Date: 23/08/2015

Leveraging Social Networks Constructed from System Engineering Repositories

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**Start date:** 01.09.2015

**Thesis type:** empirical

**Student suitability**

Software engineering course credits completed at CTH (total): 60

Software engineering courses completed at CTH relevant for thesis work:

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **Course** | **Course name** | **Credits** |
| DAT220 | Advanced software architecture | 7,5 |
| EDA397 | Agile development processes | 7,5 |
| DAT246 | Empirical software engineering | 7,5 |
| DAT240 | Model-driven engineering | 7,5 |
| TDA593 | Model-driven development | 7,5 |
| TEK365 | Project management | 7,5 |
| DAT231 | Requirements engineering | 7,5 |
| TEK236 | Social Entrepreneurship | 7,5 |

**Introduction**

In the past few decades the software market has grown and has become a crucial part of many industries which did not use any software development processes or any software development at all before. An example is the automotive industry, where software has become a very important part of the overall product since its introduction. In 2003 a joint study [4] of the Mercer Management Group, the Fraunhofer-Gesellschaft, and the Robert Bosch GmbH predicted that the market volume of software in the automotive would grow from 25 billion EUR in 2003 to 133 billion EUR in 2015, a growth of 530% in 12 years. These market trends rely on the estimations that, beginning in 2010, more than 40% of value creation in the automotive industry is realized by software and that the majority of innovations in the automotive industry will be realized by software [4]. As this increase in software development offers a great opportunity for the software market, it also causes many challenges caused by the increasing size and complexity of automotive systems. Braun et al. [5] observe that one of the challenges of software engineering in the automotive industry is due to inappropriate requirements engineering. The study shows that requirements engineering processes in the automotive industry are not well defined in most cases. As a consequence, engineering staff involved in the elicitation, specification and quality assurance of requirements mostly proceeds in an ad-hoc manner.

Requirements Engineering (RE) is an important part of the overall software development and poor requirements engineering has been described to significantly affect project success [6].  RE requires a lot of collaboration among different stakeholders in a software project, making intensive communication and organization essential and hence causing many challenges in the RE process [1]. A number of studies have been focusing on how to overcome RE challenges, e.g. [1,2,11,12]. Among these, some use social network analysis as a tool that gives insight into a software team’s communication patterns to aid tackling challenges, examples of which are the studies by Damian et al [2], which mines task-based social networks to explore collaboration in software teams, and Kwan et al. [12], which aims at answering whether socio-technical congruence has an effect on software build success.

In this study, we will address multiple of the challenges identified by Liebel et al. in their preliminary study on communicational and organizational challenges in automotive RE [1]. We will use social network analysis on real-life data extracted from Volvo GTT.  Based on an initial exploration of possible use cases and opportunities, we will develop analysis methods for leveraging the extracted social networks for tackling some of the challenges in [1].

**Aims and objectives**

The thesis project aims at developing a methodology on how to use social network networks originating from structured requirements data to address communication challenges in RE, and evaluating the developed approach in an industrial context. The following aims will be targeted during the course of the thesis project:

* Extract use cases for social network analysis in the automotive industry to tackle organizational and communicational problems discovered by Liebel et al [1].
* Automatically construct social networks in an industrial context at Volvo GTT, based on data extracted from the systems engineering tool SystemWeaver.
* Mining real-life industry data from Volvo GTT to build models that aim at resolving the challenges, based on the extracted use cases.
* Evaluate the models at Volvo GTT.
* Generalize the outcome by define a transformation model into an existing requirements standard such as ReqIF [13].

**Review of the literature**

Requirements Engineering is one of the main challenges in the automotive domain [16]. As a part of this, organizational and communicational challenges play an important role [1].

