A Systematic Mapping Study on Software Ecosystems

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Abstract. Software ecosystem is an approach that investigates the complex relationships among companies in the software industry. Companies work cooperatively and competitively in order to achieve their strategic objectives. They must engage in a new perspective considering both their own business and third party ones. Inspired from properties by natural and business ecosystems, a software ecosystem covers technical and business aspects of software development as well as partnership among companies. In this paper, we undertake a systematic mapping study to present a wide review of primary studies on software ecosystems. Systematic mapping is a methodology that gives, after a systematic research process, a visual summary map of its results. The search procedure identified 1026 studies, of which 44 were identified as relevant to answer our research questions. This study mapped what is currently known about software ecosystems perspective. We conclude that software ecosystems research is concentrated in 8 main areas in which the most relevant are open source software, ecosystem modeling, and business issues. The paper is intended to practitioners and academics investigating the field of software ecosystems. It contributes to summarize the body of knowledge in the field and direct efforts for future research in software ecosystems.

Keywords: software ecosystem, digital ecosystem, business ecosystem, systematic mapping study

1 Introduction

Increasing attention is being paid to connectivity and dependency in relationships between companies. Innovations no longer originate in a single organization; rather they are co-innovations from different players [1]. Companies co-evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations [2]. These loose networks of suppliers, distributors, outsourcing companies, developers of related products or services, technology providers, and a host of other organizations affect and are affected by, the creation and delivery of a company's own offerings [3]. According to these viewpoints, researchers have coined a new perspective to analyze the software industry, called software ecosystems. This is an emergent field inspired on concepts from Moore and Iansiti's [2,3] business and biological ecosystem. This paper provides an overview of the current literature in software ecosystem by conducting a systematic mapping study. Systematic mapping is a methodology that is frequently used in medical research, but that has largely been neglected in Software Engineering [4]. The usual outcome is a visual map classifying the results. It requires less effort than a systematic literature review while providing a more coarse-grained overview. The remainder of this paper is organized as follows. In section 2, we present the research method. We describe research questions, inclusion/exclusion criteria, sources of studies, search strategy, data extraction and synthesis of findings. In section 3, we present the results of this systematic mapping study. In section 4 we outline our conclusions, limitations of this work and discuss future research directions.

2 Research Method

A review protocol specifies the methods that will be used to undertake a specific systematic review and reduces the possibility of researcher bias [5]. Although systematic literature review and mapping study do not share all research procedures, similar processes for searching are explicitly defined in the research protocol and reported as part of the outcomes [6]. A review protocol is an essential element to conduct a secondary study that includes a description and rationale for the research questions and the proposed methods. It also includes details of how different types of studies will be located, appraised, and synthesized [7,8]. Thus, a protocol was developed in order to define the main guidelines for conducting this study. According to Brereton and others [8] a systematic map is used to describe the kinds of research activity that have been undertaken and describes the studies rather than extracting specific details. That is, it does provide a context for the later synthesis. According to Kitchenham [4] a systematic map is a method that can be conducted to get an overview of a particular research area. After this, the state of evidence in specific topics can be investigated using a systematic review, if necessary. A research question is a precisely stated question that guides the review [9]. According to Budgen and others [6], in systematic mapping study, the research question itself is likely to be much broader than in systematic review. This is necessary in order to adequately address the wider scope of study. Following these guidelines, we specified four research questions (RQs) in order to characterize the field of software ecosystems: (**RQ1**) What are the main characteristics of a Software Ecosystem? (**RQ2**) What is currently known about the benefits, challenges and limitations of Software Ecosystems? (**RQ3**) What are the implications of software ecosystem studies for research and practice in Software Engineering? (**RQ4**) What are the main areas studied from the perspective of Software Ecosystems? An important step in the search for studies is to decide on criteria for including and excluding papers [9]. Inclusion and exclusion criteria are used to exclude studies that are not relevant to answer the research questions. As pointed out by Petticrew and Roberts [7], inclusion and exclusion criteria step is one of the activities of a mapping study very similar to a systematic literature review. It comprises selecting the appropriate primary studies from literature. The following list shows the inclusion criteria adopted: (1) Only studies written in English; (2) Studies dealing and referencing any of the subjects related to software ecosystems in their title or abstract; (3) Master and Doctorate theses; (4) Studies unrestricted publication date; (5) “grey literature” [7] including reports published independently by academic and industrial consulting organizations. The exclusion criteria were: (1) Repeated studies found in different search engines. In this case, just one study was considered; (2) Duplicate studies reporting similar results. In this case, only the most complete study was considered; (3) Inaccessible papers and books.

