Aug 10th, 12:00 AM

Open Innovation via Open Source: Collaboration of Companies to Infuse Automobiles with Digital Technologies

Vinod Kumar Ahuja
University of Nebraska Omaha, vahuja@unomaha.edu

Nikolai Kazantsev
University of Exeter, n.kazantsev@exeter.ac.uk

Ralf Plattfaut
Fachhochschule Südwestfalen, plattfaut.ralf@fh-swf.de

Open Innovation via Open Source: Collaboration of Tech Companies to Infuse Automobiles with Digital Technologies

Emergent Research Forum (ERF)

Vinod Kumar Ahuja
University of Nebraska Omaha
vahuja@unomaha.edu

Nikolai Kazantsev
University of Exeter
n.kazantsev@exeter.ac.uk

Ralf Plattfaut
South Westphalia University of Applied Sciences
plattfaut.ralf@fh-swf.de

Abstract

Open innovation is a process through which companies open their borders and collaborate with external stakeholders like open source communities to bring new ideas and develop novel digital technologies to gain a competitive position. In this paper, we studied an open source project, i.e., Automotive Grade Linux (AGL) – a Linux Foundation project started by automobile manufacturers and technology companies to innovate technologies for automobiles. By analyzing the code contribution of AGL, we show that much of the code contribution is made by external companies supplying technology to automotive companies and later using the open innovation process to benefit from it. We find evidence that automobile manufacturers engage in open source communities for outside-in, inside-out, and coupled open innovation. As such, this paper shows to managers in larger companies the importance of open source as a way to do open innovation.

Keywords

Open source, open innovation, collaboration, automotive industry.

Introduction

Companies are always looking for ways to innovate that help them to gain a competitive position in the market. To innovate, companies invest in their research and development to develop unique products and services to gain a competitive advantage. With a high cost of research and development, rapid technological changes, and lack of resources, more companies are moving towards open innovation, where companies open their borders to let the innovation flow in and out (Morgan and Finnegan 2014). In open innovation, companies collaborate with various stakeholders, including competitors, suppliers, vendors, customers, universities, general public, or crowd (Dahlander and Magnusson 2005). Companies collaborate in several ways, like creating cartels, alliances, and joint ventures. One such way is through open source software development.

In open source software, people collaborate to develop software and share it with everyone (Aksulu and Wade 2010; Crowston et al. 2012). As open source evolved, companies became participants in collaboratively developing software that everyone can share, distribute, modify, and enhance (Fitzgerald 2006; Germonprez et al. 2018). Even many competing corporations and their supply chain partners collaboratively develop open source software that every member can utilize (Germonprez et al. 2013).

There is much-untapped potential for corporations to interact and participate in open source communities to utilize open innovation. To the best of our knowledge, very little research on open source communities of large companies exists (Germonprez et al. 2013). However, as collaborative software development and its shared application are closely related to open innovation (Morgan and Finnegan 2014; West and Gallagher 2006), this topic is becoming increasingly important. Using open innovation as our theoretical

lens, this study will research how large companies make the best use of open source to do open innovation leading to our research question: *How do large companies innovate through engagement in open source communities?*

To answer the above research question, we will study an open source project, Automotive Grade Linux (AGL). AGL is a Linux Foundation Project started by automobile companies and their supply chain partners who collaboratively develop open source software for automobiles, i.e., an operating system for connected car technologies with embedded features like infotainment, telematics, and others. These features are used in most modern automobiles. As of January 2019, over 7 million vehicles running on AGL have been shipped. This study will analyze how automobile companies are doing open innovation through open source software. AGL was purposely selected (Seawright and Gerring 2008) for this study. The AGL project reflects all the aspects of open innovation where competing automobile companies and various stakeholders collaboratively develop automobile technology and adopt it in their products.

The structure of the paper is as follows: First, it will explore the open innovation literature to identify how open innovation is done through open source. Next, it will present the data collection method and findings for the AGL project to assess open innovation through open source software. Last, it will discuss the contribution of this work and its implication for managers striving for open innovation and end with a conclusion and future work.

