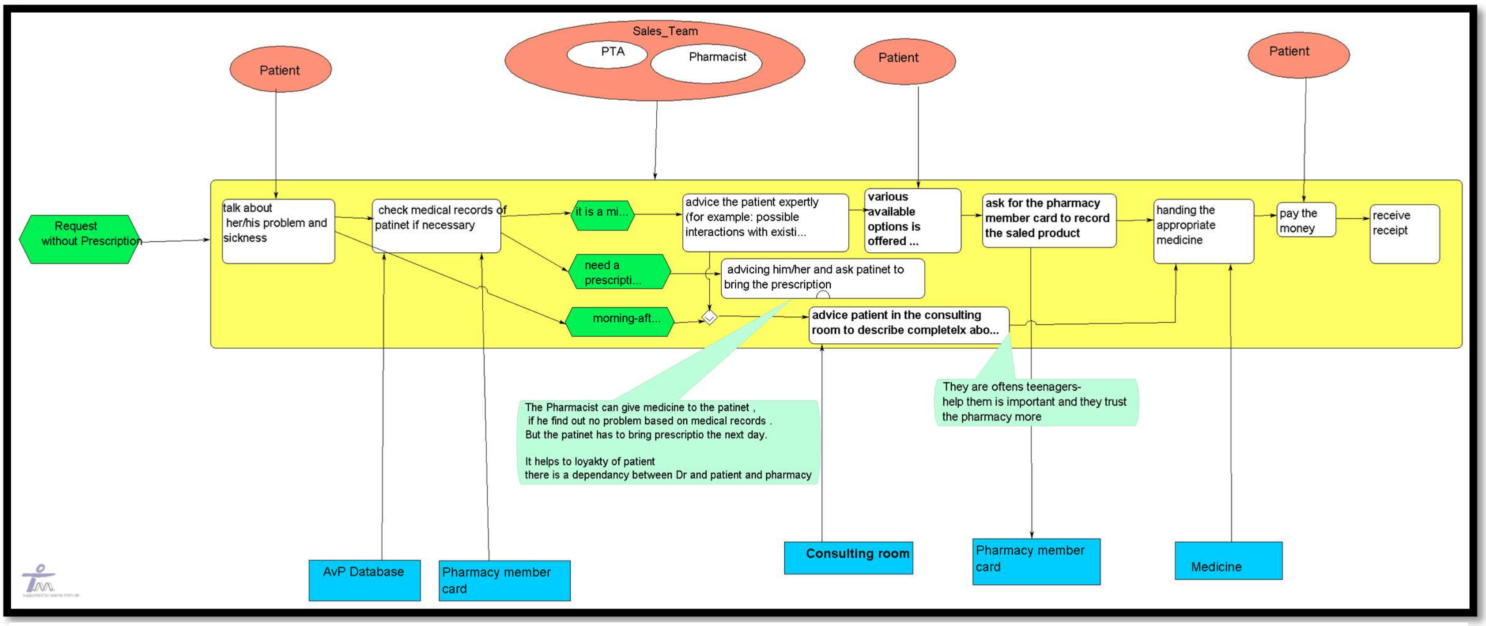


Figure 3.4. 1. “As-is” Sub-Process of SeeMe Model of the Pharmacy (Without Prescription)

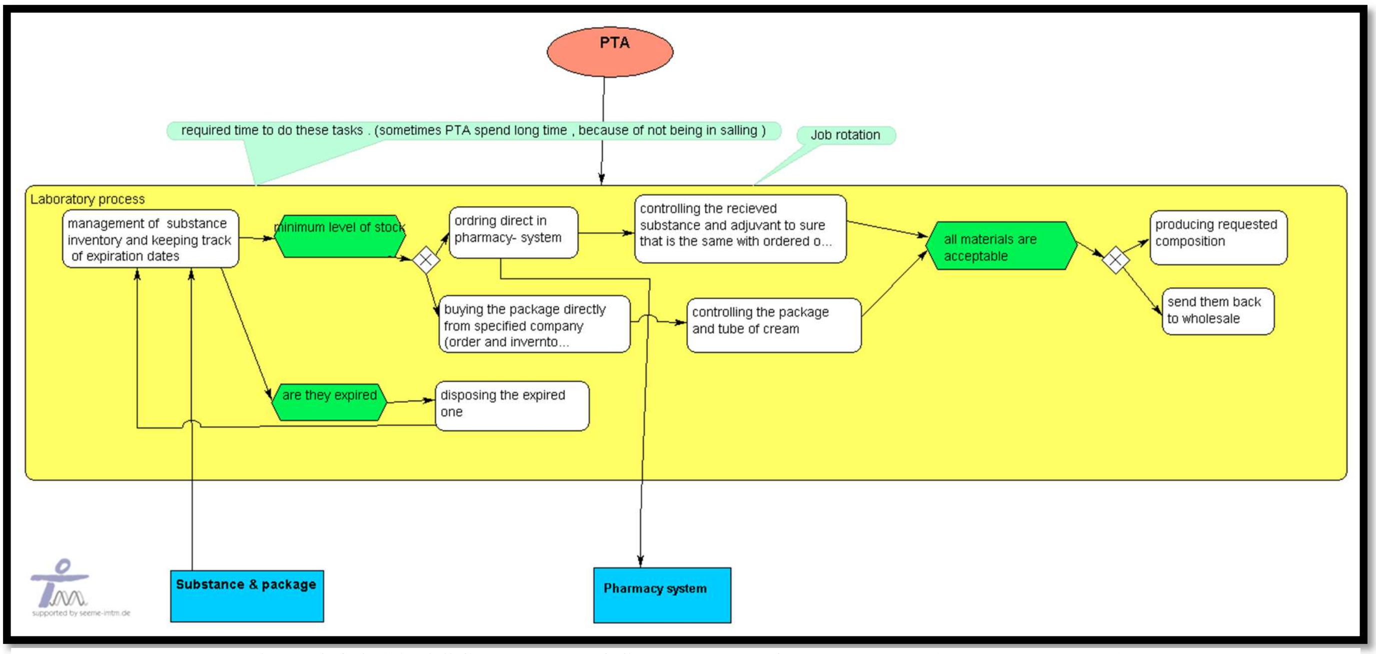


Figure 3.4. 2. “As-is” Sub-Process of SeeMe Model of the Pharmacy (Laboratory Tasks)

There are super-tasks as shown in Figure 3.4. They consider the main duties of a pharmacy team during a typical day. Pharmacy sales teams including pharmacists and pharmacy technicians are responsible for supplying medicines to patients, whether by prescription or over the counter. Processing prescriptions needs screening and interpretation of the order from a prescription in order to accurately prepare and dispense medicines. The first step to dispensing prescription medicine is controlling prescription information. Recognizing the health insurance, age of patients, and the requested medicine, is important to help the pharmacy team to supply the appropriate medicine. For example, identifying patients' health insurance type enables sales team to receive correct prescription charges from patients and also check pharmaceutical discount agreements between pharmaceutical companies and various health insurance. Different type of medicines such as medical aid or thalidomide medicines must be delivered to patients under certain conditions which make the procedure in Figure 3.4 more complex.

The availability of requested medicine is checked simultaneously by the pharmacy software. Collecting stock outs medicines and ordering them are the some of the main responsibilities of the pharmacy assistant (PKA) in the pharmacy.

Pharmacy sales teams also advise customers about health issues, symptoms, and medications in response to customer enquiries. Controlling the prescriptions to check if the delivered medicine is compatible with ordered medicine is a duty of the pharmacists. The controlled prescriptions will be sent to payment center in order to get costs of the medicines.

As shown in Figure 3.4.1, requested medicine without prescription has another small procedure which is based on more social communication between the patient and pharmacy team. The patient should explain his/her sickness or problem in order for the pharmacy sales team to consult him/her to take appropriate medicine. If the appropriate medicine is a prescription one, the supply of the medicine is based on pharmacy team decision.

Figure 3.4.2 represents some important tasks which were done in a laboratory of the pharmacy to assemble substance for producing some formulation of the prescriptions.

Then, the SD model was built with a set of actors and their dependencies representing the relationships among them. The four types of dependencies (resource dependency, softgoal dependency, task dependency, goal dependency) based on the type of dependum are presented in the SD diagram. It presents (some of the) relationships among patients, pharmacy sale teams, and pharmacy technicians. Different people modeling the same process in the same system should, in

theory, be able to come up with similar outcomes. However, in socio-technical systems, different models for the same method may be obtained if it is analyzed by different people.
Following are step-by-step revisions of the SD and SR models based on discussions with interview participants. For instance, patients depend on pharmacy sales team for getting medicine, while pharmacy sales team depend on payment or prescription from patient, pharmacy assistants for cover the role of ordering the required medicine, and that depends on collected data on the integrated system.

The i* diagrams are represented only for the process of dispensing a prescription and the sub-diagrams are not modelled via SD and SR models.

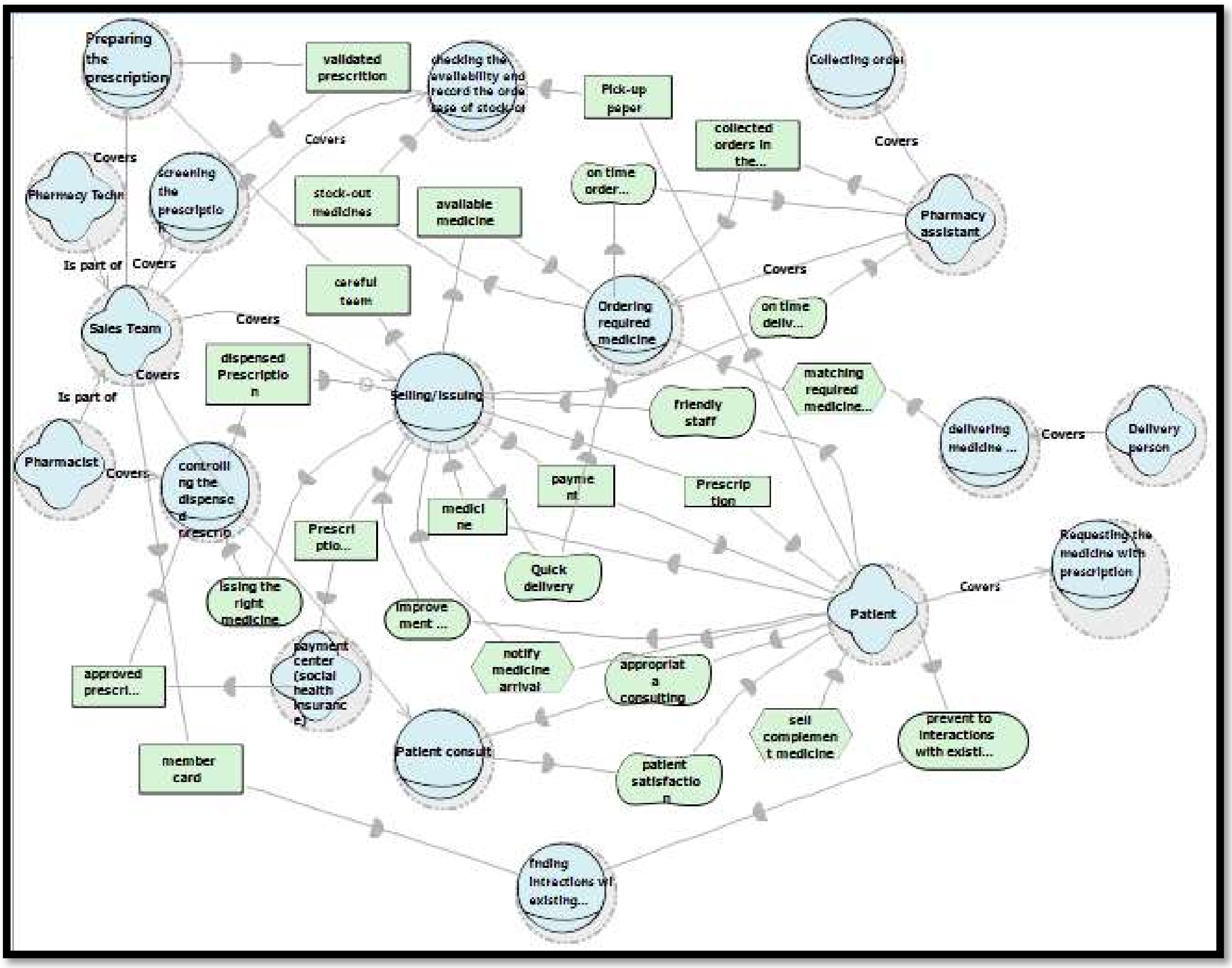


Figure 3. 5. Strategic Dependencies Model (SD) of the Pharmacy

As shown in Figure 3.5, the SD model focuses on external relationships. Motivations and intentions are often attributed to actors in order to make sense of a social world. In the Strategic Rationale (SR) model (Figure 3.6), goals, tasks, resources, and softgoals are attributed to each actor, this time as internal intentional elements that the actor wants to achieve. This method of study will provide a richer interpretation of the "whys" and "hows" due to the intentional semantics of the SR structures.

The SR model provides a more detailed understanding by looking inside actors to see how processes consist of intentional elements and how these elements contribute to the overall purpose of the system (Yu, Liu, & Li, 2001). For example, the pharmacy sales team want to offer effective medical service by good consulting and quick delivery of medicine, while the patient wants to be serviced in a pharmacy by taking the proper medicine with good consulting. The main goal of the sales team is issuing the right medicine to the patient. To accomplish this goal, the pharmacy team has to use the pharmacy system correctly and work carefully. Providing a friendly environment for patients to explain about their illness is another task of the sales team that is in conflict with one of the softgoals: quick service to patients. However, quick service is one of the conditions that increase the satisfaction of the patient. Advising patients expertly is another task which makes the efficient consulting goal possible. There are some dependencies between different roles. For example, sales teams depend on the pharmacy assistant to issue the medicine immediately. Pharmacy assistants have to order the required medicine at the right time. The other dependencies and intentional relations in a pharmacy are shown in Figure 3.6.

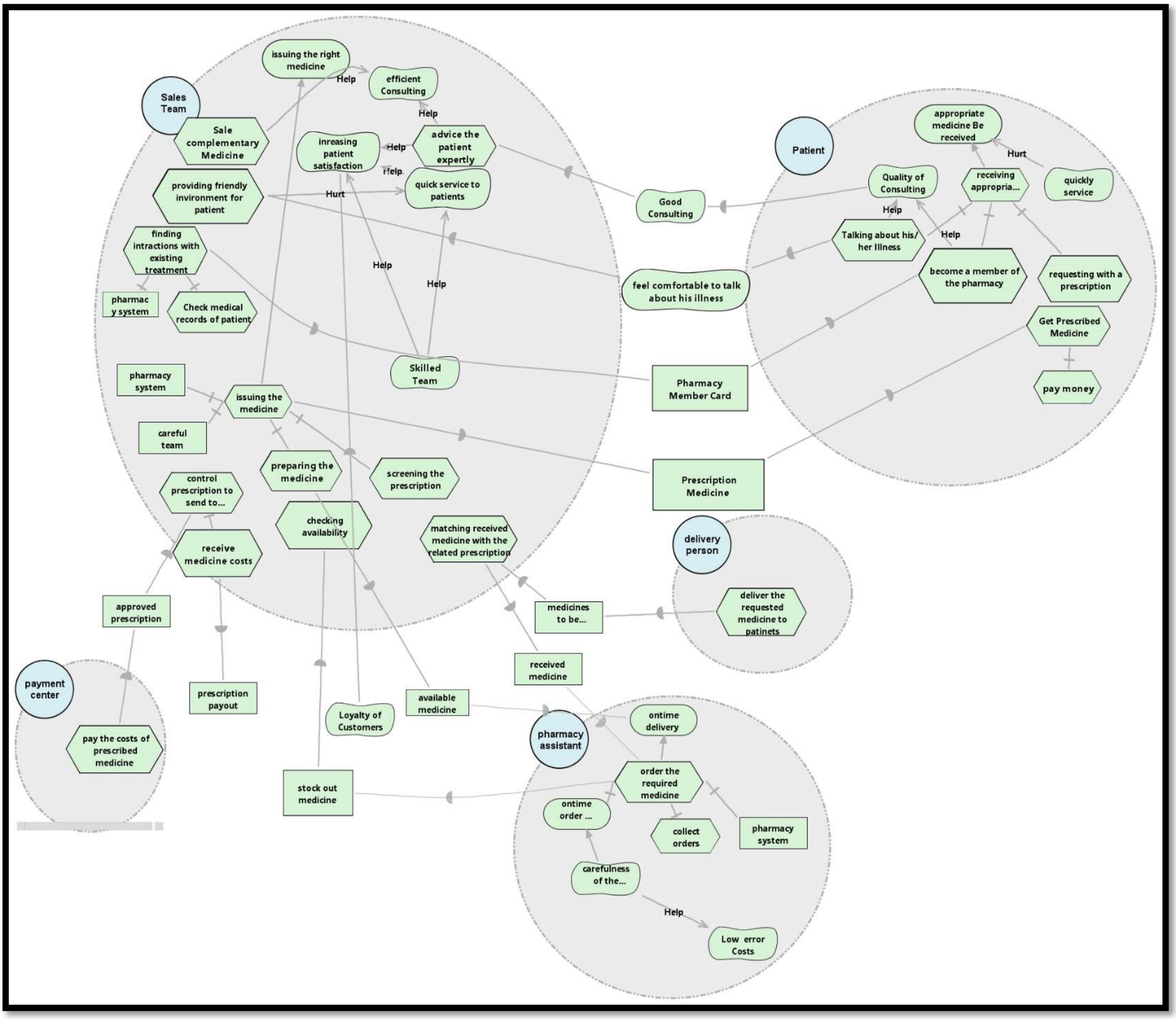


Figure 3. 6. Strategic Rational (SR) Model of the Pharmacy

3.5. Summary

To summarize, this study utilized a qualitative case study approach to research in an effort to better understand the role of social aspects in modeling process of a socio-technical system to elicit complete social and technical requirements of a system. I attempted to develop our findings from a literature review in an appropriate case study to understand how social aspects of a socio-technical system can be represented in an activity-based process modeling method. As described in Chapter 1, in an instrumental case approach, the researcher selected an instrumental case to focus on an issue or concern and illustrate the issue.

The procedure of the empirical study has been described in Figure 3.1 that shows the stages of our empirical work in the pharmacy. Two main interviews and three meetings with participants were conducted in the pharmacy. The results of the interviews and meetings were documented in written notes and recorded voices.

The first stage of this illustration is presented in this chapter. Specifically, the aim of Chapter 3 was to present the current process of the case study in detail. I have applied following methods to collect data from the case:

- Semi-structured interview with participants,
- Observation of daily works and software usage

The case has been analyzed through collected data and the results are shown in Figure 3.4, 3.5 and 3.6 as SeeMe, SD and SR models.

Chapter 4
Research Findings: The Model Improvement

The empirical work on which the thesis' methodological approach is based was discussed in the previous chapters. This chapter presents an extended modeling method notation that can be used to model socio-technical processes. In fact, in this section I answer the first research question presented in this thesis:

- How can the viewpoints, goals and dependencies of different actors within processes be represented and supported with a semi-structured, socio-technical modeling method?

In Chapter 5, this newly developed model will be applied in the case study according to the design specifications in this chapter. The discussion in Chapter 6 is aimed to compare existing and associated theoretical models to identify the similarities, weaknesses, imperfections, and new territories.

In Section 4.1, I start with the analysis of as-is SeeMe diagrams, SR and SD models obtained from the Chapter 3 (Figure 3.4, 3.5, and 3.6). More importantly, the SeeMe and i* meta-models also help to compare these two modeling tools and point out the aspects that need to be improved.

In Section 4.2 the idea of how to improve these aspects and to present the extensions for the model are developed, so that it can be used for purposes of modeling social and intentional actors in socio-technical processes.

4.1 Analysis of SeeMe and i*

After conducting interviews and modeling collected data, the necessity of analysing the models to recognize their specifications and concepts became clear. In order to merge both methods to overcome their deficits and to evaluate the extent in which currently available SeeMe and i* modeling tools are supporting the generation of socio-technical process models, an in-depth analysis of SeeMe and i* meta-model was carried out.

4.1.1 SeeMe and i* Meta-model

A meta-model is an explicit model of the constructs and rules needed to build specific models within a domain of interest (Heidari, Loucopoulos, Brazier, & Barjis, 2013). From the previous explanations of the elements of the SeeMe modeling method, the meta-model was gradually constructed. The SeeMe meta-model is shown in Figure 4.1.

The meta-model first shows the element hierarchy. As shown in Figure 4.1, basis elements, modifiers, process relationships, dividers, and vagueness are parts of a SeeMe diagram. Process relationships are composed of relations and embedment and have a logic relation with connectors. There are nine standard relations and four types of embedment that have associations with basic elements.

As described, SeeMe distinguishes between three basic elements: role, activity, and entity, which allow the basic description of processes. Elements can be embedded into other elements, which are shown as a type of SeeMe relationships. The semantics of embedding two elements can be considered a directed relation since they are also the combination of exactly two basic elements. For example, in addition to decomposition elements (role, activity, and entity decompositions), there are competencies of a role that are represented as an entity into a role. Activities can also be embedded into entities to show that these activities are carried out by entities. I have mentioned only the commonly used embedment of SeeMe that is explained in the article of “SeeMe in a nutshell” (Herrmann, 2006).

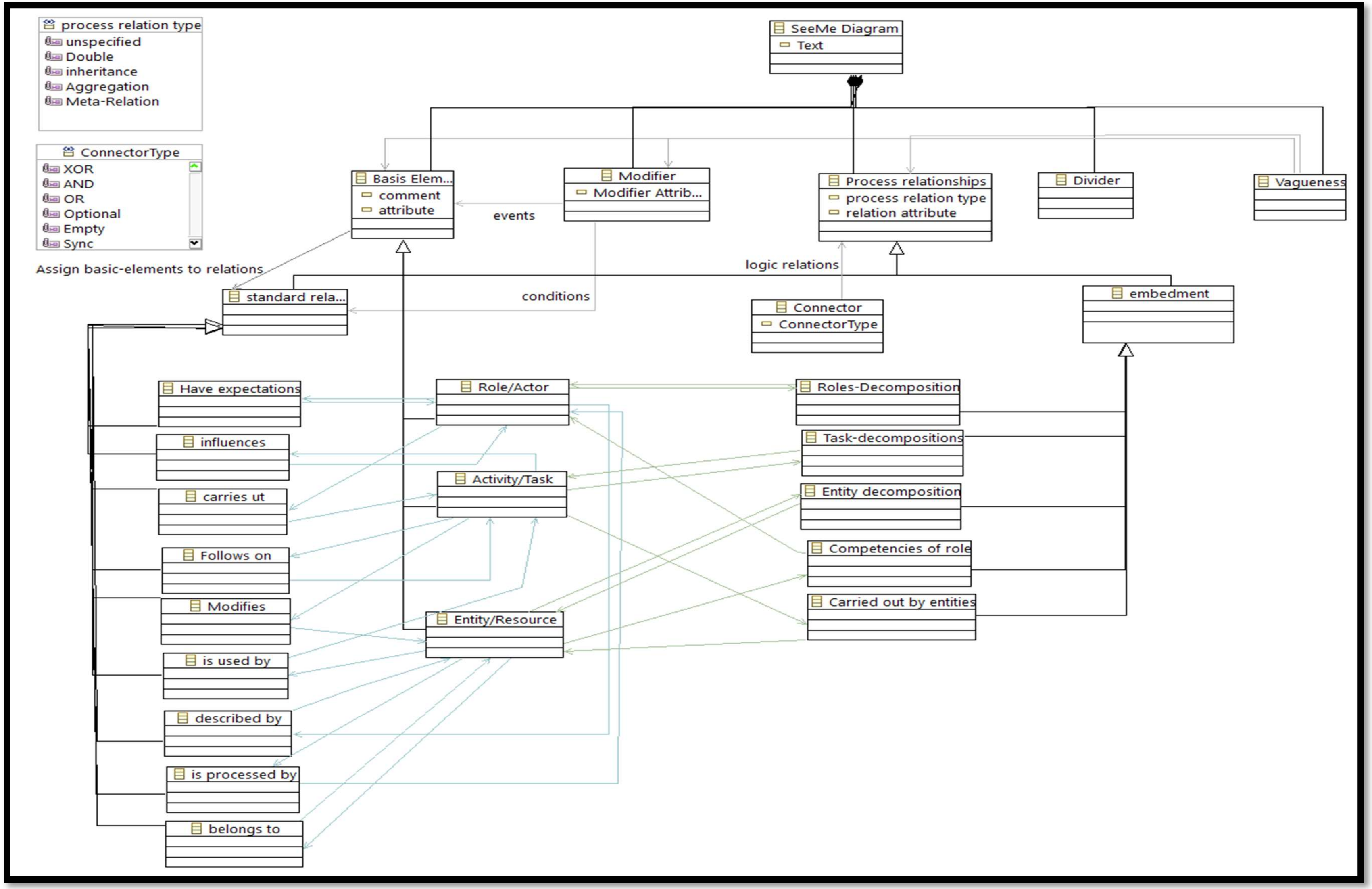


Figure 4. 1 The SeeMe Meta-Model

Another part of process relationships are relations (standard relations). Since relations represent a model's dynamics, SeeMe also allows us to assign basic -elements to relations that "assist" (or are needed) in their illustration.

