Preliminary Findings of Expert and Systematic Reviews on the Software Ecosystems Research

Olavo Barbosa[1], Rodrigo Santos[2], Davi Viana[3]

[1]State Agency for Information Technology of Pernambuco
Av. Rio Capibaribe, 147, São José – CEP 50020-080 – Recife, Brazil

[2]DIA/CCET – Federal University of the State of Rio de Janeiro (UNIRIO)

[3]Computer Engineering/CCET– Federal University of Maranhão (UFMA)

olavo.barbosa@ati.pe.gov.br, rps@uniriotec.br, davi.viana@ufma.br

Abstract. *Software Ecosystems (SECO) are a set of organizations and actors, as well as their relations that cover technical, social and business aspects of software development. As a research field, several studies and reviews were conducted towards a body of knowledge for the SECO field. In this paper, we preliminarily analyze these studies in order to provide an initial overview of the SECO literature. Our intention is to aid researchers to know some relevant opportunities to foster the field's evolution, such as collaborative governance.*

1. Introduction

The growing importance and special characteristics of software systems increasingly make it an interesting topic of study for social sciences, law, management, government, business, and economy (Santos & Werner, 2011). One of the key characteristics of the software industry like others is that most organizations do not have all the resources to satisfy the needs of customers. In addition, software organizations face some challenges in coping with market and environmental factors that are usually out of control (i.e., economic constraints). As such, infrastructure acquired from many software vendors must work mutually. Frequently, there is a need to integrate the applications in complex ways across organization boundaries in order to create and support new products and satisfy customer needs. This set of organizations, resources, customers, and products have been known as Software Ecosystems (SECO). SECO represents an approach to analyze relationships among players of software industry in which organizations must engage in a perspective that considers both their own business and third parties.

As a research field, SECO analyzes the software industry as a networked industry. Concepts from biological (Moore, 1993) and business (Iansiti & Levien, 2004) ecosystems inspired the SECO field. However, Messerschmitt & Szyperski (2003) have started the scientific research on SECO with their book. It is the oldest reference in the Software Engineering area and has been supported by several citations found in primary and secondary studies already published in the literature. Serebrenik & Mens (2016) point out Microsoft as an example of a SECO in their meta-analysis for the SECO research. In turn, we have identified that many studies and reviews were conducted towards a body of knowledge for the SECO field. In this paper, we preliminarily analyze some of them in order to provide an initial overview of the SECO literature. As such, we included Systematic Mapping Studies (SMSs), Systematic Literature Reviews (SLR) and Personal Opinion Surveys (POS) on the SECO research in our analysis. Our

intention is to aid researchers to know relevant opportunities to foster the field's evolution, such as collaborative governance. This paper is organized as follows: in Section 2, we present related work; in Section 3, we explain the research approach; in Section 4, we discuss preliminary outcomes; and in Section 5, we conclude the paper.

2. Related Work

In the SECO research field, natural ecosystems' concepts are generally accepted. The business ecosystems' perspective is considered as well, since the SECO field inherits properties from both natural and business ecosystems. Santos & Werner (2011) worked on such concepts from 2009 to 2010 and organized them in three perspectives known as architecture, strategies/tactics, and social networks. In turn, Hanssen & Dybå (2012) provided theoretical foundations for the SECO field. They proposed a framework to guide and support future directions. Based on a SMS, Barbosa et al. (2013) concluded that SECO research is concentrated in eight main areas, and the most relevant are open source software, ecosystem modeling, and business issues. They analyze SECOs in three dimensions: technical, business, and social. Manikas & Hansen (2013) also addressed those dimensions in a SLR on SECO research and provide an overview of the field.

Jansen et al. (2013) summarize a collection of studies that cover several aspects, such as SECO definitions, business network management, and SECO visualization and analysis. Fotrousi et al. (2014) provide an overview of existing research on the SECO performance with an SMS. In a SLR study, Franco-Bedoya et al. (2014) explore part of the literature of open source software for identifying quality measures and provide a quality model for the quality assessment in SECO. Axelsson & Skoglund (2015) focus on quality assurance challenges that exist in traditional development practices and also carry over to ecosystems. To complement the collection of reviews, Manikas (2016) provides an updated study on the field in order to document its evolution over the past years. According to the study, literature in SECO has evidenced signs of maturity.

3. Research Approach

Inspired by the work of Wohlin et al. (2013) and by the procedures of Petersen et al. (2015), our research follows four steps (we are focused on the step 2 at this moment). **Step 1** aims to select secondary studies on the SECO research according to the following criteria: (1) SMS/SLR studies in SECO; (2) expert reviews in SECO using *ad hoc* literature selection that adopted some practices of SLR/SMS; and (3) POS studies in SECO. **Step 2** consists of applying the method proposed by Cruzes & Dybå (2011) regarding the levels of interpretation in thematic synthesis. The process of highlighting segments of the text of each study was started with the use of spreadsheets. **Step 3** examines the results in order to reduce the overlapping, and translates codes into themes. Furthermore, this step involves the process of grouping the initial codes into a smaller number of sets and interpretations to create a model with higher-order themes. **Step 4** aims to ensure the reliability of research outcomes by recognizing the limitations of study and how they affect the results. The main threat is the selection of studies and individual bias in the assessment of those studies. Although we have identified few secondary studies well known in the community based on related conferences, workshops and special issues, some works may have been left out of our study.

