The Role of Applications and their Vendors in Evolution of Software Ecosystems

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Abstract - The most recent trends in the electronic commerce research have suggested that forming an ecosystem around a platform would create a winning solution. The ecosystem, consisting of vendors and external actors, would create competitive advantage for the platform owner. Furthermore, the sheer number of the actors has been used as the measure of the ecosystem's well-being against competing ecosystems. Whereas a number of studies has been devoted to analyse the well-being indicators or structures of software ecosystems and the importance of complementors and complements are acknowledged, there is lack of studies addressing how the complementors affect into the evolution of ecosystems. This conceptual analysis aims to open discussion on this topic by using the mobile application ecosystems—such as Google Play or Apple's iOS—as the case subject. While the results suggest some implications for the platform owners and complementors, more work is needed

I. INTRODUCTION

The summer of 2008 and the launch of App Store for smart devices using Apple's iOS operating system will likely remain a remarkable milestone in the history of the mobile industry. Although similar application stores by different vendors had been available for several years before the launch of App Store, Apple's marketplace—together with the new series of smart devices—was able to revolutionize the business and dethrone the old kings of the castle such as Nokia and BlackBerry [1]. Eventually, the previous market leaders were driven out from business, and Apple's new innovation was copied to several different industrial segments [2].

While several analyses for the reasons of Apple's iOs devices and marketplaces success have been written, e.g. [1] [3] [4], it seems to be clear that millions of applications by over hundred thousand application developers had also an important role in the outcome of the competition. The application developers and their offerings together with the platform provider and customers form a software ecosystem [1]. The concept of 'software ecosystem' is a descendent of Moore's [5] business ecosystem with focus on the software industry and its special characteristics [6].

There are several definitions for software ecosystems; however, the one by Jansen et al. [7] summarizes the concept well: a software ecosystem *"consists of the set of businesses functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources and artefacts."*

Both the definition of a software ecosystem as well as the history of App Store emphasize the presence of third parties—no company alone can run an ecosystem. However, the implications of involving third-parties have been discussed only a little in the extant literature of software ecosystems.

Some previous studies have considered the third parties role in the war of competing mobile application ecosystems, a sub-type of software ecosystems [6]. On one hand, there has been an argument that the sheer number of applications and their developers would eventually be the most important factor for the success of a mobile application ecosystem [8] [9]. On the other hand, there has been argument that instead of the sheer number, it is quality of the content offered [10]. Nevertheless, both views emphasizes the application offering and suggest that, at least in this domain, the applications are holding the highest bargaining power in the ecosystem.

This conceptual paper discusses on the implications of this assumption. The mentioned mobile application ecosystems are used an example case and limitations of generalization from the case to the general type of software ecosystems are addressed. That is, while we focus on the mobile applications and their role in the ecosystems, they are only a case study subject and we aim to generalize the result to other types of software ecosystems. As a result, this study calls for further inquiries assessing in strategical management of evolving software ecosystems.

The remaining of the study is structured as follows. The following section presents the central concepts and reviews related work. The third section presents the competition of mobile applications ecosystems in the 2010s as a case and the fourth section discusses on the findings. The final section concludes the study with some suggestion for future work.

II. BACKGROUND AND MOTIVATION

The hype of different kinds of artificial ecosystems started in the 1990s when Moore [5] published his seminal article on the ecology of competition. He defined a business ecosystem as a set of companies that evolve around a shared innovation. The companies work together, both cooperatively and competitively, to satisfy customers. Moore describes that the ecosystems evolve through four

different stages: Birth,Expansion, Fight of leadership, and Self-renewal or death.

The concept of 'software ecosystem' is a derivative of a business ecosystem. It was first used by Messerschmitt and Szyperski [11] in their book published in 2003. Since then, the number of studies assessing different kinds of software ecosystems has been growing steadily [12]. However, due to the popularity of the new conceptualization, there are lots of definitions and views what constitutes of, and what are differences and similarities between the concepts of 'ecosystem', 'platform', 'community', and 'two-sided market'. This study follows the view that a software ecosystem is formed around a platform and it consists of different kinds of actors [1] [7].