In an interview-based case study done by Soltani and Knauss [15], the authors explore the cross-organizational challenges of requirements engineering in the AUTomotive Open System ARchitecture (AUTOSAR) Ecosystem. AUTOSAR is a central standardization in the automotive industry which was developed to address the increasing complexity in the automotive embedded development. The scope of the study targets AUTOSAR-Tier-2 suppliers who deliver software components to AUTOSAR-Tier-1 suppliers who produce Electronic Control Units (ECUs) specifically for an Original Equipment Manufacturer (OEM), and sell them directly to the OEM. The researchers aimed to understand the Requirements Engineering (RE) process of an AUTOSAR-Tier-2 supplier, as well as focusing on what cross-organizational challenges exist in their RE process. As a result they identify that the challenges exist when the AUTOSAR-Tier-2 supplier operates in differentiating segment of the ecosystem, i.e developing specialized components. The researchers found  two classes of challenges for the AUTOSAR-Tier-2 supplier in the AUTOSAR ecosystem, which are: Requirements Communication and Requirements Verification. To overcome the challenges the researchers suggest using proven guidelines and tools as well as establishing continuous integration and delivery.

Liebel et al. [1] found seven key problems with communication and organization in automotive RE. Three of these, ‘Ch3: Sufficient Context Knowledge’, to have an overview over the surroundings on lower levels; ‘Ch4: Established Communication and Feedback Channels’, to communicate sufficiently with other people within or across the organization; ‘Ch6: Clear Responsibilities and Borders’, to have clear and communicated responsibilities between different parts of the organization, are essentially related to a lack of knowledge regarding the ‘right’ persons to talk to in a company. These problems, we believe, could be tackled - or at least reduced - using social network analysis based on data which already exists in many companies - namely the ownerships of requirements and the relations or traces between these requirements.

Damian et al. [3] introduce requirement driven collaboration as collaboration of a cross-functional team of business analysts, designers, developers and testers during the development and management of requirements. The authors describe an approach that (1) constructs a requirement-centric social network which represents the membership and relationships among members working on a requirement and its associated downstream artifacts and (2) outlines a number of social network analysis techniques to study collaboration aspects such as communication. They demonstrate their approach by discussing a case study that examines requirements-driven collaboration within an industrial, globally-distributed software team. Finally, they discuss implications regarding the use of our requirements-driven collaboration approach for research and practice.

Damian et al. [2] study Mining Task-Based Social Networks to Explore Collaboration in Software Teams. The study demonstrates the analysis using a social network of failure builds. In the study, the authors describe how current and timely knowledge of the project team’s social network is important in many situations, not just with broken builds. One can not always tell exactly who the project experts and central communicators are in the development environment [2]. The study also describes that the importance of the social network is for different roles in the project, i.e. project managers, team leader, and developers. The study states that the team leader can, by examining the team’s social network, identify collaboration and communication problems and project newcomers can identify the experts and active communicators. The study also mentions that the use of social networks in software engineering is relatively unexplored and holds much promise for future applications.

In this section, we reviewed four studies. The first two [1,15] are important for the thesis project as we believe that they make a ground for the intended work, as both explore challenges in RE in the automotive industry, which is the context of our study. The third and fourth studies [2,3] use social network analysis, which we also intend to use, to explore collaboration in software teams. Damian et al. [2] applies social network analysis to tackle communicational problems in a software development context. It is though unclear whether the same analysis apply to the automotive industry, which is the context that this thesis project aims at working on. Another aspect that differs between the thesis project and Damian et al. [2] study is the scope, as the latter targets software builds to build the social network upon, whereas this thesis project targets requirements and systems engineering data.

**Research questions**

In this thesis, we will aim at answering the following three research questions.

1. How can a social network be built based on extracted data from the commercial systems engineering tool SystemWeaver?

1.1 What tool features can be helpful or are necessary in order to conduct social network analysis?

2. To what extent does social network analysis aid in tackling organizational and communicational requirement engineering challenges in the automotive industry?

2.1   Which of the challenges can be addressed using social network analysis?

2.2 To what extent can an approach to utilize social networks to tackle organizational and communicational requirement engineering challenges in the automotive industry be generalized in the automotive industry context?

3. What opportunities result from applying social network analysis to requirements models in the automotive industry context?

In RQ1, we will look at SystemWeaver, the systems engineering tool used at Volvo GTT, and investigate use cases for constructing and using social networks based on the existing data at Volvo. After this is finished, we will in retrospective try to understand which features were needed for achieving this or which features were missing in order to do more, which will be the answer to RQ1.1.

