A comprehensive approach to identifying key stakeholders in complicated software ecosystems

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***Abstract*—Software stakeholders are critical to the success of software development projects, because they influence the strategic direction, the financial backing, and have specific knowledge – all of which sustains the software being developed. As the complexity of software environments increase, and expectations for cross-product integration heighten, there is more pressure on actors within software ecosystems (SECOs) to work in unison to produce reliably integrated software, efficiently. Recently collected empirical findings show that requirements managers working in SECO environments believe that all key stakeholders can be identified, but that it requires analysis, investigation and expert knowledge. Until now, the existing frameworks describing stakeholder identification do not take into account the level of dependencies that occur in SECOs nor the implications on SECO health. This research proposes that a structured comprehensive approach to identifying stakeholders in SECOs would provide practitioners the guidance they need to avoid the common pitfalls of poor stakeholder identification, including late requirements from critical stakeholders which can risk the software release schedule, software quality, and scope.**

***Index Terms*—stakeholder identification, requirements elicitation, software ecosystems**

I. Research Background and Motivation

In the last decade it has become increasingly common for software companies to cooperate around a shared platform for a shared market [1] [2]. This type of collaborative environment is termed broadly as a Software Ecosystem (SECO), where several software products, which rely on one technological base, aim to optimize their integration while diversifying their market presence. Although these partnerships are profitable to the actors involved in the SECO, they introduce complexity to the management of requirements [3] [4].

A real-world example of a SECO would be the Microsoft Dynamics CRM (MS-CRM) software platform, which offers an extension marketplace [5]. MS-CRM partners can build niche software to address market segments that Microsoft does not, and it is in the interest of Microsoft that the partner solutions are well integrated and that implementation partners and customers are satisfied with the SECO offering. In this example, MS-CRM represents the technological base and so-called keystone player of the SECO [2]. Requirements from stakeholders are made or elicited (collected) at regular intervals and also ad-hoc. In the context of this research, a "requirements manager" is considered to be anyone who has a responsibility of managing stakeholder requirements. In many software companies this role is called "product manager", "product owner", "project manager", or "requirements engineer".

One can imagine that a successful SECO, like MS-CRM, has thousands of direct customers, hundreds of partners, and many other stakeholders who have a stake in the outcomes of the SECO. With all of these stakeholders, how does a requirements manager for a product like MS-CRM know when they have successfully identified all the stakeholders, or at least all of the critical, or "key" stakeholders?

Having too many stakeholders to manage completely is a problem that requirements managers of the technological base product of SECOs face [6], which is often exacerbated by open interfaces [7], allowing any software within the same network to interface with them, without notifying the platform software product team of the integration [4] [8]. Open interfaces are desirable, as they allow for easier extensibility and integration [7]. This presents challenges in the case of requirements elicitation [9] [10], but before this can occur, it is imperative to know from whom the requirements should be elicited [4] [11]. Without identifying a representative group of stakeholders before the requirements elicitation process, the software is likely developed with an incomplete view of the stakeholder needs, which in turn leads to poor adoption or a delayed timeline to compensate for late requirements [12] [10]. These factors are both expensive, and harmful to the reputation of the software company [6] [12] [13].

The foremost SECO literature indicates that ensuring or at least supporting SECO health is in the interest of the keystone player and the SECO itself [14] [24]. Interview studies conducted with practitioners as part of this research show that while practitioners acknowledge the criticality of SECO health in theory, it does not usually actively factor into their decision-making during stakeholder identification and requirements management.

Empirical evidence from this research shows that requirements managers for software products that act as the technological base of SECOs require a comprehensive approach to stakeholder identification. Put another way, they are interested in identifying all types of stakeholders and then determining which ones are the critical (or key) stakeholders for a given release planning cycle.

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II. Research Questions and Hypothesis

The objective of this research is to explore available stakeholder identification processes and if no comprehensive approaches to stakeholder identification in SECOs exist, to design one which considers practitioner insights and the theoretical underpinnings of the foremost literature in the domain.

Based on the research objective, the following hypothesis can be made:

It is not necessary to identify every stakeholder in a SECO to achieve comprehensive requirements elicitation, as long as key stakeholders are identified.

In order to address the research problem and to confirm or deny the hypothesis, the following research questions are proposed:

- Main Research Question: How can key stakeholders be identified as part of the requirements elicitation process for SECOs?
- Sub Research Questions:
  - (RQ1) When and how is a stakeholder deemed a "key" stakeholder, and when is that status revoked?
  - (RQ2) Which stakeholder identification processes exist in literature and in practice, and which ones can be adapted for SECOs?
  - (RQ3) Which stakeholder attributes are most often referred to in literature and used by practitioners, and which are minimally required to define SECO stakeholders?
  - (RQ4) How can a valid reference process model for stakeholder identification in SECOs be designed?