Now, the search strategy and data sources are presented. According to Kitchenham [10], researchers should specify their rationale for the use of electronic or manual search or a combination of both. In this study, we used both electronic and manual search procedures. In the manual search, we decided to find papers of a specific set of conferences, researchers’ websites, and asking experts in the field of software ecosystems. The justification for not using just electronic search procedures was supported by recommendations from [10,11] who advocate the use of manual search in order to obtain a broader list of potential papers to review. According to Petticrew and Roberts [7] electronic databases are not the only source of literature, and sometimes they are not even the most useful. Another reason was due to the fact that software ecosystems is a novel field; therefore a manual search brings extra confidence that more relevant papers might be found. The electronic search was applied on the following Search Engines: IEEEXplore Digital Library, ACM Digital Library, Elsevier ScienceDirect, EI Compendex, Scopus and Web of Science. These digital libraries were selected because they are the most important repositories for research in computer science. For the manual search, we considered 11 repositories, where 9 were experts’ personal websites and 2 were the following conferences: International Workshop on Software Ecosystems (IWSECO) and ACM Conference on Management of Emergent Digital Ecosystems (MEDES). We used an approach to derive terms from the research questions to create the search string. The strategy was: (1) We derived the main search terms; (2) checked the keywords for relevant papers already known and (3) looked for alternative forms of the terms such as synonyms and relevant keywords. After that, we used Boolean operators OR and AND to incorporate them into the search string. The first segment consisted of synonyms of software ecosystem and the second one was derived from the main research questions terms. Table 1 shows the final search string.

Table 1. The search string

("software ecosystem*" OR "software supply network" OR "software vendor*" OR "software supply industry") AND (advantage* OR reward OR limitation* OR restriction* OR challenge* OR implication* OR significance* OR consequence* OR discipline* OR area* OR "subject area" OR "subject field" OR field OR "software engineering" OR "software development" OR "systems engineering" OR characteristic OR attribute OR industry OR marketplace OR market OR activity OR "academic community")

3 Results

In order to identify relevant studies, we used the following steps. First, we applied the search string in the 6 search engines listed above. The digital databases provided 668 papers, but just 418 of them were available for download. After downloading, only 117 papers were included according the inclusion and exclusion criteria. Since we used several databases, many papers were duplicated. Finally, our list was reduced to 56 papers. In the manual research, we found initially 358 papers. But just 271 were available for download and only 127 papers were included. The sum of the both manual and digital search was 183 papers. However, by crosschecking both manual and digital databases we found some duplications and the final number decreased from 183 to 141. After that, we reached the last stage when all papers were read and 44 relevant papers were selected for this systematic mapping study. Fig. 1 summarizes the selection process and presents the number of papers identified at each step.

	Set I		Set II		Set III		Set IV
Automatic Search	668	Step1	418	Step2	56	Step3	17
Manual Search	358	➡	271	➡	127	➡	27
Total	1026		689		183		44

Fig. 1. The selection process to identify relevant papers.

Spreadsheets were created to record included and excluded papers for each stage. For reading and extracting data, we used the Mendeley (http://www.mendeley.com/). We created a form to record details about how each paper would answer the four research questions. In the synthesis of findings, we adopted the method similar to the one used by Dyba and others [12]. We used a process based on the method of constant comparison used in qualitative analysis. The process begins with coding the field notes to extract pieces of text relevant to a particular theme or idea that is of interest in the study. Finally, the results are examined for underlying themes and explanations of phenomena [13]. In the Appendix, we present the complete list of selected studies enumerated from S1 to S44. Fig. 2 illustrates the year wise distribution of selected papers.