The most usable type of relations is standard relation and as you see in Figure 4.1 standard relations are subdivided into nine classes; SeeMe offers nine standard relations depending on the types of basic elements being connected and on the relation's direction. For example, the role carries out the activity or the activity influences the role. An entity is used by the activity which produces or modifies an entity.

Relations can include a modifier in the form of a condition that represents a condition for the occurrence of the relation. Basic elements can be equipped with attributes and may also contain a modifier in the form of an event.

Connectors bring together at least two relations. All basic elements as well as relationships may contain certain types of vagueness.

"The major elements of i* are actors and their intentions. The term actor refers generically to any unit to which intentional dependencies can be ascribed. A dependency is considered intentional if it is related to aims of other actor... i* models can be viewed in two different abstraction levels: The Strategic Dependency (SD) Model and Strategic Rationale (SR) Model" (Lucena, et al., 2008, p.238). The meta-model defining the elements present the i*models is shown in Figure 4.2. The proposed meta-model provides the abstract syntax to create SR model. Consequently, the SD model is a smaller version of the SR model and represents only actors and their dependencies.

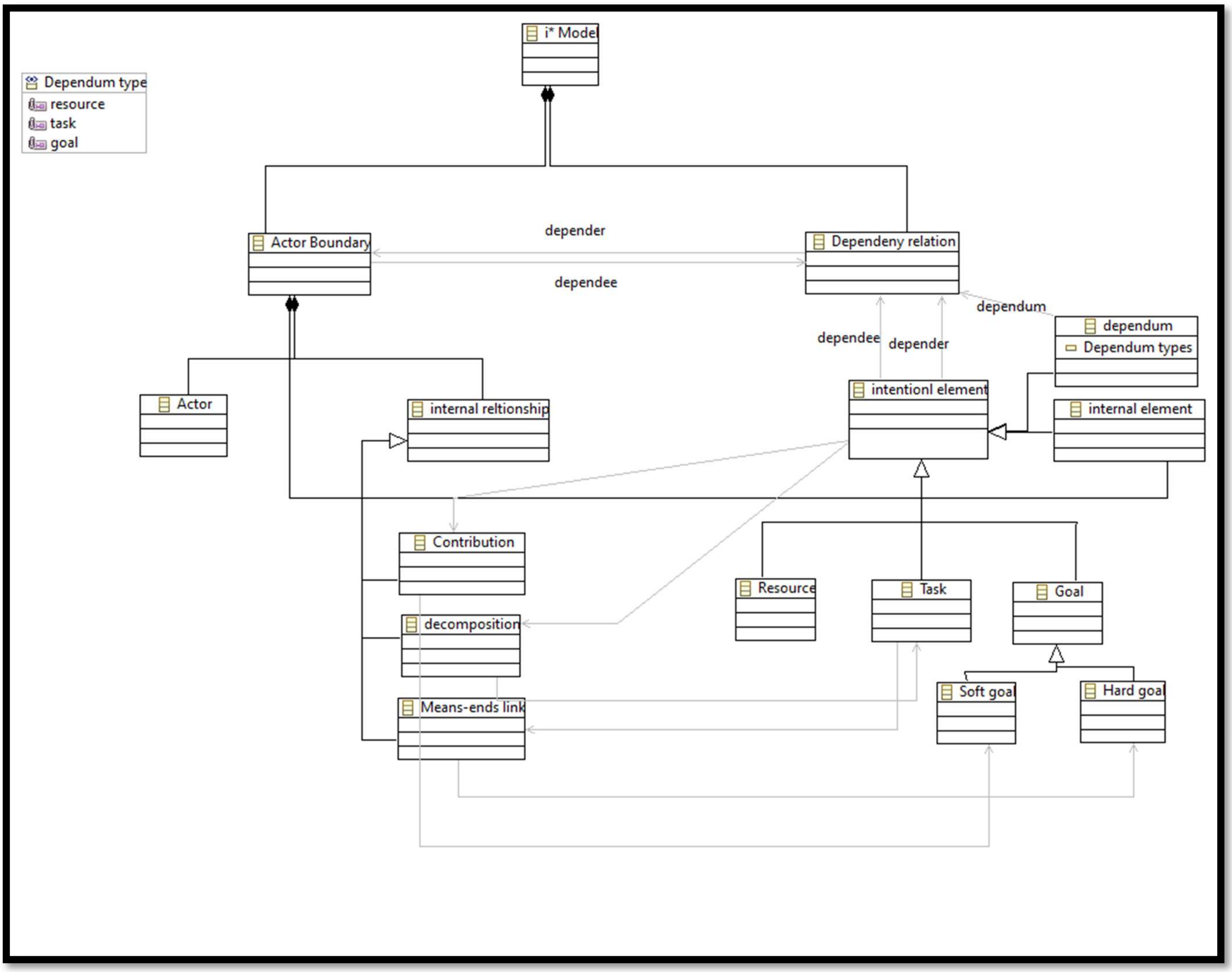


Figure 4. 2 The i* Meta-Model

As we see, the concepts of actor boundary and dependency relations are highly abstract. I* models mainly consist of dependency relationships and internal relationships.

Actor boundaries are subdivided into actors, internal elements, and the internal relations within an actor that can be means-ends link, contribution link, and decomposition. The internal elements are present inside the Actor's boundary (as in SR models). These internal relations are part of an internal element relationships which have associations with internal elements and defined according to the type of relation with intentional elements.

An intentional element represents intentions in i*: Goal, Softgoal, Task, and Resource. Internal elements and dependums are parts of intentional elements. Dependency relations are composed of

depender link and dependee link between two actors. These links are related with a dependum (as described above, dependum is an intentional element such as goal, task or entity).
A complete description of the SeeMe and i* meta-models are out of the scope of this thesis. Rather, this thesis aims to generate a comparison between these two models.

4.1.2 Comparing SeeMe and i*

To clarify the difference between the SeeMe model and i* model, I compared the elements of both models. After using i* SR and SD to model the as-is state of the pharmacy in Chapter 3 and gaining a deeper understanding of these two models, I have decided to consider the SR model for further investigation as it represents a more detailed level of modeling by looking "inside" actors to model internal intentional relationships (Tariq & Zhu, 2014). For this reason, I have used the as-is SeeMe (Figure 3.4) and SR (Figure 3.6) model of the pharmacy represented in Chapter 3 and the meta-models of Section 4.1.1.
The first impression comparing the models is that the SeeMe modeling notation is an activity-based model that helps in understanding the task processes in sequence. Processes are built around the sequence pattern. A task in a process is enabled after the completion of a preceding task in the same process. By contrast, it can be difficult to trace the activities in i* models because i* models do not represent the sequence of events.

Moreover, during modeling the pharmacy case interviews I have realized that i* models do not aim to execute level analysis and subsequently are more difficult to use to precisely define the complexities in a work process. In order to correctly define the process flows and communicate them to the different stakeholders, an expressive and comprehensible means to illustrate process descriptions is needed. However, according to the i* meta-model, there are no attributes or sub-processes. On the other hand, i* models with representing goals and intentions answer the question Who and Why An SR model allows modeling of the reasons associated with each actor and their dependencies and provides information about how actors achieve their goals and softgoals. These elements cannot be shown in a SeeMe diagram. The table below shows the comparison of both models in detail:

SeeMe Element	I* Framework Element
Role	Actor
Activity	Task
Entity	Resource
----	Softgoal
-----	Goal
-----	Dependency relationship
Embedded Relations: Task decomposition	Internal element relationship: Decomposition Link
Embedded Relations: Role decomposition	Different type of actors (Role, Agent, Position)
Embedded Relations: Entity decomposition	---------
Embedded Relations: Competencies of roles	They are sometimes shown as a softgoal of an actor
Embedded Relations: carried out by entities	-------
Standard relation: have expectations	It can be shown sometimes with a dependency relationship
Standard relation: influences	--------
Standard relation: carries out	Task in an actor boundary
Standard relation: follows on	------
Standard relation: modifies	------
Standard relation: is used by	Entity as a Task decomposition
Standard relation: described by	------
Standard relation: is processed by	-------
Standard relation: belongs to	-------
------	Internal element relationship: Means-Ends Link
------	Internal element relationship: Contribution Link
Vagueness/ Incompleteness	------
connectors	------
Modifiers	------
Dividers	------
Assign basic-elements to relations	------
Sub-process (embedded /included process)	-----

Table 4. 1 Comparison of SeeMe and i*

The explanation of the Table 4.1 is as follows:

1. Actor and role: Physically represented characters, such as humans, as well as abstract "logical" actors, such as roles, must be included in social modeling. The word "agent" is used in i* to describe actors who have actual manifestations. An agent may take on a variety of roles. A position is a group of roles that is usually filled by a single agent. But the roles

in SeeMe are a means of introducing social aspects into the models and representing a set of rights and duties as they can be assigned to persons, teams, or organizations.

2. Softgoal and goals: Actors in i* are strategic in the sense that they act in such a way that help them achieve their goals. Softgoals are process qualitative objective and goals process functional objective. These concepts are not represented graphically in SeeMe but it is sometimes possible to express the goals implicitly and in an indirect way by showing what can happen next in a sequence.
3. Dependency relationship: i* actors depend on each other for goals to be achieved (goal dependency), tasks to be performed (task dependency), and resources to be furnished (resource dependency) (Yu E. , 1997). In a dependency relationship, the depender depends on the dependee. There is no intentional dependency relationship between actors with a task, resource or goal as a dependum.
4. Task Decomposition Link as an internal element relationship: in i*, a task is linked to its components by this link. There are four types of task decomposition links: sub-goal, sub-task, softgoalFor and resourceFor (Tiki Wiki CMS Groupware, 2011). This link can be compared with the task decomposition as an embedded Relations in SeeMe.
5. Role decomposition as an embedded Relations: in SeeMe, sub-roles can represent parts of the organizational structure of a more complex role. Different type of actors in i* (roles, agents, positions) can be compared with this decomposition.
6. Other types of embedded relations: The competencies of a role can be shown in as an embedded resource into a role. These types of relation are sometimes shown as a softgoal of an actor in i*. As shown in the table, entity decomposition are carried out by entities cannot be represented in i*.
7. Contribution links: This i* concept represents the effect of different elements on a soft-goal. For example, Softgoals have contribution connections that show how tasks contribute to achieving certain values (either positively or negatively). As SeeMe represent no goal in its notation, there is no possibility for the contribution links.
8. Means-Ends Links: As described in Chapter 2, Means-ends link indicates a relationship between an end, which is a goal to be achieved. The means is usually expressed in the form of a task. There is no need to represent task-goal relation in SeeMe.

9. Standard relation: There are nine standard relationships between basic elements in SeeMe. For example, “Having expectations” which is a relation between roles, can be supposed sometimes as a dependency relationship between actors in i*. As another example, the roles carry out the tasks in SeeMe, this relation is similar to the tasks that are located in an Actor boundary. Moreover, an entity can be used by a task in SeeMe that have similarities with entity as a Task decomposition.

   There are no notations to represent the other types of standard relations in i*.
10. Incompleteness/Vagueness: For modeling the socio-technical processes, it is required to represent those parts of information which cannot be stated clearly and therefore must be modeled vaguely. Some aspects of social systems can never be modeled completely, and we need to show incompleteness in that model. SeeMe enables us to model incompleteness, while in i* there is no opportunity to model it. Maybe softgoals can be considered as an example for incompleteness in i*, but there is no specific notation to show it.
11. Connector, modifiers, dividers and the other type of standard relations are the elements which allow basic description of processes. Since i* does not show the sequence of activities, these elements are not applied in the i* framework. The concept of transition and sequence flow (follows on as a standard relation) cannot be represented in i*.
12. Sub-processes: In SeeMe a process is refined by one or many Sub-Processes to further structure the process’ fine-grained parts which logically stick together. However, we cannot represent levels of processes in a i* model.
13. Tasks and resources in i* are similar to the activity and entities in SeeMe, respectively, and they can be used instead.

4.2 Improvement of the Modeling Notations

As described in literature, the combination of social models and work process model allows analysis of the “why” (goals) and the “what” and “how” (work processes) aspects of the business requirements for a socio-technical system. In reality, determining which methods are appropriate and readily interpreted by stakeholders is difficult. Therefore, the expressive capacity of the models to represent all possible aspects of a work process have been considered to determine which modeling method should be used for our research to be improved. The analysis of the meta-models, revealed a couple of points which are described below.

I have analysed the capacity of each model by defining the graphical objects that represent one or another business issue. These objects construct the ability of the model to describe processes, decisions and states.

For example, every socio-technical system involves many different processes to achieve its goals. Process is a sequential flow of activities performed by system stakeholders that leads to some end state or result. SeeMe allows for creating sub-processes, using parallel gateways to fork the flow into some synchronous flows, involving OR-Gateways to give a preference to one of the forked flows (the i* Means end link describes alternative task to reach a goal, it is similar to OR-Gateway but it is without a sequential flow of activities).

Moreover, decisions are involved in almost every work process, because it should provide optioning in majority of cases. SeeMe provides branching of the process flow and allows making the choice what path to follow. This is realized with so called XOR-Gateways in SeeMe. And finally, SeeMe defines the concepts of sub-process and intermediate events that allow representing work process to be more granular and detailed.

As mentioned in Chapter 2 (Section 2.2.3), some of the socio-technical design principles are as follows:

The process of design must be compatible with its objectives. This is often interpreted as giving employee groups clear objectives but leaving them to decide how to achieve these. For groups to be flexible and able to respond to change, they need a variety of skills. All groups should learn from each other despite the existence of the boundary (Cherns, 1976). Systems of social support must be designed to represent the social behavior, conditions, desired skills, and objectives in the work environment, which means a process-oriented modeling notations and social modeling methods are required.

Considering all aspects mentioned above, we could come to the decision to improve SeeMe as our original model to extend it with i* social factors such as goals and dependencies between intentional actors.

4.2.1 Requirements for the Extension of SeeMe

As I learned more about the modeling notations, it become clear that activity-based SeeMe modeling notation would facilitate the modeling of a process as it is easy to understand for technical and non-technical participants and is more conducive to the way business analysts model.

At this point, the SeeMe limitations have been analyzed in order to cover the social aspects of i*. To determine whether it is worth to imply all of i* notations in the extended SeeMe modeling notation, I needed to take a deeper look into the interview transcriptions and some short conversations with the pharmacists. As the participants of the case study expressed their viewpoints and as discussions occurred, the requirements of extended SeeMe were determined. All the discussed requirements of this section are summarized in Table 4.2.

Requirement	Description
Softgoal	Softgoals are similar to (hard) goals except that the criteria for the goal's satisfaction are not clear-cut, it is judged to be sufficiently satisfied from the point of view of the actor.
Goal	Represents and intentional desire of an actor, the specifics of how the goal is to be satisfied is not described by the goal. This can be described through tasks.
Dependency link	Dependencies express that an actor (depender) depends on some other (dependee) in order to obtain some objective (dependum). Thus, the depender depends on the dependee to bring about a certain state in the world, to attain a goal in a particular way (goal dependency), to carry out an activity (task dependency), for the availability of a physical or informational entity (resource dependency) or to meet some non-functional requirement (softgoal dependency).
Contribution link	The means to satisfy softgoals are described via contribution links. Two types of contribution links are applied here: • Make/help: A positive contribution strong enough to satisfy a softgoal. • Hurt: A partial negative contribution, not sufficient by itself to deny the softgoal.
Means-Ends Link	A means-ends link is used to connect a task to a hard-goal, indicating a specific way to achieve the goal.

Table 4. 2 Requirements for the SeeMe Extension

As we can see in Table 4.2, the sub-units of a social actor (agents, positions, roles) have not been considered for an improved SeeMe model. In fact, this research considers the term role in SeeMe notation as all types of social actors with intentional dependencies. There is no need to represent an actor in a more specialized sense. If someone needs to imply whether a role is represented by specific agents or positions, sub-roles in SeeMe could be used to specify them.

4.2.2 Meta Model Based Extension

In this section, I illustrate an extended notation of SeeMe for facilating the lifecycle of work process models with the complementary use of i* - a well-developed notation for modeling socio-technical process. I call the proposed method SeeMe*.

As I described earlier, a common way to extend modeling languages is a meta-model extension. The goal of such a model is to serve as a common framework for proposals that appear in the future.

The use of a meta-model-based approach to carry out the SeeMe extension is advantageous, because there is the sense that the extension can be easily customized to include additional properties or modify the currently available ones.

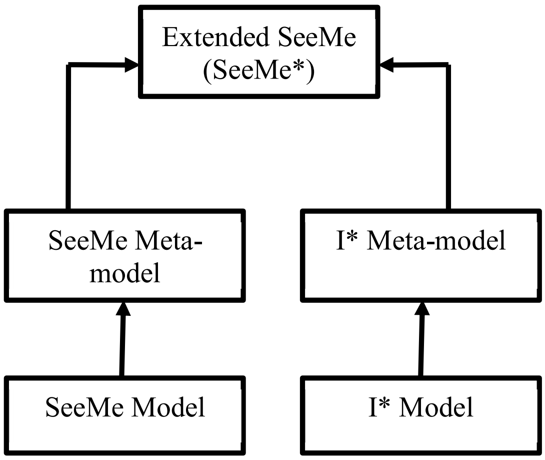


Figure 4. 3 Metamodel-Based Approach

The strategy that has been used here to build the meta-model is based on following rules:

- All the common concepts and properties have been included.
- Concepts that are constrained or changed in SeeMe* (in comparison with these concepts in SeeMe or i* separately) have been represented in detail.
- To clarify the new proposed concepts, the purpose of this meta-model is to capture conceptual relations of the world to be represented. For example, the association links which describe any logical connection or relationship between classes, have been also included.

As represented in Figure 4.4, the model backbone elements are perspective levels, modifiers, relations, base elements, and vagueness. Goals are added as a new element to the base elements of SeeMe*. The SeeMe* allows for the description of the interactions among the different parties of the domain at the strategic level represented in the diagram by means of goals (softgoals and hard-goals) that is definable as the motivation of doing activities. Furthermore, the social-oriented relationships have been added to relationships of SeeMe.

The different levels of SeeMe* are also shown in meta-model as perspective levels. I followed the idea of keeping syntax simple, clear, and user-friendly in order to avoid the congestion of the SeeMe* model. As mentioned previously in Chapter 2, SeeMe for the layout of a socio-technical diagram recommend that roles are at the top, activities in the middle, and entities in the bottom of a diagram. After analyzing SeeMe and i*, I have decided to add two other levels to the SeeMe*:

1. The strategic or goal level on the top of the roles
    a. The goals can be also embedded in the roles
2. The dependency level at the bottom of the activities

The newly-defined classes are interrelated to each other in specific ways which have been described in Table 4.3. This table complements the meta-model with the existing restrictions of the main concepts.

The process-oriented relationships are the same as relations in SeeMe meta-model. The social oriented relationships are composed of contribution, means-ends, and dependency. The decomposition is not mentioned as a social oriented relationship, because it is exactly as the same “embedment” in SeeMe*.

To simplify, the SeeMe* meta-model, standard relationships and embedment are represented as associations or attribute type. The association between roles and task are easily identified: “Role carries out the task” is represented as the actor boundary in SeeMe*.

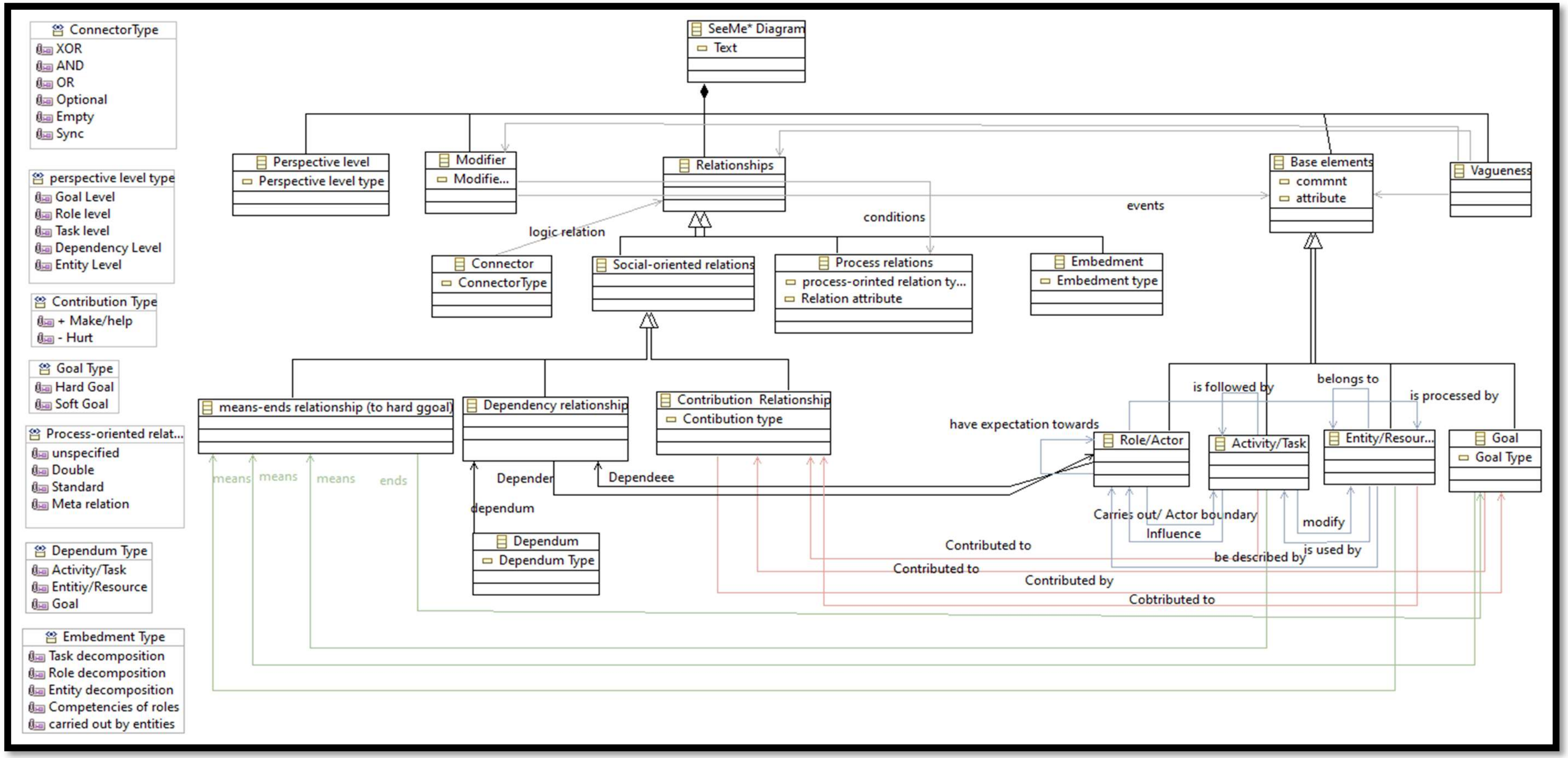


Figure 4. 4 The SeeMe Extended Meta-Model (SeeMe*)

Base elements and relations between them	Remarks
- A role execute an activity. - A role can have expectations towards another role. - An activity can influence a role. - An activity is followed by another one. - An entity is used by the activity. - An activity produces or modifies an entity. -An entity can belong to another one. -A role can be described by an entity - An entity points to a role with an arc, if this entity is possessed by the role.	- A SeeMe* does not always consist of 4 base elements. - At initial steps of modeling a SeeMe*, it is possible to represent tasks which specify a particular way of attaining goals and their related goals. Also, they can depend on other elements to achieve these goals. It means that sometimes SeeMe* consists of activities and their dependencies to achieve some goals (without roles that carry out activities or entities that being used or modified by activities). - Actors want some goals and they do some activities to attain these goals so that there are relations between tasks and goals and actors are indirectly related to their goals; The goals can be also related to the roles with an unspecified relation (the modeller can decide to represent goals in the goal level or link them to the roles). -Sometimes roles execute no activities in a process, but they are only influenced by some activities or have expectations towards another role.
Contribution link	**Remarks**
- The concept that is related to contribution relationship is softgoal that can be analyzed from the point of view of an actor. - The fulfillment of a softgoal contributes positively or negatively toward fulfillment of another goal, doing an activity or having a resource.	- Contribution links are the relationships that are contributed from an activity, a resource, or a goal to a softgoal. - Contribution and means-ends relations show that performing each activity is accompanied by achieving a goal.
Means-ends link	**Remarks**
- The concept that is related to means-ends relationship is a hard-goal. - Means-ends is a relationship defined with a hard-goal (end) and an activity, or resource, or goal (the means).	- Means-ends links are the relationships that end with a hard-goal. - Hard-goals can also relate to each other with means-ends link.
Dependency relationship	**Remarks**
-Dependable node may participate as depender or dependee in some dependency; and this dependency is known as a dependum which is a task, resource or goal. -Dependency is a relationship that depender depends on dependee for something (dependum) that is essential to the depender to attain a goal or do an activity.	- The roles or sub-roles depend on each other directly - In SeeMe*, dependum can be a goal, an activity or a resource.
Connectors	**Remarks**
-If two or more relations are assigned to the same base element with their starting- or end-points, they expressed with connectors.	-Since goals are also new nodes in SeeMe*, the connectors can be used for goals too.