These research questions present a number of technical challenges associated with obtaining answers.

Qualitative studies conducted with practitioners are a crucial component to this research, however experts in the field often have limited time for participation or cannot participate at all. Studies must be designed in a way that fit with practitioners' schedules, because any time commitment longer than one hour (continuously) would limit participation even more. On a positive note, experience shows that once practitioners are engaged in a study, they remain interested for further engagement.

Another challenge of answering these research questions is determining an appropriate number of studies, participants, and the period of evaluation. Especially in the case of artefact design, improvement and evaluation iterations can be made whenever new insights are uncovered, which have the potential to change an aspect of the design. In the context of PhD research, it is of vital importance to the project to scope the research such that it fits within the given timeline, but also that outcomes have been reached using rigorous methods.

III. Related Literature

Systematic literature reviews were performed to discover the foremost literature related to the research domain and the research questions [15]. The systematic literature review returned the following results:

- 288 reviewed conference papers and articles in total,
  - Reduced to 73 selected sources on which the research is based,
    - 28 of the 73 mention stakeholder identification processes and/or attributes
      - 15 of the 73 included processes, methods, or frameworks for identifying software stakeholders,
      - 20 of the 73 included attributes of software stakeholders.

The 28 papers and articles were synthesized together to identify common themes and research gaps, which are summarized in Figure 1.

The remaining conference papers and articles (73 less 28 synthesized in this section) provide a foundation of literature surrounding SECOs and requirements elicitation. They will provide an anchor in theory in the future of the research project when design decisions need to be made.

Figure 1 represents common concept areas within the selected literature. As SECOs are still an emerging field of research, most of the literature around stakeholder identification is written in the context of a traditional software project, where the dependencies between stakeholders are not as complex.

Typically, in the selected literature, it is more common to see detailed descriptions of stakeholder attributes, which include roles (keystone player, niche players, etc.), participation level, geographical location, and more. In the literature that proposes a stakeholder identification method, there is almost certainly also mention of stakeholder attributes, since many of the process steps involve defining particular attributes of a stakeholder in a given order. This is the motivation for classifying the literature based on both stakeholder identification process and stakeholder attribute components.

It was discovered that most of the literature, where a stakeholder identification process is present, aims to optimize the stakeholder identification process with a particular focus. Linåker et al. [4], for example, focus their research on identifying the stakeholders within the SECO that have a large amount of influence on the decision-making over the rest of the ecosystem actors. The other common stakeholder identification focuses are on identifying more stakeholders through known stakeholders and identifying stakeholders of noteworthy roles. Only Zhao et al. [16] propose a stakeholder identification process that addresses, at a high-level, identifying stakeholders with influence, and within certain roles (including the keystone actor) while building the network. This is considered to be a comprehensive approach, because it covers a broader attribute scope.

It is clear that from the analysis of the literature that there is a lack of comprehensive approaches to stakeholder identification, and especially in the context of SECOs. This lack of and need for a comprehensive approach is also echoed by practitioners and my own industry experience. One of the goals of this research project is to make a contribution that is generalized, such that it is optimized for a SECO environment, but it not limited to a particular SECO. Providing this type

Stakeholder Attributes		Stakeholder Identification Methods				
		Focus on influence	Focus on network	Focus on stakeholder roles	Comprehensive approach	No method for stakeholder identification
	In SECOs	(Linåker, et al., 2016) (Linåker, et al., 2019)				(Axelsson & Skoglund, 2016) (Jansen, et al., 2012) (Handoyo, et al., 2013) (Sadi & Yu, 2015)
	Traditional	(Harbers, et al., 2015) (Smith, 2000) (Babar, et al., 2015) (Anwar & Razali, 2015)	(Costa & da Cunha, 2010) (Lim, et al., 2010)	(Ballejos & Montagna, 2006) (Ballejos & Montagna, 2008) (Sadiq & Jain, 2014) (Konaté, et al., 2014) (Sharp, et al., 1999)	(Zhao & Zhao, 2018)	(McManus, 2004) (Mitchell, et al., 1997) (Kulkarni, 2008) (Sherkat, et al., 2016) (Lim, et al., 2013) (Penzenstadler, et al., 2013) (Alexander & Robertson, 2004) (Preiss & Wegmann, 2001) (Rahman, et al., 2017) (Tovar & Pacheco, 2006)

Fig. 1. Synthesis of selected literature – concept matrix.

of comprehensive approach to stakeholder identification in SECOs would also lay the foundation for further research in requirements elicitation in SECOs.