In RQ2, we will mainly be studying the organizational and communicational requirement engineering challenges that were discovered by other researchers [1,15] and using the use cases that we extracted in RQ1 to answer whether social network analysis techniques can be employed to solve those problems and to what extent.

RQ3 will be answered by evaluating the constructed social network at Volvo GTT and then study what further use cases and opportunities it opens up.

**Expected outcomes**

The expected outcome is a methodology on how to build a social network based on structured requirement data. We expect to achieve that by using real-life requirement data taken from the automotive industry, and build the social network based on it. We also expect to answer whether the built network will aid in tackling RE challenges found in Liebel et al. [1] by evaluating it in an industrial context. Eventually we expect to achieve a transformation tool that allows us to generalize the outcome to an industry standard such as ReqIF [13].

The thesis work furthermore targets two submissions at international conferences:

1. International Requirements Engineering Conference (RE) with submission date around March 2016
2. A submission to another high-ranked conference or journal in a relevant area, depending on the results, towards the end of the study.

**Research Methodology**

The thesis project is going to be split into two phases. Both phases will be conducted at Volvo Group Trucks Technology (Volvo GTT), a Swedish multinational automotive company, with the second phase having different possible scenarios depending on the outcome of phase one.

**Phase One – Design Science Research – Volvo GTT**

Phase one will take place at Volvo GTT, which is one of the world's largest manufacturers of heavy trucks. The research will be in collaboration with the EE system engineering department. As its name indicates, the EE department is responsible for system engineering at Volvo GTT, e.g. diverse areas such as Infotainment or Active Safety.

We will base our work in this phase on the organizational and communicational challenges Liebel et al. describe in [1]. The thesis aims at addressing several of these challenges using social network analysis. The EE department at Volvo GTT uses the tool SystemWeaver [7] as a systems engineering environment. SystemWeaver is a model-driven development environment in which all development artifacts, e.g. Requirements, Design Components, or ECUs, are represented as Items. These Items, in turn, are related to each other. Owner attributes of each item make it possible to extract the underlying social network from this model via a programmatic API or a template language. In the scope of the thesis (a) an artifact for extracting and visualizing the social network will be built and evaluated and (b) the extracted social network will be leveraged in order to address several of the named challenges, e.g. by building a recommender system for staff turnover

The research will be conducted using the design science research methodology and will follow the model described by Vijay Vaishnavi and Bill Kuechler  [8] and the Guidelines for Design Science in Information Systems Research described by Hevner et al. [9].

In detail, we plan to structure the Design Science methodology as follows:

**Awareness of the problem:** In this phase of the thesis project, the problem we are focusing on is the requirements engineering challenges in the automotive industry. The initial base for the problem awareness step will be the study conducted by Liebel et al. [1] that points out multiple challenges in the very same industry. In addition to the study, we will be working in collaboration with the EE department to analyze those challenges. We plan to use interviews as the source of data.

**Suggestion:** When the problem is well understood, we start to build the tentative design for a social network to tackle the challenges that we found out in the first step. This step will also be conducted in collaboration with the EE department to analyze how the social network analysis will aid in tackling the challenges. This time a focus group is most likely to be used.

**Development:** In this step, the suggested tentative design will be further developed and implemented into an artifact. At EE, the tool SystemWeaver is used as a repository to document requirements as a structured graph of items. We will have access to that repository which opens up the opportunity for us to use the data to build the artifact. Additionally, Systemite as the manufacturer of SystemWeaver is involved in the study and can help out with technical issues.

**Evaluation:** The evaluation of the constructed artifact will be conducted after the design has been stabilized. It will be conducted at EE department, and will be evaluated against the challenges analyzed in the "*awareness of the problem*” step.

**Conclusion:** After the evaluation is conducted and the results are in hand, we will be able to conclude our work and answer our research questions, leading to an intermediate report and the first publication submission.

**Phase Two**

This phase will depend on the outcome of Phase One. We will describe in this section the possible scenarios we have planned and the methodologies that are going to be used in each scenario.

