A Framework to Represent Antecedents of User Interest in Open-Source Software Projects

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Published
2010

Conference Title
International Business Information Management Conference

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A Framework to Represent Antecedents of User Interest in
Open-Source Software Projects

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Abstract:
This paper uses a literature survey to gain an insight into existing studies on the success of open source software (OSS) projects. Current literature has studied various aspects of OSS success such as project activity, user interest, and project effectiveness. However, this study focuses on user interest because, according to prior research, a higher user interest contributes to positive project outcomes (e.g. product quality, project performance, and project vitality). Based on the literature survey in this study, we found 43 conceptually distinct determinants of user interest in OSS projects. We classified them into 7 broad categories of including project status, project characteristics, community contribution, process, network structure, product characteristics, and resources. Implications for practice and research are also presented.

Key Words: Project success, Open source software, User interest, OSS project success.

1. 1. Introduction

Adoption of open source software (OSS) has resulted in $60 billion per year savings to its consumers. Johnson (2008) states “… while it [OSS] is only 6% of estimated trillion dollars IT budgeted annually, it represents a real loss of $60 billion in annual revenues to software companies”. However, despite its obvious benefits, around 63% of OSS projects on Sourceforge.net, the largest OSS
repository in the world, don’t grow and as a result cannot succeed (Krishnamurthy, 2002). Thus, a critical area of academic interest in OSS has been investigating antecedents of OSS success.

Current literature has studied various aspects of OSS success such as project activity (e.g. Liu, 2008; Stewart et al., 2006; Colazo, 2007; Long, 2006a; Grewal et al., 2006), user interest (e.g. Subramaniam et al., 2009; Stewart et al., 2006; Crowston and Scozzi, 2002; Midha, 2007), and project performance (e.g. Liu, 2008; Long, 2006a; Guiri et al., 2004; Hahn and Zhang, 2005). Among the OSS success aspects mentioned, this proposed research focuses on user interest because high user interest can impact project outcomes such as project vitality and activity (Giuri, 2004; Stewart et al., 2005). In addition, the larger the community around an OSS project, the higher the potential to achieve quality (Michlmayr, 2007), the broader the scope of the project (Michlmayr, 2004) and the richer the software knowledgebase (Subramaniam et al., 2009).

This paper provides an overview of current state-of-the-art research in “user interest” literature. The aim of this research is to help OSS projects attract a higher level of “user interest” by developing a framework that represents antecedents of “user interest” in OSS projects according to the literature. Moreover, in order to make more sense of the list of antecedents, this paper aims to bundle the antecedents into meaningful categories. Hence the research question guiding this study is as below:

**RQ. What are the factors that influence user interest in OSS projects?**

This paper is organized as follows. Section 2 contains a literature review on OSS success. Section 3 investigates user interest as a key aspect of OSS success. Section 4 presents the research methodology. Section 5 presents the results of the research, i.e. a framework for antecedents to user interest in OSS projects. Section 6 presents discussions, followed by concluding remarks in Section 7.

### 2. OSS Success

Open Source Initiative (OSI) defines OSS as software released under a license approved by OSI (Open Source Initiative, 2005). Many OSS projects cannot grow and stay immature or even die for different reasons. On the other hand, there are many successful examples of open source projects that have achieved huge success in the market. Mozilla Firefox, Apache, Open office, and Linux operating system are examples of such projects.

In simple terms, success is the achievement of something that is desired (Midha, 2007). Measuring success for OSS can be difficult because it is subjective. Crowston et al. (2006) says “… these measures [OSS success measures] are hard to define for regular I/S [closed source software] projects and doubly hard for FLOSS [Free/Libre OSS] projects, because of the problems defining the intended
user base and expected outcomes”. That is why there are different perspectives in the literature on OSS success.

Current literature has studied various aspects of OSS success including: (1) development success, (2) product success, (3) project effectiveness, (4) project efficiency, (5) project activity, and (6) user interest. Among the OSS success aspects investigated, this proposed research focuses on user interest because high user interest can impact project outcomes such as project vitality and activity (Giuri, 2004; Stewart et al., 2005). In addition, the larger the community around an OSS project, the higher the potential to achieve quality (Michlmayr, 2007) the broader the scope of the project (Michlmayr, 2004) and the richer the software knowledgebase (Subramaniam et al., 2009). In the next section we will focus on user interest as the phenomenon under study.

3. User interest

“User Interest” is defined as the ability of an OSS project to attract community users to adopt the project software (Stewart et al., 2006; Subramaniam et al., 2009). In other words, user interest shows the level of popularity a project achieves in the community (Long, 2006a). The interest shown by these users might be a pivotal indicator of the OSS project’s success (Stewart et al., 2006; Subramaniam et al., 2009).

Some indicators of “user interest” in prior research include traffic on the project website (Crowston et al., 2003 and 2006), downloads of the code (Subramaniam et al., 2009; Crowston et al., 2003 and 2006), and the number of people who have registered on the project mailing list to receive announcements such as new releases of the project (Stewart et al., 2006; Crowston et al., 2003 and 2006).