The software ecosystem conceptualization has become important in the field electronic commerce due to the popularity of platformization, i.e., the process of establishing a platform [13], in business. Platforms and ecosystems are nowadays seen as a winning solution in the new era business [14] and the whole field has been started to call as 'platform economy' [15]. Classic examples of platform economies—or software ecosystems—in the field of electronic commerce, are Apple App Store, Google Play as well as Valve's Steam [1].

The actors are important part of an ecosystem. In their literature review, Manikas and Hansen [16] categorized the presented roles of actors (i.e., an independent person, a team, an entity or an organization) associated with software ecosystems into five main groups: 1) *Ecosystem orchestrator*; 2) *Niche player*; 3) *External actor*; 4) *Vendor*, i.e., independent software vendor (ISV) or value-added reseller (VAR); and 5) *Customer*. The first of these is the main actor being responsible for keeping the ecosystem functioning whereas the last one is the buying customer. The remaining three are complementors, i.e., they are offering their complementing services and products to the ecosystem [17].

The differences between three remaining groups are little and one actor can serve in several roles for the ecosystem at the same time. A niche player is often developing and adding components to the platform and thus producing value to customers. External actors use the possibilities provided by an ecosystem and create, thus, indirect value to the ecosystem. External actors can, e.g., promote the ecosystem and its auxiliaries, serve as an external tester or do parallel developing to the ecosystem platform. Finally, a vendor is an actor who makes profit by selling the products of the ecosystem. A vendor can sell, e.g., integration services, components, support agreements or licenses to the main product. [16] Altogether, the actors belonging to these groups are the complementors for the main ecosystem and the remaining of this study focuses on them.

Complementors' ability to freely choose to what ecosystem being a part with [18] [19] or even to rethink its position in the ecosystem [5], makes software ecosystems interesting study subjects. A complementor can decide to be a part of several competing ecosystems at the same time, a strategy called as multi-homing whereas the opposite decision is called as single-homing [20] [21] [22]. Furthermore, in his seminal paper Moore [5] describes, that as a part of a healthy business ecosystem's evolution, complementors will challenge the ecosystem orchestrator for the leadership of an ecosystem. As an example, Microsoft and Intel challenged and won IBM for the supremacy of a personal computer ecosystem's leadership in the 1980s [5].

In the field of software ecosystems, a remarkable number of literature studies have been published, e.g. [6] [12] [16] [23] [24] [25]. These studies were looked through for this study in order to map whether there are existing discussions on the evolution or not. So far, there seems to be no previous discussion on the implications of the complementors' roles in the evolution of software ecosystems. Therefore, this study aims to open discussion on the issue by analyzing a case and discussing research avenues that it opens. In the following section, we will present the case and it is followed by analysis in Section IV.

III. Evolution of Mobile App Ecosystems

The mobile application stores—such as Google Play, Apple's App Store and Microsoft's Windows Phone Store—are frequently assessed software ecosystems [12]. In these kinds of ecosystems, there are three major actor groups: *the orchestrator* (i.e., Google, Apple and Microsoft, respectively), *the customers* (i.e., the end-users of smart devices) and *the application developers* (e.g., Supercell, King Digital Entertainment) [1]. Whereas there are, e.g., niche players contributing to the core platform and external actors (e.g., Samsung and HTC) adding value to the ecosystem, they are infrequently discussed in this domain.

The three mentioned mobile application ecosystems were competing for the customers as well as from the application developers at the beginning of the 2010s. In addition to the big three, also smaller ecosystems and orchestrators such as Nokia with Ovi and RIM with BlackBerry World marketplaces were involved in the war of smart devices' supremacy. [1]

Most of the orchestrators were most likely looking for, so called, the *virtuous cycle* effect [8]. In virtuous cycle, a high number of potential applications lure more customers to use the smart device platforms. More customers mean more sales in the marketplace, which in turn tempt more developers to join into the ecosystem. Finally, more developers mean more potential applications for the customers which start the cycle again.