By performing the concept-based analysis on the selected literature, the knowledge gap was confirmed, and the sources identified, which have been used to generate early artefacts – stakeholder identification process step categories and an ontology of stakeholder attributes.

IV. Research Methodology and Approach

The Design Science Research Methodology (DSRM) is one of the most distinctive approaches for Information Systems (IS) research projects, because of the guidance it provides in iterative design improvements and evaluation [17] [18]. DSRM positions itself as a problem-solving paradigm [18] with the objective of producing an artefact that has been designed and then evaluated thoroughly [19] [20]. It is technology-oriented and its products are assessed against criteria of value and utility [21]. DSRM is focused on creations of artificial systems, and it addresses the building and evaluation of artefacts to meet business needs [19]. So-called "wicked problems" – problems that exist in vicious circles, or lack self-evident solutions – are good candidates for a DSRM approach [17].

The objective of this research is to examine how key stakeholders can be identified in complicated SECOs. The main component of the current research is the design of an artefact in the form of a reference process model, that can be used by practitioners to derive their own business process model instantiations from the reference process model, which are tailored to their own business and SECO environment. The task of identifying all stakeholders in a SECO is often not possible due to the high volume of stakeholders and open interfaces. There is no self-evident solution for how to identify the necessary stakeholders. Furthermore, when stakeholders are not adequately identified, it translates to an impact on the development project. This indicates that there is a business need for an artefact (model) that is built and evaluated in a real-world environment. Therefore, DSRM provides an appropriate approach for this research.

More specifically, this research follows the DSRM approach originally proposed by Peffers [18] and extended by Ostrowski [19], who offers methods for the meta-design phase and provides, in particular, a detailed approach for the design of a reference process model artifact. The application of this DSRM approach to the research is depicted in Figure 2.

V. Data Collection and Initial Results

A. Qualitative Study with Practitioners of Requirements Management in SECOs (RQ1, RQ2, RQ3)

A study was designed to collect empirical insights from practitioners. Practitioners were recruited by accessing my professional network and using social media to cast the widest possible net. In total, 97 participants were contacted directly with the goal to recruit at least 12 qualified practitioners to participate in both semi-structured interviews and focus groups (three groups of 4-6 people). At the time of writing, 35 have expressed interest, and 13 interviews have been conducted. Participants were given a brief introduction to the grounding definitions "software ecosystem" and "stakeholder". Then they were asked to describe a successful SECO they have first-hand experience with, and answer questions about stakeholder identification, attributes, and requirements elicitation:

- If you were a requirements manager for the platform product in a software ecosystem, which stakeholder attributes would you collect during the identification process?
- From the perspective of the platform product, what is a "key stakeholder"?
- When and how do you decide who is a key stakeholder?
- Can this status of key stakeholder be revoked? What would cause it to be?

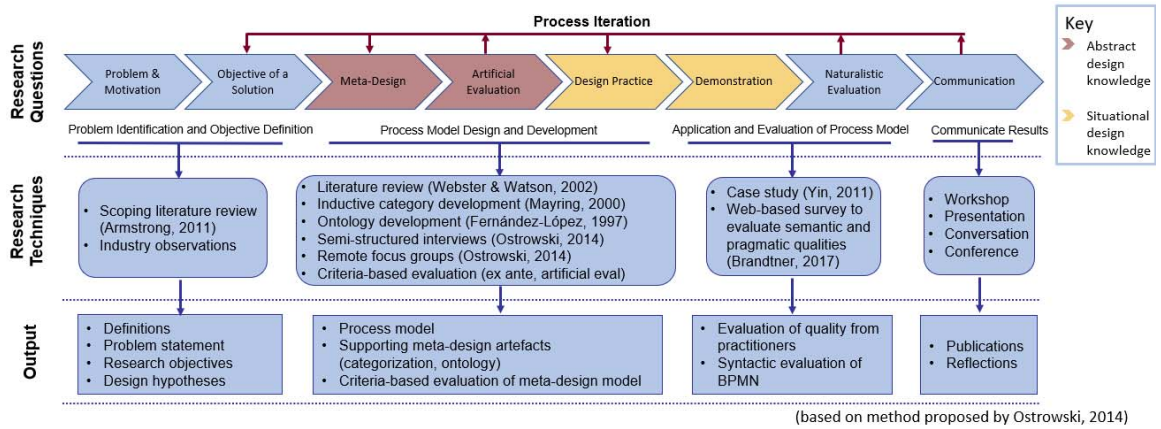

Fig. 2. Design Science Research Methodology applied to the given research project.