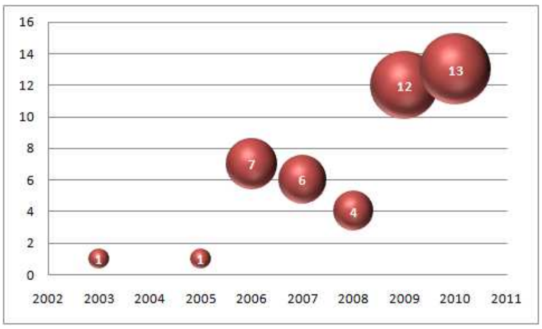

Fig. 2. Year wise distribution.

It is possible to notice an increase in the number of papers in the last two years. This suggests a growing interest by the community in the field. Moreover, it indicates this topic is relatively recent in publications. The oldest study found was published in 2003 (S43). We emphasize that papers like [2, 3] are not in the selected studies due to the fact that they do not focus specifically on software ecosystem. Instead, these papers primarily address the business ecosystem topic. Following, we discuss how each research question was answered.

(**RQ-1**) What are the main characteristics of a Software Ecosystem?

Table 2 lists the main characteristics of software ecosystems identified in the reviewed studies. A notable result is the relevance of open source models in the context of software ecosystems. In fact, literature in open source software reinforces the importance of collaboration among players to build a mature open source platform. Other results state that software ecosystems are linked to natural ecosystems, software product lines, and business ecosystems. These fields are considered by many authors the origins of software ecosystem research.

Table 2. Characteristics of a Software Ecosystem

Characteristics	Study ID
Inherit characteristics of natural ecosystems like mutualism, commensalism, amensalism, symbiosis and so on.	1,2,17
Is linked to business ecosystem perspective	5,12,22,25,29,35,42
Is linked to architectural concepts like interface stability, evolution management, security, reliability.	7,10
Is linked to Software Product Lines development model	8,32
Is linked to Open Source Development Model	9,14,16,17,28,27
Can be used to negotiate requirements for aligning needs with solutions, components, and portfolios	30
Collaborative Development in Government can be seen as a type of Digital ecosystem	34
Is related to innovation processes	1,3,4
Have their characteristics inspired by concepts like Software Supply Networks	5,15,41
Have impact on small and medium-sized Enterprises	36,40

Table 3 presents the most common terms and acronyms related to software ecosystems. Given that software ecosystem is an emergent field, different research and industry communities have been investigating the area independently. Therefore, there is a lack of widely agreed terminology and characteristics of what constitutes a software ecosystem.

Table 3. Terms related to software ecosystems field

Terms used explicitly	Study ID
Software Ecosystems	1,8,13,16,18,26,30,31,38,43,44
SECO (Software Ecosystems)	5,6,7,12,29

Mobile Learning Ecosystems / Mobile Ecosystem	6,11
Free Open Source Software Ecosystem, Open Ecosystem	9,13,31,34
Digital (Business) Ecosystem	33,34,36,39,42,43

(**RQ-2**) What is currently known about the benefits, challenges and limitations of Software Ecosystems?

Table 4 shows the benefits of a software ecosystem according to the outcomes of this mapping study. Several studies (S1, S2, S4, S7, S9, S10, and S23) discuss the benefits of software ecosystems to foster co-evolution, innovation and increase attractiveness for new players. Other general benefits found in studies emphasize that software ecosystems enable companies to decrease costs (S3, S10) while supporting architectural decision making (S11, S23, and S24), sharing knowledge (S20, S33) and communicating requirements among players (S30).

Table 4. Benefits of Software Ecosystems Perspective

Benefits	Study ID
Fosters the success of software, the co-evolution and innovation inside the organization, increase attractiveness for new players	1,2,4,7 9,10,23
Decreases costs involved in software development and distribution	3,10
Helps analyzing and understanding the software architecture in order to decide which platform to use	11,23,24
Supports the cooperation and knowledge sharing among multiple and independent entities.	20,33
Enables analysis of requirements communication among stakeholders	30
Comes as alternative to overcome the challenges during design and maintenance of distributed applications	16,36
Provides help to the tasks of business identification, product architecture design, risk identification	19
Provides information for the product line manager regarding software dependencies	32

Table 5 presents the main challenges and limitations involved in the software ecosystems perspective. From the studies reviewed, we can observe many difficulties regarding ecosystem modeling (S2, S15), architectural challenges (S8), heterogeneity of licenses and software evolution (S5, S31, S41).