Prior research on “user interest” has resulted in interesting findings. One of the first attempts in this regard was the research by Crowston and Scozzi (2002). They showed that using more common programming languages, having more developers, and more highly ranked or rated project administrators influenced project success defined by activity, development status, and use. Hahn and Zhang (2005) surveyed a sample of 673 open source projects from Sourceforge.net. They concluded that firstly, project management practices like human resource staffing, release management, communication and coordination, and compensation management, impact on project performance. Secondly, project type (i.e. user targeted or developer targeted) moderates this relationship. Moreover, Stewart et al. (2006) showed that license restrictiveness is negatively associated with user interest, while having a sponsor has a positive impact on user interest. Furthermore, user interest has a positive impact on the amount of OSS project development activity. Stewart and Ammeter (2002)
also, investigated that vitality has a significant impact on popularity over time, showing that the more active a project is in terms of posting new releases and making announcements, the more attention it receives from the community. The next section depicts the antecedents of user interest explored by our literature survey.

4. Research Methodology

Our literature survey involved searching certain key words on variety of academic databases (e.g. ScienceDirect, Business Source Premier, Scopus and etc). Depending on the search services offered by the search engine, the titles, abstracts, keywords, and in some cases full text of the journal articles and conference proceedings in the included electronic databases were searched using the following search terms:

(“Open source software” OR “OSS” OR “Open source project”)

AND

(“Success” OR “Failure” OR “User interest” OR “Performance” OR “Effectiveness” OR “Software success” OR “Software quality” OR “Project success” OR “Efficiency” OR “Popularity”)

The publications extracted (e.g. journal papers, conference proceedings, and dissertations) were then reviewed and filtered based on reading their titles, abstracts, or full text. This process resulted in a final list of 14 papers which explored antecedents of user interest in OSS projects. Table 1 shows each paper in the extracted list of papers as well as the findings of each paper. Having reviewed the 14 extracted papers, we identified 43 factors affecting user interest. In order to make our analysis more informative, we next sought to categorize them into meaningful clusters. Therefore, we went through our source of studies in the literature, and looked for appropriate labels for each set of factors. It helped us to bundle most of the factors. For those factors that we could not bundle with others, once the appropriate labels were identified, the author and two other researchers individually classified the factors under these labels. We then compared the results, discussed the clusters and finalized the classification process. The process of individual classification and group discussion was conducted three times until we came on agreement.
5. Result: A Framework for Antecedents of User Interest

In brief, we identified 7 main categories, including project status, project characteristics, community contribution, process, network structure, product characteristics, and resources. Figure 1 shows our taxonomy of antecedents to user interest in OSS projects.

Table 1. Brief introduction of the papers extracted in literature survey

<table>
<thead>
<tr>
<th>Author</th>
<th>Survey Sample</th>
<th>Key Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subramaniam et al. (2009)</td>
<td>8627 projects</td>
<td>Developer interest, user interest and project activity are correlated to project activity, developer interest, project license and development status impact user interest</td>
</tr>
<tr>
<td>Hahn and Zhang (2005)</td>
<td>673 projects</td>
<td>Project management practices like HR staffing, release management, communication and coordination, and compensation management impact on project performance.</td>
</tr>
<tr>
<td>Stewart et al. (2006)</td>
<td>138 projects</td>
<td>License restrictiveness is negatively associated with user interest. Having a sponsor is positively associated with user interest.</td>
</tr>
<tr>
<td>Long (2006b)</td>
<td>300 projects</td>
<td>The number of messages in the forums and the number of bug and patch reports from non-core developers are positively associated with OSS project success.</td>
</tr>
<tr>
<td>Midha (2007)</td>
<td>156 projects</td>
<td>The number of download in the previous releases, the number of translated languages, and the number of developers impact on project popularity. Product complexity and modularity, the number of developers, and project license type influence the project level of activity</td>
</tr>
<tr>
<td>Crowston and Scozzi (2002)</td>
<td>7477 projects</td>
<td>Projects using more common programming languages are more successful (a) more active, (b) in more advanced states of development and (c) more used Projects with more developers are more successful (a) more active, (b) in more advanced states of development and (c) more used</td>
</tr>
<tr>
<td>Liu (2008)</td>
<td>200 projects</td>
<td>Degree of product decomposition is curvilinearly related to its project performance. Degree of product coupling is negatively related to product quality and market success.</td>
</tr>
<tr>
<td>Rehman (2006)</td>
<td>350 projects</td>
<td>The number of developers, developers’ years of experience, and targeting developer impact on project success. Developing application development tools impacts on the number of downloads.</td>
</tr>
<tr>
<td>Stewart et al. (2005)</td>
<td>147 projects</td>
<td>Sponsored OSS projects will become more popular over time than non-sponsored OSS projects.</td>
</tr>
<tr>
<td>Long (2004)</td>
<td>300 projects</td>
<td>Developers’ contribution from the community impacts the success or failure of the open source projects.</td>
</tr>
<tr>
<td>Long (2006b)</td>
<td>150 projects</td>
<td>Network structure (centralization and core/periphery fitness) impacts on project performance. Quantity of knowledge sharing mediates the relationship between network structure (centralization and core/periphery fitness) and project performance.</td>
</tr>
<tr>
<td>Stewart and Ammeter (2002)</td>
<td>240 projects</td>
<td>Vitality has a significant impact on popularity over time showing that the more active a project is in terms of posting new releases and making announcements, the more attention it receives from the community.</td>
</tr>
</tbody>
</table>
Table 2 presents the number of factors belonging to each category. As shown in Table 2, project characteristics and community contribution with 8 factors each, put these two categories in the majority, followed by Project status and Network structure clusters (each with 6 factors). A brief explanation of each antecedent is provided below as per the associated category.
Table 2. Categorization of User interest determinants

