Soft System Stakeholder Analysis Methodology

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***Abstract*— Understanding problems and the values of any solution from multiple stakeholder perspectives is a fundamental feature of stakeholder analysis. As modern systems increase in size and functionality and include services and other non-software or hardware components, more stakeholders are involved. These stakeholders have different interests and needs, which are often expressed in a multitude of ways. Describing problems and identifying the local strategic values in a constantly changing business environment is strategically important to companies. This paper describes action research conducted within a large, global telecommunication company to study how stakeholder analysis can support software-intensive systems development. The results of the study demonstrate the need to analyse, structure and identify problems and solutions with different local and strategical values. Furthermore, the results show the importance of method usability and the role of stakeholder analysis in supporting software intensive systems development. The outcome of the study was a method for a practical stakeholder analysis that supports the identified needs in the software-intensive systems development.**

Keywords-Software Intensive Systems; Stakeholder; Stakeholder Analysis; Action Research.

I. INTRODUCTION

In today's world, software systems development is becoming increasingly challenging. Software systems are typically not developed by a single company. Rather, they are developed globally, with collaboration between subcontractors, third-party suppliers and in-house developers. Modern systems like software intensive systems (SIS) have not remained local isolated applications, but have become large and complex systems with increased communication with other systems and attached services. Few can master the entire process of product development, so several experts pool their expertise and work together, especially when the software is the main component and affects the product's usability, functionality, development tools and methods, production mechanisms and innovation. Such systems are known as SIS [1][2][3].

The case company, Nokia Networks, develops very large-scale SIS for the global telecommunication market. Development occurs across several countries, which requires knowledge workers [4][5] with a common understanding, shared goals, awareness and practices that support the work. Knowledge-intensive processes are characterised by dynamic changes of goals, information, environment and constraints, as well as intensive individual ad hoc communication and collaboration patterns; thus, it is not easy to plan the work in detail beforehand [6]. SIS are often very large-scale systems, and various stakeholders from different organisations work in collaboration, forming teams that are dynamically and spontaneously assembled and work together via communications technology [7].

In the case of Nokia Networks, large-scale SIS developers often find it difficult to approach, collect, analyse and structure all the information that is currently available. Similar challenges are presented by the information that is obtained as time progresses. The company has adapted agile development approaches to answer these problems, and the individual teams have especially benefitted from this approach. When, however, products or features are analysed from the platform or architectural level, the problems still exist. These challenges often result from ill-defined goals and evaluation criteria and require changes in goals and plans during development. Multiple actors and perspectives, incommensurable and/or conflicting interests, important intangibles, and key uncertainties are typical in such situations [8].

To solve problems like this, a common approach in Requirements Engineering (RE) is to perform a *stakeholder analysis* [9][10]. This type of analysis aims to discover the stakeholders relevant to the problem faced by the developers. Analysing the stakeholders' needs allows the real system and environment of the stakeholders to be defined and the problem to be further understood from multiple perspectives. Utilising this information, a company can design an initial solution and negotiate with stakeholders to solve conflicting interests and produce a solution that results in the most value for the stakeholders and the company. However, the environment in which the company works is highly competitive and dynamic, requiring speed and agility from the development process. There are often uncertainties about whether information is valid or common enough when new features or products are developed. In addition, the development situation also changes as more information becomes available. Uncertainty and changes are common in software development because the processes are complicated

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and not all circumstances can be predicted [12][13]. Furthermore, the order in which activities are executed is not necessarily important—it may even be impractical as interaction with the environment, activities and underlying business logic determines the order of execution rather than predetermined, static process schema [11]. The analysis of information is often done intangibly, since the development process involves numerous personalities, experiences, types of education and backgrounds. Understanding and processing is essential for properly structuring information as it helps the company identify the real problem, determine where it can potentially gain the most value and discover the type of solution that is capable of realising this value.