Perspective levels	Remarks
To represent different levels of a socio-technical process, perspective levels are used.	-Each perspective level contains one type of base element, except for the dependency level that can include resources, activities and goals as dependums.

Table 4. 3 Complementary Remarks and Constraints to SeeMe*

As shown in meta-model, decomposition links for i* are not shown here, because it is same as the embedded relationship in SeeMe*. The other classes of SeeMe* are not defined here in detail, because these elements were explained in SeeMe and they will be used in SeeMe* furthermore.

The next important step is to define notations that enable us to model the essence of proposed social aspect in SeeMe* as clearly as possible. To capture these aspects within the SeeMe* model, we have used the current symbols of SeeMe notation with another meaning for defining goals, softgoals, dependencies and social-oriented relationships. In Table 4.4, the graphical notations of new elements are indicated.

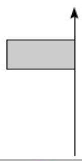
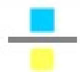
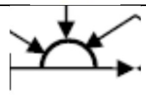
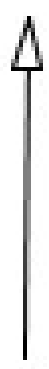
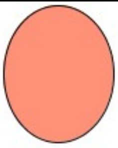
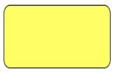
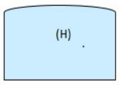
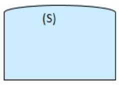
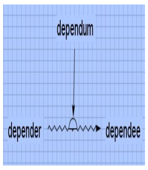
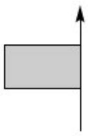
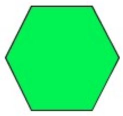
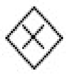
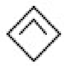
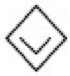
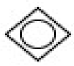
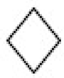
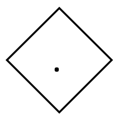
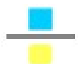
SeeMe Element	SeeMe* Element	Notation
Meta-Basic-Element	Goal and Softgoals in SeeMe (different types of relations are used to differentiate between hard and softgoals)	
Normal relation and entity on the relation	Contribution link to softgoals (make/help/+, hurt /-)	
Divider swim lane	Determining perspective levels	
Assign basic elements to relations	Dependency link	
Inheritance Relation	Link to hard goal (Means-ends link)	
Unspecified relation	Link goals to roles	

Table 4. 4 Extensions on SeeMe Notations: Social-Related Concept

4.2.3 SeeMe* Modeling Guide

This technical recommendation defines the guidelines that have to be taken into account during the creation of a socio-technical work process using the SeeMe* method. The suggested subset of elements is described in the table below. It is based on the specification of SeeMe and i*. The information is split into existing classes in the meta-model.

SeeMe*	Element		Notation	Description
Basic element	Role/Actor			An actor is an active entity that carries out activities to achieve goals by exercising its know-how. In other words, actors are a means to introduce social aspects into the models. They have freedom of action, constrained by relationships with others (sub-roles can be used as position or agent in SeeMe*).
	Activity/Task			Activities specify a particular way of doing something to attain a goal. They are carried out by roles. They stand for the dynamic aspects which represent change, such as completing of tasks, functions etc. On the other hand, an end-user or an application is used to perform the task when it is executed (influence).
	Entity/Resource			Entity represents passive phenomena; e.g. resources being used or modified by activities. It can be an information, software, hardware, or material object. Abilities and skills of roles are types of resources too.
	Hard-goal			Hard-goal describes desired states of affairs. It is "binary", they can be satisfied or not satisfied (the notation of hard goal is the same as softgoal, however it is distinguishable by the type of relations).
	Softgoal			Softgoals are process qualitative objective which the actor would like to achieve but whose achievement cannot be defined a priority as true or false, because it is subject to interpretation and/or negotiation.
Relations	Process-oriented	unspecified		This is a kind of incompleteness: a relation needs not to be directed by an arrow head if its direction is unknown or cannot be identified. In SeeMe*, this relation can be used also to link goals to the roles.
		standard		Standard relation offers nine standard relations (as described in table 4.3) depending on the types of elements (role, activity, entity) being connected and on the relation's direction.
		embedded		Elements can be embedded into other elements; "a sub-element is part of a super-element". It subdivided into three decomposition links, competencies of a role, and carried out by the entity.

	Social-oriented	Dependency		A dependency link indicates that one role (the depender) depends on another role (the dependee) for something (the dependum). Depender depends on dependee for tasks to be performed, resources to be furnished, or goals to be achieved: Type of dependum distinguishes task dependency from resource dependency and goal dependency.
		Inheritance (Means-ends link)		An inheritance link in SeeMe* is used to connect a task to a hard-goal, indicating a specific way to achieve the goal. (means-ends)
		Contribution		Tasks have contributions links to softgoals, indicating how they contribute to achieving those qualities (positively or negatively). We define the type of the contribution (Make/help or hurt) by using entity on the relation.
Modifier	Relation Modifier			The modifiers contain the conditions or events which are assigned to the instantiation of a relation.
	Element Modifier			Modifiers can not only be annotated to relations but also to all kinds of basic elements to represent if the modification has nothing to do with any relations.
Connector	XOR			We use Connectors if two or more relations are assigned to the same element with their starting- or end-points. • The AND-Connector should be used, if all of the relations have to always be instantiated together. • The XOR-connector expresses that exactly one of the connected relations can be instantiated, both relations together are not. • The OR-connector which expresses that either one, a subset or all of the connected relations can be instantiated • The OPTIONAL-connector expresses that one certain relation (which goes through the connector) is mandatory while the other one is optional. • The logical type of a connector can be left unspecified, if its meaning is clear by the context of a diagram or if we do not want to be more precise. • If we want to indicate that further research and decision making is required to specify the connector, we should fill in three dots.
	And			
	OR			
	Optional			
	Empty			
	Needs specification			
Perspective level	Goal level			Different levels allow for the description of the interactions among basic elements of a process and the relations between them. For example, the strategic/goal level defines different aspects of the goals that process tries to achieve them with doing the tasks. It should be mentioned that "Dependum" would be represented at the dependency level.
	Role level			
	Task level			
	Dependency level			
	Entity level			

Attribute			The elements of SeeMe* can be completed with text and numbers. It is possible to add attributes to the elements.
Text			It is possible to add free text to diagrams which is not connected with certain elements. This text can be used to add a headline to a diagram or to make explanations which refer to the whole diagram.
Incompleteness/Vagueness			Incompleteness is indicated by a semi-circle. It is empty if the incompleteness is intentional; three dots indicate that we do not know enough to complete the specification and that further research is required. A question mark indicates doubts about the correctness of the used sub-elements. Note: Relations can be also incomplete. If it is not clear whether a relation should be connected with the whole super-element or only with its sub-elements (and with which of them), the relation crosses the super-element (team) and is not connected with a distinctive sub-element.

Table 4. 5 SeeMe* Modeling Guide

To make SeeMe* easier to comprehend, the following description is mainly focused on the syntactical and semantical aspects of the modeling notation with some examples. The further information about SeeMe notations that are repeated in SeeMe* can be studied from the “SeeMe in a nutshell” article (Herrmann, 2006).

- It can start with the perspective levels which help us to separate the different levels of a SeeMe* diagram. Goal, role, activity, and entity levels include basic elements of a SeeMe* and dependency level can contain three basic elements as a dependum.

Figure 4. 5 Perspective Level

- The sequence of activities are shown in the activity level. The relation between activities is a standard one and it means: an activity is followed by another one.

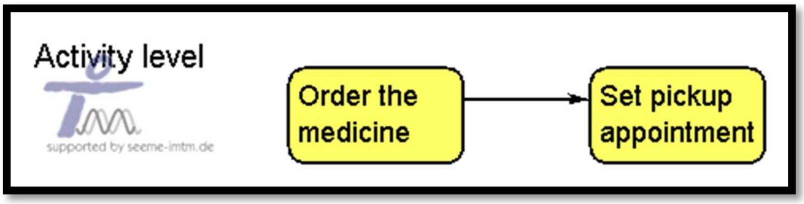


Figure 4. 6 Activity Level

- The roles carry out the activities or are influenced by them (the influence-relation is not often used). For example, the pharmacy sales team check if the prescribed medicine is in discount agreement with the given health insurance or not. The health insurance role is influenced by this activity. Sometimes there are some roles in a work process that carry out no activities; they are only influenced by one or some tasks or have expectations toward other roles.

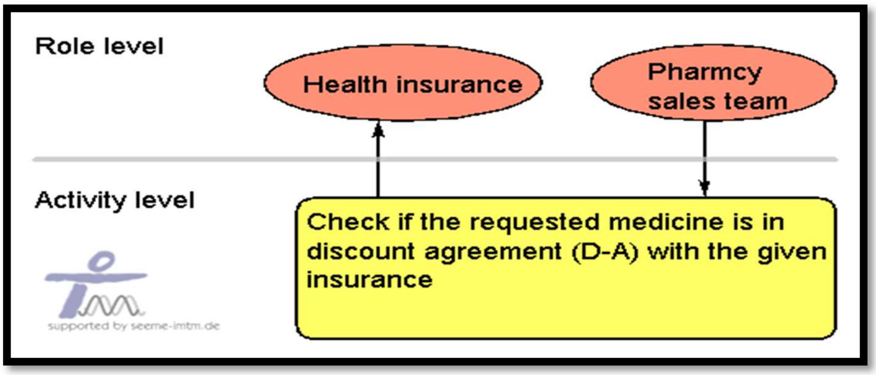


Figure 4. 7 Relations between Roles & Activities

- Entities (customer member card) is used by the activities or activities produce or modify an entity (pharmacy software). Every entity has to be created somehow and/or be used somewhere – and it has to be asked whether this should be modeled or not (Herrmann, 2006). There are also relations between roles and entities: A role can be described by an entity or an entity is possessed by the role. The relations between roles and entities are not common relations.

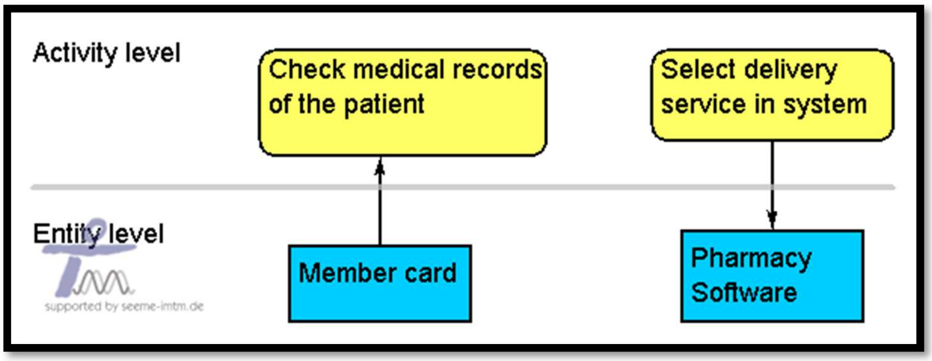


Figure 4. 8 Relations between Activities & Entities

- Elements can be embedded into other elements; a sub-element is part of a super-element. Sub activities describe the steps of the task diagnose sickness. Sub-roles can represent parts of the organizational structure of a more complex role (the sub-roles are used also in SeeMe* to represent different positions/agents of an actor). Entities can also contain their components as sub-entities. Sub-elements can be of another type besides their super-elements:

    - A task can be carried out by an entity (task embedded in an entity).
    - A role may contain an entity which represents its competence.

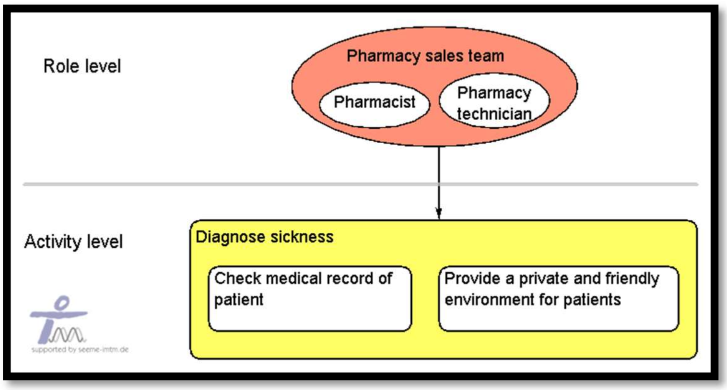


Figure 4. 9 Sub-Elements

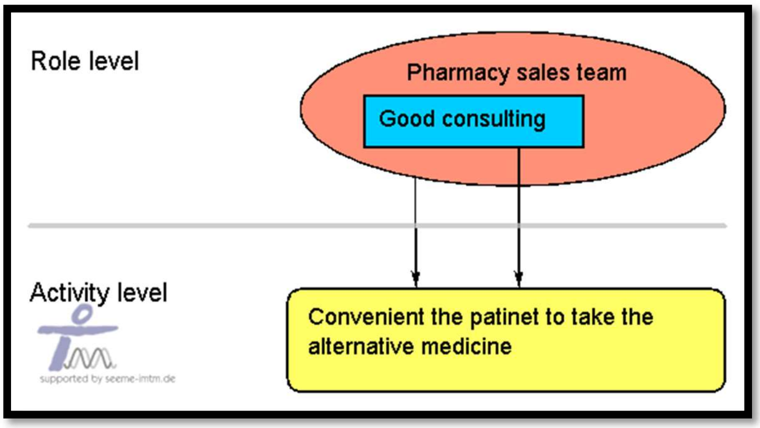


Figure 4. 10 Sub-Elements (Competences)

Note 1: Skills and abilities of roles are represented as a resource in the role. These abilities relate to a task, because it is possible that in several steps of the work process various competences are required to accomplish a task or achieve a goal and these competences are shown as sub-elements within the roles with a relationship to the tasks. This allows us to understand why and where they are required.

- Tasks have connections to hard-goals with means-ends links, which indicates a specific way to achieve the goals. For instance, activity of “check if the prescribed medicine is in discount agreement” is performed in order to “get money back from health insurance”. Besides, tasks have contributions links to softgoals indicating how they contribute to achieving those qualities (positively or negatively is represented with an entity on a relation). Providing a private and friendly environment for patients helps them to have a good consultation.
  - A state (condition or event) can also have a contribution link to a softgoal or a means-ends link to a hard-goal.

Note 2: Each task in SeeMe* has at least one goal. (In some cases, only super-task has one or several goals that can be considered as goals of sub-tasks too)

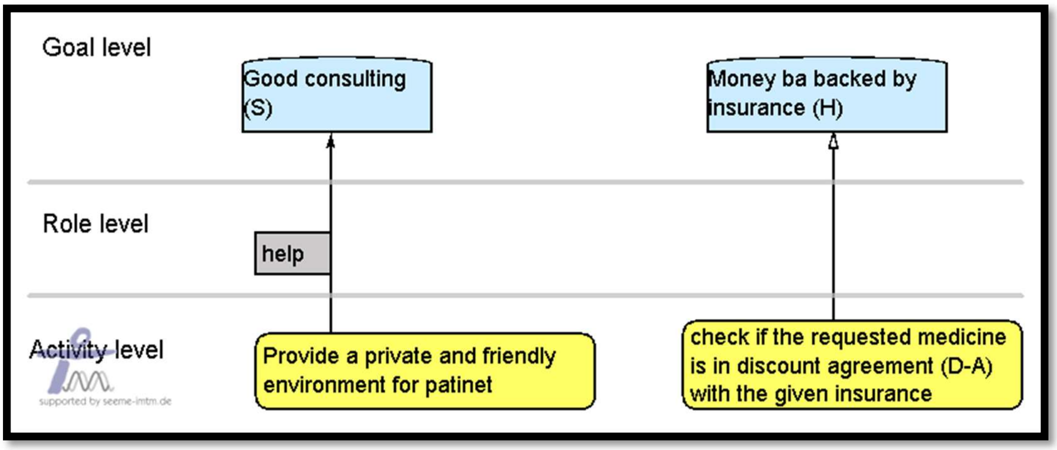


Figure 4. 11 Relation between Activities & Goals

- There is also a way to link goals to the roles. It is an optional semantic and can be omitted from SeeMe* model to simplify the diagram. The unspecified relation between goals and roles can be represented indirectly via the relation between task and goal, because the task carries out by the roles and the goals which are related to these tasks are assigned indirectly to the roles.

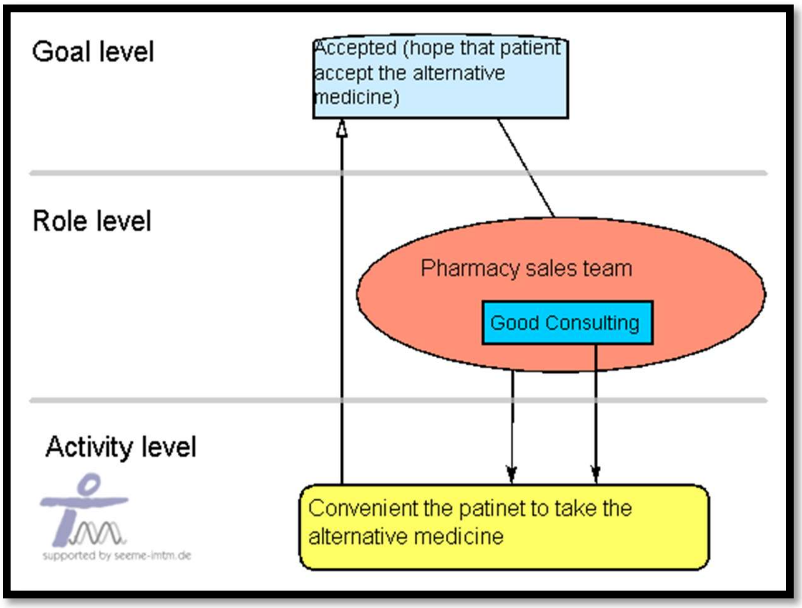


Figure 4. 12 Relation between Goals & Roles

- A dependency link indicates that one actor (the depender) depends on another (the dependee) for something (the dependum). Dependencies can occur between different roles for goals to be achieved, tasks to be performed, and resources to be furnished. We represent follow three types of dependencies as examples:
    - Task-dependency: In order for the patient to achieve the goal of quick service, the patient depends on the sales team to perform the task of "making an efficient service time" successfully. The depender is vulnerable since the dependee may fail to perform the task.

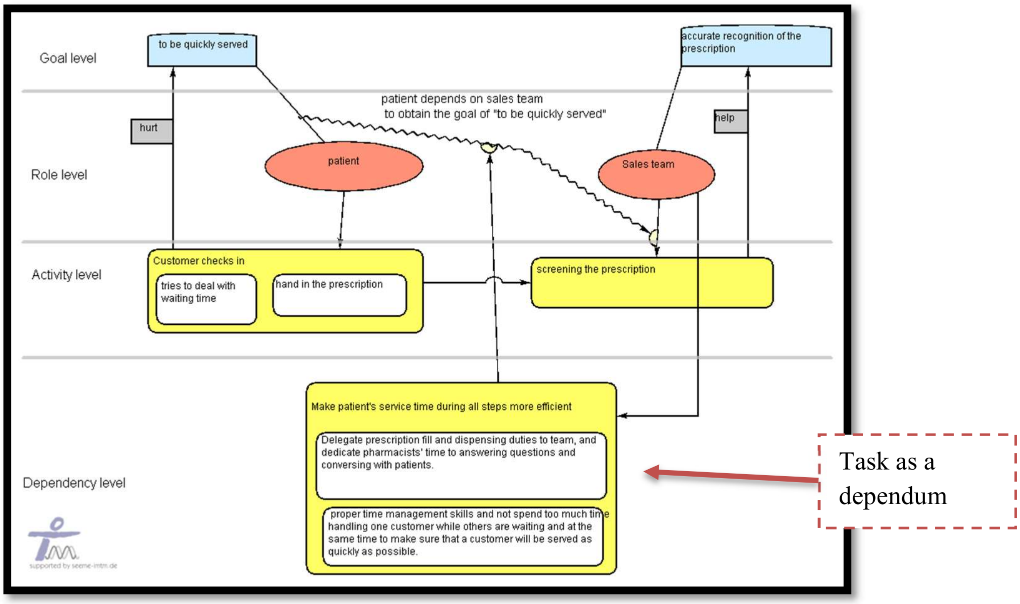


Figure 4. 13 Task Dependency

-
    - Goal-dependency: In this dependency type, the dependum is a goal. The example shows a dependency between one collaborative activities. The sale team talks with the patient to convince him/her to take a discount agreement medicine. The patient' acceptance depends on ability of sales-team to good consulting to give him secure knowledge about the alternative's efficiency. This softgoal to be attained is elaborated as the task of "talking about alternative medication" is performed. The ability of good consulting is a defined skill to perform this task successfully.

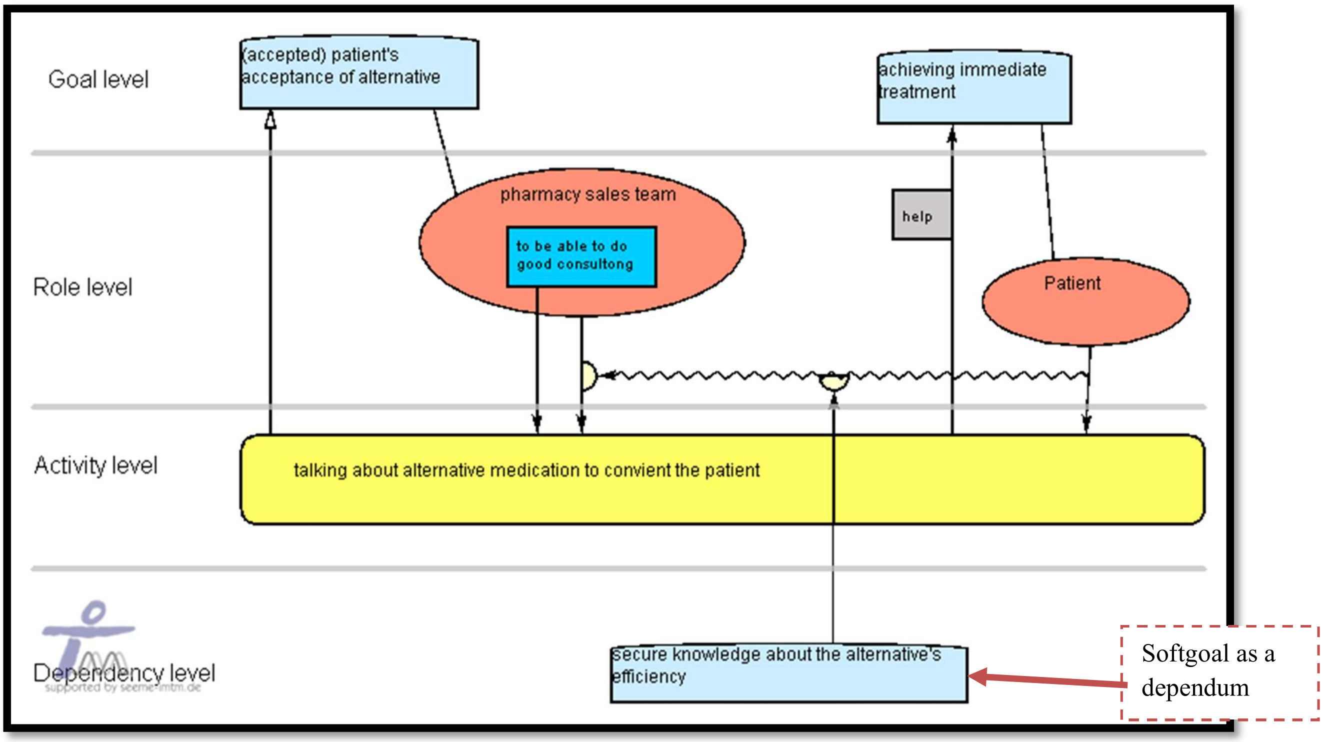


Figure 4. 14 Goal Dependency

- Resource-dependency: As shown in meta-model, the resources can also be an element which be used to achieve a goal. In a resource-dependency, one actor depends on the other for the availability of an entity. In this example, the pharmacist's dependency on the sales teams' recorded data would be modeled as a resource dependency. Only then, the pharmacist is able to optimize the minimum order amounts of the store. In other words, the depender gains the ability to use this entity as a resource. The pharmacy team should set the no-sale medicine (lost sale because lack of stock) in system in order to have statistic record of the data for later analysis. Here the ability of pharmacy team is shown as a resource within the role: "not to forget to set this data in system".