Due to the virtuous cycle, it was not a surprise that the sheer numbers of application developers joined and applications offered in the marketplace have been seen as the measure of success of an ecosystem. This has often been presented in the extant literature [8] [9] [26] as well as in the news analysis and marketing[1][2]. However, there are some critics of using the number of applications as the measure of well-being of an ecosystem [10] [27] and also practitioners have argued for content over quality[3].

[1] http://www.wired.com/gadgetlab/2010/10/app-for-that/
[2] http://www.reuters.com/article/2012/06/11/apple-developersidUSL1E8HB4Z820120611
[3] https://www.cnet.com/news/does-an-app-stores-size-matter-ifcontent-is-the-killer-app/

Nevertheless, after assessing the success of an ecosystem with the sheer number of applications, arguments have been moved to claim that either the best content [22] or the killer applications [1] would define the success of a mobile application ecosystem. A case in point was a sequel of a popular mobile game that was announced to skip Windows Phone platform. Market analysts quickly judged that the lack of a blockbuster game would be a significant hit against the ecosystem and endangers its future[4].

While Windows Phone ecosystem still exists, it is currently silently dying out. Similarly, most of the other old challengers have given up and only the two of the largest application ecosystems survived: Apple's App Store for iOS devices and Google Play for smart devices with Android operating system. Often, the lack of specific applications—together with insufficient devices—is credited as the source of downfall for at least Microsoft's solution[5]. For example, official Facebook and Instagram applications did not offer the same set of features that a user could get with Android or iOS devices.

However, the app economy has also demonstrated that good ideas are swiftly copied [1]. For example, the Flappy bird game, published in 2013, was replicated by different developers to other ecosystems in a few days. After the withdrawal from the market, the number of copies was still growing[6][7]. Similarly, the same kinds of applications are occupying the top lists of all major mobile application ecosystems even though the applications are not necessarily produced by the same developers [22].

IV. ANALYSIS AND DISCUSSION

In the following, we will discuss on the importance of complementors for mobile application ecosystems and address shifts in relative bargaining powers. This section ends with discussion on the limitations and suggestion for future work.

A. *The importance of complements*

Based on the presented discussion from the mobile application ecosystems, it seems that the sheer number of applications is one of the most important measures of success in the beginning. After a certain point, adding new applications does not seem to bring as much value to the customers as previously. In this phase, content of applications seems to be more important. In other words, lacking of certain key applications such as WhatsApp, Facebook or Instagram can be a major disadvantage for an ecosystem.

This chain of thoughts leads easily to the question presented in the title of this study: *Are applications holding the highest bargaining power in the ecosystem?* Whereas this is, in the context of smart devices, a clear simplification of several complex phenomena occurring—e.g., physical devices, network operators are not considered here—at the same in the market, complements (i.e. applications) seem to be crucial for the ecosystems.

While mobile application ecosystems have some specific features such as the remarkable dependency on the physical devices and ubiquitous nature of smart devices to every aspect of people's life, they still share also remarkable similarities with general type of software ecosystems. For example, the 'app store' approach is spread in numerous different areas [2] and several, if not all, software ecosystems can be characterized as a two-sided platform connecting complementors to customers.

Therefore, an easy deduction is to argue that complementors and their offerings are important also for general type of software ecosystems. Furthermore, the importance of complementors to platforms of all kind of and their ecosystems has also been emphasized [14].

B. *Shifts in bargaining powers*

An important but still mainly uncovered, to the best of author's knowledge, question arises: *If content and complements have the greatest bargaining power, do they still need the basis ecosystem?* That is, when a complement has come into such a position of power that customers make decision based on availability or absence of certain services, its relative bargaining power would be higher than the ecosystem orchestrator. Thus, the complementor could even abandon the ecosystem and form a new one when it is more valuable to the ecosystem orchestrator than the ecosystem is for it. With a quick glance, one can argue that complements cannot bypass the basis ecosystem, but the recent development has hinted that this can actually be a reasonable threat to an ecosystem.