- Requirement elicitation is the act of retrieving requirements from stakeholders. Do you think requirements are elicited from all key stakeholders of a platform product in a software ecosystem?
- When should the requirements elicited? In your experience, how often are they elicited?
- Please complete the sentence with the most appropriate ending: *The identification of all key stakeholders in software ecosystems...*
  - *...is obvious to all.*
  - *...requires analysis, investigation and/or expert knowledge.*
  - *...can only be perceived in retrospect.*
  - *...is not possible.*

The interviews were recorded and are currently being transcribed and anonymized for data analysis.

B. Exploring What Makes a Key Stakeholder (RQ1)

In the selected literature, the term "key stakeholder" is used to refer to the stakeholders whose requirements are more worthy of consideration based on a quantitative rating of several factors (some examples are communication, objectivity, and language barriers) [22], or stakeholders that are ranked in a high influence-high importance category [23]. Over long project periods, the set of key stakeholders tends to change. Because the literature does not provide a conclusive definition or approach for giving a stakeholder "key" status, the question "When and how is a stakeholder deemed a key stakeholder, and when is that status revoked?" is being addressed as part of a series of semi-structured interviews and focus groups with practitioners.

Early insights emerging from the semi-structured interviews with practitioners show that key stakeholders are often viewed as the ones that have the largest financial impact or deep expert knowledge on technological platform software. There are more varied opinions on when a stakeholder becomes key. A stakeholder is no longer a key stakeholder if the financial investment is stopped or if the SECO strategy takes a different direction that excludes a formerly key stakeholder.

C. Category Induction of Stakeholder Identification Process Steps (RQ2)

A stakeholder identification process in literature was considered for this research if it was a novel model or framework which had multiple steps detailing how to identify the stakeholder. The analysis returned 15 processes, which were distilled into 58 process steps in total. Next, the process steps were assessed and categories were induced and combined when there was a strong resemblance. The final result of the inductive category development process is a list of 15 stakeholder identification steps [15]. The next step is to collect stakeholder identification process steps in a comprehensive focus group study and compare the results to these initial results.

D. Ontological Modelling of Stakeholder Attributes (RQ3)

Stakeholder attributes are the characteristics by which stakeholders can be defined (some examples include influence over other stakeholders, collaborative ability, or geography). As a result of the literature synthesis, it was possible to enumerate attribute terms, and create a taxonomy reflecting the hierarchy [15].

The taxonomy was then extended to an ontology to reflect the relationships between terms. To create the ontology, first the terms and their relationships were modelled conceptually, and then modelled with Web Ontology Language (OWL) in Protégé software. Ontologies which are written using OWL, semantically valid, and published publicly can be used in object-oriented programming as part of the program logic by any developer who requires the knowledge base the ontology describes. The ontology will be validated in a semantic check using description logic, which is supported by Protégé and as part of planned focus groups. In the focus groups, practitioners will be asked to list and describe relationships between stakeholder attributes. Additionally, they will be asked if there

are terms missing from the ontology and they will be offered the opportunity to navigate the ontology as part of the process development.

E. Design Science Artefact – Reference Process Model Development (RQ4)

The expected outcome of the research project is a model artefact, specifically a reference process model to identify key stakeholders in SECOs. The reference process model (Figure 3) is undergoing a design iteration which combines the process steps and stakeholder attributes from the early artefacts. It also reflects some initial results from the semi-structured interviews, such as the decision element at the beginning of the model to determine if the environment is complicated, complex, or chaotic based on the Cynefin framework. The Cynefin framework aims to classify systems in various states of order and disorder, and to offer different approaches to problem solving depending on the state of the system. The framework is already used in the software development domain, and most of the early empirical insights collected from practitioners in the semi-structured interviews echo the guidance of the Cynefin framework. The resulting design iteration of the reference process model now includes a decision element at the beginning. If the system is deemed complicated, the process model continues using a structured approach, if the system is chaotic or complicated, less structured approaches must be taken for stakeholder identification. This iteration of the reference process model was modelled using Business Process Model and Notation (BPMN) and Decision Model and Notation (DMN) in Signavio software.

VI. Contributions

The contributions of this research will ultimately include a reference process model for identifying key stakeholders in software ecosystems, which is depicted in its early stages in Figure 3. The reference process model will be designed to be used by requirements managers of the technological base (keystone player) of platform-based SECOs. It will provide a structured approach to identifying stakeholders in complicated environments as defined by the Cynefin framework. The reference process model will be designed in a way that practitioners can derive their own business process model instantiations from the reference process model, which are tailored to their own business and SECO environment. Existing methods of stakeholder identification in the literature do not take a comprehensive approach to considering all stakeholders, while pinpointing only a subset from whom to elicit requirements (in this research, referred to as key stakeholders) and also with approaches that preserve SECO health, especially in SECOs that include proprietary software.