Therefore, the research problem of this paper is: how can problems in SIS development be described and structured using stakeholder analysis? In particular, *how can problems in an SIS development environment be described and analysed in order to identify the impact and value from different stakeholder viewpoints?*

Action research [14] was conducted over a period of one year in the case company to research and develop a practical way to perform stakeholder analysis. The rest of the paper is structured as follows. Section 2 presents the related research, and Section 3 presents the research method. Section 4 describes how the action research cycles were performed and their results. Section 5 presents the soft system stakeholder analysis methodology (S3AM) developed as a result of the action research. Section 6 discusses the results of the research and how problems in SIS should be approached and section 7 describes threats to validity and the limitations of the research. Section 8 presents the conclusions and future topics.

II. Related research

Freeman [15] was the first to popularise the concept of 'stakeholder'. He defined a stakeholder as a group or individual affected by the achievement of an organisation's objectives, or a group or individual that can affect them. This concept introduced ethical thinking to businesses, causing a company to consider other stakeholders' benefits rather than just stockholders' [16]. This is known as a stakeholder approach where company needs to identify stakeholders in order to identify their needs and manage them [17].

Stakeholder analysis is an internal part of RE in any software development process. An RE stakeholder is generally a person, group or organisation that has an interest in or is connected to the system under development [9][10]. Common stakeholders are end users, engineers, managers and customers [18][19]. Stakeholder analysis is generally integrated into the specific RE method and does not exist as an independent method. It mainly supports the [9][10][19]:

- identification of relevant stakeholders,
- elicitation of stakeholder requirements,
- analysis of requirements from stakeholders' perspectives,
- validation of requirements,
- negotiation of requirements with stakeholders, and
- prioritisation of requirement implementation.

A common approach is to utilise user stories, requirement templates or other structured or semi-structured data containers to capture information about a system and how it works from a stakeholder's perspective. This process can be guided by practical perspective [20] or used to support negotiations [21].

The main critique of stakeholder analysis is that it is not systematic and well defined [18][22]. Either it supports few activities in the development process or its instructions and process are vaguely described. To counter this problem, multiple stakeholder analysis methods have been developed.

Ballejos and Montagna [18] describe a specific method for stakeholder identification in an inter-organisational environment utilising generic stakeholder categories. McManus [22] defines a general systematic approach to stakeholder analysis that describes the identification, elicitation, analysis and negotiation processes in RE. McManus also provides an identification and analysis method based on the World Bank's list of possible stakeholders. Alexander and Robertson [33] use the onion model to identify and involve stakeholders to the development process. Lim et al. [23] utilises social networks to systematically analyse stakeholders in large-scale software projects. They utilise crowdsourcing to automate stakeholder analysis by asking the stakeholders to recommend other relevant stakeholders and aggregating the answers via social network analysis.

While there are known and established methods for stakeholder analysis, none has established itself as the benchmark method in a development effort dominated by software. Furthermore, the methods typically concentrate on small- and medium-scale development efforts. However, instead of abolishing any of the existing methods, it is worthwhile to examine how the stakeholder analysis should work in SIS development context and how it should be implemented in order to benefit its users.

III. Research setting and process

To monitor their development process, the case company utilises metrics that measure the process on different levels. Data is collected and then synthesised for different stakeholders to compare the development to pre-defined guidelines. This system is known as a metrics reporting system (MRS). The main benefit of this type of system is that it helps analyse and visualise the statuses of different organisational units and the overall picture.

The data for the MRS is provided and calculated by multiple units. The units participating in this research had been experiencing organisational changes: some of the work was done manually, and some was assisted by tools. The company was interested in finding a way to automate the reporting system—or at least parts of it—to try to avoid manual data collection. Its goals were to determine the extent to which the MRS could be automated, discover its requirements and calculate the value of the automation. In this case, part of the MRS (8 metrics) was deployed to measure the performance of product lines. The metrics reported the data for each product line at the end of a reporting period.

In order to reach these goals, the company needed a method for collecting and structuring information to describe the current MRS from multiple stakeholder perspectives. This would allow for the analysis of changes to the system and their potential value. Because the current understanding of the MRS was unclear and there were a number of unknown variables, action research [14] was selected as the research method. It was important to establish constant collaboration between the company, participants and researchers to ensure a complete understanding of the environment and problem. Action research offered flexibility and an iterative approach to the problem.