For example, if Facebook's project Spartan[8] is considered, that would have added another layer into the top of mobile operating systems. After that, application developers would have been able to pass over the mobile operating system vendor's marketplace and rules by producing for and distributing content by the Spartan platform. However, the rumoured project got eventually cancelled and this kind of a revolution did not happened.

The cancelled project Spartan was not the only option for reducing the power of the platform owner. In the mobile application domain, the number of new cross-platform development tools and techniques has been rising [28]. With these kinds of tools, a developer can program an application once and it will run on several different technological platforms. While these tools have some remarkable weaknesses [28], the technology is developing constantly and the cross-platform development methods are constantly improving. In the near future, these might be a reasonable alternative for native development tools.

When the cross-platform development tools have gained enough maturity, the application developers can be expected to use them to publish the same application instantly for several platforms. With these kinds of tools, a developer can achieve reasonable benefits from being first in several markets to cost savings in development work

[4] http://www.bloomberg.com/news/2012-03-22/-angry-birds-space-edition-skips-windows-phone-in-blow-to-nokia.html
[5] http://www.theverge.com/2015/10/23/9602350/microsoft-windows-phoneapp-removal-windows-store
[6] https://www.cnet.com/news/the-search-for-an-awesome-flappybird-replacement/
[7] https://techcrunch.com/2014/03/24/clones-clones-everywhere-1024-2048-and-other-copies-of-popular-paid-game-threes-fill-the-app-stores/
[8] https://techcrunch.com/2011/09/28/this-sure-looks-a-lot-like-facebooksproject-spartan-screenshots/

[19] [28]. At the same time, these kinds of tools cause that the ecosystem where a complement is published and offered becomes less relevant — a developer can publish it to almost all alternatives. This makes the platform providers' role less important and the platform can turn out to be 'just distribution channels' for the content.

C. Struggle for leadership

In his seminal work, Moore [5] already addressed the evolution stages of an ecosystem. While this aspect seems to be mostly forgotten by, at least, software ecosystem researchers, the evolution model is even more topical nowadays as the software ecosystems are coming of age.

According to Moore [5], there are two conditions that must be fulfilled that the leadership struggles would occur at the third stage of the ecosystem's life-cycle model. First, the ecosystem must be strong and profitable enough to be worth fighting for. Second, the central value-adding components of an ecosystem should be reasonable stable. According to Moore, the latter condition allows contenders to attack those components and diminish the dependence to the original ecosystem orchestrator.

For example, the mobile applications ecosystems seem to fulfil both conditions. The survived ecosystems are profitable and the components that add value to the customers are stable. Thus, according to the original theory of the business ecosystem, the fight for leadership inside the mobile application ecosystems should be expected to start. Some elements of this can be seen in Android ecosystem as the mobile phone manufacturers and Amazon has founded their own application stores and distribute the content through them.

What makes software ecosystem interesting in the light of the ecosystem evolution model is the relatively easiness of multi-homing. The same application can be offered with relatively cheap cost to several competing ecosystems [19]. When compared with, e.g., the personal computer ecosystems' fight against each other's and struggle for leadership, this would have mean that a vendor would have steadily worked for both IBM's and Apple's ecosystems. For a software vendor, this is easier than for a hardware vendor due to the intangibility, changeability and portability of software. Thus, in the software industry, it seems that vendors can challenge more easily the ecosystem orchestrator for the battle of leadership.

D. Implications and future work

To summarize the above chain of thoughts, the argument presented by Lemstra et al.'s [29] for mobile network operators is followed: Will the mobile application ecosystems become just another distribution channel when a complementor takes over the ecosystems? Based on the original theory of the business ecosystem, a struggle of leadership is expected as the preconditions seem to be fulfilled.

The conceptual analysis presented in previous sections has certain implications for practitioners. First, if the presented hypothesis, that in software ecosystems battle for leadership is more probable holds true, the ecosystem orchestrators should carefully follow their position in the market as well as in their own ecosystem. While giving more power to complementors might be a good tool in the war against other ecosystems, it can cause that the orchestrator loses its own bargaining power against its cooperators. In this case, the initial platform can turn to be only just another distribution channel.