Table 5. Challenges and Limitations of Software Ecosystems Perspective

Challenges and Limitations	Study ID
Establishing relationships between ecosystem actors and proposing an adequate representation of people and their knowledge in the ecosystem modeling.	2, 15
Several key architectural challenges such as: platform interface stability, evolution management, security, reliability, how to support the business strategy, suitable architectures to support open source style development; how open and flexible an architectural is.	5,8,11,21,2 7

Heterogeneity of software licenses and systems evolution in an ecosystem. Organizations must manage these issues in order to decrease risks of dependence.	5,31,41
Companies have difficulty at establishing a set of resources in order to differentiate from competitors. It is necessary a correct engagement of the keystone organization in the social dimension.	3,7
Technical and socio-organizational barriers for coordination and communication of requirements in geographic distributed projects.	16,30
Infrastructure and tools for fostering social interaction, decision-making and development across organizations involved in both open source and proprietary ecosystems.	9,14,17,28

RQ-3) What are the implications of software ecosystem studies for research and practice in Software Engineering?

The findings indicate a strong significance of academic institutions involved in the software ecosystem field with 70% (31 studies) of papers. The most active academic institutions are: Utrecht University, in The Netherlands (S5, S11, S12, S15, S18, S19, S29 and S41); University College London, in the UK (S5, S18, S19 and S29); Boston University, in the USA (S20, S21, S22, S23, S24 and S26), Babson College, in the USA (S20, S21, S23) and University of Lugano, in Switzerland (S4, S37 and S38). We also mention London School of Economics in the UK (S36, S40) and Imperial College London (S39). Although there are no many papers of these last two institutions it appears that there is an emergent group of researchers studying this topic. In addition, industrial institutions and government published 9 papers (S8, S10, S12, S13, S24, S27, S28, S33 and S37) and 1 paper (S34), respectively. This result suggests that the field is also investigated from the industrial standpoint.

Regarding the research methods adopted by selected studies, we found a strong importance of theoretical studies, with 12 papers (S5, S7, S8, S10, S16, S28, S33, S34, S40, S42, S43 and S44). On the other hand, we found some studies that applied qualitative methods, in special the case study method with 10 papers (S12, S13, S14, S15, S18, S19, S21, S27, S29 and S41). This means that many researchers have been conducting foundation studies that aim to define or classify the characteristics of software ecosystems. Regarding the empirical papers, we observed that case studies were conducted with varying level of rigor. The majority of studies were primary studies; only 2 papers reported ad hoc literature reviews (S9 and S40). The topics addressed by these studies, we identified that many studies point software evolution (S31, S33, S34, S36, S37, S38, S39 and S43) and co-innovation (S3, S7, S43 and S44) like an essential property of a product that sounds like a vital implication for the industry development. We also identified that many studies have proposed approaches for software ecosystem modeling, conceptual models or ecosystem analysis (S4, S5, S12, S15, S20, S22, S40, S41, S43 and S44).

(**RQ-4**) What are the main areas studied from the perspective of Software Ecosystems?

Fig. 3 presents a radar map presenting the most frequent areas investigated in the studies. 15 papers address software ecosystems regarding to open source model of development. 10 papers present modeling techniques to represent or analyze software ecosystems. Given that several authors come from the software engineering field, we found 8 papers focusing on software evolution as part of a software ecosystem strategy, 7 papers on software architecture and 4 papers relating software ecosystems to software product lines. This demonstrates the relevance of traditional software engineering areas to the current body of knowledge in software ecosystems. From the managerial perspective, we found 7 papers dealing with business aspects of software ecosystems and 4 papers on software co-innovation. Finally, 5 papers present results on operating systems. These studies describe ecosystems such as Microsoft, SAP and Linux. It is important to mention that some papers cover more than one aspect found in the Fig. 3. Both S43 and S44, for instance, cover areas such as operating systems, software architecture, open source, business and software evolution.