Action research is an iterative and systematic process that addresses concrete organisational problems through the application of theories in practice. It allows both researchers and practitioners to gradually create a satisfactory solution to the organisation's problem while adding to the scientific knowledge on the topic [24][25]. Action research is composed of cycles or iterations, allowing for constant re-evaluation of the problem, implementation of the solution and learning in short intervals [14][26][27]. The cycles are divided into the following phases:

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

The action research method in this study was implemented as follows. A pre-study was conducted to analyse the company's problem and select a suitable approach from the literature. After the pre-study, the iterations began and were continued until a suitable solution was devised. Each iteration began with a diagnosis meeting between at least two company representatives and one researcher, who analysed the results of the pre-study or a previous iteration. Based on the results, they determined the desired actions for the iteration and how long the iteration would last. After the meeting, the actions were implemented; this was done primarily by the researcher, who was assisted by the company representatives. When this phase ended, the researcher evaluated the results and presented them in a retrospective meeting. The purpose of the retrospective meeting was to specify what was learned. This meeting is open to the company representatives and other company personnel, especially those who were involved in the research.

A total of five iterations were completed during 2014, and a total of 30 modelling sessions were completed with 20 MRS stakeholders. Five meetings and five workshops were held at the beginning and end of each iteration, respectively.

IV. Research execution

This chapter describes the execution and results of the research.

A. Pre-study

The first step was to analyse the problem the company was experiencing with the MRS. The company representatives provided a data set containing descriptions of the reports, the reports' data structures and the stakeholders who were responsible for providing the reports. In addition, descriptions of the metrics in the MRS were provided, including metric input data, calculation formulas and the organisational units responsible for providing data. Currently, the metrics in question are reported both manually and with Excel templates.

After analysing the information, the scale and amount of the information presented from multiple stakeholder perspectives became the main problem. The first step was to select a way to structure all the information. A problem structuring method was determined to be a suitable framework since similar problems are generally approached in this way, a soft systems methodology (SSM) [28]. SSM was selected due its iterative approach and ability to conceptually model any stakeholder viewpoint into a *soft system model*. A soft system can be any system where both natural objects and humans interact, which is essential for SIS descriptions. SSM consists of:

- entering the problem situation,
- expressing the problem situation,
- formulating root definitions of relevant systems,
- building conceptual models of human activity systems,
- comparing the models with the real world,
- defining changes that are desirable and feasible, and
- taking action to improve the real-world situation.

Other problem structuring methods exist, such as multiview, information requirements analysis and logico-linguistic modelling. They are similar in approach to SSM but are designed to be more systematic and rigorous. In this case, because the principles remained the same, SSM was used to structure the MRS.

B. Action research iterations

Based on the pre-study, the action research began by structuring the problem situation so that it could be understood properly. SSM was selected as a starting point for the research activities. Table 1 describes the first two iterations.