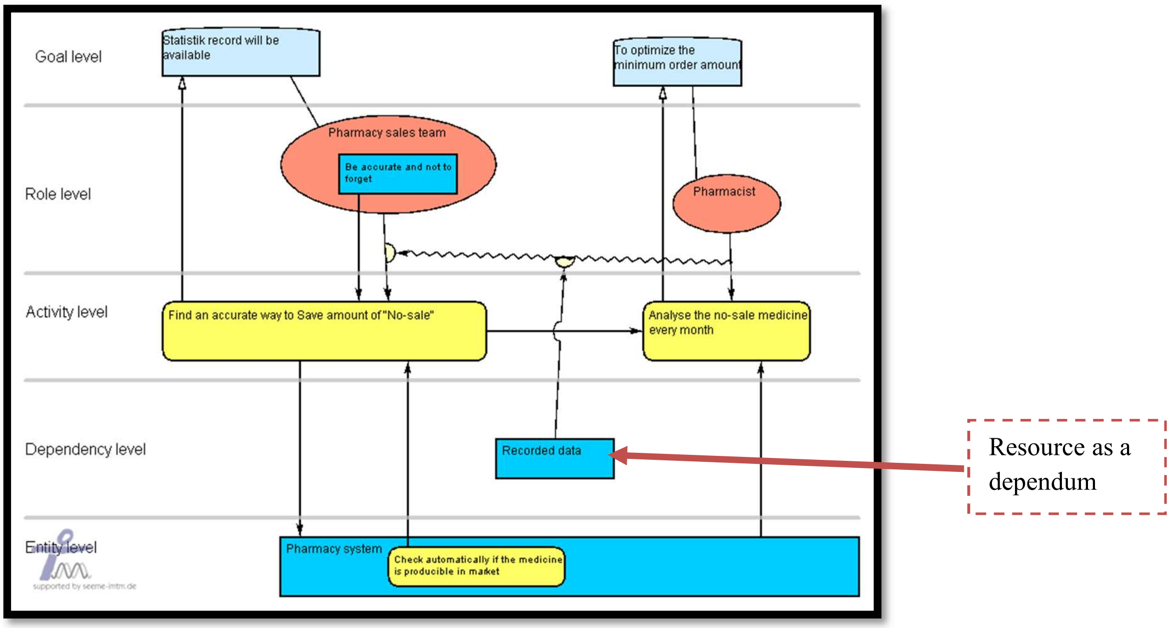


Figure 4. 15 Resource Dependency

- Goals can have relations with each other. One goal can support the other one or conflict with it. Conflicts among stakeholders' goals are usually unavoidable, and the designer needs to balance the trade-offs among conflicting goals. Therefore, the modeling technique should provide ways to represent how goals influence each other.

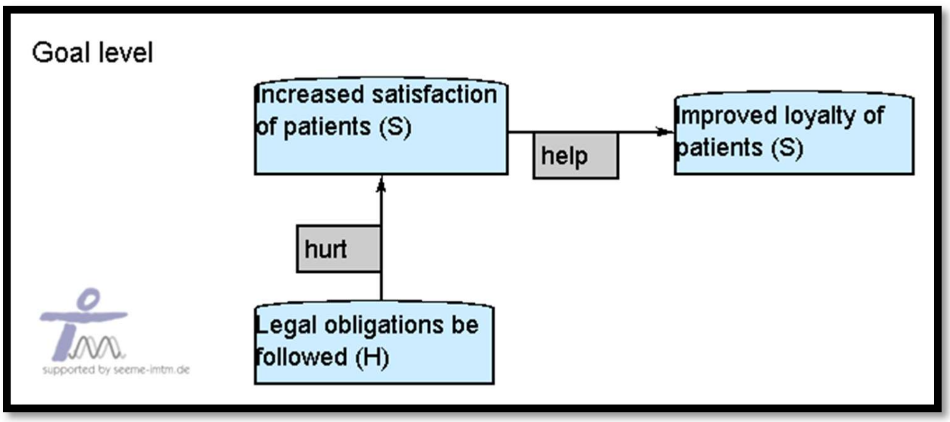


Figure 4. 16 Relation between Goals

As we see in the example above, when legal obligations of consulting patients be followed by pharmacy team, satisfaction of patients can be hurt. Sometimes, patients don't need a long consultation or would like to leave pharmacy fast. Therefore, long consultations conflict with satisfaction of patients in these cases. On the other hand, increasing satisfaction of patients helps improve their loyalty.

Note 3: If one hard-goal has conflict with the other one, the entity on relation can be used to represent the negative effect of one hard goal on the other hard goal. However, in a positive effect, it is not needed to use entity on relation and it can be indicated by a usual inheritance (means-ends) relation which be used always for hard-goals.

- Connectors, modifiers and incompleteness and their application are usual elements of SeeMe and are described thoroughly in Chapter 2.

In Figure 4.17, the graphical notations of the SeeMe* are depicted by means of a small example of the pharmacy case study in order to better understand the new notations.

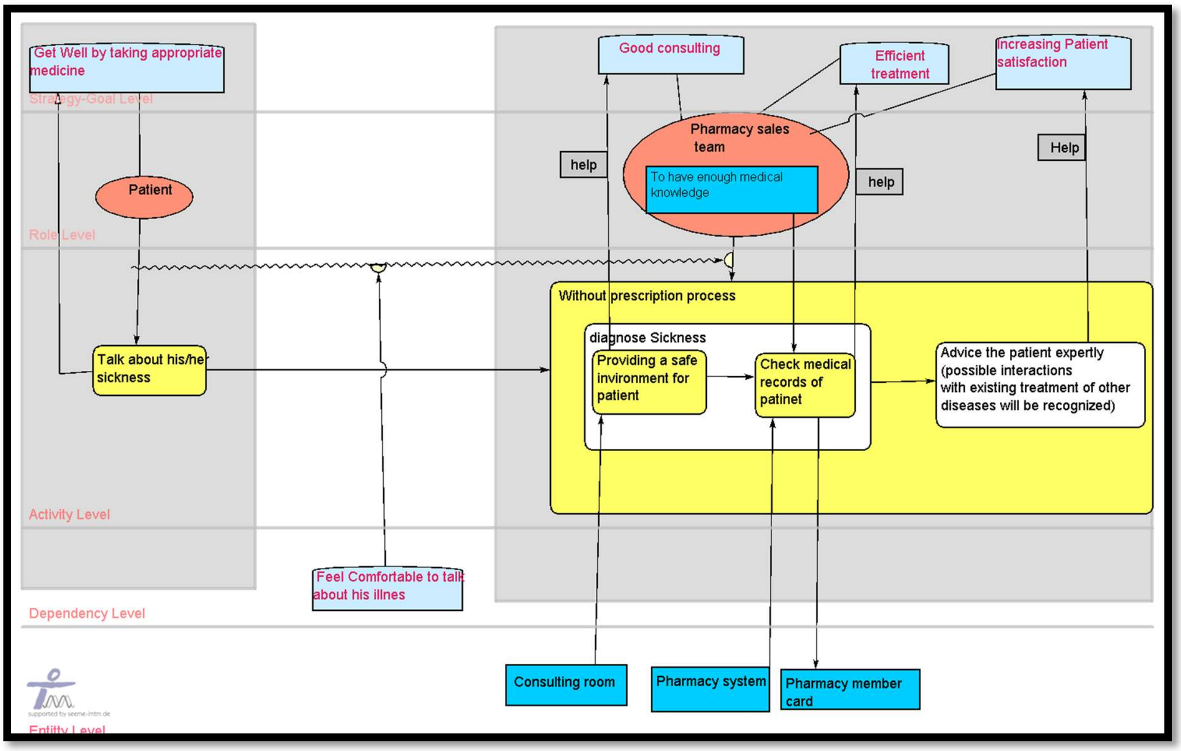


Figure 4. 17 A Small Example of the SeeMe* Notation

As represented, the softgoals such as “efficient treatment” or “increasing patient satisfaction”, are defined as goals of the pharmacy team. These goals can be achieved by carrying out some activities. Moreover, a goal-dependency is shown between two roles. The patient depends on the sales team to perform the task of “providing a safe environment for patient” in order to achieve his goal, which is to “feel comfortable to talk about his illness”. To best accommodate patients and their needs, pharmacists should listen carefully to each patient's needs and establish a sense of trust. Talking about the sickness and asking more questions requires a safe and trusted environment that must be provided by the pharmacy team. Sometimes using a consulting room can provide a reliable environment for patients to ask all of their questions.

The sales team should have enough medical knowledge (as a resource within the role) to check the medical record of patient successfully.

4.3 Evaluation of the Comprehensibility of the Improved Model (SeeMe*)

It is important to determine whether SeeMe* modeling is functional and understandable outside of the group of experts in order to study the technique's theoretical applicability. It is a metric for determining how well a variation of a graphical symbol expresses the intended meaning. The purpose is to ensure that improved modeling method using graphical symbols are readily understood. If the technique is overly complicated, it can cause modellers to become puzzled, resulting in the development of syntactically invalid models.

This section details a small study in which non-expert modellers were asked to explain what they understood from a SeeMe* model. . The primary question for this investigation is ‘How can SeeMe* be understood by non-expert modellers?’ To answer this question, the following study has been applied:

The participants in this study were two students who study IT-management and one research assistant in applied computer science. The experiment lasted one hour for each participant. They were first introduced to the technique with a short tutorial (only the first 30% of a SeeMe* process). Participants were then asked to describe the further explanation of the model themselves. After their explanation, I recognized where they can handle with the model independently and where there are still problems.

Participants were first given a beginner guide introduction to the SeeMe* notation and methodology, which included definitions of basic elements and relationships based on a case study illustration. This tutorial introduced the general motivation for SeeMe*. Additionally, it discussed social characteristics of SeeMe* modeling (the complexity of social roles and their dependencies and goals). This brief instruction does not describe all features of SeeMe* modeling of the pharmacy example in order to examine the participants' understanding of the model. Participants were asked to explain the rest of the SeeMe* in their own terms after being introduced to the technique. This provides a baseline for assessing if the model is understandable or still has some confusing features which should be improved. These contained both questions about the notation (such as whether they had not realized a specific feature of the notation), and questions about the model structure (such as if it was difficult to follow the process of the model). In order to collect more detail, participants were asked to identify the aspects of the technique that they find easier and hardest to comprehend or use.

As a result, participants stated that they found SeeMe* modeling and the method definition easy to understand. Their experience of explaining SeeMe* modeling was generally straightforward and it was easy for them to follow the model. They noticed that the most difficult part of the exercise was "going to come up with the resources and their similarity with dependum in a dependency relationship". Although Overall, The core principles of SeeMe* modeling were commonly understood by non-expert modelers, according to this user report.

The participants had a clear understanding of the basic ideas, though some elements were more complex for them to comprehend. In particular, the distinguished resources from dependencies were sometimes unclear and more difficult to understand. For example, "To have enough medical knowledge" is defined in Figure 4.5 as a dependum to reach the goal: "Efficient treatment". It means that for having an efficient treatment, the pharmacy sales team should have enough medical knowledge to check correctly the medical records of a patient. Understanding this dependency could be not clear on first view.

Sometimes, there was challenging to track a dependency between two activities with a long physical distance. As an instance, one of the activities in the payment segment (end of the process) is dependent on one activity in checking the prescription (at beginning of the process). One of the participants believed that these types of dependencies are not rational for the sake of clarity in the process.

After analyzing the problems, we found that the first problem comes from using the same symbols for representing a resource-dependency (resource as dependum) and an entity in SeeMe*, although they are located in different levels. Maybe as a recommendation for future work, it could be designed a different notation or a different color for resource-dependencies for distinguishing entities from resource-dependency.

Furthermore, for the layout of a SeeMe* diagram, it is recommended that the perspective levels goals are in the top, roles and activities in the middle, and dependencies and entities in the bottom of a diagram. However, this is not a strict semantical rule, and for solving this problem, we can put dependencies and entities with another ordering format; for example, dependencies in the top of the diagram and under the goals.

For solving the other problem, dependencies between two elements locating in a long physical distance, we recommend to apply a different type of relation to show the dependencies. For example, a relation with dashed lines. These changes in graphical representation can probably make tracking the dependencies easier. All of these semantic changes could be a future work that should be developed by software engineers.

4.4 Summary

The main contribution of this chapter is to answer the first research question. To investigate this research question we started with analysis of SeeMe and i* models from Chapter 3 in order to perform the comparison between these models. The summary of this comparison result is conducted into Table 4.1. Considering these analyses and meta-models, it has been summarized that integration of SeeMe and i* models is clearly justifiable and even necessary for the pharmacy in order to represent socio-technical processes in an activity-based diagram representing intentional actors with their dependencies and goals.

The meta-model based approach has been used to the extend SeeMe (It is called SeeMe*). The new graphical notations of SeeMe* are shown in Table 4.4.

As a result, we can see that socially-related concepts such as goals and dependencies can be sufficiently addressed by SeeMe*. I* complements SeeMe by allowing system analysts to model details of relations and dependencies among actors and their motivation and goals. The modeling guide has been explained in Section 4.2.3.

Finally, in order to evaluate the Comprehensibility of SeeMe*, a comprehensive analysis is performed of participants' experience using the SeeMe* notation. The goal was to test if the developed method is understandable to and usable by inexperienced designers. Overall, this research shows that non-expert modelers can understand SeeMe* modeling with reasonable effectiveness.

Chapter5

Eliciting Requirements from SeeMe*

This chapter conducts the application of SeeMe* according to the design specifications in the previous chapter. SeeMe* is applied to the pharmacy case study to elicit socio-technical requirements. This chapter aims to answer the second research question:

- How can socio-technical requirements be elicited from the socio-technical process modeling method?

As mentioned in Chapter 4, the SeeMe* method will be used in this research to understand the processes and goals of the pharmacy - and this understanding helps to redesign the pharmacy as a socio-technical system.

To collect the required data, the second series of interviews (in-depth interviews) were conducted with the pharmacy members. The individual steps of this application of the SeeMe* in order to elicit the requirement are outlined here:

1. Phase 1: „As-is" study
2. Phase 2: Gathering socio-technical requirements of the pharmacy manager
3. Phase 3: "To-be" study
4. Phase 4: Elicitation of solution requirements specification

5.1. Application of SeeM* for Modeling As-Is Process

5.1.1. Data Collection

To be able to answer our second research question, an "as-is" study was performed to understand the current work processes in the context of goals and social dependencies and to provide outputs for a "to-be" study by describing existing work processes.

During the initial observations and first interviews (explained in Chapter 3), it became obvious that the process of "Filling a prescription / dispensing a medication" in the pharmacy is sometimes problematic and needs to be analyzed and improved. Consequently, this part of the pharmacy process has been selected to be analyzed in detail. The procedure of preparing and supplying medications to a named person, along with clear instructions, guidance, and counselling on how to use such medicines, is referred to as dispensing. To exactly understand this process, the second series of interviews were conducted with the pharmacy team. The interviews were carried out face to face in a semi-structured format and lasted five hours (the detailed information about collecting methods are described in Chapter 3).

To understand the problems and bottlenecks, we added some supplementary questions to the second series of interviews (the first interview questions was described in Chapter 3):

- What are the biggest challenges in this activity?
- How will you know you have been successful?
- What problems are there for performing this activity?
- Do you need any assistance to do your work better?

I collected the gathered information from interviews with pharmacy team and analyzed them to better encompass the socio-technical aspects (the detailed questions about social aspects have been mentioned in Chapter 3) and obtain more details to work on where improvements are needed. The data was gathered from the interviews by writing down and taking notes on the facts and viewpoints that the participants had on their past and current experiences.

5.1.2. Data Analysis and Creating "as-is" Process Model

After analyzing the collected data, the "as-is" process had been modeled using the SeeMe* modeling method. To build an as-is process model, I have decided to model the work process with role and entities and represent only the main goal of each super-task, so that the pharmacy manager could use this "as-is" process to analyze the challenges and find the goals and dependencies which are significant for improving this process. Importing opinions of the sales team (about goals and dependencies) in this phase could affect the manager's opinion. However, I applied the social aspects deriving from the interviews with sales team in the next SeeMe*-models (Figure 5.2, 5.3 and 5.4). In many cases the goals and dependencies mentioned by pharmacy team have a lot in common with manager opinions and cover them. Hence, I have analyzed and compared both opinions in the next phases and represent all of them on the next diagrams.

When adopting a social perspective, process roles become the central modeling construct. The "as-is" process is shown in Figure 5.1. (Appendix A contains a detailed description of the process).

As shown in the figure, so many goals aren't defined in this phase, only the main goals for each super-activity. As described above, after gathering requirements of pharmacy manager in the next section, the goals and dependencies are represented accurately in Figure 5.2.

The grey divider areas of SeeMe have been used to represent the phases of the work process, so that it is easier to understand the different phases of activities in the process of “filling a prescription”.

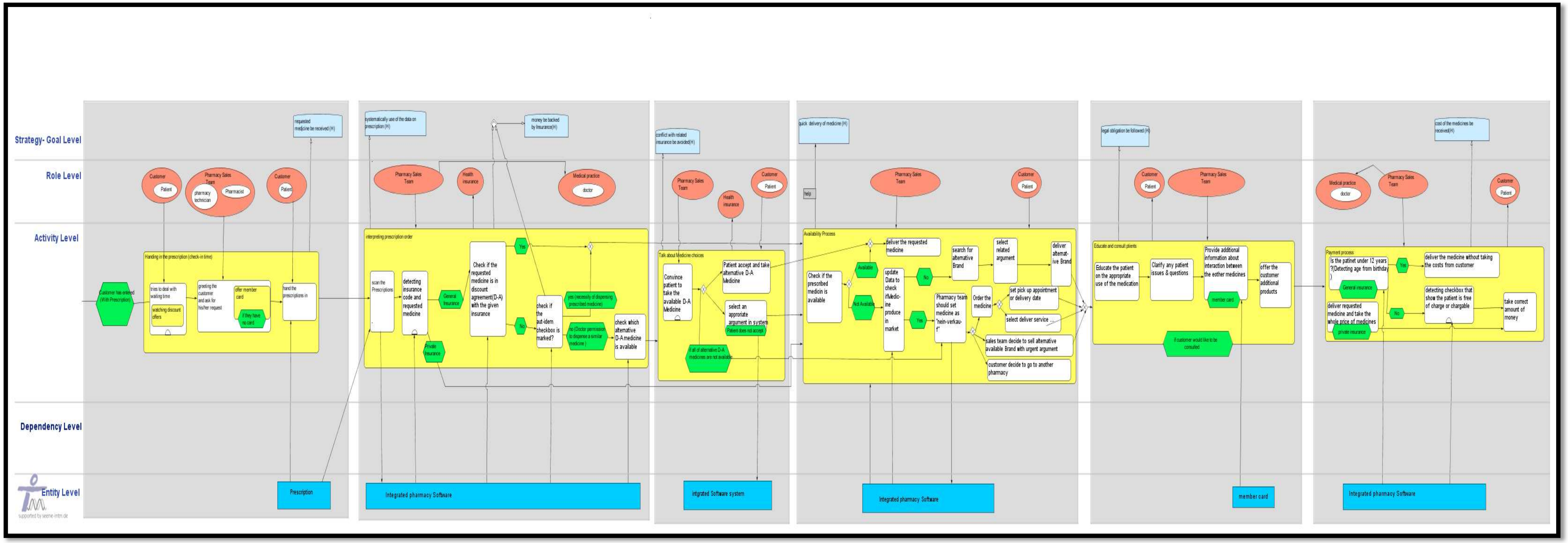


Figure 5. 1 As –is process of „filling a prescription"

5.2. Gathering Socio-Technical Requirements

The use of process descriptions or models during the requirements elicitation process has been discussed in the literature previously. After completion of "as-is" study, it was time to analysis the "as-is" process in order to find work process problems and improvement opportunities (stakeholder requirements). In this thesis, the requirement analysis is done through analyzing the data gathered during the discussions that happened in the interviews and one meeting with the pharmacy manager to recognize his needs. For analysing current situation, I have tried to concentrate on the determination of bottlenecks, conflict among goals of different roles, required skills to do a job correctly, process execution time, and negative effect of some tasks on softgoals, etc.

This meeting with pharmacy manager took three hours and I have summarized the needs as user stories. This analysis helps me to gather social and technical requirements which reveal the opportunities of improving the process. It allows me to define high level requirements without having to go through low level detail too early. In many cases the manager's wishes were from the customer point of view that should be met with the help of the pharmacy team.

The following list of gathered pharmacy manager requirements that cause improvement of the mentioned process and have to be fulfilled by the socio-technical pharmacy system, including software and organizational measures is:

- The check-in time phase in Figure 5.1:
    1. As a pharmacy manager, I want to improve patient service, so that we retain our patients.
    2. As a pharmacy manager, I need better ways to deal with patient check-in time, so that patients have a positive experience during waiting time.
    3. As a pharmacy manager, I need streamlining the patient check-in process, so that patients can experience shorter wait time.
- The availability check phase in Figure 5.1:
    4. As a pharmacy manager, I need checking exact amounts of sale falling due to lack of inventory, so that sale falling can be analyzed and reduced.

5. As a pharmacy manager, I need a better way to know if a medicine is producible or not, so that pharmacy team will not forget to check this option during dispensing medicine.

- The interpreting/screening of prescription phase in Figure 5.1:

6. As a pharmacy manager, I need for ensuring that the scanned data from prescription is comprehensive, so that I know delivery and payment process is more accurate.

- The payment phase in Figure 5.1:

7. As a pharmacy manager, I need a better payment system, so that payments of patient can be collected correctly and without mistakes.

- The educate and consult phase in Figure 5.1:

8. As a pharmacy manager, I need an efficient service time, so that patients are not consulted too long.

- The whole process in Figure 5.1:

9. As a pharmacy manager, I need more accurate processes and support of guiding the patient, so that I can make sure that patients take the correct medicine (pharmacy team mistakes).
10. As a pharmacy manager, I want a trustworthy filling prescription process, so that I can make sure that costs of medicines are returned by health insurance.

5.3. To-Be Study

5.3.1. Creating Goal-Oriented To-Be Diagram of SeeMe*

Considering the overall social and technical requirements of the current pharmacy process, it is clear that the most important issue for modeling "to-be" processes is emphasis on customer satisfaction results from accelerated and qualified services.

To meet the pharmacy manager requirements, I start with the SeeMe* diagram of the "to-be" process that does not include all roles and entities, thereby better understanding and simplifying of the ideal process. Figure 5.2 depicts the SeeMe* without entities; and only some roles which I need to represent the dependencies or goals have been shown in this figure.

Analysing pharmacist's goals and requirements help me to clarify how the process will work, at some point in the future, once changes are made. Those changes have influences on the work methods of the pharmacy team as well as technical systems.

For the case study, Figure 5.2 shows the future process of filling a prescription. Some new tasks, goals, and dependencies have been defined to meet the pharmacist's needs. The data in Table 5.1 provides an overview of these new elements. As in the last section, we gathered high-level requirements from viewpoint of the manager, the new activities in Figure 5.2 include some overall ideas to improve the process and contained implementation details and solutions.
For example, I added some general tasks to manage patients' check-in time and the goals that pharmacy achieve with carrying out these tasks. There are also some new skills that are necessary to reduce the pharmacy team errors or improve the accuracy of the system during this process. "being careful" or "providing good consulting" are some examples of these required skills. All of these improvements try to help the pharmacy to have more loyal and satisfied customers. The new elements of Figure 5.2 are marked in red color to facilitate their recognition. The supplementary description of work processes of Figure 5.2 is available in Appendix B.

Representing actionable approaches to solve the problems and meet pharmacist's goals will be discussed in Section 5.3.2.