Background

Open innovation has captured the attention and efforts of scholars and industry practitioners. Introduced by Chesbrough (2003), open innovation rests on the principle that firms leverage both internal and external ideas and paths to market to innovate, defining new organizational architectures and systems (Bogers et al. 2018). Chesbrough and Bogers (2014, p. 17) define open innovation as "a distributed innovation process based on purposefully managed knowledge flows across organizational boundaries." Open innovation can be transformative when external ideas are integrated with internal resources to improve the company's competitive position (Chesbrough 2003; West and Gallagher 2006).

Companies perform open innovation in three ways (Gassmann and Enkel 2004). First, *outside in*, where companies bring the innovation from the outside by collaborating with their suppliers and customers to bring innovation inside to improve existing products or innovate new ones. Second, *inside out*, where companies bring their intellectual property to outside by selling the intellectual property and monetizing from it or by outsourcing it to open source communities to grow the user base further enhance the technology. Third, *a coupled process*, where both inside out and outside in are linked by collaborating with competitors, supply chain partners, and other stakeholders to give and take the resources to innovate new technology. Companies can focus on any one process of open innovation and may use some element of other processes to innovate (Gassmann and Enkel 2004; Morgan and Finnegan 2014).

Each of the above three ways of innovation requires some form of collaboration with different stakeholders, and one such way through which this collaboration can be achieved is open source software development. Open source software is the collaborative development of software by individuals and companies (Crowston et al. 2012). Open source was started by individuals to solve their personal technological problems by developing the software and sharing it with everyone to improve their work and innovate (Raymond 2001). Due to the innovative potential of open source, companies started engaging with open source communities to innovate new technologies (Dahlander and Magnusson 2005) and generate business value from those innovations (Morgan and Finnegan 2014). Aksulu & Wade (2010) and Crowston et al., (2012) have provided comprehensive literature reviews explaining the landscape where open source research is headed. Within that landscape, how the three ways of open innovation are being achieved through open source is still unexplored. This research covers this gap by studying AGL to understand how automobile companies use the three ways of open innovation through open source.

Method

The data for research is obtained through publicly available sources and collected from Gerrit, a web-based team collaboration platform, and Jira, an issue tracker platform both used by the AGL community. Though AGL was started in September 2012, the data from both platforms are available from November 2015. The data contained the record of all the code contributed and reviewed by different individuals and employees of each participating company. The data was extracted using GrimoreLab, an open source python data extraction library, using Jupiter notebook. Grimorelab connects with Gerrit and Jira API to extract the data in JSON format, which was then queried to extract the contributor id, name, email id, reviewer name, and reviewer email id for all the repositories in the AGL project.

Most of the contributions in AGL are from the employees of companies. The company's name was identified from the domain contained in the contributor or reviewer's emails. One of the authors identified the industry to which these companies belong. Also, there are some corporate employees who, instead of using their company email, use a personal email like qq.com or gmail.com. To check whether individual contributors belong to a company, a google search was performed for the top 10 contributing individuals to identify if they belong to a company. Google search helped identify two employees belonging to the company but using their personal email to contribute. Thus, instead of keeping those contributors as individuals, they were tagged with their respective companies. Further, some companies have employees using email addresses from different company domains (e.g., company.com and company.com.uk). In data cleaning, all such contributions were merged to represent one company. There are some individual contributions, e.g., Google Summer of Code (GSoC) students learning from AGL contributors and contributing the code. Those individual contributions were tagged as individual. In the end, all the bot reviews were removed to analyze actual company contributions. All the extracted data was then sorted by the top 10 companies in terms of contributors and reviewers (refer to table 1). Contributors contribute the code to AGL, whereas reviewers review and approve the code before it gets merged to the main codebase. In sorting, all the individual contributions were merged to reflect as one category of contributors and represented as individuals.

Moreover, we collected data from the AGL community wikis, meeting minutes, press releases, announcements, and blog posts chronologically from the AGL website[1]. The first author reviewed this data to extract the contextual information to understand how the AGL community evolved and the major innovation milestones achieved.