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TABLE I. ITERATIONS 1–2

Iter.	Diagnosis	Action planning and taking	Evaluation	Learning
1	Problem should be further modelled and analysed in order to understand it properly.	Create a soft system model from the MRS using SSM and the data obtained in the pre-study. Use a UML flowchart as a modelling language. Use Microsoft Visio as a modelling tool. Perform iteration lasting 3 months; one researcher creates the soft system model from MRS.	The soft system model resulting from SSM was found to be informative and easy to understand. The UML flowchart was able to model the information, and participants had experience using it. Microsoft Visio was able to model the soft system model.	The data given by the company in the beginning was insufficient, as the resulting soft system model in the end of the iteration was missing information. Stakeholders need to be involved directly. Data and functions were found to be missing after the soft system model was finished, especially manual work, which was done but is missing from the official documentation. A visual model of the soft system promotes communication and information distribution between stakeholders. The UML flowchart was sufficient for describing the MRS. It utilised familiar language and increased the acceptance of the method.
2	Stakeholders need to be directly involved to discover their understanding of the problem and the soft system where it resides. UML flowcharts and Microsoft Visio should still be used to visualise the soft system model. SSM should be used as long as the soft system model is able to present the problem. The modelling approach needs to be structured since data and activities can be hidden. An approach is needed to identify and model these data and activities.	Select two example metrics and relevant stakeholders in order to discover whether the soft system model is beneficial. Organise 1.5-hour modelling sessions with the identified stakeholders. One researcher and at least one stakeholder participate in each modelling session. The participating stakeholder must identify other stakeholders that can describe the soft system if the original stakeholder was not able to do so. Separate each stakeholder viewpoint with layers in Microsoft Visio. Utilise an input(s)–function(s)–output(s) structure for information flow to help identify what the stakeholders actually do in the system.	Using actual stakeholders helped create a soft system model that represented how the MRS worked in reality. Modelling sessions with each stakeholder allowed for the modelling and separation of stakeholder viewpoints within the same soft system model. Multiple viewpoints helped to remove uncertain parts from the model and increased the quality of data as they were refined and confirmed by more than one stakeholder. Stakeholders can be systematically added to the model by asking the stakeholders to identify who provides them with information or uses information provided by them. The layers used in Microsoft Visio clearly visualise how different stakeholders see, understand and work within the MRS. The input(s)–function(s)–output(s) structure of the model increased the level of detail and helped stakeholders work through the details of their work and the process.	The soft system model must allow for irregular and abstract viewpoint descriptions from different stakeholders, as it cannot be guaranteed that every stakeholder is able to use formal language. The input(s)–function(s)–output(s) structure should not be strictly enforced. Multiple viewpoints revealed variations and different data and activities than were originally known by the stakeholders. The differences and variations affected metric generation. A systematic method is needed, as multiple stakeholders are required to work on it simultaneously due to the scale of the problems and working environment. The soft system model was easy to understand, but the concept of SSM was not. It was seen as too vague, and it is unusable in its current form. Participants felt that the methodology, which helped them to approach problems in their work, was more valuable than solving the problem in the MRS. Participants discussed different problems related to MRS that became visible form the model, as they appeared to have even more value if solved. A need to analyse value from stakeholder's perspective surfaces as different changes or impacts were evaluated against the soft system model.

The first iteration concentrated on creating a conceptual model of the problem. Unified Modelling Language (UML) flowchart was selected as a basic modelling language. However, it quickly became obvious that a structure for the modelling approach was required to obtain an accurate model. Allowing abstract descriptions hid the information obtained by the stakeholders. Therefore, the second iteration utilised the input–function–output structure to describe any activity performed by the stakeholders. In addition, actual stakeholders were involved to obtain the data directly from the stakeholders themselves, as the original data was insufficient. The results of the second iteration indicated that the company's problem was not to just to solve the problems in MRS, but also how to analyse it systematically in SIS environment. It became clear the company personnel had to work in a certain manner and with certain restrictions caused by the SIS development. The participants felt that the methodology used in the research would be more useful than just solving the problem they had with the MRS.

It was determined that the actual goal of the research should be to design a methodology that the company could use to analyse problems during SIS development, as it was believed that the stakeholders would benefit from analysing the problems themselves. Since SSM was perceived to be too vague and unfamiliar to participants, it was designed to be part of a stakeholder analysis. Essentially, stakeholder analysis and SSM have similar outcomes. However, the participants understood the concept of stakeholder analysis better. Utilising a UML flowchart (UML was identified to be a suitable modelling language) and existing systematic approaches to stakeholder analysis (e.g., [22], [23]), three more iterations were run in order to develop and refine a stakeholder analysis (S3AM) suitable for an SIS development environment. Table 2 describes the following three iterations, which aimed to develop a methodology to analyse problems during SIS development.

Iterations 3–5 mainly concentrated on identifying the special attributes of SIS development and how the S3AM needs to support the company's development process. The result of the action research was an exact methodology, which is described in the next sub-chapter.