4. Initial Results and Discussion

For step 1, we selected nine studies that are SLR/SMS, expert reviews or POS in the SECO research field. After performing an initial analysis of this set of studies, we found some preliminary results that we describe bellow. The selected studies are in Table 1.

Table 1. Set of secondary studies on SECO field and its classifications.

Study	Authors	Research methods	Publication venues
S1	Hanssen & Dybå (2012)	Some practices of SMS/SLR	Conferences/workshops
S2	Barbosa et al. (2013)	SMS	Conferences/workshops
S3	Jansen et al. (2013)	Set of scientific studies	Scientific book
S4	Manikas & Hansen (2013)	SLR	Journal
S5	Franco-Bedoya et al. (2014)	SLR	Conferences/workshops
S6	Fotrousi et al (2014)	SMS	Conferences/workshops
S7	Axelsson & Skoglund (2015)	SMS	Journal
S8	Manikas (2016)	SMS	Journal
S9	Serebrenik & Mens (2016)	POS	Conferences/workshops

Outcomes in S3, S6, and S8 identify that the SECO field was inspired by several other fields. Some of them bring concepts of natural, business and digital ecosystems, and proposes new definitions for SECO. In spite of proposing a suitable overlapping and interrelation of the concepts found in the set of studies, we suggest that the social, technical and business perspectives discussed as the key dimensions for SECO (S1, S2, S3, and S6) can be seen as the three levels or themes of governance. As concluded in S8, there is an intersection between Information Technology governance and SECO. One relevant aspect is the decision-making regarding who makes decisions in a SECO (and how to do it) (S2, S3, S4, and S7). Regarding the support for the platform development, a challenge is to provide an actor of a SECO with information to make SECO management activities feasible in order to assist platform updates (S7). An approach to represent such concepts is to use definitions such as codes, themes, and high-order themes, as proposed by Cruzes & Dybå (2011). Codes can be defined as interesting concepts, categories, findings, and results of studies. A theme describes and organizes possible observations and/or interprets aspects of a phenomenon. Once themes are identified, they can be explored and interpreted to create a model consisting of higher-order themes and relationships among them. Preliminary themes presented in this study are represented in a mind-map, i.e., a tool used to do it, as recommended by Cruzes & Dybå (2011). As such, Figure 1 shows a visual illustration to help sorting the different codes into themes and finally in higher-order themes.

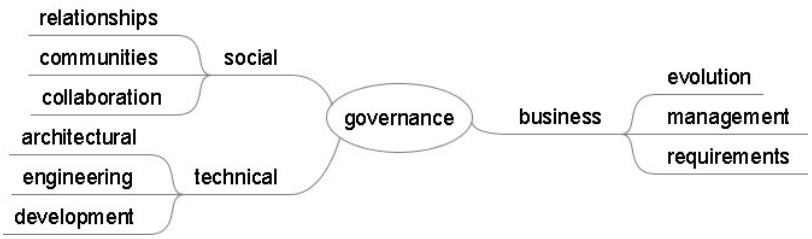

Figure 1. SECO concepts in the context of governance

In Figure 1, governance is seen as a higher-order theme that includes decision-making regarding what best strategies are needed for the actors' survival in any SECO, in any role, taking into account social, technical, and business perspectives as themes. Moreover, concepts of business such as evolution, management and requirements are

defined as codes in the context of SECO, as identify in S9, S2, and S8, respectively. These three themes are linked to SECO governance, as presented in Figure 1. There is an interrelation between each theme, even though they are represented in isolation. Once SECO comprises software development activities in which people take an important role, governance also covers social aspects (S1, S2, S7, and S9), relationships inside the communities, and levels of collaboration (S1, S2, S3, S6, S7, and S9). For each ecosystem participant, for example, there are many demands on how to be (and keep as) a leader, as well as relations with other perspectives, such as technical and business (and vice-versa). As identified in S2, S3, S6, S7, and S8, strategic decision-making in the SECO context can be reflected in the software (and organizational) structure by applying specific rules in the common technological infrastructure.

On the technical governance theme, there are codes such as architectural issues, as identified in S1, S2, S3, S4, and S8. They are subsets of the development process concerns in the context of SECO. In turn, S8 argues that a software architecture in SECO supports the ecosystem nature (i.e., be flexible to meet the needs of a specific SECO), management, and business model. Furthermore, patterns and architectural styles need to address other governance themes in order to create better and more reusable platforms. In turn, on the business theme, S1, S2, S8 and S9 identify that the ecosystem management can define, for example, how simple it is for new members to be engaged in a SECO. Moreover, the business model can attract new actors, while the way the software is produced and the common infrastructure's and products' architectures can influence actors' relationships and should reflect SECO management (S1, S2, and S3).