Findings

Our findings revolve around the two data sets we extracted. First, from contextual data like community meetings, wikis, blogs, and announcements, we found that AGL started with three automobile competitors, i.e., Jaguar Land Rover, Nissan, Toyota, and 13 other technology companies, and now it has 146 members, including automobiles manufactures like Suzuki, Daimler, Hyundai, Volkswagen along with other technology companies. AGL has released my software version with added innovative technologies with this growth. It started with a demo version in May 2013 based on Tizen (i.e., a Linux version for mobile devices developed through open source by Samsung electronics, a founding member of AGL). Since then, it has released 12 versions as of Dec 2021 with features like rear seat display, video playback, audio routing, application framework, smart device link for mobile integration, window manager, software development kit, secure over-the-air update, speech recognition APIs, support for control from multiple surfaces, audio management, telematics systems, electronic instrument clusters, and Amazon Alexa integration and many other features. Different working groups like Virtualization, Speech Recognition, Vehicle-to-Cloud Connectivity, and Instrument Cluster working group develop these innovative features focusing on specific aspects of innovation for automobiles. Participating companies created these working groups to develop specific technologies to achieve their innovation goals.

Second, from code contribution and review data of company employees and individuals, we found that none of the top 10 companies (refer to table 1) (out of 57 companies who contributed the code) is an automobile manufacturer. Although automobile manufacturers developed the AGL project to support digital

[1] https://www.automotivelinux.org/news/ and https://wiki.automotivelinux.org/

innovation, these companies contributed very little to the code. For instance, Toyota and Mazda reviewed the code but did not contribute to the code base themselves. Most code contributions came from tech companies and the AGL *community maintainers*. These companies are followed by automotive suppliers focusing on electronic circuit boards and microchips. Looking at the top 10 contributors and reviewers, it is observed that most of the companies contributed and reviewed each other's code. Further, collectively 34 individuals have made some code contributions, especially a good portion by GSoC students, but in total, it is a small portion of code contribution and review.

N	Company	Industry	Contri-butions
1	iot.bzh	Tech	3759
2	konsulko.com	Tech	2837
3	linuxfoundation.org	Foundation	2432
4	fujitsu.com	Tech	716
5	collabora.com	Tech	609
6	Individuals		546
7	witz-inc.co.jp	Tech	381
8	baylibre.com	Tech	312
9	nexty-ele.com	Electronics	289
10	jp.panasonic.com	Electronics	263

A. Code Contributors

Company	Industry	Reviews
linuxfoundation.org	Foundation	34178
iot.bzh	Tech	19921
konsulko.com	Tech	9460
collabora.com	Tech	2155
fujitsu.com	Tech	1749
Individuals		1620
witz-inc.co.jp	Tech	1288
jp.panasonic.com	Electronics	1224
baylibre.com	Tech	1061
nexty-ele.com	Electronics	805

B. Code Reviewers

Table 1. Top 10 contributing and reviewing companies in AGL

Discussion

Based on our findings, we observed all three open innovation methods (Gassmann and Enkel 2004) in an open source software. First inside out, where AGL started with a demo version from Tizen - an open source project developed by Samsung for mobile devices. Using Tizen helped AGL kick start the development, and later various collaborators developed this technology and customized it for automobiles, and released their own Linux Unified Code Base (UCB).

Second, outside in, where many automobiles integrated AGL in their automobiles, starting with Toyota, who adopted AGL in their automobiles in May 2017 in their next-generation vehicles. By January 2018, Toyota adopted AGL in their automobiles manufactured worldwide. Later, many other automobile manufacturers like Mazda, Subaru, and Mercedes Benz adopted AGL operating systems. All the automobile manufacturers use open innovative technology and combine it with their internal resources to improve their competitive position and save resources (Chesbrough 2003; West and Gallagher 2006).

Third, a coupled process, where automobiles collaborate with their competitors, technology suppliers, chip manufacturers, and other OEM providers to keep the innovation ongoing by continuously adding innovative features in each release. Further, to achieve this process of continuous innovation over the period, various expert groups formed by participating companies focus on specific features like virtualization, speech Recognition, Vehicle-to-Cloud (V2C) connectivity, and Instrument Cluster Expert.