TABLE II. ITERATIONS 3–5

Iter.	Diagnosis	Action planning and taking	Evaluation	Learning
3	The fact that SSM creates soft system models helps individuals comprehend and approach problems during SIS development. The SSM approach adapted in the research should be methodised for the company. The SSM was perceived as too vague and difficult, and it was too general to be used as such in SIS environment. Stakeholder analysis is a better-known concept in software development and has similar outcomes to SSM. The solution was to combine stakeholder analysis and a framework for creating a soft system model from SSM. The value of introducing any change to the soft system should be analysed, preferably by asking the stakeholder directly or using a pre-defined value measurement.	Design a first version of the S3AM based on the findings of previous iterations utilising existing systematic stakeholder analysis approaches. Extend the analysis to a larger part of the MRS to test the S3AM in its intended environment. Select eight metrics reported by eight different product lines with responsible stakeholders to be analysed. Organise 1.5-hour modelling sessions with each stakeholder. One researcher and at least one stakeholder participate in each modelling session. Ask each stakeholder how many working hours they spend performing particular tasks to evaluate value.	Identifying additional stakeholders by asking participating stakeholders was effective. As the analysis was extended to a larger portion of the MRS, the analysis must be conducted by multiple persons. Getting stakeholders to participate is becoming difficult due to the number of stakeholders and scheduling problems. When stakeholders saw the existing model during modelling sessions, they seemed to understand the modelling approach, and in most cases, they described their activities related to MRS without requiring further instruction. This applied to both managers and engineers.	The variations and differences between data and activities become even more pronounced as more stakeholder viewpoints are added. Promoting the input(s)–function(s)–output(s)—language structure, which is typical in system descriptions, produced a richer and more detailed soft system model. Visualising the models increased the effectiveness of communication in every meeting. The existing soft system model helped participants understand their tasks and increased the speed of the modelling process faster as participants had an example to work from. Stakeholders felt that the ability to see other stakeholders' viewpoints in the model increased their understanding of how the MRS worked. This led to discussions on how the MRS could be improved and how it should be analysed to understand its problems.
4	Explicit visualisation of stakeholders' viewpoints was an eye-opener for many stakeholders. Stakeholders who can see and understand other viewpoints are able to evaluate impact and value from a wider perspective.	Continue the modelling performed in Iteration 3. Make the existing soft system model available and present it to stakeholders.	Adding more stakeholder viewpoints to the soft system model helped stakeholders evaluate impact and value from a wider perspective. Improving the soft system model makes interpretation and reading the model more difficult for stakeholders.	Model abstraction is needed in both the soft system model and in the tool used to generate the soft system model. Gradually building and constantly refining a soft system model supports the distribution of work and the co-operative nature of the development environment. Feedback from stakeholders signalled a need to identify the most important areas to analyse and where there is missing information in order to determine how the system should be changed to address problems.
5	Abstraction of stakeholders' viewpoints is necessary in large systems. The SIS environment causes certain restrictions and requirements for the S3AM because work is continuous and the aim of the analysis changes when new information is made available.	Model abstraction layers using descriptions of stakeholders' viewpoints. Analyse the original problem based on the soft system model and create a separate impact layer where the system automation can be evaluated. This information can be used to determine whether the current soft system model is adequate for determining the value of automation and how it should be implemented. Continue the modelling performed in Iterations 3 and 4.	The implementation layer allowed stakeholders to identify missing information and unclear areas. Stakeholders identified problems with more value than the original problem. The soft system model, along with the implementation layer, helped to direct the analysis based on unclear data that was connected to the impact model. Previously unknown but relevant stakeholders were identified based on the analysis in the impact layer due to missing information.	Multiple viewpoints increased the visibility and transparency of the MRS and refined the original problem. Multiple viewpoints allowed for the evaluation of different value perspectives, especially local and strategic perspectives. Constant analysis of the problem directed the modelling of the soft system and provided direction for the analysis based on the impact of the problem. When the impact extended out of the model, it was an indication for doing further analysis on those sections. The introduction of an analysis layer for analysing the impact of automation helped stakeholders identify missing or unclear information and find previously unknown stakeholders.