1. Extending the design science research conducted in Phase One at Volvo GTT to provide a general solution by defining a transformation model for the solution into a standard, e.g. ReqIF [13]. Generalizing the approach in this manner will aid us in mitigating the external validity threat to our study, and will be helpful for Volvo GTT in case they decide to migrate to other tools than those used in phase one.
2. Extending the work conducted in phase one by implementing further social network analysis to either be able to gather more data to answer our research questions, to improve the quality of the approach, or both.
3. Demonstrating how the piloted technique that was built in phase one can be used in practice. Possible aspects to this demonstrations could for example be guidelines to use the technique, recommendations to who and when the technique should be used within Volvo GTT, and a study of the possible ethical consequences of misusing the developed technique, such as using an employee turnover suggestion system for firing the ‘least important’ employees.

Risks

There are numerous threats to this study. This section of the proposal will contain the most significant expected threats along with ways to mitigate them.

* First of all, we are building most of the objectives of the first phase of the study on the assumption that we will, in collaboration with Volvo GTT/the EE department, be able to address organizational and communicational challenges in the automotive industry by using social network analysis. While we build this assumption on the fact that previous studies found social network analysis to be effective in addressing challenges, e.g. in Damian et al. [2], there is still a probability that we will not be able to significantly address these challenges, especially as there is a lack of similar studies in the automotive industry. In this case, our results will increase the knowledge in the research community, and we will have the second phase of the project, in which we can work from a different angle. One possible scenario of the second phase focuses on building a platform independent requirement model and transform the documented data at Volvo GTT into that model using model-driven techniques and finally do the same analysis with other standards e.g. ReqIF [13].
* Time limitis another threat to this study.As this study will be done as a master thesis project, it has a limited time of approximately ten months. We believe that there is a risk that the approach of building the social network based on the structured data that is extracted from SystemWeaver tool can be time consuming, especially as it involves a large technical portion. To mitigate this risk, we have technical support from Systemite, the company that produces SystemWeaver. This can help us to overcome technical problems that we might face during the project and hence speed up the development process.
* External Validity concerns to what extent it is possible to generalize the findings and to what extent the findings are of interest to other people outside the investigated case [9]. This study will be conducted in one automotive company, which makes it vulnerable to threats to external validity. To mitigate the risk, we included phase two of the project, in which the work might be extended and generalized to cover a standard. On the other hand, there is a lack of similar studies in the automotive industry, so we believe that this study will be significant and of added value even if it cannot be generalized to industries other than automotive, or replicated at other companies in the same industry.

**Time Plan**

We will in this section list the main milestones of the thesis project and the dates in which they are to be achieved:

**First semester Sep 2015 - Jan 2016: Phase one**,

SEP 2015:

* Extracting the use cases of Social Network Analysis at volvo GTT
* Collect the data that the thesis work will be based on.
* Familiarize ourselves with the data.

OCT 2015:

* Construct a social network based on the extracted data.

NOV 2015:

* Evaluate the outcome at Volvo GTT

DEC 2015- JAN 2016:

* Document the first phase
* Write a paper for publication

**Second semester FEB 2016 - JUN 2016: Phase two**

FEB 2016:

* Extending the study to generalize it (could be at Volvo GTT or another company)

MAR 2016:

* Define a transformation model to transform the resulted network into a standard

APR 2016:

* Document the second phase

MAY 2016:

* Write a paper for publication
* Start of feedback/polishing phase
* Complete, preliminary thesis ready for review

JUN 2016:

* Final thesis exam

**Significance of the study**

With this study, we expect to have both an industrial and an academic impact. In terms of academia, we address challenges which have previously been identified by empirical studies (While the paper by Liebel et al. [1] is currently not published, similar challenges have been identified in different contexts, e.g. in [14,10]). Additionally, by targeting an existing standard such as ReqIF [13] in the second part of the study, we aim at generalizing the findings from the first half to a broader context, independent of domain or company. As the targeted challenges are highly relevant to industry, successfully addressing these would automatically have an impact on industry. Furthermore, if the analyses show potential, there is a realistic chance that proposed solutions can directly be transferred to industry, due to the collaboration with Volvo GTT.

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