Conclusion and Future Work

This work focused on how different automobile companies are innovating through open source by collaborating with technology, electronic, OEM companies, and other stakeholders. By analyzing the AGL code contribution, reviews, and contextual data, we found that *automobile companies used open source*

best to innovate new technology. This innovation was possible due to the collaborative environment provided by the open source software (Dahlander and Magnusson 2005). By analyzing the code contribution of AGL, we show that much of the code contribution is made by external companies supplying technology to automotive companies, though the latter started this open source project. Generalizing these findings, we provide evidence of the open innovation when the external ideals are penetrating the incumbent companies. This paper shows managers in larger companies the importance of open source to do open innovation.

In the future, we will further develop this research project as follows. Next to our secondary data collected from Gerrit and Jira and the contextual data (e.g., blog posts, press releases, AGL meeting minutes), we will collect primary data building on the insights presented here. To this end, we will interview key participants in the AGL community to analyze their individual views and infer the view of their respective employers (i.e., the AGL member companies). Here, we aim to understand how they choose specific strategies to participate in open source for open innovation. Using a coding scheme building on open innovation theory with a socio-technical lens and open coding, we will analyze these data to derive insights into open innovation through open source. We thus aim to contribute to open innovation theory and our understanding of open sources in Information Systems research more deeply.

Acknowledgments

Development of this paper started at ICIS 2021 paper-a-thon and authors thank organizers. The first author acknowledges funding through Alfred P. Sloan Foundation grant https://sloan.org/grant-detail/9549, and the second author acknowledges EPSRC and UKRI funding, grant reference EP/T022566/1.

REFERENCES

Aksulu, A., and Wade, M. 2010. "A Comprehensive Review and Synthesis of Open Source Research," Journal of the Association for Information Systems (11:11), pp. 576–656.

Bogers, M., Chesbrough, H., and Moedas, C. 2018. "Open Innovation: Research, Practices, and Policies," California Management Review (60:2), SAGE Publications Inc, pp. 5–16.

Chesbrough, H., and Bogers, M. 2014. "Explicating Open Innovation: Clarifying an Emerging Paradigm for Understanding Innovation," in New Frontiers in Open Innovation, Oxford: Oxford University Press.

Chesbrough, H. W. 2003. Open Innovation: The New Imperative for Creating and Profiting from Technology, Boston, Mass: Harvard Business School Press.

Crowston, K., Wei, K., Howison, J., and Wiggins, A. 2012. "Free/Libre Open-Source Software Development: What We Know and What We Do Not Know," ACM Computing Surveys (44:2), pp. 1–35.

Dahlander, L., and Magnusson, M. G. 2005. "Relationships between Open Source Software Companies and Communities: Observations from Nordic Firms," Research Policy (34:4), pp. 481–493.

Fitzgerald, B. 2006. "The Transformation of Open Source Software," MIS Quarterly (30:3), p. 587.

Gassmann, O., and Enkel, E. 2004. Towards a Theory of Open Innovation: Three Core Process Archetypes, presented at the R&D Management Conference (RADMA) 2004, Lissabon, July 7.

Germonprez, M., Allen, J. P., Warner, B., Hill, J., and McClements, G. 2013. "Open Source Communities of Competitors," ACM Interactions (20:6), pp. 54–59.

Germonprez, M., Link, G. J. P., Lumbard, K., and Goggins, S. 2018. "Eight Observations and 24 Research Questions About Open Source Projects: Illuminating New Realities," Proceedings of the ACM on Human-Computer Interaction (2:CSCW), pp. 1–22.

Morgan, L., and Finnegan, P. 2014. "Beyond Free Software: An Exploration of the Business Value of Strategic Open Source," The Journal of Strategic Information Systems (23:3), pp. 226–238.

Raymond, E. S. 2001. The Cathedral & the Bazaar, O'Reilly Media, Inc.

Seawright, J., and Gerring, J. 2008. "Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options," Political Research Quarterly (61:2), [University of Utah, Sage Publications, Inc.], pp. 294–308.

West, J., and Gallagher, S. 2006. "Challenges of Open Innovation: The Paradox of Firm Investment in Open-Source Software," R&D Management (36:3), pp. 319–331.