C. *S3AM*

The principle idea of S3AM is to model different stakeholder viewpoints into the same soft system model. Each viewpoint, however, is the conceptualisation of a stakeholder's understanding of the soft system. In essence, each viewpoint contains information about how the stakeholder perceives and understands the way in which a real life phenomenon works.

The S3AM starts with a single stakeholder, who identifies a soft system of interest. Due to this interest, the stakeholder intends to present a request, requirement, need or problem that aims to change that soft system in a certain manner. The stakeholder is seeking to provide information about how to change a certain soft system he believes requires such change.

In order to create the soft system model, a certain structure was required to describe stakeholder viewpoints. In this case, all soft system descriptions follow the same principle of information flow description: input(s)-function(s)-output(s). Each stakeholder's viewpoint is constructed in a similar manner: information (documents, emails, communication, etc.) is received, something is done with the information (analysis, transfer, format changes etc.) and the result is a defined output (report, piece of information, emails, etc.). For example, a stakeholder is in charge of collecting summaries of metric data from two other stakeholders. Figure 1 demonstrates the soft system model created from the stakeholder's viewpoint.

From this stakeholder viewpoint, the summarised metric data element in the upper right corner and the summarised data element on the upper left form the boundaries of the stakeholder's viewpoint. The stakeholder does not know how the other stakeholders actually perform the data summaries and what data is used.

Now that the boundaries are known for the first stakeholder, the next step is to analyse the intent of the stakeholder (e.g., to automate data collection and create a data summary). The known soft system model is now analysed to determine whether it contains enough information to analyse the real impact from all relevant stakeholder viewpoints.

After the initial soft system model is created, the next step is either to analyse how the soft system would change if some desired change were introduced, or to simply extend the model by adding more stakeholder viewpoints. The first case asks practitioners to analyse how the current soft system changes if some desired change, for example a stakeholder's need, affects it. In this case, an impact layer is drawn using the existing soft system model modified by the change. If the change affects any of the boundary elements in the soft system model, the stakeholder whose viewpoint has the boundary element should identify a stakeholder who knows how the soft system worked prior to that element, and it should then be modelled. This continues until there are no boundary elements affected by the change. This helps to direct the analysis effort to those parts that are not yet modelled but will be affected by the desired change. The other option is to simply ask each stakeholder to identify other stakeholders that can describe the system beyond the boundary elements of his or her own viewpoint and keep extending the model.

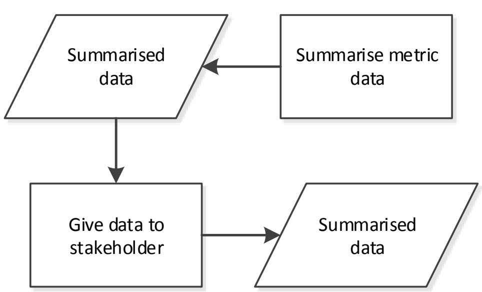

Figure 1. An example of a single stakeholder viewpoint

As more stakeholder viewpoints are added, there will eventually be shared elements and conflicting viewpoints. Figure 2. demonstrates an additional stakeholder viewpoint added to the soft system model. The colour white indicates a stakeholder who collects the metric data from the report, summarises it as a single figure and gives it to the original stakeholder. Another stakeholder asks for the metric data directly from the engineers, summarises it and gives it to the original stakeholder. However, the stakeholder also states that it is not exactly the same metric data; it is presented by a separate data element.

As the model is updated, it is important to verify with each stakeholder that existing elements (both functions and data) remain the same along with the data flows. If they are not, they must be modelled separately to highlight the differences. One of the key principles is that each stakeholder 'owns' his or her own system description. Thus, if any changes were made to a single viewpoint, the stakeholder who owns it had to accept the change. This was determined to be an important feature, as it prevents a loss of information by assuming the elements in the soft system are the same. Therefore, each element in the soft system model belongs to one or multiple stakeholders, and any change to an element requires all stakeholders to agree to the change or newly created element.