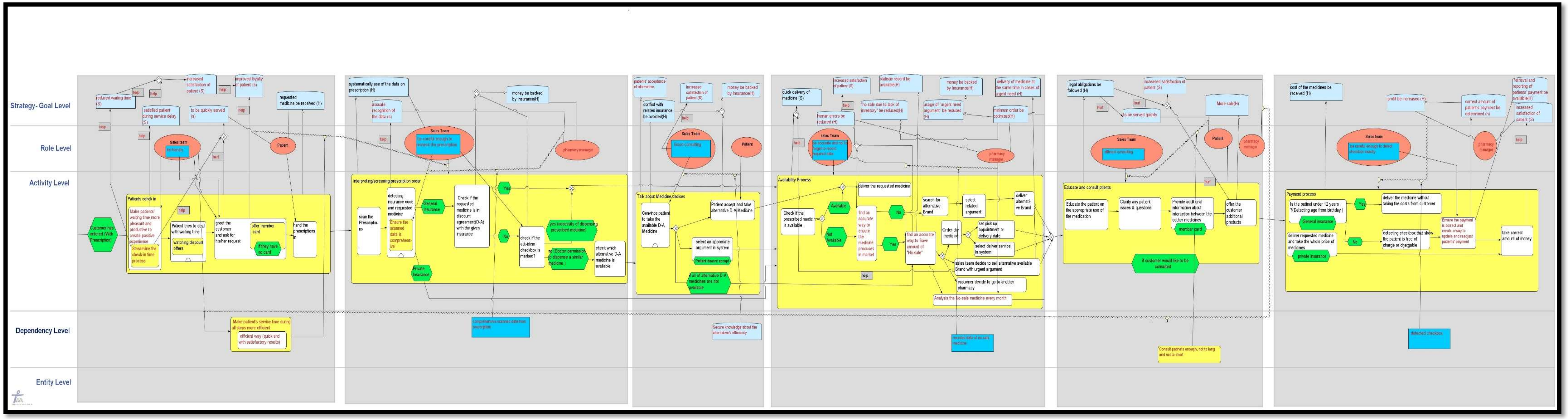


Figure 5. 2 Goal-oriented to-be process of "filling a prescription" (Without entities)

5.3.2. Quality Check of Goal-Oriented Model

To see how correct and exact the pharmacy manager requirements have been mapped into the goal-oriented to-be models, I suggest completing a quality check that ensures correspondence between gathered requirements from stakeholders and new defined elements in the to-be model. For this purpose, the gathered requirements from pharmacy manager have been listed in Table 5.1 and subsequently, it has been checked if all of these requirements are covered with some measures in the to-be diagram or not. These measures have been added as new resources, goals, dependencies, and tasks to the as-is model.

No.	Gathered Requirements	New Task	New Goal	New Dependency	New resource as skill
1	As a pharmacy manager, I want to improve patient service, so that we retain our patients.	------	Improved loyalty of patients (softgoal)	---------	Be friendly
2	As a pharmacy manager, I need better ways to deal with patient check-in time, so that patients have a positive experience during waiting time.	Make patients' waiting time more pleasant and productive to create a positive experience	Satisfied patient during service delay (softgoal)	--------	----------
3	As a pharmacy manager, I need to streamline patient check-in process, so that patients can experience shorter wait time.	Streamline the check-in time process	Reduced waiting time, which helps increased satisfaction of patients (softgoals)	----------	-----------
4	As a pharmacy manager, I need to see exact amounts of sale falling due to lack of inventory, so that sale falling can be analyzed and reduced.	- Find an accurate way to save exact amount of "No-sale" - Analyze the data monthly	- Optimized min order - Instant delivery of medicines - Usage of "urgent need argument" be reduced (hard-goals)	Resource dependency: Pharmacy manager depends on the sales team to have the required data.	Be accurate and not to forget to record required data
5	As a pharmacy manager, I need to ensure that the scanned data from prescription is comprehensive, so that I know delivery and	Ensure the scanned data is comprehensive	Accurate recognition of scanned data (softgoal)	Resource dependency: Pharmacy manager depends on the sales team to	Be careful enough to recheck the prescription

	payment process is more accurate.			receive comprehensive scanned data from prescription	
6	As a pharmacy manager, I need a better payment system, so that payments of patient can be collected correctly and without mistake.	Ensure the payment is correct and create a way to update and readjust patients' payment	- Correct amount of patient payment be determined - Retrieval and reporting of patients' payment be available (hard-goals)	Resource dependency: Pharmacy manager depends on the sales team to detect the checkbox, so that the right amount will be received and profit be increased	Be careful enough to detect checkbox exactly
7	As a pharmacy manager, I need a better way to know if a medicine is producible or not, so that pharmacy team cannot forget to check this option during dispensing medicine.	Find an accurate way to ensure the medicine produces in market	Human errors be reduced (hard-goal)	---------	---------
8	As a pharmacy manager, I want a trustable filling prescription process, so that I can make sure that costs of medicines are returned by health insurance.	----------	- Conflict with related insurance be avoided - Money be backed by Insurance (hard-goal)	Softgoal dependency: Patient depends on the sales team to have secure knowledge about the alternative's efficiency	-Good consulting (for convincing patients to take the discount agreement medicine) - Be careful enough to recheck the prescription and ensure if the first aut-idem checkbox is marked
9	As a pharmacy manager, I need an efficient service time, so that patients are not consulted too long.	---------	To be quickly served (softgoal)	Task dependency: Patient depends on sales team to Consult them	Efficient consulting

				enough, not to long and not to short - Task dependency: Pharmacy manager depends on sales team to make the service time more efficient in order to increase satisfaction of the patient	

Table 5. 1 Quality Check of Requirements

As we see in Table 5.1, necessary measures are regarded as new tasks, new goals, new skills, or new dependencies to meet all of the pharmacy manager requirements, and dependency between roles is also something that has to be taken into account so that social relationships can become productive. One of the pharmacy needs is not mentioned in the table:

"As a pharmacy manager, I need more accurate process to deal with dispensing of medicines, so that I can make sure that patients take the correct medicine (pharmacy team mistakes)."

To meet this requirement, we need to do all of the defined activities in the to-be "filling a prescription" process exactly and while regarding all the new dependencies and required skills. The manger depends on the accuracy of the team (as a softgoal), and he depends on the patients cooperative behavior. For example, if the pharmacy team is able to be careful enough to recheck the scanned data from the prescription, it prevents some human mistakes such as disregarding the discount agreement with insurance, forgetting to update producibility of the requested medicine, or carelessness during different tasks of work process from occurring. Lack of consideration of these new social elements and new tasks lead to dispense incorrect medicine to the patients.

In some cases, I have defined some new softgoals for an existing activity as encompassing the full range of motivations and reasons behind doing a task. It enables analysts and stakeholders to take all factors into consideration for finding solutions to enhance an as-is process. The conflicts between goals are also indicated in the model.

5.3.3. Creating Solution-Oriented To-Be Diagram of SeeMe*

In Section 5.3.1, the goal-oriented SeeMe* is represented. This is all about finding the root cause of the process problems and determining general tasks to achieve pharmacist's goals and needs.

After ensuring the correspondence between new elements of goal-oriented diagram and gathering requirements from pharmacy manager, I have an understanding of the current state pharmacy context and the main opportunities and areas that require improvement. Therefore, I can provide the pharmacy team the opportunity to give their ideas and solutions for how best to solve problems for their business needs. From a manager perspective, the solution requirements may be viewed as describing "how" the solution requirements will meet his need, but even from this perspective it would define the "how" logically and at a high level rather than give details of the implementation of the solution. These requirements describe the characteristics of a solution that meet pharmacy manager requirements.

For instance, one of the pharmacy manager goals is to have more loyal customers who will repeatedly come back if they need medicine. One of the defined tasks in goal-oriented SeeMe* in order to achieve this goal is "make patients waiting time more pleasant and productive". But "how" can this be accomplished?

To find these solutions, I held a brainstorming meeting with the pharmacy team to analyze the requirements in detail and gather a list of ideas. At the meeting, we assumed ourselves as a patient and investigate what s/he needs s in order to be more satisfied during pharmacy visit.

It is important during the solution requirements meeting to provide this opportunity to the pharmacy team because not only have they probably spent a lot more time thinking about these process problems and therefore can provide valuable input into a proposed solution discussion, but they need to feel engaged and part of the solution. We did not take the constraints and limitations into account and tried to consider the ideal future state of the pharmacy process. Then, the proposed solutions were integrated into the existing process to determine capabilities that the solution should have to facilitate getting from the goal-oriented to solution-oriented. We did not elicit only what the user wants, but helped explore what is possible, desirable, and viable. Detail of the analysis represented in Figure 5.3 includes the solutions requirements of the mentioned process in the form of sub-tasks and the goals that would be achieved.

For example, as you see in the Figure 5.3, “to be quickly served” is defined as a goal for the patient. Achieving of this goal is dependent on the sales team. Making patient's service time more efficient is defined as a task dependency to meet this goal. After discussion with the pharmacy team, it became clear that proper time management skills and not spend too much time handling one customer while others are waiting are determined as solution requirements that support the pharmacy team to be more efficient. As you saw in the example above, using dependencies and goals in the diagram facilitate the team to find an appropriate solution in order to improve the process.

The roles and entities were not our focus in this phase. The new elements of Figure 5.3 are marked in red. In the next step we decided whether these requirements are fulfilled with the help of technical support (entities) or by the people / roles in the pharmacy.

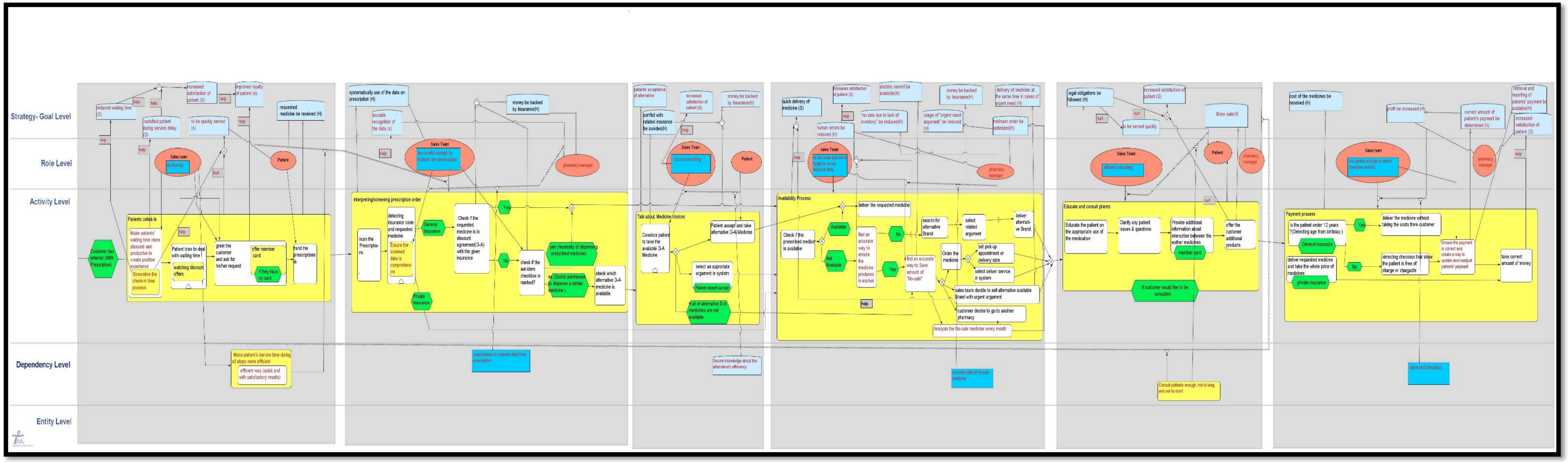


Figure 5. 3 Solution-oriented to-be SeeMe

5.4. Elicitation of Solution Requirements Specification

5.4.1. Defining a Solution Requirements Specification

The SeeMe* diagram alone is not for understanding solution requirements because it does not provide the specification of constraints, such as incompleteness and preconditions, and also is not easy for business members to elicit requirement solutions from the SeeMe diagram. As I mentioned in Chapter 2 (Section 2.5.2), I applied a scenario-based approach to define a specification template and enhance the model with different aspects of the SeeMe* model. The proposed template of scenario-based approaches contains this information:

- Name of the scenario
- Goal that should be achieved by executing the scenario
- Preconditions for execution of the scenario
- General Tasks which help us to achieve stakeholder requirements
- Socio-technical solution requirements (User story format)
- Existed incompleteness and uncertainty during process

The approach is based on the idea of a sequence of action that must be performed by a user and by a software system. With the following table, all of the new activities within goal-oriented SeeMe* (Figure 5.3) are listed, followed by the relevant solution requirements for each activity. The vagueness and preconditions are also represented. To guide the mapping and integration process of eliciting the requirements from SeeMe*, I have defined some guidelines in Section 5.4.1.

Work Process	Filling a prescription
Business Requirement	Pharmacy needs to increase patient satisfaction
Hard Goal	Quick and correct dispensation of requested medicine
Preconditions	Log into the integrated pharmacy system

No.	**New Tasks from goal-oriented to-be SeeMe***	**Socio-Technical Solution Requirement**	**Vagueness/Incompleteness**	**Precondition**
1	Make patients' waiting time more pleasant and productive to create positive experience	As a patient, the pharmacy socio-technical system guides me to enter the reason for the visit and take a number to estimate my waiting time, in order to avoid insecurity during waiting time and increase my satisfaction.	What happens if a patient could be served although he is stilling working on the registration form?	
		As a patient, the pharmacy socio-technical system guides me to scan the prescription by myself during waiting time in order to keep me happy during waiting time and increase my satisfaction.		
		As a new patient, the pharmacy socio-technical system invites and helps me to fill out a registration form in case of longer waiting time in order to increase my satisfaction.		New patient
1.1	Streamline the check-in time process	As a patient, the pharmacy socio-technical system invites me to purchase over-the-counter medicines using drive-through service, in order to reduce waiting time.		
		As a patient, the pharmacy socio-technical system provides me to order my prescription request online and then use separate queues to take the ordered medicine in order to reduce waiting time.	Does this solution meet legal requirements of the pharmacist association?	
2	Patient tries to deal with waiting time	As a patient, the pharmacy socio-technical system invites me to use a well-designed waiting area with interesting magazines in order to increase my satisfaction.		
		As a patient, the pharmacy socio-technical system makes me feel respected with comfortable furniture and facility in waiting area in order to increase my satisfaction.		
3	Welcome the patient and clarify of medication order	As a patient, the pharmacy socio-technical system provides me a customer-friendly environment to encourage me to come		

		back repeatedly if I need medicines (or to improve my loyalty).		
		As a patient, pharmacy the socio-technical system offers a highly skilled team, so that I can receive better customer service and it increase my loyalty.		
4	Make patient's service time more efficient	As a patient, the pharmacy socio-technical system offers me to take the medicines from pharmacy assistance and the consulting services from the pharmacist, so that I can get better service and they can manage their service time.		
		As a patient, the pharmacy socio-technical system offers the pharmacy team with proper time management to not spend too much time handling one patient while others are waiting at the same time, in order to serve me as quickly as possible.		
5	Ensure the scanned data is comprehensive	As a pharmacy manager, the pharmacy socio-technical system provides me with accrue pharmacy team to correct the unreadable field of prescription (such as insurance code, etc.) and full recognition of the imported data from the prescription, so that the patient can take the correct prescribed medicine.	When is all info readable? What information is important?	Data is imported from scanned prescriptio n
6	Convince the patient to take the discount agreement medicine	As a pharmacy manager, the pharmacy socio-technical system offers good communication skills to convince patients to buy the intended medicine, so that we can pay the costs of medicine to pharmacy without conflicting with health insurance.	To some extent is it important to convince patient to take DA medicine?	Patient does not need use definitely the prescriptio n medicine
		As a patient, the pharmacy socio-technical system guides me to take the alternative medicine, so that I can get secure knowledge about the alternative's efficiency		
7	Find an accurate way to ensure the medicine produces in market	As a pharmacy manager, the pharmacy socio-technical system provides me with the correct information about producible medicine in market, so that it avoids making a promise of delivering the medicine, which does not exist in the market and it increases patient's satisfaction.		The product is not available in pharmacy inventory
8	Save exact amount of "no-sale "	As a patient, the pharmacy socio-technical system is able to save exact records of the lack of requested medicine in stock ("no-		The medicine

		sale" medicine), so that we can receive our requested medicine instantly.		produces in market
		As a pharmacy team, we want to have the order of “no-sale” medicine automatically, in order to make order process easier and avoid errors.		
9	Analysis of the “no-sale” medicine every month	As a pharmacy manager, the pharmacy socio-technical system provides me with recorded data of no-sale medicine in order to enable me to optimize the minimum order amount of “no-stock” medicine and to store the safety stock constantly.		
10	Consult and educate patients	As a patient, the pharmacy socio-technical system makes consulting efficient, so that I can take the medicine accordance with the instruction and served as quickly as possible.		
11	Ensure that the payment is correct and create a way to update and readjust patients' payment	As a patient, the pharmacy socio-technical system provides me an opportunity to manage my payment account, so that I can get a refund or payout the rest amount of payments in case of payment mistake.		
		As a pharmacy manager, the pharmacy socio-technical system is accurate enough to ask the patient if he or she is free of charge or not, in order to inform him or her with the correct amount of payment.		
		As a patient, the socio-technical system guides the sales team to make sure that I am free of charge or chargeable, so that I can pay the correct cost of the medicine.	Sometimes doctor assistants mark the checkbox false/ sometimes the marked check box is not clear	Patients with general insurance and more than 12 years old

Table 5. 2 Solution Requirements Specification

As I mentioned before, analysis of the “why” (goals) helped the pharmacy team to find the solutions easier. For example, pharmacy team has found that “to improve customers’ loyalty”, they should offer a customer-friendly environment. In the next phase, I held a meeting with the pharmacy manager to agree upon the solution requirements of target system using Table 5.2. By analyzing each item, we determined whether these requirements were fulfilled with the help of technical support or by the social roles/people in the pharmacy. To facilitate this analysis, a table with three columns was created: the first column to list the solutions, the second one to describe how we can execute this solution, and the last column to specify the type of requirements with answering following questions (who or what is responsible):

- Who are the actors that execute the activity in order to achieve its goal?
- Has the activity or requires some form of support from an information system?

No.	Solution Requirements	How	Who/ What
1	As a patient, the pharmacy socio-technical system guides me to enter the reason for the visit and take a number to estimate my waiting time, in order to keep me happy during waiting time and increase my satisfaction	As patients arrive, they enter their reason for the visit into a ticket system and take a number. The information is organized and presented to pharmacy team to allow for faster customer service response	Technical
2	As a patient, the pharmacy socio-technical system guides me to scan the prescription by myself during waiting time in order to keep me happy during waiting time and increase my satisfaction.	Providing a scanner which allows patients to scan their prescription during waiting time and send it to the pharmacy system	Technical
3	As a new patient, the pharmacy socio-technical system invites and helps me to fill out a registration form in case of longer waiting time in order to keep me happy during waiting time and increase my satisfaction.	Provide waiting area with a registration form for new patients and guide them to fill out the forms (if the patient is new).	Social (Pharmacy team)
4	As a patient, the pharmacy socio-technical system invites me to purchase over-the-counter medicines using drive-through service, in order to reduce waiting time.	Update pharmacy layout to apply one cash desk for drive-through service and allow customers to purchase products without leaving their cars.	Social (Pharmacy team)
5	As a patient, the pharmacy socio-technical system provides me to order my prescription request online and then use separate queue to take the ordered medicine in order to reduce waiting time.	Provide a website which allows patients to upload their prescription and order the medicine online. Provide a new and separate queue for these patients.	Technical/ Social (Pharmacy team)
6	As a patient, the pharmacy socio-technical system invites me to use a well-designed waiting area with interesting magazines in order to increase my satisfaction.	Improve waiting area with health and medicine magazines and update this area frequently.	Social (Pharmacy team)

7	As a patient, the pharmacy socio-technical system makes me feel respected with comfortable furniture and facility in waiting area in order to increase my satisfaction.	Provide patients with comfortable furniture and facility in waiting area (a task that must be done only one time).	Social (Pharmacy team)
8	As a patient, the pharmacy socio-technical system provides me a customer-friendly environment to encourage me to come back repeatedly if I need medicines (or to improve my loyalty).	Culturing a customer-friendly environment at the pharmacy.	Social (Pharmacy team)
9	As a patient, the pharmacy socio-technical system offers a highly skilled team, so that I can receive better customer service and it increase my loyalty.	Hold some courses to improve customer service skills.	Social (Pharmacy team)
10	As a patient, the pharmacy socio-technical system offers me to take the medicines from pharmacy assistance and the consulting services from pharmacist, so that I can get better service and they can manage their service time.	Delegate dispensing medicine duties to pharmacy assistants and dedicate consulting duties to pharmacists to manage service time.	Social (Pharmacy team)
11	As a patient, the pharmacy socio-technical system offers pharmacy team with proper time management to not spend too much time handling one patient while others are waiting at the same time, in order to serve me as quickly as possible.	Not to spend too much time handling one patient while others are waiting at the same time.	Social (Pharmacy team)
12	As a pharmacy manager, the pharmacy socio-technical system provide me with accrue pharmacy team to correct the unreadable field of prescription (such as insurance code, etc.) and full recognition of the imported data from the prescription, so that the patient can take the correct prescribed medicine.	After scanning the prescription, pharmacy teams have to check all imported data and correct the unreadable parts of prescription	Social (Pharmacy team)
13	As a pharmacy manager, the pharmacy socio-technical system offers good communication skills to convince patients to buy the intended medicine, so that we can pay the costs of medicine to pharmacy without conflicting with health insurance.	Pharmacy team is responsible to sell the prescribed medicine which is in discount agreement with patients' health insurance. Pharmacy team must have good communication skills to convince patients to buy intended medicine.	Social (Pharmacy team)

14	As a patient, the pharmacy socio-technical system guides me to take the alternative medicine, so that I can get secure knowledge about the alternative's efficiency	Pharmacy team should provide the patient with good consulting skills in order to give patient enough knowledge about the alternative's efficiency	Social (Pharmacy team)
15	As a pharmacy manager, the pharmacy socio-technical system provides me with the correct information about producible medicine in market, so that it avoids making a promise of delivering the medicine, which does not exist in the market and it increases patient's satisfaction.	The integrated pharmacy system must automatically check if the medicine is available in market or not (in case of out of stock medicine)	Technical
16	As a patient, the pharmacy socio-technical system is able to save exact record of the lack of requested medicine in stock ("no-sale" medicine), so that we can receive our requested medicine instantly.	The integrated pharmacy system must set the medicine automatically as "no-sale "(after going through previous steps).	Technical
17	As a pharmacy team, we want to have the order of "no-sale" medicine automatically, in order to make order process easier and avoid our errors.	The integrated pharmacy system must order the no-sale medicine automatically.	Technical
18	As a pharmacy manager, the pharmacy socio-technical system provides me with recorded data of no-sale medicine in order to enable me to optimize the minimum order amount of "no-stock" medicine and to store the safety stock constantly.	The pharmacy manager must analyse the no-sale medicine monthly and optimize the order point in system.	Social (Pharmacy manager)
19	As a patient, the pharmacy socio-technical system makes consulting efficient, so that I can take the medicine accordance with the instruction and served as quickly as possible.	The pharmacy team must be able to educate the patient on the appropriate use of the medication.	Social (Pharmacy team)
20	As a patient, the pharmacy socio-technical system guides the sales team to make sure that I am free of charge or chargeable, so that I can pay the correct cost of the medicine.	The integrated pharmacy system must ask the question in last step: is the patient free of charge or chargeable? Therefore, the pharmacy team needs to recheck the status of patients again.	Technical
21	As a patient, the pharmacy socio-technical system provides me an opportunity to manage my	Improve integrated pharmacy system with creating payment account for each patient.	Technical

	payment account, so that I can refund or payout the rest amount of payments in case of payment mistake.		
22	As a pharmacy manager, the pharmacy socio-technical system is accurate enough to ask the patient if he or she is free of charge or not, in order to inform him or her with the correct amount of payment.	The pharmacy team must recheck the payment amount and reduce human errors.	Social (Pharmacy team)

Table 5. 3 Types of Solution Requirements

As explained above, twenty two solution requirements are listed from the analysis of to-be SeeMe*. With regard to the third column of Table 5.3, the SeeMe* model is completed with role and entity. As mentioned in Chapter 2, the roles in SeeMe modeling notation is to introduce social aspects into the models and represents persons, teams, or organizations. Besides, the entities are utilized to assign the technical system as a participant who is responsible for doing the activities. Figure 5.4 shows the solution-oriented SeeMe* with all required roles and entities (detailed description is presented in Appendix C).

5.4.2. Guidelines for Deriving Requirement from SeeMe* Model

To guide the deriving process of requirement specification from SeeMe* model, I have defined some guidelines to translate the information of the SeeMe* (Figure 5.4) to the requirements specification (Table 5.2), by applying the following rules.

In the sequel, we suggest eight heuristics for eliciting requirements from the to-be solution-oriented SeeMe*.