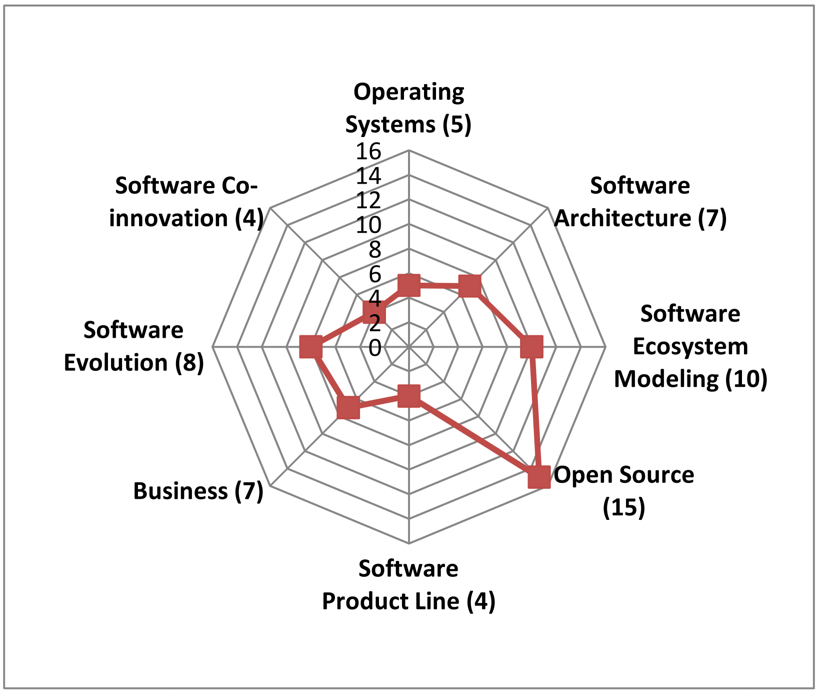

Fig. 3. The most common areas studied in software ecosystems.

4 Discussion

This paper presented a mapping study on software ecosystems. A total of 44 papers were included in the study. To the best of our knowledge, this is the first study aiming to classify current research in software ecosystem. Secondary reviews like mapping studies and systematic literature reviews are important methods to summarize and provide overview of a maturing discipline [4]. The main limitations of this mapping study are eventual omission of papers and bias in the extraction data. Results indicate that our choice of using manual search was crucial to increase the number of studies, 61% of papers were found through this strategy. To aid the selection of relevant papers, we contacted experts to identify more papers. Even though this is considered a useful strategy to conduct mapping studies, this approach may cause some bias. Another potential risk that we may have missed relevant papers is due to the lack of agreed terminology for software ecosystems and to the possible existence of relevant papers that do not mention the keywords we chose. With respect to bias in the data extraction, we had some difficulties to extract relevant information from the papers. Several papers did not explicitly address the research questions in sufficient detail. Our inclusion criteria clearly mentioned that selected papers should answer the research questions. However, once we started reading the papers we noticed that several issues were not clearly presented in the paper.

It is important to note that our goal for this systematic mapping study was providing an overview of current literature in software ecosystems; it was outside the scope of the paper to evaluate the quality of studied papers or explain specific findings. Further analysis is needed to address these specific issues. The mapping study confirms that software ecosystem is an emergent field. The first study was published in 2003 (S43), the last two years were the most productive period. The outcomes of our study indicate that software ecosystem research has been mainly inspired by studies from business and natural ecosystems [2,3] as well as traditional software engineering research on software product lines, software evolution and open source software. Currently, there are two key communities investigating the topic: digital ecosystem from MEDES conference and IWSECO community. We observed these two communities generally do not cite each other. Even though, both areas have inherited similar concepts from business ecosystems. To strengthen the field, we suggest more collaboration between both communities. Results reveal that key areas investigated by the papers were open source software, ecosystems modeling and business issues. Academic institutions published 70% of papers. This finding reinforces the current trend in software engineering where academics publish the majority of papers. A promising result that highlights the industrial relevance of software ecosystems is that 10 papers presented case studies. However, the methodology rigor and quality of these case studies were not carefully assessed. Our preliminary opinion on this issue is that software ecosystems need more industrial studies to increase the body of evidence in the field. Given the current state of research and practice in software ecosystems, we envisage the need to conduct integrative studies among research communities and industry.

Acknowledgments

We are grateful to authors in the field of software ecosystems for their contribution to conduct this study.