To analyse the value of any change to the soft system, a need presented by a stakeholder should be analysed and modelled as an impact model, describing a solution for the need. The impact model can be used to determine all elements affected by the impact and therefore track all the viewpoints in which those new, modified or deleted elements reside. The value can be analysed either by measuring impact to the work effort or by asking the stakeholder directly what value he believes the new soft system would bring.

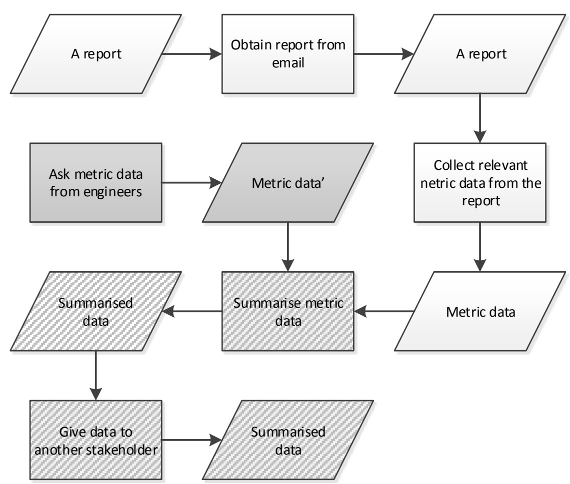

Figure 2. Two stakeholder viewpoints in a single soft system model

These values can be summarised to evaluate the overall impact. Furthermore, these values can also be used to redesign the solution to achieve a different impact with

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different values. When the value is known for each stakeholder, it is possible to determine the overall effect and analyse the effect for different groups of stakeholders. Values can be both negative and positive.

Based on the results, it was determined that using a modelling language with which the organisation is familiar supports the usability of the method. Therefore, S3AM allows utilisation of any modelling language as long as it supports visualisation, an input(s)-function(s)-output(s) model structure and allows attributes to be defined for each element. The important factor, however, is the ability to visualise the soft system and only promote the input(s)-function(s)-output(s) modelling structure to help stakeholders structure their viewpoints. This allows practitioners with varying levels of technical understanding to understand the described soft system more quickly and from different perspectives.

V. Discussion

The results from the action research show that problems in which humans are an integral part are hard to describe, comprehend and communicate. Understanding and structuring such a problem requires human understanding. The results further demonstrate how the same phenomena, the MRS and data used by the system, are perceived and understood in a different manner by each stakeholder. S3AM was developed as a combination of SSM principles, stakeholder analysis and a model-based approach to a soft system where humans play an integral role. These systems are never plain, hard systems. They are, rather, a collection of hard systems interacting with themselves or with humans. While they can be described using a hard system approach, the difference is that hard systems are considered to be free of interpretation and follow almost exact rules. Such systems can be described with exact languages due the nature of them. However, when humans are added to these systems as actors or observers, the way the system is perceived and how it functions now depends on individual perception, understanding and behaviour. Multiple actors can understand and describe same phenomena in equally different ways, all of which need to be captured somehow. For example, a single product in the telecommunication domain can simultaneously include building the physical network, maintenance and customer support. Due to the nature of human thinking, the same principles do not apply to designing, analysing and modelling, and a ‘soft’ approach is required. While the goal of a soft system approach is the same as a hard system approach (i.e., model a real world phenomena), the soft system approach introduces a way to capture and understand different viewpoints of human actors.

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

S3AM fulfilled the role of stakeholder analysis by allowing participants to identify relevant stakeholders, elicit and analyse their needs and have the means to verify and validate the problem system. In the end, S3AM was designed to be simplistic and direct the user to structure any problem as a soft system model, utilising stakeholder viewpoints to describe it as accurately as possible. It also provides information in the form of impact and value to facilitate understanding of the requirements, negotiation and agreement on a solution. The S3A also addresses the identified issues within stakeholder analysis by providing a systematic and defined approach and analysis method. It allows systematic construction of a soft system model explaining how different stakeholders perceive the real world. A local problem was structured and expanded to describe the soft system from additional perspectives, especially a strategic perspective, which allowed identification of problems and issues that potentially bring more value to multiple stakeholders rather than a few local stakeholders.