On the context of governance, for example, S9 identifies evolution as a key aspect for the success of a SECO. Once the evolution is related to the business model of a SECO regarding how close/open a SECO is in terms of its platform, procedures and processes are expected to emerge to determine the future evolution of the SECO. S5 discusses evolution as a sub-characteristic of ecosystem quality. Study S5 also defines quality as one dimension the software platform in which the ecosystem's projects are built upon; for example, the Android SECO provides the Android platform used by all the Android mobile apps. In spite of changes or evolution of the platform, how can external developers contribute to partially-closed and -controlled SECO's platforms, such as Apple/iPhone? In this regards, the business model can influence a community of organizations or developers that base their relations to each other on a common interest.

Regarding to the relations of actors on a common interest, a software developer assumes ownership or responsibility of part of the software (S2). Either an open or a closed platform that is defined by the business model may influence important social factors that affect an ecosystem, such as recognition from peers, sense of community, and sense of code ownership, as identified in S2. In tum, the business theme defines the SECO architecture that influences the social perspective, i.e., cooperation/knowledge sharing with multiple and independent entities (S2). On the technical level of governance, there is a need to link the process requirements (S7) with a proper management as part of the software development in the context of business governance. In S5, we identify this relation from business to evolution and requirements in open source SECOs. Such link supports the quality assurance as a way to prevent bad decisions and avoid problems, as well as allow verifying the compliance with the requirements and the business goals.

5. Conclusions and Future Work

In this paper, we preliminarily analyzed studies and reviews in the SECO field in order to provide an initial overview of related literature. We selected a set of nine studies and extracted codes into themes for providing some relevant opportunities to foster the field's evolution, such as collaborative governance. Once this study aimed to provide an initial synthesis by using high-order themes previously presented, we intend to use other tools such as thematic networks, tables, and tree-maps for a depth understanding of the relationships of governance as the central-topic of these themes in a future work. We hope that our preliminary outcomes aid researchers to know future directions according to what is already addressed in the studies in SECO, since SECO field has demonstrated signs of maturity and affect the treatment of economic and social aspects of software.

Acknowledgements

The second author thanks CNPq (Proc. No. PDJ 150539/20016-9) for financial support.

References

Axelsson, J., Skoglund, M. (2015) "Quality Assurance in Software Ecosystems: A Systematic Literature Mapping and Research Agenda". The Journal of Systems and Software 114(2016):69-81.

Barbosa, O. et al. (2013) "A Systematic Mapping Study on Software Ecosystems through a Three-dimensional Perspective". In: Jansen, S. et al. (eds.) Software Ecosystems: Analyzing and Managing Business Networks in the Software Industry, Edward Elgar Publishing, 59-81.

Cruzes, D.S., Dybå, T. (2011) "Recommended Steps for Thematic Synthesis in Software Engineering". 5th Intl. Symposium on Empirical Software Engineering and Measurement, Banff, Canada, 275-284.

Franco-Bedoya, O. et al. (2014) "QuESo: A Quality Model for Open Source Software Ecosystems". In: 9th International Conference on Software Engineering and Applications, Vienna, Austria, 209–221.

Fotrousi, F. et al. (2014) "KPIs for Software Ecosystems: A Systematic Mapping Study". In: 5th Intl. Conference on Software Business, Paphos, Cyprus, 194-211.

Hanssen, G.K., Dybå, T. (2012) "Theoretical Foundations of Software Ecosystems". In: 4th International Workshop on Software Ecosystems, Cambridge, USA, 6-17.

Jansen, S., Brinkkemper, S., Cusumano, M.A. (2013) "Software Ecosystems: Analyzing and Managing Business Networks in the Software Industry". Edward Elgar Publishing.

Iansiti, M., Levien, R. (2004) "Strategy as Ecology". Harvard Business Review 82(3):68-78

Manikas, K. (2016) "Revisiting Software Ecosystems Research: A Longitudinal Literature Study". The Journal of Systems and Software 117(2016):84-103.

Manikas, K. Hansen, K.M. (2013) "Software Ecosystems – A Systematic Literature Review". The Journal of Systems and Software 86(5):1294-1306.

Messerschmitt, D.G., Szyperski, C. (2003) "Software Ecosystems, Understanding an Indispensable Technology and Industry". Cambridge: The MIT Press.

Moore, J.F. (1993) "Predators and Prey: A New Ecology of Competition". Harvard Business Review 71(3):75-86.

Petersen, K., Vakkalanka, S., Kuzniarz, L. (2015) "Guidelines for Conducting Systematic Mapping Studies in Software Engineering: An Update". Information and Software Technology 64(2015):1-18.

Santos, R., Werner, C. (2011) "Treating Business Dimension in Software Ecosystems". In: 3rd ACM/IFIP Intl. Conference on Management of Emergent Digital EcoSystems, San Francisco, USA, 197-201.

Serebrenik, A., Mens, T. (2016) "Challenges in Software Ecosystems Research". In: 9th European Conference on Software Architecture Workshops, Dubrovnik/Cavtat, Croatia, Article No. 40.

Wohlin, C. et al. (2013) "On the Reliability of Mapping Studies in Software Engineering". The Journal of Systems and Software 86(10):2594-2610.