1. Guideline G1: How to derive activities from SeeMe*;
2. Guideline G2: How to derive goals and softgoals from SeeMe*;
3. Guideline G3: How to derive task dependencies from SeeMe*;
4. Guideline G4: How to derive resources from SeeMe*;
5. Guideline G5: How to derive goal dependencies from SeeMe*;
6. Guideline G6: How to derive skills from SeeMe*;
7. Guideline G7: How to derive incompleteness from SeeMe*;
8. Guideline G8: How to derive modifiers from SeeMe*;

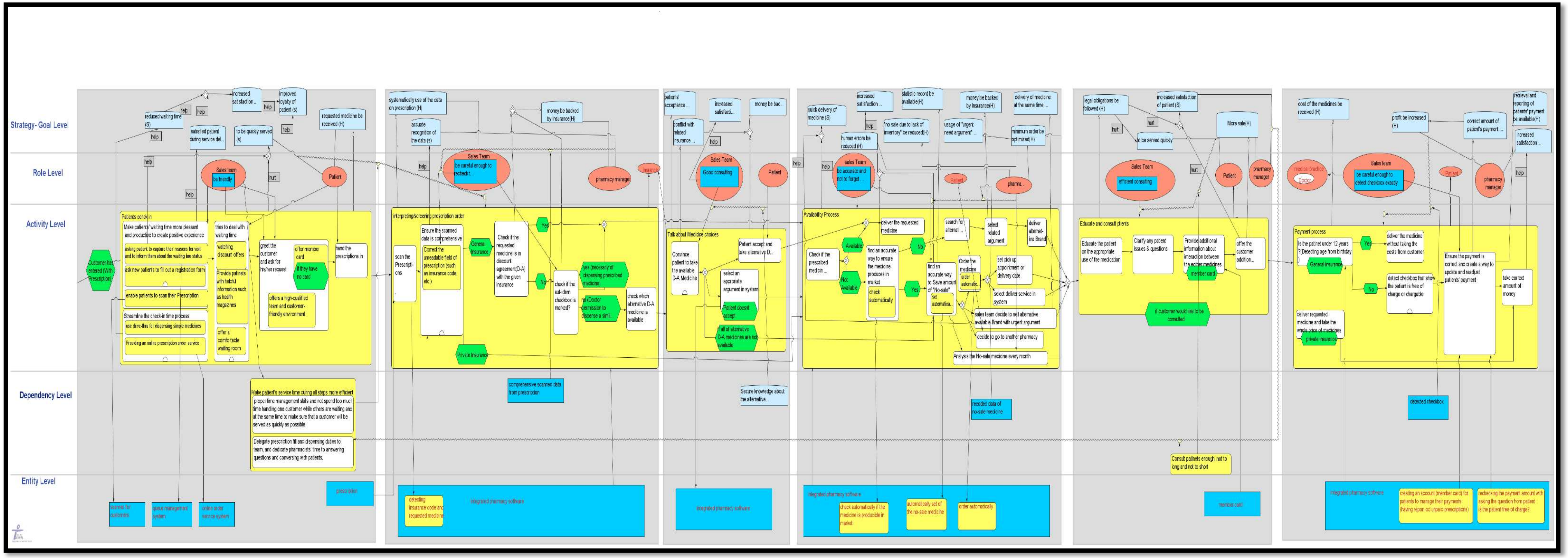


Figure 5. 4 Solution-oriented to-be SeeMe with Entities

1. Guideline G1: How to Derive Activities from SeeMe*

The first step is to determine whether the activity is relevant, if the activity is new and it is therefore not defined in „as-is" model, then it needs to have its requirements specified. An activity that is not changed in the to-be model, does not need to be mentioned as a derived requirement. Each relevant activity in goal-oriented SeeMe* is usually mapped onto a super-activity in the solution-oriented to-be diagram. Therefore, the relevant solutions for each activity is stated as sub-tasks in the model. The following questions are to be asked in order to determine whether an activity is relevant or not:

- Is it a new task in the to-be model?
- If not, is it an existing task with new goals or dependencies?

If the answer to one of the questions above is yes, the activity is relevant to be specified as a requirement in the requirement specification table. To elicit requirements from to-be solution-oriented SeeMe*, the super-tasks should be listed in the first column of the specification table and sub-tasks are represented as solution requirements in the second column.

For example, in the Table 5.2 the activity "Make patients' waiting time more pleasant and productive to create positive experience" is defined as a new task (super-task) and the solution socio-technical requirement is represented as the second column: "As a new patient, the pharmacy sociotechnical system invites and helps me to fill out a registration form in case of longer waiting time in order to increase my satisfaction".

I suggest expressing solution requirements in a similar form to user stories, which is an informal, natural language description of one or more features of a system. User stories are often written from the perspective of an end user or user of a system and explain the reason of doing activities.

Our defined solution requirements follow following formats:

- As a <role>, the system provides me <capability>, so that I can <receive benefit>.
- As a <role>, the system provides me <capability>, in order to enable me to <receive benefit>.

2. **Guideline G2: How to Derive Goals and Softgoals from SeeMe***

An activity is always performed in order to meet some interest of the stakeholders. The new goals defined for each activity can be stated as the "receive benefit" or the "why" part of the defined format above, that is stated usually after "so that" or "in order to" part. Assuming that each of the studied activities represents the achievement of a goal, strategic goals are obtained as a response to the following question:

- What is the final state achieved by executing the activity?

For example, in the pharmacy case study to-be process (see Figure 5.3) the first super task is: "Make patients' waiting time more pleasant and productive to create a positive experience"

This activity is stated in the first column of Table 5.2. One of its sub-tasks is explained as the first solution requirement in the specification table as follows:

> "As **a patient**, the **pharmacy socio-technical system guides me** to enter the reason for the visit and take a number to estimate my waiting time **in order to** keep me happy during waiting time and increase my satisfaction."
>
> "As **a patient**, the **pharmacy socio-technical system guides me** to scan the prescription by myself during that waiting time in order to keep me happy during waiting time and increase my satisfaction."

As mentioned in Section 5.3.3, these solutions have been determined during the discussion with the pharmacy team to meet the defined goals for each task. For instance, to make the patients' waiting time more efficient, the pharmacy team support patients to enter the reason for their visit and take a number to estimate their waiting time. This solution is defined to increase the satisfaction of the patient during the waiting time.

3. **Guideline G3: How to Derive Task Dependencies from SeeMe***

The task dependency should be, like the other activities, taken into consideration. For instance, "to be quickly served" as a softgoal of the patient is dependent on the efficiency of the task "interpreting/screening prescription", which is performed by the sales team. Therefore, "make patient's service time more efficient" as a task-dependum in Figure 5.4 can be considered as an activity in the first column of the specification and its sub-tasks as solution requirements in the second column:

"As a patient, pharmacy socio-technical system offers me to take the medicines from pharmacy assistants and the consulting services from the pharmacist, so that I can get better service and they can manage their service time."

4. **Guideline G4: How to Derive Resource Dependencies from SeeMe***

The resource dependencies are like solutions requirements and should be stated as "capabilities" in user story statements. In Figure 5.4, the pharmacist/pharmacy manager depends on the sales team to have "recorded data" as a resource-dependum in order to "optimize the minimum order amount". It is expressed in Table 5.2:

"As a pharmacy manager, the pharmacy socio-technical system provides me with **recorded data of no-sale medicine** to enable me to optimize the minimum order amount".

5. **Guideline G5: How to Derive Goal Dependencies from SeeMe***

The goals dependency can be stated as the "receive benefit" or the "why" part of the defined format above that is stated usually after "so that" or "in order to" part. For instance, the patient's decision to take the alternative medicine depends on the secure knowledge of the pharmacy team about the alternative's efficiency.

"As **a patient**, the **pharmacy socio-technical system guides me** to take the alternative medicine, so that I can get secure knowledge about the alternative's efficiency"

6. **Guideline G6: How to Derive Skills from SeeMe***

The skills included in roles are like solutions requirements and should be stated as "capabilities" in the user story statements. In Figure 5.4, "be friendly" is defined as a capability of pharmacy team that indirectly "improves patient loyalty" in the welcome task of a pharmacy team. It is expressed in Table 5.2:

"As a patient, the pharmacy socio-technical system provides me a **customer-friendly environment** to encourage me to come back repeatedly if I need medicines (or to improve my loyalty)."

7. **Guideline G7: How to Derive Incompleteness from SeeMe***

The incompleteness in SeeMe*, which is shown by mouse hole, can be described in the third column of the specification, to represent incomplete or uncertain information and to indicate those aspects of a model which are only incompletely specified. For example, a vagueness issue defining for the first super-task is as follows:
"What happens if a patient could be served although he is stilling working on the registration form?"

8. **Guideline G8: How to Derive Modifiers from SeeMe***
   - G8.1: Start event

Modifiers show conditions or events in SeeMe. Events are passive elements that describe under what circumstances a function or a process works or which state a function or a process results in. In general, process diagrams can start and/or end with relations instead with activities – these relations can be indicated with start- or end-modifiers. The first Modifier is considered as a start event in SeeMe*.

   - G8.2: Preconditions

The preconditions in the specification are the modifiers in the SeeMe*. Modifiers can be annotated to relations and all kinds of basic elements as conditions. Generally, preconditions are a condition or predicate that must always be true just prior to the execution of some activities or before an operation in a formal specification. The last column of the table is dedicated to writing preconditions.
In Table 5.4, a compact template of the eliciting method is presented that can be useful for software engineering experts to automatize the elicitation of the requirement specification table from the solution-oriented to-be SeeMe*. All the proposed guidelines can be performed systematically and even automatically with appropriate tool support in future works.

The first column of the table represents the steps to filling the table in order of preference. The second column shows the description of each step that is to be populated with information.

Steps	Description
Finding the start point	The first activity that is located after the first modifier defines the first point of the process. The modifier appears at the beginning of the process and there is no activity before it.
Finding the relevant tasks	To find the relevant tasks, the answer to one of these questions must be yes: ***Is it a new task in the to-be model?*** ***If not, is it an existing task with new goals or dependencies?***
Filling the first column	To write relevant tasks from goal-oriented to-be SeeMe* in the first column.
Eliciting solution requirements and filling the second column	To use a user story template.
	To find the end user of each solution requirement (Who receive benefit from doing this task) and to replace it with <role> in the template.
	-To replace the <capability> part of the template with the help of the presented solution as sub-tasks. -To replace the <receive benefit> part of the template with the help of the related goals to this task. Note: Task dependency has also the same structure
	-To replace the <capability> part of the template with the help of the presented resource dependency. -To replace the <receive benefit> part of the template with the help of the related goals to this dependency.
Finding the preconditions and filling the last column	-To find modifiers before each activity that shows the conditions. -To find modifiers that be annotated to activities.
Finding the vagueness and filling the third column	To find mouse hole embedded in an activity. In the third column we must describe about the incompleteness or lack of knowledge which existed during this activity.

Table 5. 4 Summary of Deriving Solution-Requirements from SeeMe*

All the proposed guidelines provide support for deriving requirements specification from a SeeMe* model. These guidelines obtain the elements of a requirement specification from a to-be model, then help the analyst to determine who/what is responsible to achieve the goals and to obtain different courses of action.

5.5. Summary

This chapter has presented the application of SeeMe* to specify the socio-technical requirements, which is the answer of second research question. The purpose of this question is to find a comprehensive list of stakeholder requirements using as-is SeeMe*.

As an input for this section, we conducted the second interview with pharmacy participants to model the "as-is" state of "filling a prescription" process and simultaneously realize stakeholder needs in order to improve this process.

Analyzing the "as-is" situation and the gathered socio-technical requirements resulted in the goal-oriented "to-be" process. This phase helped us to do a root cause analysis to understand the problems and consequently find solution requirements for target systems. As a result, solution requirements have been represented by requirement specification (Table 5.2) and thereby helped pharmacy members to document solution requirements easier. In Section 5.4.1, we have suggested some guidelines that would assist a systematic requirements elicitation from SeeMe* models. This thesis presents a method for eliciting requirements from solution-oriented to-be models.

Using the SeeMe* modeling method provide us this opportunity to gather a comprehensive list of solution requirements which is not achievable with i* or SeeMe models alone. Considering complex relationships among pharmacy members, their strategic interests and goals (sometimes conflicting), and their dependencies in a workflow, process modeling method improved elicitation of social requirements from a work process model.

Chapter 6
SeeMe* Evaluation

Once presentation of the application of SeeMe* for eliciting socio-technical requirements is finished, this chapter describes the evaluation that has been performed to validate the developed model (SeeMe*) to answer the third research question:

- Can the use of our new integrated model lead to a better understanding of the motivation of social actors and improve the comprehension of their requirements?

The chapter is organized as follows. In Section 6.1, I have conducted an expert workshop for evaluating internal validity which means if the results of our research are credible or believable from the perspective of the participant in the research and tried to explore whether changes of the method were needed. The lessons learned from workshop are also expressed in this section.

Next, external validity of the research findings is evaluated in another context in order to evaluate whether the results are generalizable and can be applied to other similar situations or not. Finally, a summary of the chapter is provided.

6.1. Credibility: Internal Validity

As mentioned in Chapter 3, the credibility criteria involve establishing that the results of qualitative research are credible or believable from the perspective of the people from practice. From this perspective, the purpose of qualitative research is to describe or understand the phenomena of interest from the participant's eyes, as the participants are the only ones who can legitimately judge the credibility of the results. This section contains the validation of the SeeMe* method and its implementation by conducting an expert-workshop with people from the practice.

6.1.1. Testing and Analysis of SeeMe* Based on Expert-Workshops

The expert-workshops were conducted with the focus of validating the correctness and usefulness of the SeeMe* implementation and its containing elements. The experts were selected based on their knowledge and experience of the of pharmacy system. I have selected three pharmacists and one pharmacy technician with practical experience of working in public pharmacies. Four modeling method experts of the SeeMe were also selected.

However, in the first part of the workshop, they have been considered as pharmacy customers or patients and their experience as patients of a pharmacy has been taken into consideration. The experts consisted of four research assistants in the chair of Information and Technology Management at the Institute of Work Science in Bochum University. The supervisor of the research has played the role of the moderator in the workshop.

A schedule has been used during the workshop. There are 11 stages, as illustrated in Table 6.1. More precisely, to validate the SeeMe*, I have used following procedure:

- The workshop began with an introductory presentation on the concept and the purpose of the work, as well as an overview of the SeeMe.
- In the next step, the moderator described the as-is SeeMe process of "filling a prescription", without the extended elements (goals, dependencies, and new relations).
- The participants were then asked to use an online brainstorming tool to share their ideas about the problems and improvement suggestions of the pharmacy process.

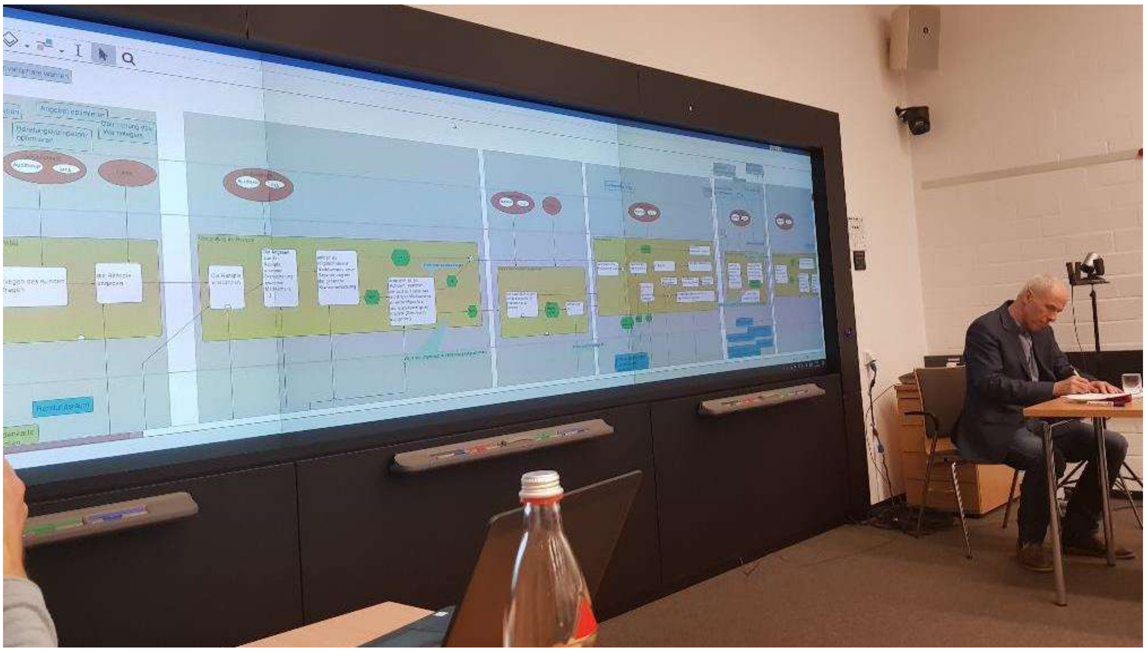


Figure 6. 1 Validation Workshop

- The researcher presented several slides to provide a summary explanation about the extended elements of the SeeMe*.
- Then, the participants were asked to add goals and dependencies into some important phases of the mentioned process.
- Afterwards, the second brainstorming was performed to find the problems and improvement suggestions once again. But this time, the participants had the opportunity to consider social and intentional factors such as goals and dependencies to give their ideas.
- Finally, a plenary and concluding session with recommendations and ways forward was conducted. To provide feedback to the SeeMe* and realize the usefulness of the model, participants were led through a series of questions and asked to validate the model and the process. The questions to experts addressing scientific and applicable validation of the SeeMe* and necessary developments for the future were as follows:
  1. Was the as-is process comprehensible?
  2. Was the process well selected?
  3. What were the uses of the extended elements to find the problems of the process?
     a. Goals?
     b. Dependencies?
  4. Did the application of SeeMe* result in better understanding and finding of improvement suggestions than the previously used method (SeeMe)?
  5. How should the graphic representation of the extended model be improved in SeeMe*?
  6. What are the advantages and limitations of using the SeeMe*?
  7. Would you use the SeeMe* in the future?

Participants received a copy of the agenda and a summary of the SeeMe and SeeMe* elements in advance to use them during the workshop. To develop a shared understanding of work activities in a pharmacy, the model experts played the role of patients of a pharmacy in these two brainstorming sessions to have an overall perspective of both important points of view of a pharmacy: The customers and pharmacy team.

No.	Activities	Presenter	Required Time
1	Initial briefing and clarification of the purpose of the workshop	Moderator/ researcher	10 min
2	Introducing the participants	Participants	10 min
3	Overview of SeeMe method	Moderator	10 min
4	Presentation of the as-is SeeMe process from the pharmacy case study (filling a prescription)	Researcher	10 min
5	Initial brainstorming to collect problems and suggestions for improvement of the process	Participants	10 min
6	Presenting of SeeMe* (explaining about extended elements to SeeMe)	Researcher	20 Min
7	Importing the goals and dependencies to the as-is process	Moderator/ participants	20 Min
	Coffee break		15 Min
8	Second brainstorming to collect problems and suggestions for improvement of the process	Participants	15 Min
9	Discussing the results of the brainstorming and finding the social and technical requirements	Participants	25 Min
10	Getting feedback on SeeMe*	Participants	25 Min
11	Debriefing of results	Researcher	10 Min

Table 6. 1 Structure of the Workshop

6.1.2. Findings of the Workshop

The validation workshop results will be elaborated and summarized in this section. There was an excellent level of participation to the discussions by all experts present at the workshop, which resulted in a range of constructive comments, questions, and suggestions which I have taken into account to improve the SeeMe* modeling method.

At the end of each brainstorming session, the comments, suggestions, and ideas of the participants were collected, compiled, and analysed. I have found that the second brainstorming was more productive and was followed by more ideas for finding problems and improvement suggestions (10 more ideas after the second brainstorming). The participants believed that analysing goals and the conditions to achieve these goals was very helpful, and they were able to suggest more ideas about the process in comparison with the first brainstorming (No.7 in Table 6.2). Pharmacists found the goals for analysing a process necessary, because considering goals enable them to realize the reason and motivation of doing each task, which was unclear without these elements. For example, considering the goals of "consulting the patient", such as increasing satisfaction and loyalty of patients, could help pharmacists to have more ideas to improve this task according to the defined goals for this task. The Pharmacists also felt more involved in process improvement and claimed that they had a more participative attitude, because they can now realize the reasons behind doing some activities better.

One of the pharmacists believed that some other roles should be added to the as-is process and it was stated as an improvement suggestion after the second brainstorming. We argue that under three conditions the roles are permitted to be modeled (Chapter 4): (1) They have to execute a task, (2) be influenced by a task, or (3) have relationship (expectations) with other roles. Sometimes, the goals and motivations of a role are mirrored in goals of the other role and thus we don't need to use this role again in the model.

Furthermore, during the seventh activity of the workshop, "importing the goals and dependencies to the as-is process", we have noticed that adding all of the relationships between depender and dependee was very time-consuming and generated numerous relationships that make a complicated diagram. However, the pharmacists stated that they could understand and validate the SeeMe* model more easily than the classic workflow diagrams such as flowcharts. Thus, consideration of all communications and interactions in the SeeMe* method was valid.

When asking model experts about the usefulness of the approach, we obtained different opinions. Although all the analysts stated that the approach allowed them to better understand the process, the purpose, and, consequently, the requirements, there were some model experts who thought that the dependencies could not improve their job significantly and they would like to use and analyse them separately without using the modeling method (No. 4-13 of Table 6.2).

We do not find these comments about the approach discouraging. The experts who did not think that the dependencies were very useful were senior analysts that are already very skilled in using SeeMe and interacting with customers. They usually model the process while the customer describes what the system should do. In these cases they quickly generate it, validate it, and fix it if needed. However, most of the junior modellers, who have less experience in understanding what is needed, considered that the conditions and dependencies to achieve a goal or to deal with a task could really help them.

Another interesting subject that arose while discussing the approach was the viewpoint to improvements of graphical design (No. 17-22 of Table 6.2). We have collected some recommendations to represent SeeMe* more clearly. The derived recommendations for graphical design can be used to improve the SeeMe* notation. For instance, indicating dependencies more closely to goals, or showing conflict between the goals more boldly, can help to better analyze the problems. They argued that sometimes the companies' viewpoint is different from customers' and these conflicts should be highlighted in order to allow the analysts to focus on them and solve the problems. For example, encouraging a patient to have a member card is contrary to the desire of some customers to protect their data privacy.

Moreover, the participants expressed their interest in the proposed method for their own future needs, especially because considering the goals and ever growing number of variables that have to be represented in the model, it would make showing task processes easier and inclusive of considerations of more perspectives. However, as mentioned above, some model experts expressed that dependencies should not be shown in SeeMe* and can be analysed out of the model.

Finally, the participants endorsed the SeeMe* method, with the inclusion of the additional improvements suggested during the workshop. The opinions of the experts in the workshop are summarized in Table 6.2.

No.	Aspects	Questions	Feedbacks/ Results
1	As-is process: Correctness of the selection and its comprehensibility	1, 2	It was a proper process which is used daily in a pharmacy.
2			It was easy to understand and not so complicated, because it was limited to the standard steps and without the sub-process, which maybe occur infrequently.
3			The other appropriate processes to analyse could be for example: dispensing medical aids or formulation of a new medication.
4	Usefulness of SeeMe*	3,4	In comparison with the classic workflow diagram, the SeeMe* is more complex but more explicit.
5			In this diagram we can consider more variables and aspects. They are helpful to understand different perspectives of doing a task.
6			Dependencies and goals are not considered in other classic workflows.
7			We can the answer the "why" questions in SeeMe*. It strengthens us to understand for what reasons the daily tasks are being done.
8			Dependencies are useful to realize the preconditions between the roles to achieve a goal or deal with a task. With analysing dependencies, we can understand which modifications are needed to attain the goals.
9			SeeMe* is especially useful in initial training periods whenever new employees are still in the familiarization phase, because all details of a process including how, who, why and with which entity (Software or etc.) are represented here clearly.
10			With regarding goals, employees are able to realize why they are doing some activities and it helps them to have more ideas to improve their daily routines.

11			Dependencies are unnecessary in SeeMe* and should be analysed out of it.
12			Conflicts between goals can be very helpful to understand the discriminative motivations of different roles.
13			The dependencies are helpful to analyse the conditions and existing problems of doing the works.
14	Future perspective	6,7	All experts would like to use and test SeeMe* in the future.
15			Pharmacists believe that SeeMe* is an appropriate way to analyse as-is processes (because of goals) and they are eager to use it to find problems in their own processes.
16			Pharmacists would like to use SeeMe* in the Quality Management systems.
17	Graphic design	5	Documenting numerous relations between goals and dependencies during the workshop was not easy.
18			Goal level is well located but the dependencies should maybe be nearer to goals.
19			It is helpful if we define one key goal for all process and some other goals related to each task/ super-task. This way, the modeller has the opportunity not to repeat one important goal several times.
20			Goal and dependencies are better than comments that we have used them previously in SeeMe. They are more clearly defined and less ambiguous.
21			The conflict between goals should be represented with more clear emphasis. For example, with a different colour or notation.
22			As a suggestion, each task in SeeMe* can own different goals from different perspectives; for example, one time with point of view of the customer, and the other time with pharmacist view. These goals can be represented in different levels.