Second, if the presented argument holds true, it questions some of the hyped platform economy arguments. By 'platforming' company's old product and opening them for cooperation, a company might also accidentally weaken its own position. However, based on the presented conceptual analysis, this seems to be only a case in software ecosystems and in the field of electronic commerce, where the role of a physical device is a smaller. Nevertheless, companies should also pay attention to this aspect when they are deciding to go or not to go in the platform economy.

Finally, to the best of author's knowledge, not much has been studied in the evolution of software ecosystems. Therefore, this study calls for further work on analysing and theorizing 1) an evolution model of software ecosystems whether they follow the same pattern and conditions that business ecosystems; 2) assessing the role of complementors and complements in the evolution of the ecosystem; and 3) investigating counter-measures for ecosystems' orchestrators to mitigate contenders' actions.

E. Limits of generalization

There are a few major questions related to the presented ideas in this paper. The first is related to software ecosystem studies itself. The software ecosystem conceptualization has been used in a wide array of different context ranging from World of Warcraft to SAP [12]. Thus, it is not a surprise that the software ecosystem literature seems to be started to diverge into different sub-communities [23].

Two large sub-communities are rather easily identifiable when the results by Suominen et al.'s [23] and Manikas' [12] bibliographical studies are combined: On one hand, a stream of literature is devoted to study large-scale software, often open-source, projects consisting of hundreds if not thousands of auxiliary projects, such as R and Python programming languages, and their packages. On the other hand, another literature stream is devoted to understand marketplace-centered ecosystems, such as Google Play and Apple App Store.

This paper contributes mainly on the latter literature stream and the division between these two literature streams is meaningful to this study: The application developers belonging to the former group are often motivated with a different set of reasons ranging from meritocracy to fame and improving the CV or just contributing for the society. Whereas these reasons are also available in more business-oriented ecosystems [30], often financial benefits are the main reason.

In the open-source related software ecosystems, the first condition presented by Moore [5] for the struggle of leadership might not be fulfilled: while the ecosystem is healthy according to its own indicators, the ecosystem might not be interesting to fight over. Thus, software ecosystems should be selected with a care for empirical stud-

ies as well as generalizability of results should be well justified.

Second, the argument presented in this conceptual study is deduced from only one case. It might be that the case is not representative enough that general rules of an ecosystem's lifecycle could be identified. It can be, for example, that there are certain specific features of mobile application ecosystems that cause the seen shifts in bargaining powers. Therefore, more case studies about different ecosystems fields are needed to verify the found observations.

V. CONCLUSION

This paper presented and analysed a case of mobile application ecosystems. Based on analysis, it can be argued that applications are likely to increase their relative bargaining power in the mobile industry due to their impact even on the sales of different phones. This conceptual analysis, however, raised the question whether complementors and complements—i.e., the applications—can obtain such position that they start to threat the initial ecosystem orchestrator for the leadership of the ecosystem. While this analysis hinted that such a phenomenon might occur in the software ecosystems due to the improvements in cross-platform development tools, this analysis also emphasized that not much is understood about the evolution of business or software ecosystems. Therefore, this study calls for further work to analyse and clarify the role of complements in the evolution of artificial ecosystems.

REFERENCES

[1] S. Hyrynsalmi, "Letters from the war of ecosystems — an analysis of independent software vendors in mobile application marketplaces," Doctoral dissertation, University of Turku, Turku, Finland, December 2014, TUCS Dissertations No 188. [Online]. Available: http: //urn.fi/URN:ISBN:978-952-12-3144-5

[2] S. Jansen and E. Bloemendal, "Defining app stores: The role of curated marketplaces in software ecosystems," in Software Business. From Physical Products to Software Services and Solutions, ser. Lecture Notes in Business Information Processing, G. Herzwurm and T. Margaria, Eds., vol. 150. Berlin, Germany: Springer Berlin Heidelberg, 2013, pp. 195–206.