However, the research also showed that systematic and defined stakeholder analysis alone is not enough. How it is implemented and how it creates new information for the process is equally important. This defines the usefulness of the method and justifies its existence. Stakeholder analysis in SIS development is not only about identifying the requirements and agreeing on their specification through negotiation, prioritisation and validation. It also communicates information, creates awareness and elevates thinking to higher abstraction layers, enabling the discovery of problems or issues that create strategic value. S3AM enabled discovery and analysis of impacts and values outside the original problem description. In such a situation, the original requirement only presented a situational or tactical problem. Analysing it systematically from different stakeholder viewpoints revealed ‘strategic’ problems that were previously unknown. As local and strategic perspectives were visible, S3AM had a clear impact on removing uncertainty within the participants. It effectively increased the quality of the information that described the soft system. Essentially, this helped the stakeholders evaluate how much information they had and what information was potentially missing. Furthermore, as more stakeholders shared a viewpoint, the quality of the information increased.

The action research also revealed the needs and limitations of the SIS development process. This had a clear impact on the usability of the method. The case company's development process leans towards a decision-oriented [29] culture, emphasising the nature of information needed in the process. Furthermore, the need to make decisions in quick intervals was also apparent, and some kind of result was always necessary to either satisfy the information need to make a decision or to continue the analysis, as the risk of the unknown was too great. In this sense, stakeholder analysis also needs to inform the practitioners whether they know enough or whether there is missing information that still must be analysed. The process, methods and practices, as well as the workflow used to implement and enact them, should support freedom in the order of activities and the implementation of practices and strategies. In the modern world, stakeholders come from different organisations, forming distributed teams that work with the help of communications technology. In distributed teams, people work as dynamically and spontaneously assembled groups in a collaborative mode [7]. However, the developer's activity is still guided by objectives, work requirements, constraints and resources, which form the fundamental constraints on workers' behaviour [30]. Software design is never a fully rational process [31][32] as:

- People who commission software system do not know exactly what they want and frequently are unable to elaborate what they want.
- Even if the real need is known, further information needs surface as development moves towards implementation.
- Most humans cannot comprehend all information, even if all information is available.
- Only the most trivial projects are not subject to external changes.
- Human errors can only be avoided by excluding humans in the development.
- Preconceived ideas often influence the design process in ways that are not necessarily appropriate.
- There may be a reuse of software developed by others or from other projects that is not necessary ideal.

For the SIS development, gradual expansion, refinement and correction of the entire soft system model was a practical approach. The complexity and uncertainty in the beginning required that the problem first be structured and the data refined to validate it. The ability to modify any part at any given time was seen as an important aspect of the method. Since the information was not complete in the beginning (or it could not be properly comprehended), validation from multiple viewpoints was also essential.

The participants saw visualisation as an essential feature. They frequently talked about the same system but tried to explain the differences they perceived. They lacked either the words or expressions to describe this effectively for other stakeholders. However, when each viewpoint was modelled and the entire soft system was visible in a single model, the differences were communicated to each stakeholder more easily.

VI. THREATS TO VALIDITY AND LIMITATIONS

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

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

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

VII. CONCLUSIONS

In this paper, action research was conducted in a telecommunication domain company, aiming to create a stakeholder analysis for SIS development. Using the SSM as a starting template, the result was a Soft System Stakeholder Analysis Methodology (S3AM).

The main contribution of this paper is that it shows the importance of systematic analysis of stakeholder viewpoints from a soft system perspective. Furthermore, it raises the importance of method usability, a factor that cannot be ignored in SIS development as it directly affects data collection, quality and analysis. From an academic perspective, this study provides industry insight in terms of stakeholder analysis and utilisation in an SIS environment. It demonstrated the importance of systematic problem structuring and model creation in stakeholder analysis. Finally, the results present a systematic and practical approach for stakeholder analysis in an SIS development environment.

Future research should examine the use of S3M in domains other than telecommunication to verify and validate the methodology and its generalisability. In addition, more research is needed concerning the development of the modelling language.

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