Table 6. 2 Viewpoints of the Experts in Detail

This section summarizes our internal validity experiences and presents the conclusions from the evaluation effort. From the expert-workshop, it is clear that our SeeMe* method is somewhat limited. Our survey of process improvement methods showed that this aspect was essential if we wanted to use process models for process improvement.

If we want to use models for the beginning phase of a new system, it is needed to know what relationships exist among various actors with different perspectives. In this scenario, I recommend using the i* SD and SR models first to represent different relationships and then, when the process of doing works is more obvious, the SeeMe* helps analyst to model a work process with social factors which focus on understanding purpose of doing activities and the conditions to achieve these purposes. Because with using i* alone, it may happen, that the resulting SD and SR models quickly grows and makes it difficult to embrace all the details. Scalability is a well-known problem with i* models. The practical experiences highlighted several obstacles on the adoption of i* in medium- and large-scale projects (Franch, 2010).

6.2. Transferability: External Validity

As mentioned in Chapter 1, external validity is concerned with the generalization of the conclusions of an empirical study. In the evaluation of the methodological approach, this validity is related to how general the lessons learned are, i.e., if they are related to general practice and could be considered that they could affect more cases that those associated to the participants in the survey. Actually, in this section, I want to check the external validity of the research with using the applicability of the tool for other fields than pharmacy.

6.2.1. Introducing an Example of a Car Rental System

I have chosen an example from requirement context to evaluate whether the SeeMe* could be applicable to other contexts and situations (transferability). For more detailed description, it is also analyzed whether the application of SeeMe* results in additional insights- e.g. requirements that are not found by conventional methods. These additional insights could either cover organizational issues - instead of software issues - or could even lead to new software-related requirements.

To brief explanation of how I performed this validity, SeeMe* has been used to model the considered business process from the selected example. The goals and dependencies for using in SeeMe* were based on my personal analysis. Then the requirements specification are derived from the represented SeeMe*.

To develop this evaluation, one example from a thesis in the area of requirements management (González J. L., 2011) is used and this thesis presents a methodological approach for business process-based requirements specification and object-oriented conceptual modeling of information systems. The methodological approach mainly aims to help system analysts to elicit system requirements from business process models and derive the object-oriented conceptual schema of an information system from its system requirements.

As a running example in Gonzalez' thesis, a rent-a-car company is introduced. "The company is located in a tourist area, and its fleet of cars and workload greatly vary between the summer and the winter seasons. The number of cars in the summer season is around 250, whereas in the winter season is around 50. As a result, cars are usually bought at the beginning of a season and sold at the end. Its main activity is car rental, but it involves other activities (e.g., car maintenance)" (González J. L., 2011, p.148). Figure 6.2 has presented in the mentioned thesis (Figure 6.3 in the thesis of González) as the to-be design of the business process 'car rental' of the company, which is performed by office employees. "When a customer wants to rent a car, he must choose one, and what that implies is that the customer is requesting a rental contract. Rental contracts can also include extras (e.g., a GPS or a baby chair), and the price of the contract is determined on the basis of the rate of the car selected. If a customer is new, then the office employee records his data. Under certain circumstances, customers have to pay a deposit of money. The business process finishes when the office employee prints a copy of the rental contract and gives it to the customer, as well as the keys of the car. Cars need a valid insurance (policy) that covers them in case of accident so that they can be rented" (González J. L., 2011, p.148). For the rent-a-car company, it will be assumed that it aims to automate its business processes.

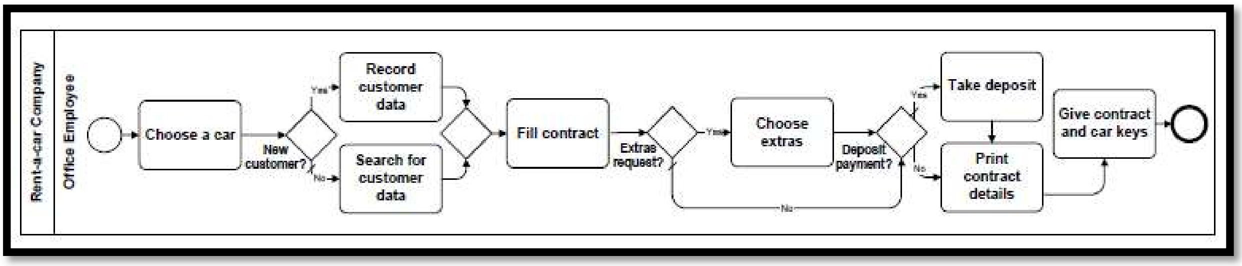


Figure 6. 2 To-Be Business Process Modeling (Renting a Car) (González J. L., 2011, p.149)

Figure 6.3 has been represented in the thesis as an example of textual template that has been specified from the business process of Figure 6.2. As shown in Figure 6.3, textual templates are described the requirements of the new system. They are a way to express what the system actors want to perform (user tasks), including domain-level information and how a system could support an activity or solve a problem.

<table>
<tr><th colspan="4">Extended Task Description: CAR RENTAL</th></tr>
<tr><td colspan="2">Business process: Car rental</td><td colspan="2">Role: Office employee</td></tr>
<tr><td colspan="4">Subtasks: Choose a car, Check whether a customer is new or not, Record customer data, Search for customer data, Fill contract, Choose extras, Take deposit, Print contract details</td></tr>
<tr><td colspan="4">Triggers: -
Preconditions: -
Postconditions: -</td></tr>
<tr><td colspan="4">Frequency: 10 times per day during winter season; 40 times per day during summer season
Critical: Days on which a holiday period begins in summer season</td></tr>
<tr><th colspan="2">Input</th><th colspan="2">Output</th></tr>
<tr><th>Domain Entity</th><th>State</th><th>Domain Entity</th><th>State</th></tr>
<tr><td>Car
Customer (1)
Extra</td><td>Ready
-
Ready</td><td>Rental contract
Car
Customer (2)
Extra</td><td>Open
Rented
-
Rented</td></tr>
<tr><td colspan="4">Business Rules
• The insurance of a car must be valid during the rental period
• A car cannot be rented if it has more than 300000 km
• The total cost of a rental contract is calculated from the rate of a car and the price of the extras requested, multiplied by the number of rental days and VAT</td></tr>
<tr><th>User Intention</th><th>System Responsibility</th><th colspan="2">Information Flows</th></tr>
<tr><td colspan="4">Normal interaction</td></tr>
<tr><td>2. Select a car

4. Select a customer
5. Introduce rental contract information</td><td>1. Show cars

3. Show customers

6. Show rental contract details

7. Print rental contract details</td><td colspan="2">← $_{1}${ <u>Car</u> / make + model / }$_{n}$
→ <u>Car</u>
← $_{1}${ <u>Customer</u> / name + surname + ID number/ }$_{n}$
→ <u>Customer (1)</u>
→ <u>Rental contract</u> / contract number + current date + current time + office + return date + return office /
← <u>Rental contract</u> / contract number + current date + current time + office + return date + return office + rental cost + extras cost + VAT + deposit + total cost / + <u>Car</u> / make + model + plate number / + (<u>Customer (1)</u> / name + surname + ID number / | <u>Customer (2)</u> / name + surname + ID number /) + [$_{1}${ Extra / name / }$_{n}$]</td></tr>
<tr><td colspan="4">Alternatives</td></tr>
<tr><td>(New customer)
4.a.1. Introduce customer data [5]</td><td></td><td colspan="2">→ <u>Customer (2)</u> / number + name + surname + ID number + address + city + telephone number + credit card type + credit card number + credit card expiration date /</td></tr>
<tr><td colspan="4">Extensions</td></tr>
<tr><td>5.a.2. Select extras</td><td>(Extras request)
5.a.1. Show extras</td><td colspan="2">← $_{1}${ <u>Extra</u> / name / }$_{n}$
→ $_{1}${ <u>Extra</u> }$_{n}$</td></tr>
<tr><td>(Deposit payment)
5.b.1. Introduce deposit amount</td><td></td><td colspan="2">→ <u>Rental contract</u> / deposit /</td></tr>
<tr><td colspan="4">Quality attributes
• When an office employee selects a car, no other office employee will be able to select the same car (Functionality/Suitability)</td></tr>
</table>

Figure 6. 3 Requirement Description (Renting a Car) (González J. L., 2011, p.161)

In the thesis of González, mechanisms and detailed guidance have been presented in order to properly elicit and specify the system requirements of an IS from the business processes of an organization. As a result, the gap between BPMN and ETDs (Extended Task Description) has been bridged, BPMN has been extended graphically by specifying the automation of its elements with labels and by defining the concept of consecutive flow, and thus BPMN expressiveness and usefulness for the RE process has been improved.

6.2.2. Using SeeMe* for the Car Rental System

To evaluate the generalization of SeeMe* and to analyze whether SeeMe* provides a benefit in more than just in the pharmacy domain, we have used the mentioned process as an example to model the process of renting a car with help of SeeMe*. Renting a car in a company should be considered as a socio-technical process which is made up of a set of interacting sub-systems. A rent-a-car company employs people with capabilities who work towards goals, follow processes, use technology, operate within a physical infrastructure, and share certain cultural assumptions and norms. Actors (employees and customers) are intentional as they aim to attain their goals; they are social, for they interact with others by delegating goals and exchanging documents and they depend on each other. I have extracted some missions and values of the car rental companies from their mission statements. They are listed as follows:

1. We will place the interests of our customers first.
2. We will be dedicated to providing an individualized rental experience that assures customer satisfaction and earns the unwavering loyalty of our customers.
3. We will consistently deliver a quality product, friendly service and great value that make customers confident that we are their best car rental choice.
4. We provide great service at a great price that clearly demonstrates to our customers that they received the best car rental value.
5. We use new ideas and innovations to enhance service and increase customer satisfaction.
6. We solve problems creatively and take action on behalf of our customers.
7. We deliver quality work for the benefit of our customers and coworkers.
8. We provide consistent and dependable service that exceeds expectations and creates loyal customers.
9. We care each day about how our job affects the quality of our product

10. We believe in creating a fun and friendly car rental experience for employees and customers alike.
11. We maintain an upbeat work environment that is respectful of and welcoming to all employees and customers of all backgrounds.
12. We are committed to a well-maintained, safe and presentable workplace.

According to missions and values of car rental companies, I have defined some dependencies and goals in the mentioned process. It enables analyst to elicit social requirements which should be added to technical requirements. Some goals and tasks (as dependum) deriving from these missions are as follows:

- Increased loyalty of customer (softgoal) ; (Mission 2,8)
- Providing good services (task dependency); (Mission 1, 4, 8, 9)
- Sending offers to customer (hard goal); (Mission 3,8)
- Extra services be sold (hard goal); (Mission 8)
- Increased customer satisfaction (softgoal) ; (Mission 2)
- Taking no deposit from loyal customer (task dependency) ;(Mission 5, 6)
- Be satisfied as a loyal customer (hard goal) ;(Mission 6, 5)

Rent-a-car process is represented in Figure 6.4 with using of SeeMe* elements.

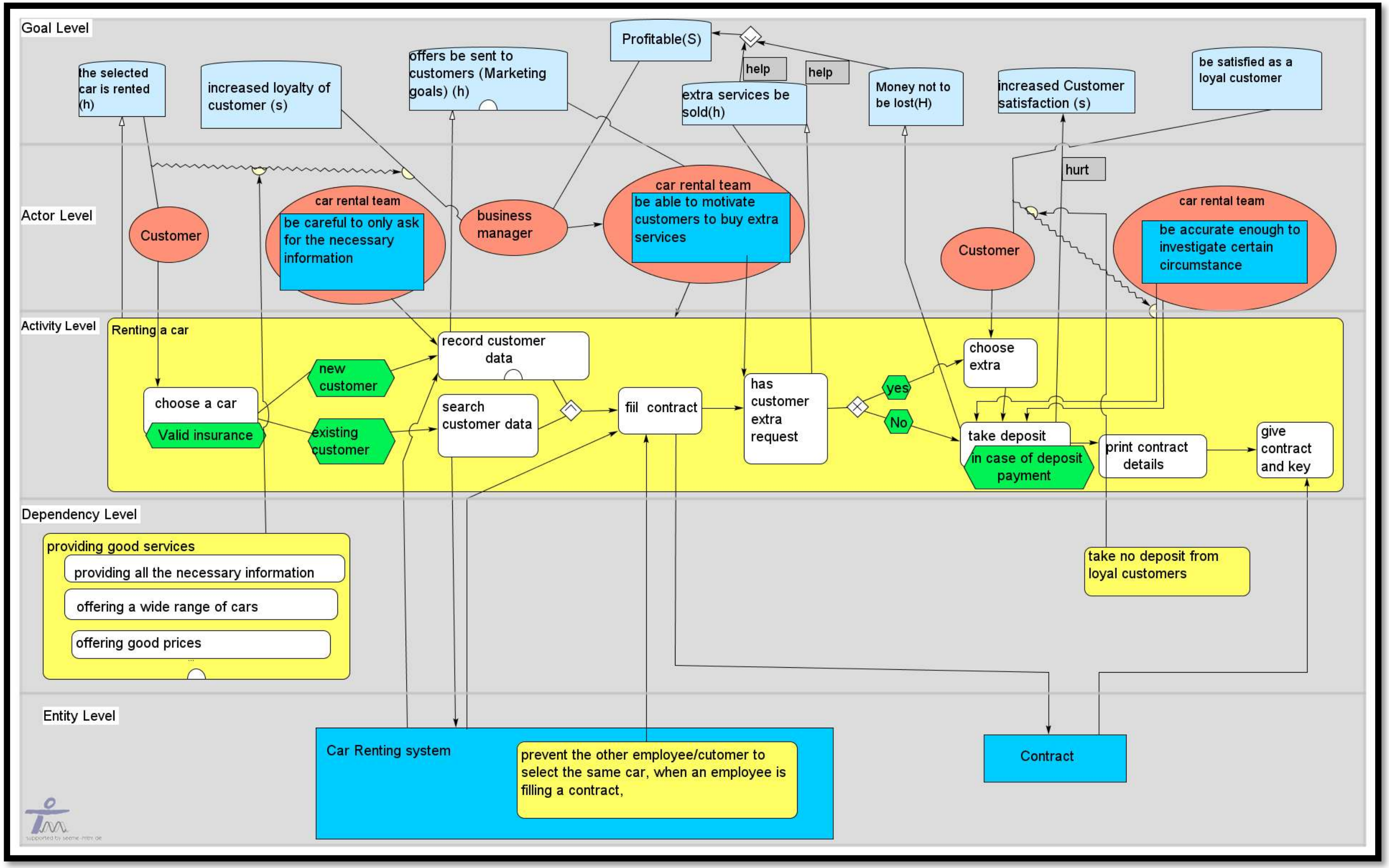


Figure 6. 4 SeeMe* Model of Car Rental System

As shown in Figure 6.4, some goals and dependencies are added to the process. It depicts the intentional or "why" aspects of the domain, via the inclusion of goals and softgoals. SeeMe* incorporates the notion of softgoals and hard-goals which are used to express desirable characteristics of the process rather than core functional requirements. For example, a customer choosing a car depends on the rental company to provide good services and the necessary information about the cars; these services help the company to increase loyalty of customers (as a softgoal). The other service that customers want from the renting company is offering a wide range of cars with fair prices to suit their needs; it keeps customer coming back to the company. I didn't know if providing good services has been defined completely and with enough sub-elements or not. Thus, I have used incompleteness to show the doubts. These indicators, which are some aspects of a socio-technical work process, cannot be shown in a BPMN process. Figure 6.5 shows the mentioned dependency and goal in a simplified syntax.

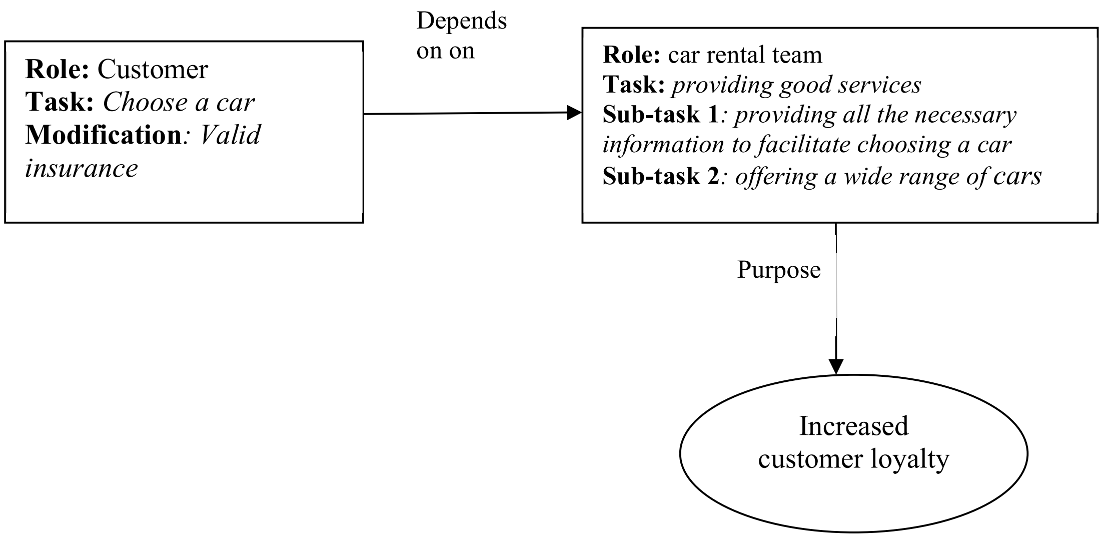


Figure 6. 5 Task of Choosing a Car and Corresponding Dependencies and Goals

The other defined dependency has been represented as follows:

Keeping the customer's satisfaction depends on the car rental team by taking no deposit from loyal customers. The car rental team should be accurate enough to investigate certain circumstance and decide whether customers must give a deposit or not. Taking a deposit helps the company to avoid losing money (hard goal).

As another ability, team needs to be able to motivate customers to purchase extra services to them. It helps the business to be profitable. All these goals, motivations, and dependencies, which play important roles in the social interactions and help employees to know why they are doing these tasks, cannot be shown in the represented BPMN modeling method in Figure 6.2. As mentioned in chapter 2, BPMN does not trigger the including of social aspects and dependencies by its nature. Providing good services and professional consulting, using customer data for shaping marketing strategy, and sending offers to customers, help the car rental company to keep its customers loyal and improve the business. Considering these goals during a work process gives frequent hints at the need to understand the primacy of the value to the customers and organize work around outcomes.

If the employees know that they are recording customer data for use in a marketing program, it can help them to be careful to only ask for the information they need, because asking for too much information can turn customers away. They can encourage them to share their information by offering a freebie or a special discount on their next purchase. This social and intentional knowledge can be suggested to help in the interpretation of situations and implementing a customer loyalty program.

In order to represent requirements of the car-rental system textually, we have selected some activities as instances from Figure 6.4 and specify the related requirements in Table 6.3.

<table>
<tr><th colspan="2">Work Process</th><td colspan="3">Renting a car</td></tr>
<tr><th colspan="2">Business Requirement</th><td colspan="3">Renting company should increase loyalty of customers</td></tr>
<tr><th colspan="2">Hard Goal</th><td colspan="3">Quick and correct rental of requested car</td></tr>
<tr><th colspan="2">Preconditions</th><td colspan="3">Log into the car rental system</td></tr>
<tr><th>No.</th><th>New Tasks from To-Be model</th><th>Socio-Technical Solution Requirement</th><th>Vagueness</th><th>Precondition</th></tr>
<tr><td>1</td><td>Choose a car</td><td>As a customer, the car rental system invites me to choose my favorite car which includes valid insurance.</td><td></td><td></td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">providing good services</td><td>As a customer, the car rental system provides me all the necessary information to choose the best car according my request.</td><td rowspan="4">Are these activities enough to keep the customers loyal?</td><td rowspan="4"></td></tr>
<tr><td>As a customer, the car rental system provides me a large range of cars to suite my needs.</td></tr>
<tr><td>As a customer, the car rental system provides me with fair prices.</td></tr>
<tr><td>As a customer, the car rental socio-technical system encourages me to come back repeatedly if I need a car by providing a good service.</td></tr>
<tr><td>3</td><td>Record customer data</td><td>As a customer, the car rental system encourages me to share my personal information in exchange for rewards if asked.</td><td>Privacy of customer information</td><td>New customer</td></tr>
<tr><td>4</td><td>take no deposit from loyal customers</td><td>As a loyal customer, the car rental system offers me the option to not give a deposit in order to keep me satisfied.</td><td></td><td>In case of a deposit payment</td></tr>
</table>

Table 6. 3 Solution Requirements Specification of Car Rental System

As shown in Figure 6.3, the elicited system requirements from BPMN has been included the user intention and the system responsibility. The specification of product requirements represents a combination and extension of essential use cases, information flows of the info cases approach, and task descriptions. Showing cars, selecting a car, showing customers, and selecting a customer, are the tasks which must be done before completing the rental contract. However, the social factors such as defining good services to increase loyal customers or having employees with good communication skills are also important elements which should be considered as requirements of a car rental socio-technical system. Given this quality requirement direct in the work process model represents a major advantage of the SeeMe*.

With regard to applying SeeMe* in another example, I evaluate the extent to which the findings in our study can be generalized to other socio-technical contexts and situations. My job as the researcher is to provide the evidence that the findings of my research could be applicable in other contexts.

Also, the analysis of car rental work process provides evidence that the SeeMe* is a helpful method to model socio-technical work processes and enable the modeller to capture social and intentional aspects while modeling a work process. It helps analysts to discover all important requirements of a system which could even represent required skills of an employee to achieve a goal in the system. However, as you have seen in the mentioned research from Gonzalez, it was not possible to derive socio-technical requirements from the BPMN diagram.

6.3. Summary

This chapter has presented the evaluation of the proposed modeling method of the thesis to answer the third research question.

> "Can the use of our new integrated model lead to a better understanding of the motivation of social actors and improve the comprehension of their requirements? "

The research findings are validated regarding two criteria. First, we had conducted an expert-workshop to evaluate internal validity which means if the results of our research are credible or believable from the perspective of the participant in the research. Conducting the expert-workshop helped us to evaluate both the practical and theoretical sides of the method. Regarding the workshop results, we were able to evaluate the approach and identify the advantages and disadvantages of the extended model. The overview of the viewpoints of the experts are provided in Table 6.2.

Next, external validity of the research findings is evaluated in a "rent-a-car" process example in order to evaluate if SeeMe* is generalizable and can be applied to other similar situations or not. The evaluation performed is considered to have been positive. SeeMe* has allowed the process modeller to represent some goals and quality attributes of the rent-a-car process which were not representable in BPMN example and, therefore, it can be concluded that this modeling method can be used in other socio-technical contexts.

Chapter 7
Conclusions and Future work

This chapter presents the main conclusions that can be drawn after the development of this study. It concludes the thesis by presenting the main research contributions, addressing the original research questions, and presenting suggestions for future work. Section 7.1 addresses each of the research questions initially presented in Chapter 1, using the evidence presented throughout the proceeding chapters. Section 7.2 then summarises the main research contributions of the thesis. In Section 7.3, the limitations and possible future works are described. Finally, Section 7.4 concludes the thesis by providing an overall summary of the research.

7.1. Research Questions

The first research question 'How can the viewpoints, goals and dependencies of different actors within processes be represented and supported in semi-structured, socio-technical modeling method?' is addressed in Chapters 3 & 4. To find the answer to this question, at first, a case study in a pharmacy is selected in order to represent the process modeling of a socio-technical system by the chosen modeling methods from Chapter 2. As described in Chapter 4, after analyzing the SeeMe and i* frameworks, it is recognized that these two modeling tools are not good enough to represent social factors of a socio-technical system (the pharmacy in this case) in a semi-structured work process. Therefore, the SeeMe modeling method is extended and named as SeeMe*. The SeeMe* metamodel is developed to show the descriptive elements of the new model and provide an overlook of how to bring these two models together. SeeMe modeling is selected as the main method which is based on representing the sequence of activities in a process. Then, some social aspects of i* are integrated to the SeeMe to represent the viewpoints, goals, and dependencies. Consequently, the SeeMe is extended with softgoal, contribution relationship, hard-goal, dependency relationship, and perspective levels. With taking these factors into account, the socio-technical modeling method can bring social understanding into the pharmacy process and into the core of the daily activities of system analysts and designers. The SeeMe* can represent the roles of a process as social and initial actors that have motivations and intentions and are dependent to other roles to achieve their goals. The achievement criteria between goals is clarified by separating them into "soft" and "hard" goals.

The dependency relationships are represented between roles that are also connected to dependums. A dependency link indicates that one role (a depender) depends on another role (a dependee) for achieving a goal (dependum). The depender depends on the dependee for tasks to be performed, resources to be furnished or goals to be achieved. The type of dependum distinguishes task dependency from resource and goal dependency.