An auxiliary artefact to designing the reference process model artefact is an ontology of stakeholder attributes. The ontology is an additional contribution which will be made publicly available in ontology repositories, and could be used by software developers who require validated stakeholder attribute description logic as part of their application development.

Another outcome of this research is the synthesis of the foremost literature, which has been enriched with current practitioner insight therefore adding a knowledge contribution to the domain.

In the initial scoping of this research project, the goal was to address interdependencies between requirements in SECOs, especially with regard to requirement prioritization. However, it soon became apparent that before requirements interdependencies can be adequately considered, one must ensure that the necessary stakeholders are accounted for. Therefore this research also aims to provide a foundation for future researchers of requirements engineering topics to build on.

VII. Publications

The following papers were published in the course of this research project:

- S. Lewellen, "Identifying key stakeholders as part of requirements elicitation in software ecosystems," in 24th ACM International Systems and Software Product Line Conference (SPLC'20), 2020. [15]
- S. Lewellen and M. Helfert, "Identifying Suitable Representation Techniques for the Prioritization of Requirements and Their Interdependencies for Multiple Software Product Lines," in International Conference on Business Information Systems, 2018.

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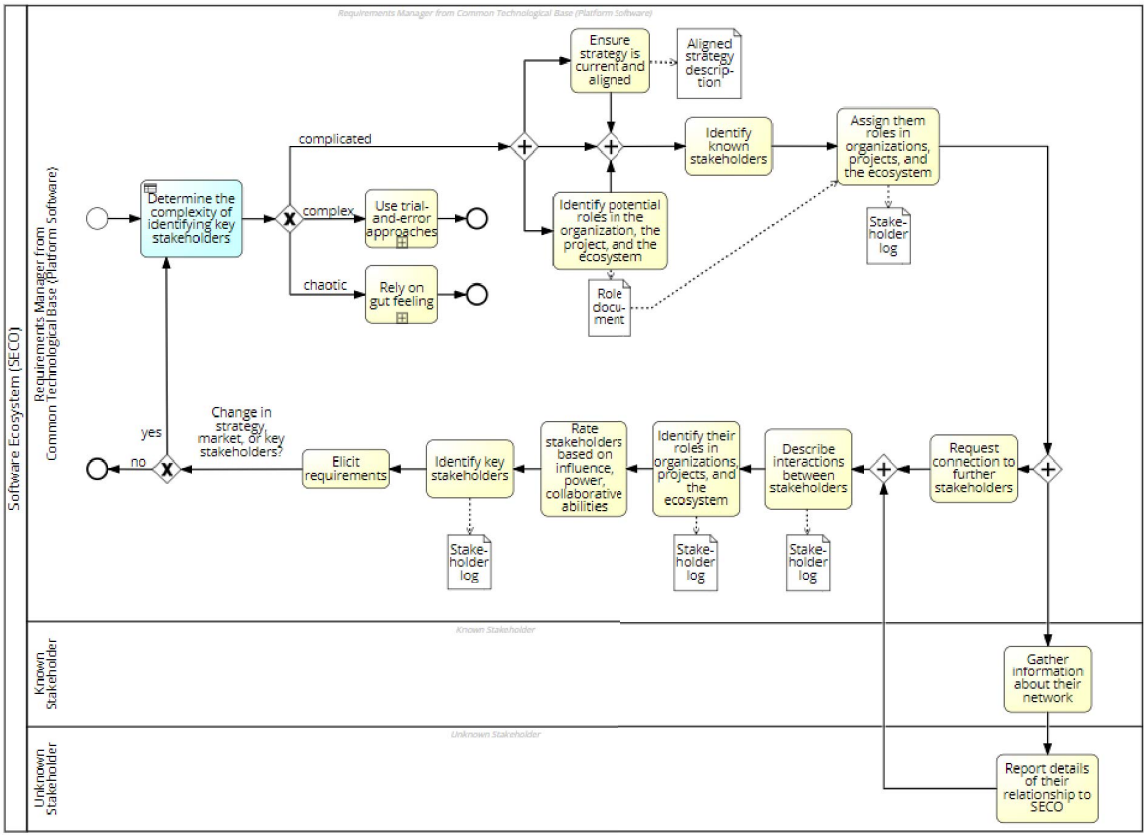

Fig. 3. Reference process model for stakeholder identification in SECOs

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