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Appendix: The selected studies

ID	Reference
S1	Yu, L., Ramaswamy, S., Bush, J. Software Evolvability: An Ecosystem Point of View. In: 3rd International IEEE Workshop on Software Evolvability. (2007)
S2	Janner, T., Schroth, C., Schmid, B. Modelling Service Systems for Collaborative Innovation in the Enterprise Software Industry. In: IEEE International Conference on Services Computing vol. 2, (2008)
S3	Arndt, J. M., Dibbern, J. Co-Innovation in a Service Oriented Strategic Network. In: IEEE International Conference on Services Computing. (2006)
S4	Lungu M., Malnati J., Lanza, M. Visualizing gnome with the small project observatory. In: 6th Working Conference on Mining Software Repositories. (2009)
S5	Jansen S., Brinkkemper S., Finkelstein, A. A Sense of community: A research agenda for software ecosystems. In: Proceedings of the 31st International Conference on Software Engineering. (2009)
S6	Pettersson, O., Svensson, M., Gil, D., Andersson, J., Milrad, M., On the Role of Software Process Modeling in Software Ecosystem Design. In: 2nd International

	Workshop on Software Ecosystems. (2010)
S7	Campbell, P.R.J., Ahmed, F., A Three-Dimensional View of Software Ecosystems. In: 2nd International Workshop on Software Ecosystems. (2010)
S8	Bosch, J., Architecture Challenges for Software Ecosystems. In: 2nd International Workshop on Software Ecosystems. (2010)
S9	Scacchi, W. Free/Open Source Software Development: Recent Research Results and Emerging Opportunities. In: Symposium on the Foundations of Software Engineering. (2007)
S10	Bosch, J. From software product lines to software ecosystems. In: Proceedings of the 13th International Conference on Software Product Lines. (2009)
S11	Anvaari, M., Jansen, S., Evaluating Architectural Openness in Mobile Software Platforms. In: 2nd International Workshop on Software Ecosystems. (2010)
S12	Berk, I. V. D., Jansen, S., Luinenburg, L. Software Ecosystems: A Software Ecosystem Strategy Assessment Model. In: 2nd International Workshop on Software Ecosystems. (2010)
S13	Bosch, J., Sijtsema, P. B. From Integration to Composition: On the Impact of Software Product Lines. Global Development and Ecosystems. Journal of Systems and Software. (2009)
S14	Ven, K., Mannaert, H. Challenges and strategies in the use of Open Source Software by Independent Software Vendors. Information and Software Technology. (2008)
S15	Hunink, I., Van Erk, R. Jansen, S., Brinkkemper, S. Industry Taxonomy Engineering: the Case of the European Software Ecosystem. In: Proceedings of European Conference on Software Architecture. (2010)
S16	Cataldo, M., Herbsleb, J. D. Architecting in software ecosystems: interface translucence as an enabler for scalable collaboration. In: Proceedings of European Conference on Software Architecture. (2010).
S17	Dhungana, D., Groher, I., Schludermann, E., Biffl, S. Software Ecosystems vs. Natural Ecosystems: Learning from the Ingenious Mind of Nature. In: : 2nd International Workshop on Software Ecosystems. (2010)
S18	Jansen, S., Brinkkemper, S., Finkelstein, A. Component Assembly Mechanisms and Relationship Intimacy in a Software Supply Network. In: 15th Annual EuroMA Conference. (2008)
S19	Jansen, S., Brinkkemper, S., Finkelstein, A. Providing Transparency In The Business Of Software: A Modeling Technique For Software Supply Networks. In: IFIP Working Conference on Virtual Enterprises (Pro-VE) (2007).
S20	Dreyfus, D., Iyer, B., Lee, C. H., Venkatraman, N. Dual Networks of Knowledge Flows: An Empirical Test of Complementarity in the Prepackaged Software Industry. In: International Conference on Information Systems (ICIS). (2005)
S21	Dreyfus, D., Iyer, B., Managing Architecture Under Emergence: A Conceptual Model and Simulation. In: Decision Support Systems. (2008)
S22	Iyer, B., Lee, C.H., Venkatraman, N. Managing in a "Small World Ecosystem": Some Lessons from the Software Sector. California Mgmt. pp. 28--47 (2006)
S23	Iyer, B., Lee, C.H., Venkatramen, N., Vesset, D. Monitoring Platform Emergence: Guidelines from Software Networks. Communications of the Association for Information Systems. vol. 19, (2007)
S24	Iyer, B., Dreyfus, D., Gyllstrom, P. A Network Based View of Enterprise Architecture. Handbook of Enterprise Systems Architecture in Practice, Idea Group publishing (forthcoming). (2007)
S25	Iyer, B., Venkatraman, N. The changing architecture of global work: opportunities and challenges. In: Keane Workshop. (2006)