[3] J. West and M. Mace, "Browsing as the killer app: Explaining the rapid success of Apple's iPhone," Telecommunications Policy, vol. 34, no. 5–6, pp. 270–286, June 2010.

[4] R. C. Basole and J. Karla, "On the evolution of mobile platform ecosystem structure and strategy," Business & Information Systems Engineering, vol. 3, pp. 313–322, 2011.

[5] J. F. Moore, "Predators and prey: A new ecology of competition," Harvard Business Review, vol. 71, no. 3, pp. 75–86, May-June 1993.

[6] S. Hyrynsalmi, M. Sepp¨anen, T. Nokkala, A. Suominen, and A. J¨arvi, "Wealthy, healthy and/or happy — what does 'ecosystem health' stand for?" in Software Business — 6th International Conference, ICSOB 2015, Braga, Portugal, June 10-12, 2015, Proceedings, ser. Lecture Notes in Business Information Processing, M. J. a. Fernandes, R. J. Machado, and K. Wnuk, Eds., vol. 210. Springer International Publishing, 2015, pp. 272–287.

[7] S. Jansen, A. Finkelstein, and S. Brinkkemper, "A sense of community: A research agenda for software ecosystems," in 31st International Conference on Software Engineering — Companion Volume, ICSE-Companion 2009. IEEE, May 2009, pp. 187–190.

[8] A. Holzer and J. Ondrus, "Mobile application market: A developer's perspective," Telematics and Informatics, vol. 28, no. 1, pp. 22–31, February 2011.

[9] T. Yamakami, "A mobile digital ecosystem framework: Lessons from the evolution of mobile data services," in Proceedings of the 2010 13th International Conference on Network-Based Information Systems, ser. NBIS '10. Washington, DC, USA: IEEE Computer Society, September 2010, pp. 516–520.

[10] S. Hyrynsalmi, A. Suominen, and M. Mäntymäki, "The influence of application developer multi-homing and keystone developers on competition between mobile application ecosystems," The Journal of Systems and Software, vol. 111, pp. 119–127, January 2016.

[11] D. G. Messerschmitt and C. Szyperski, Software Ecosystem: Understanding an Indispensable Technology and Industry. Cambridge, MA, USA: The MIT Press, 2003.

[12] K. Manikas, "Revisiting software ecosystems research: A longitudinal literature study," Journal of Systems and Software, vol. 117, pp. 84–103, July 2016.

[13] A. S. Islind, T. Lindroth, U. L. Snis, and C. Sørensen, "Co-creation and fine-tuning of boundary resources in small-scale platformization," in Nordic Contributions in IS Research: 7th Scandinavian Conference on Information Systems, SCIS 2016 and IFIP8.6 2016, Ljungskile, Sweden, August 7-10, 2016, Proceedings, U. Lundh Snis, Ed. Cham: Springer International Publishing, 2016, pp. 149–162. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-43597-8 11

[14] M. Van Alstyne, G. G. Parker, and S. P. Choudary, "Pipelines, platforms, and the new rules of strategy," Harvard Business Review, vol. 94, pp. 54–62, April 2016.

[15] M. Kenney and J. Zysman, "The rise of platform economy," Issues in Science and Technology, vol. XXXII, Spring. [Online]. Available: http://issues.org/32-3/the-rise-of-the-platform-economy/

[16] K. Manikas and K. M. Hansen, "Software ecosystems — A systematic literature review," Journal of Systems and Software, vol. 86, no. 5, pp. 1294–1306, May 2013.

[17] A. M. Brandenburger and B. J. Nalebuff, Co-opetition, 1st ed. New York, NY, USA: Currency Doubleday, 1997.

[18] R. M. Stallman, Free Software, Free Society: Selected Essays of Richard M. Stallman, 2nd ed. Boston, MA, USA: Free Software Foundation, Inc., 2010.