The second research question 'How can socio-technical requirements be elicited from the socio-technical process modeling method?' is primarily addressed by the application of the new method in Chapter 5. The extended SeeMe modeling method (SeeMe*) is applied for modeling a selected as-is process of the pharmacy. The to-be model is generated after analyzing the gathered requirements from the pharmacy manager. With the help of the to-be goal-oriented and solution-oriented SeeMe*, a requirement specification is developed which helps the pharmacy team to understand the requirements easier. The application of SeeMe* for requirement elicitation helps analysts to discover the social and technical requirements in a systematic way. A scenario-based approach was applied to define a specification template and enhanced the model with different aspects of the SeeMe* model. The proposed template of this scenario-based approach is based on the idea of a sequence of action that needs to be performed by a user and a software system. In Table 5.2, all of the new activities within goal-oriented SeeMe* and the related socio-technical requirements are listed.

To guide the deriving process of requirement specification from the SeeMe* model, the researchers of this study propose to use eight guidelines (represented in Chapter 5), which are for the prescriptive construction of requirements specification from the SeeMe* to-be models.

The third research question "Can the use of the new modeling method lead to a better understanding of the motivation of social actors and improve the comprehension of their requirements?" is addressed in Chapter 6, which demonstrates the evaluation of the SeeMe*.

To find the answer of the third question, the findings of this research is initially validated and then a workshop to establish the credibility of the approach is presented. The expert-workshops were conducted with the focus of validating the correctness and usefulness of the SeeMe* implementation and its containing elements. The participants believed that analyzing goals and the conditions to achieve these goals were very helpful, and they were able to suggest more ideas about the process. Pharmacists found the goals are necessary for analyzing a process, because considering these goals enables them to realize the reason and motivation of performing each task. They also stated that they could understand and validate the SeeMe* model more easily than the classic workflow diagrams such as flowcharts. Most of the participants considered that the conditions and dependencies to achieve a goal or to deal with a task could significantly help to comprehend the process more precisely.

Additionally, a car rental process has been selected to confirm that the SeeMe* modeling method was able to be applied in other socio-technical situations (external validity). As shown in Chapter 6, the elicited system requirements BPMN has only included the user intention and system responsibility. Showing cars, selecting a car, showing customers, and selecting a customer, are the tasks which need to be done before completing the rental contract. However, the social factors such as defining good services to increase loyal customers or having employees with good communication skills are also important elements which need to be considered as requirements of a car rental socio-technical system. Direct representation of these quality requirements in a work process model is a major advantage of the SeeMe*. Also, the analysis of the car rental work process provides an evidence that the SeeMe* is a helpful method to model socio-technical work processes and enables the modeller to capture social and intentional aspects while modeling a work process. The applied evaluating methods enabled us to realize if using the goals and dependencies in the SeeMe method could help a work process to have more and better ideas for finding problems or to improve suggestions about the as-is process.

7.2. Research Contributions

This thesis makes a number of contributions to the improvement of a socio-technical process modeling, as well as to the wider field of socio-technical requirement analysis. These contributions include:

> **Analysis of process modeling methods**. By analyzing the existing process modeling methods for socio-technical systems by our desired criteria, the semi-structured SeeMe method described in Herrmann's (2006) research was chosen as it provides the most appropriate base for smooth communication processes which contain vagueness. Additionally, i* which is a social modeling for requirements engineering has been selected which helps to integrate social concepts into the core of daily activities and overcome the limitations of the mechanistic worldview. The i* modeling method shifts the attention away

from the usual focus on activities and information flows and primarily emphasizes on the following questions:

- ✓ "What does each actor want?
- ✓ How do they achieve what they want?
- ✓ And who do they depend on to achieve what they want?" (Yu E. , 2009, p.100).

Expansion of the SeeMe Method with i* factors for the specification of system requirements from a work process. A meta-model-based approach is presented to integrate both selected models. Therefore, meta-models of i* and SeeMe were generated and analyzed; consequently, the meta-model of the proposed model has been created. The new modeling method has been called SeeMe*, which provides a method to elicit requirements of the socio-technical systems from a process model. The exploration of this semantic and syntactic model and complementary remarks of the SeeMe* meta-model have been developed in Chapter 4.

Application to a pharmacy case study. In order to test the applicability of the SeeMe*, a pharmacy case study was selected. In Chapter 5, an as-is process of the pharmacy has been created by SeeMe*, which enabled us to analyze the goals and dependencies between social elements for eliciting the requirements. The to-be process had been used to create the requirements specification which includes solutions and their preconditions and incompleteness.

Provision of guidance for systematic derivation of the requirements specification from to-be SeeMe*. In Chapter 5, some guidelines to systematically obtain the requirements specification from the to-be model were presented. This allows system analysts to adequately link socio-technical requirements to subsequent elements of the to-be SeeMe* by following a set of rules. As a result, the basic elements of the model and their relations can be integrated into a requirement specification table to help users with the comprehension of the requirements.

Qualitative evaluation of SeeMe* usage. Through the achievement of the above contributions, it has been shown that the model developed in this work sufficiently encompasses the desired evaluation criteria of qualitative research. Internal validity has been evaluated by an expert-workshop, including pharmacists and analysts, to establish that the results of our research are credible or believable from the perspective of the people in practice. The result of the workshop was presented in Chapter 6.
Moreover, external validity of the research findings was evaluated in a "rent-a-car" process example to evaluate if the SeeMe* method is generalizable and can be applied to other similar situations. The performed evaluation is considered to be positive. SeeMe* has allowed the process modeller to represent some goals and quality attributes of the rent-a-car process which are not representable in BPMN example and, therefore, it can be concluded that this modeling method can be used in other socio-technical contexts.

Discovering areas of future investigation. In this chapter, we make suggestions concerning the adoption of various useful graphical notations to the SeeMe* method to comprehend the model more easily.

7.3. Limitations and Future Work

No PhD thesis is perfect or complete. The rationale is simple: no single research thesis can answer all of the issues that may occur in the actual world within its subject field. Problems arise and disappear when new technology and techniques are proposed, and stakeholder preferences change over time. As a result, further work on a study may always be necessary to improve the state of the art or to address new issues in the field of study.

One first key limitation of this study arises from the diversity of possible cases that exist in the real world. While it was attempted to select a good socio-technical representative case study, there are simply too many possible contexts to be covered in a limited period of time and are hence out of the scope of this thesis. Despite this, we believe that we have demonstrated the proposed method of this research in an important part of a health-care system that considers the technical features of the system as well as social features of the work. However, extensive further research and exploration of other case studies need to be performed to fully evaluate the proposed method in other cases.

The other limitation is related to the expert-workshop. The ideal sample of participants for the validation workshop would consist of modellers and analysts from across different domains and with different backgrounds, including requirements engineering, social modeling experts, organizational and business modeling and so on. Our sample of experts differs from this in several important ways; it is likely to be over-weighted for experience with SeeMe modeling techniques and short of those with any background in other forms of modeling. As a result, experts may deliver better analysis for techniques that are similar to the techniques that they have recently used. However, we argue that the use of this sample does not adversely affect internal validity of our findings.

It is hardly possible to prove the usefulness of a new modeling notation. No existing modeling notion is well-suited for all types of systems. Furthermore, most of the modeling methods that are targeted at specific contexts (for example socio-technical systems) will not always be useful and may include inadequacies.

Future work. More work can be performed based on this thesis for further advancement and improvement of the RE process of socio-technical systems. This is true especially in regard to other processes in different case studies with more stakeholders to show the conflict between their goals and finding solutions. Therefore, many future works could be performed as a continuation of this thesis.

In SeeMe* evaluation, it may be useful to highlight the presence of conflicting evidence in order to explicitly assess areas of the model which could be of particular interest in the analysis. There are some recommendations for graphical design that can be used to improve the SeeMe* notation. For instance, showing highlighting the conflict between the goals can help the analyst to better analyze the problems. These improvement opportunities regarding the graphical design can be presented as follows:

- Adding a new notation to represent the dependency relations, which is easier to recognize and visualize in the model.
- Adding a new notation to highlight the conflicts between goals.

Furthermore, the benefits obtained by SeeMe* can be increased after automation of eliciting requirements from the to-be SeeMe*. The effectiveness of its guidelines and rules can be evaluated by using them systematically.

Finally, and as stated above, future work is neither perfect nor complete. Many other future works can be defined, but their relevance will depend on the needs and interests of businesses and researchers. In addition, a future work that has not been listed is further publishing of different sections of this thesis. This future work is implicit in any thesis, provided that all its results have not been published yet in journals, conferences, or workshops.

7.4. Conclusions

Requirements analysis is still a stage of software development where mistakes are common. Therefore, it can be the source of problems in subsequent development stages and can cause a socio-technical system to not fulfil the real needs of the stakeholders. Some of the mistakes detected in practice are the lack of understanding of the business by system analysts and the lack of focus on social worldview that actors have intentions and motivations behind their task completion; they perform actions to fulfil their wants and desires and depend on other actors to accomplish some goals.

This research has described a method to try to prevent these problems based on modeling of a process by means of the SeeMe and social modeling i* approach. The approach allows system analysts to properly understand and analyze the process, its needs, and the system goals in a participative way with actors. By using the SeeMe and i* method and requirement specification, business people and system analysts share a common model that is understandable to both of them . Furthermore, the method tries to mitigate the weaknesses of a separate use of SeeMe and i* method, and benefit from the advantages of their integrated use. In addition to optimizing the modeling notation, the development of some guidelines that support eliciting social and system requirements from the extended model is also included in this research.

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Appendices

Appendix A: Description of Diagram 5.1

- A customer (patient or customer with a prescription is taken into account here) has entered the pharmacy and in the case of waiting line, s/he tries to cope with it. For example s/he can monitor the discount offers.
- The pharmacy team greets patients and clarifies the medication order.
    - The pharmacy team offer the patient to use a membership card if s/he has no one.
- The patient gives the prescriptions to pharmacy in order to receive the prescribed medicine.
- Upon receiving a prescription, it should be screened to use the information of the prescription systematically.
- The information on prescription will be recognized in system.
- Check if the prescribed medicine is included in discount agreement with the patients' health insurance because the insurance company won't pay for the prescription if the delivered medicine is not included in discount agreement (D-A).
    - In the case of private insurance, the process goes to an availability phase and doesn't need to do discount agreement checks.
    - If the prescribed medicine is in D-A, the availability of the medicine will be checked.
    - If the prescribed medicine is not in D-A: Check if the doctor signed that the patient must take the prescribed medicine in any case. In case of marking the aut-idem checkbox by a doctor, pharmacy team must give patient the prescribed medicine even if it is not included in discount agreement.
    - If the prescribed medicine is not in D-A and the checkbox isn't marked: the pharmacy team should first check which alternative D-A is available and then convince the patient to take alternative medicines which is included the discount agreement in order to avoid potential conflict with insurance company.
    - If the patient does not want to take the D-A medicine, the pharmacy team has to choose the reason of not selling the D-A medicine in system and check the availability of not D-A medicine. The aim of this activity is to be able to get money back from the insurance company.

- If the patient accepts taking the alternative D-A medicine, the pharmacy team delivers it to the patient.
- If all of the alternative D-A medicines are not available, the process goes to next phase and should the medicines as “no-sale” in system and order them.

- In the next step, the pharmacy team checks availability of the required medicine. If the medicine is out of stock, it must be verified whether the medicine is produced in market or not.
  - ✓ The pharmacy team should be accurate enough to update this information each time in system.
  - If the medicine is not produced in market any more, the pharmacy team must sell an alternative brand and select an argumentation for health insurance.
  - But in the case of existing the medicine in market, the pharmacy team must set the unavailable medicine as “no-sale” in system and order the medicine for supplying it at a later time.
    - ✓ Pharmacy team should be accurate enough to not forget to set the medicine as “no-sale“.
  - Arrange a pick up or delivery time with the patient.
  - If the patient requires the medicine urgently, the pharmacy team can substitute it with another brand which is readily available and select an argument for insurance company.
  - In case of not available medicine, sometimes the patient goas to another pharmacy.
- At the time of delivery of the medicine, the pharmacy team has to give the patients the clear instructions and proper advice (Follow legal obligation) on how to take the medicines and ensure the patient is made aware if there are special requirements during transportation, proper storage conditions and usage requirements for the medicines.
  - In the case of having a member card, pharmacy team is able to consult patients with additional information about the possible interaction between other used medicines.
  - In this phase, the pharmacy team should offer the patient the additional product to have more sale.

- If a patient has to pay prescription charges, the correct amount must be entered on the prescription.
- Children under 12 years of age must not pay for the required medicines. Also, some patients are exempt from paying charges. The pharmacy team has to check the related checkbox to verify if the patient requires to make copayment or not.
    - The patients with private health insurance must pay the complete cost of the prescription.

Appendix B: Description of Diagram 5.2

To obtain pharmacy manager requirements, we seek to gain a better understanding of communication between pharmacy team and patients and how it needs to be structured and designed when the patient has gone to the pharmacy. Figure 5.2 shows the goal-oriented to-be work process diagram of “Filling a prescription”; the new tasks and dependencies which support pharmacy team to satisfy the stakeholder requirements and goals are represented here:

- A customer (patient or customer with a prescription is taken into account here) has entered the pharmacy and in the case of waiting in line, s/he tries to cope with it. For example s/he can monitor the discount offers.
    - Spending time waiting in line hurts the goal of the patient: to be quickly serviced.
- The pharmacy should make patients' waiting time more pleasant and productive to create positive experience to keep patients happy during service delay.
    - Streamline the check-in time process to reduce waiting time. This activity should help patients to be served as fast as possible.
    - All these tasks should help pharmacy to increase patients’ satisfaction.
- The pharmacy team greets patients and clarifies the medication order.
    - The pharmacy team offers the patient to use a membership card if s/he has no one.
    - Having more loyal customers depend on behaving patients with a friendly attitude.
- The patient gives the prescriptions to the pharmacy team in order to receive the prescribed medicine.

- Offering quickly service depends on making patient's service time during all steps more efficient. It means the pharmacy team should serve patients quick and with satisfactory results in all steps of the process.
- Upon receiving a prescription, it should be screened to use the information of the prescription systematically.
- The information on prescription will be recognized in system.
    - In order to accurate recognition of scanned data, the pharmacy team must ensure that the patient information and prescription details are comprehensive.
- Check if the prescribed medicine is included in discount agreement with the patients' health insurance because the insurance company won't pay for the prescription if the delivered medicine is not included in discount agreement (D-A).
    - In the case of private insurance, the process goes to an availability phase and doesn't need to do discount agreement checks.
    - If the prescribed medicine is in D-A, the availability of the medicine will be checked.
    - If the prescribed medicine is not in D-A: Check if the doctor signed that the patient must take the prescribed medicine in any case. In case of marking the aut-idem checkbox by a doctor, the pharmacy team must give the patient the prescribed medicine even if it is not included in discount agreement.
        - ✓ This activity depends on the accuracy of the pharmacy team to recognize all of the prescription information.
    - If the prescribed medicine is not in D-A and the checkbox isn't marked: the pharmacy team should first check which alternative D-A is available and then convince the patient to take alternative medicines which is included the discount agreement in order to avoid potential conflict with insurance company and getting the money back from the insurance.
        - ✓ Convincing patients need qualified and trained staff with good consulting skill. It leads to satisfaction of patients.

- If the patient does not want to take the D-A medicine, the pharmacy team has to choose the reason of not selling the D-A medicine in system and check the availability of not D-A medicine. The aim of this activity is to be able to get money back from the insurance company.
- If the patient accepts to take the alternative D-A medicine, the pharmacy team delivers it to the patient.
- If all of the alternative D-A medicines are not available, the process goes to next phase and it should be saved as "no-sale" medicines in system to order them.

- In the next step, the pharmacy team check availability of the required medicine. If the medicine is out of stock, it must be verified whether the medicine is produced in market or not.
  - ✓ The pharmacy team should find an accurate way to check if the medicine produces in market or not. This method has to reduce human errors and finally to increase satisfaction of the patients.
  - If the medicine does not produce in market any more, the pharmacy team must sell an alternative brand and select an argumentation for health insurance.
  - But in the case of existing the medicine in market, the pharmacy team must set the unavailable medicine as "no-sale" in system and order the medicine for supplying it at a later time.
    - ✓ The pharmacy should save the amount of "no-sale" medicine automatically and in an accurate way to reduce human errors. These data should be analyzed to optimize minimum order quantity and reduce "no-sale" medicine amount.

  - Arrange a pick up or delivery time with the patient.
  - If the patient requires the medicine urgently, the pharmacy team can substitute it with another brand which is readily available and select an argument for insurance company.
    - ✓ To reduce the application of urgent justifications for insurance company, the pharmacy team should reduce no-sale due to stock-out medicine.

- In case of unavailable medicine, sometimes the patient goas to another pharmacy in order to take the medicine instantly.

- At the time of delivery or order of the medicine, pharmacy team has to give the patients clear instructions and proper advice (Follow legal obligation) on how to take the medicines and ensure the patient is made aware if there are special requirements during transportation, proper storage conditions and usage requirements for the medicines.
  - Following the legal obligation to consult patients can hurt the goal of offering quick service and also can decrease satisfaction of patients, because sometimes, the patients are impatient to listen the information and would like to leave fast.
  - In the case of having a member card, the pharmacy team is able to consult patients with additional information about the possible interaction between other used medicines.
  - In this phase, the pharmacy team should offer the patient the additional product to have more sale.
  - The satisfaction of patients in this phase depends on the efficient consulting based on the need of the customers (not too long, not too short).
- If *a* patient has to pay prescription charges, the correct amount must be entered on the prescription.
- Children under 12 years of age must not pay for the required medicines. Also, some patients are exempt from paying charges. The pharmacy team has to check the related checkbox to verify if the patient requires to make copayment or not.
  - The patients with private health insurance must pay the complete cost of the prescription.
- The pharmacy needs to ensure the payment is correct and create a way to update and readjust patients' payment.
  - It depends on the ability of pharmacy team to be careful enough to detect the related checkbox exactly.

Appendix C: Description of Diagram 5.4

Solution-oriented SeeMe* aims to address solution requirements and specify the conditions and capabilities a solution has to have in order to meet the need or solve the problem and provide clarity around delivery needs. The current work aims to address this fundamental asymmetry between "goals" and "solutions activities" by developing a diagram that enables pharmacy to follow-up and efficiently support their patients over the time of visiting.

- A customer (patient or customer with a prescription is taken into account here) has entered the pharmacy and in the case of waiting in line, s/he tries to cope with it. For example, s/he can monitor the discount offers.
    - Spending time waiting in line hurts the goal of the patient: to be quickly serviced.
    - The pharmacy team should provide patients with helpful information such as health magazines during waiting time.
    - The pharmacy team should offer a comfortable waiting room.
- The pharmacy should make patients' waiting time more pleasant and productive to create a positive experience to keep patients happy during service delay.
    - All these tasks should help pharmacy to increase patients' satisfaction and loyalty.
    - The pharmacy team should manage patient check-in times by asking them to capture their reasons for visit and to inform them about the waiting line status.
    - The pharmacy team should enable patients to scan their prescription during waiting time.
    - The pharmacy team should ask new patients to fill out a registration form, in order to record patients' data in the system.
    - These tasks should help the pharmacy to increase patients' satisfaction.
- Streamline check-in time process
    - The pharmacy should open a drive-thru for dispensing simple medicines which don't need consulting.
    - If there are no legal barriers, the pharmacy should provide an online service at any time of the day or night, in order to enable patients to order their prescription online, wherever they are, and then take their medicine in the special and fast queue or make an appointment to be delivered.

    - These activities should help patients to be served as fast as possible.
- The pharmacy team greets patients and clarifies the medication order.
    - The pharmacy team offer the patient to use a membership card if s/he has one.
    - The pharmacy should offer a highly-qualified team and customer-friendly environment.
- The patient gives the prescriptions to the pharmacy team in order to receive the prescribed medicine.
- Patients depend on the pharmacy team to be quickly served. The pharmacy team should make patient's service time during all steps more efficient. It means the pharmacy team should serve patients quickly and with satisfactory results in all steps of the process.
    - The pharmacy system should delegate prescription fulfillment and dispense duties to team, and dedicate pharmacists' time to answering questions and conversing with patients.
    - The pharmacy team should have proper time management skills and not spend too much time handling one customer while others are waiting and at the same time to make sure that customers will be served as quickly as possible.
- Upon receiving a prescription, it should be screened to use the information of the prescription systematically.
- The information on prescription will be recognized in system.
    - In order to accurately recognize scanned data, the pharmacy team must ensure that the patient information and prescription details are comprehensive.
    - Being careful enough to recheck the prescription is one of the important required skills in this phase.
    - The pharmacy manager depends on the sales team to have comprehensively scanned data from prescription, so that the goal of accurate recognition of data is fulfilled.
    - The pharmacy team should correct the unreadable field of prescription (such as insurance code, etc.)
- Check if the prescribed medicine is included in discount agreement with the patients' health insurance because the insurance company won't pay for the prescription if the delivered medicine is not included in discount agreement (D-A).

- In the case of private insurance, the process goes to an availability phase and doesn't need to do discount agreement checks.
- If the prescribed medicine is in D-A, the availability of the medicine will be checked.
- If the prescribed medicine is not in D-A: Check if the doctor signed that the patient must take the prescribed medicine in any case. In case of marking the aut-idem checkbox by a doctor, the pharmacy team must give the patient the prescribed medicine even if it is not included in discount agreement.
- If the prescribed medicine is not in D-A and the checkbox isn't marked: the pharmacy team should first check which alternative D-A is available and then convince the patient to take alternative medicines which is included the discount agreement in order to avoid potential conflicts with insurance company and getting the money back from the insurance.
  - ✓ Convincing patients requires qualified and trained staff with good consulting skills. This leads to satisfaction of patients.
- If the patient does not want to take the D-A medicine, the pharmacy team has to choose the reason of not selling the D-A medicine in system and check the availability of not D-A medicine. The aim of this activity is to be able to get money back from the insurance company.
- If the patient accepts taking the alternative D-A medicine, the pharmacy team delivers it to the patient.
  - ✓ The patient depends on the sales team to receive secure knowledge about the alternative's efficiency.
- If all of the alternative D-A medicines are not available, the process goes to next phase and it should be saved as "no-sale" medicine in system to order them.

- In the next step, the pharmacy team checks availability of the required medicine. If the medicine is out of stock, it must be verified whether the medicine is produced in market or not.

- The pharmacy system should check it automatically to find if the medicine is produced in the market or not. This method should reduce human errors and increase satisfaction of the patients.
- If the medicine is not produced in the market any more, the pharmacy team must sell an alternative brand and select an argumentation for health insurance.
- In the case of existing medicine in market, the pharmacy team must set the unavailable medicine as “no-sale” in system and order the medicine for supplying it at a later time. The pharmacy software should set it automatically.
  - ✓ The pharmacy should save the amount of “no-sale” medicine automatically in an accurate way to reduce human errors. These data should be analyzed to optimize minimum order quantity and reduce “no-sale” medicine amounts.
  - ✓ The pharmacy manager depends on the skill (being accurate and not forgetting to record required data) of the sales team to have recoded data of no-sale medicine.

- Arrange a pick-up or delivery time with the patient.
- If the patient requires the medicine urgently, the pharmacy team can substitute it with another brand which is readily available and select an argument for insurance company.
  - ✓ To reduce the application of urgent justifications for insurance company, the pharmacy should reduce no-sale due to stock-out medicine.
- In case of unavailable medicine, sometimes the patient goes to another pharmacy in order to take the medicine instantly.

- At the time of delivery or order of the medicine, the pharmacy team has to give the patients clear instructions and proper advice (following legal obligation) on how to take the medicines and ensure the patient is made aware if there are special requirements during transportation, proper storage conditions, and usage requirements for the medicines.

    - Following the legal obligation to consult patients can hurt the goal of offering quick service and can also decrease satisfaction of patients, because sometimes, the patients are too impatient to listen to the information and would like to leave fast.
    - In the case of having a member card, the pharmacy team is able to consult patients with additional information about the possible interaction between other used medicines.
    - In this phase, the pharmacy team should offer the patient the additional product to have more sales.
    - The satisfaction of patients in this phase depends on the efficient consulting based on the need of the customers (not too long, not too short).
    - Be able to offer efficient consulting is one of the needed skill in this phase.
- If a patient has to pay prescription charges, the correct amount must be entered on the prescription.
- Children under 12 years of age must not pay for the required medicines. Also, some patients are exempt from paying charges. The pharmacy team has to check the related checkbox to verify if the patient is required to make copayment or not.
    - The patients with private health insurance must pay the complete cost of the prescription.
- The pharmacy needs to ensure the payment is correct and create a way to update and readjust the patients' payment.
    - The pharmacy system should recheck the payment amount with forcing the team to ask the question from patient: is the patient free of charge?
    - In the pharmacy system, it should be possible to create an account (member card) for patients to manage their payments (having report or unpaid prescriptions)
    - The pharmacy manager depends on the ability of pharmacy team to be careful enough to detect the related checkbox exactly.

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