S26	Liu, X., Lee, C.H., Iyer, B. The Impact of Design Moves on Platform Adoption: The Case of Microsoft Windows OS. In: 39th Annual Hawaii International Conference on System Sciences. (2006)
S27	Gurbani, V.K., Garvert, A., & Herbsleb, J.D. A Case study of a corporate open source development model. In: Proceedings of the International Conference on Software Engineering. (2006)
S28	Gurbani, V.K., Garvert, A., & Herbsleb, J.D. Managing a Corporate Open Source Software Asset. Communications of the ACM. (2010)
S29	Jansen, S., Brinkkemper, S., Finkelstein, A. Business Network Management as a Survival Strategy: A Tale of Two Software Ecosystems. In: 1st International Workshop on Software Ecosystems. (2009)
S30	Fricker, S. Specification and analysis of requirements negotiation strategy in software ecosystems. In: 1st International Workshop on Software Ecosystems. (2009)
S31	Alspaugh, T., Asuncion, H. U., Walt, S. The Role of Software Licenses in Open Architecture Ecosystems. In: 1st International Workshop on Software Ecosystems. (2009)
S32	McGregor, J. D. A method for analyzing software product line ecosystems. In: 2nd Workshop on Software Ecosystems. (2010)
S33	Caschera, M. C., D'Ulizia, A., Ferri, F., Grifoni, P. Studying Network Dynamics in Digital Ecosystems. In: International ACM Conference on Management of Emergent Digital EcoSystems. (2009)
S34	Alves, A. M., Stefanuto, G. N., Salviano, C. F., Drummond, P., Meffe, C. Learning Path to an Emergent Ecosystem: The Brazilian Public Software Experience. In: ACM Conference on Management of Emergent Digital EcoSystems (2009)
S35	Nassar, P. B., Badr, Y., Biennier, F., Barbar, K. Extended BPEL with heterogeneous authentication mechanisms in service ecosystems. In: ACM Conference on Management of Emergent Digital EcoSystems (2009)
S36	Briscoe, G., Wilde, P. D. Computing of Applied Digital Ecosystems. In: ACM Conference on Management of Emergent Digital EcoSystems (2009).
S37	Lungu, M., Lanza, M., Girba, T., Heeck, R. Reverse Engineering Super-Repositories. In: 14th Working Conference on Reverse Engineering. (2007)
S38	Lungu, M., Lanza, M. The small project observatory: a tool for reverse engineering software ecosystems. In: Proceedings of the 32nd ACM/IEEE International Conference on Software Engineering. (2010)
S39	Briscoe, G., De Wilde, P. Digital Ecosystems: Evolving Service-Orientated Architectures. Bio-Inspired Models of Network, Information and Computing Systems. (2006)
S40	Stanley, J., Briscoe, G. The ABC of Digital Business Ecosystems. Communications Law, Journal of Computer, Media and Telecommunications Law, 15(1). (2010).
S41	Jansen, S. Customer configuration updating in a software supply network. Doctoral thesis Utrecht University, The Netherlands. (2007)
S42	Rong, K., Shi, Y. Constructing business ecosystem from firm perspective: cases in high-tech industry. In: ACM Conference on Management of Emergent Digital EcoSystems (2009).
S43	Messerschmitt, D. G., Szyperski, C. Software Ecosystem: Understanding an Indispensable Technology and Industry. The MIT Press. (2003)
S44	Popp, K. M., Meyer, R. Profit from Software Ecosystems: Business Models, Ecosystems and Partnerships in the Software Industry. Books On Demand, Germany. (2010)