[19] S. Hyrynsalmi, A. Suominen, S. Jansen, and K. Yrjönkoski, "Multi-homing in ecosystems and firm performance: Does it improve software companies' ROA?" in Proceedings of the International Workshop on Software Ecosystems 2016, 2016, pp. 1–14.

[20] B. Caillaud and B. Jullien, "Chicken & egg: Competition among intermediation service providers," The RAND Journal of Economics, vol. 34, no. 2, pp. 309–328, Summer 2003. [Online]. Available: http://www.jstor.org/stable/1593720

[21] J. C. Rochet and J. Tirole, "Platform competition in two-sided markets," Journal of the European Economic Association, vol. 1, no. 4, pp. 990–1029, June 2003.

[22] S. Hyrynsalmi, "To redefine ecosystem health, or not to redefine? a view of scientific knowledge on the "software ecosystem health" concept," in Proceedings of the European Workshop on Software Ecosystems 2015, K. M. Popp, P. Buxmann, T. Aidan Curran, G. Eichler, S. Jansen, and T. Kude, Eds., Synomic Academy. Books on Demand, 2016, pp. 47–51.

[23] A. Suominen, S. Hyrynsalmi, and M. Seppänen, "Ecosystems here, there, and everywhere — a barometrical analysis of the roots of 'software ecosystem'," in Software Business: 7th International Conference, ICSOB 2016, Ljubljana, Slovenia, June 13-14, 2016, Proceedings, A. Maglyas and A.-L. Lamprecht, Eds. Springer International Publishing, 2016, pp. 32–46.

[24] O. Barbosa and C. Alves, "A systematic mapping study on software ecosystems," in Proceedings of the Workshop on Software Ecosystems 2011, ser. CEUR Workshop Proceedings, S. Jansen, J. Bosch, P. Campell, and F. Ahmed, Eds., vol. 746. CEUR-WS, June 2011, pp. 15–26. [Online]. Available: http://ceur-ws.org/Vol-746/IWSECO2011-2-BarbosaAlves.pdf

[25] O. Barbosa, R. P. dos Santos, C. Alves, C. Werner, and S. Jansen, "A systematic mapping study on software ecosystems from a three-dimensional perspective," in Software Ecosystems: Analyzing and Managing Business Networks in the Software Industry, S. Jansen, S. Brinkkemper, and M. A. Cusumano, Eds. Northampton, MA, USA: Edward Elgar Publisher Inc., 2013, ch. 4, pp. 59–81.

[26] N. Schultz, R. Zarnekow, J. Wulf, and Q.-T. Nguyen, "The new role of developers in the mobile ecosystem: An Apple and Google case study," in 15th International Conference on Intelligence in Next Generation Networks (ICIN), October 2011, pp. 103–108.

[27] K. Boudreau, "Too many complementors? Evidence on software developers," HEC-Paris School of Management, Tech. Rep., January 2007, working Paper Series, Social Science Research Network. [Online]. Available: http://hal-hec.archives-ouvertes.fr/hal-00597766

[28] V. Ahti, S. Hyrynsalmi, and O. Nevalainen, "An evaluation framework for cross-platform mobile app development tools: A case analysis of adobe phonegap framework," in Compsystech'16, B. Rachev, D. Tegolo, Y. Kalmukov, S. Smrikarova, and A. Smrikarov, Eds., 2016.

[29] W. Lemstra, G.-J. Leeuw, E. Kar, and P. Brand, " 'Just another distribution channel?'," in Mobile Wireless Middleware, Operating Systems, and Applications — Workshops, ser. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, C. Hesselman and C. Giannelli, Eds. Berlin, Germany: Springer Berlin Heidelberg, 2009, vol. 12, pp. 1–12.

[30] S. Hyrynsalmi, A. Suominen, T. Mäkilä, A. Järvi, and T. Knuutila, "Revenue models of application developers in Android Market ecosystem," in ICSOB 2012, ser. Lecture Notes in Business Information Processing, M. Cusumano, B. Iyer, and N. Venkatraman, Eds., no. 114. Berlin, Germany: Springer Berlin Heidelberg, 2012, pp. 209–222.