<table>
<thead>
<tr>
<th>Row</th>
<th>Category Name</th>
<th>Number of Factors</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project characteristics</td>
<td>8</td>
<td>18.6%</td>
</tr>
<tr>
<td>2</td>
<td>Project status</td>
<td>6</td>
<td>14%</td>
</tr>
<tr>
<td>3</td>
<td>Resource</td>
<td>5</td>
<td>11.6%</td>
</tr>
<tr>
<td>4</td>
<td>Product characteristics</td>
<td>5</td>
<td>11.6%</td>
</tr>
<tr>
<td>5</td>
<td>Network structure</td>
<td>6</td>
<td>14%</td>
</tr>
<tr>
<td>6</td>
<td>Process</td>
<td>5</td>
<td>11.6%</td>
</tr>
<tr>
<td>7</td>
<td>Community contribution</td>
<td>8</td>
<td>18.6%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>43</td>
<td>%100</td>
</tr>
</tbody>
</table>

1. **5.1 Project status**

These factors show the current situation of the project in terms of activity. Factors in this category, which have been looked into in the OSS literature include: *Project vitality*: a measure of the success for OSS projects which shows how active the project has been; *Development status*: an indicator which shows the development stage of an OSS project (planning, pre-alpha, alpha, beta, stable, or mature); *Number of downloads*: The number of times that the product has been downloaded; *Project activity*: The level of project activity (e.g. the number of code commits); *Number of file releases*: How frequent a project releases new versions of the software; *Number of news releases*: OSS repositories (e.g. Sourceforge) allow OSS projects to publish news on their projects (e.g. announcing a new release).

2. **5.2 Project characteristics**

Project Characteristics incorporates various characteristics of the project defined by project initiator(s). The factors in this category that have been looked into in OSS “user interest” include: *Project type*: whether the software is an application development tool; *Project topic*: OSS repositories (e.g. Sourceforge) classify OSS projects into different topic categories (e.g. communication); *Licence*: the Open Source Initiative (OSI) has introduced different OSS licenses in terms of certain characteristics [this is a vague description] (Open Source Initiative, 2005); *Sponsorship*: Whether the project is sponsored by a company; *Number of translated language*: The number of [spoken?] languages that the software is translated into; *Using common programming languages*: Whether the project uses a common programming language (e.g. C, C++, Java); *Audience*: Whether the project is user-targeted or developer-targeted; *Project lifespan*: How long has the project has existed.
3. **5.3 Community contribution**

One of the advantages of OSS is that the community can contribute to the project in different ways. One reason people make software source code publicly available is that they want the community to contribute to the projects in different ways, such as reporting bugs and features, fixing bugs, and contributing to forum discussions. The factors in this category that have been investigated in OSS “user interest” literature include: *Number of messages in the forums*: Forums can be used as a place for public discussions between users, developers, and even outsiders; *Number of messages in the mailing lists*: Mailing lists are a place where users and/or developers communicate each other with regard to different topics, like making decisions on issues; *Number of bugs reported*: OSS hosts provide registered projects with bug reporting systems, in which people can report the bugs; *Number of patches*: A patch is a piece of code which is normally used to fix a bug; *Number of CVS reports*: Concurrent Versioning System (CVS) is a tool offered by OSS hosts which can be used to manage software versioning. It allows developers to work on the source code simultaneously; *Knowledge quality*: The quality of the knowledge which is being shared across project communication tools like forums and mailing lists; *Knowledge quantity*: The amount of the knowledge which is being shared in project communication tools, such as forums and mailing lists; *Community service quality*: The quality of the service given to community users.

4. **5.4 Process**

Those project processes which can be tracked through the project websites on the OSS hosts. They can be management processes, like Human Resource Management (e.g. attracting new developers), or development processes (e.g. bug fixing). The factors in this category that have been looked into in OSS “user interest” literature include: *HRM*: This process includes all sub-processes related to HRM, such as developer join and turnover; *Compensation management*: This process refers to whether the project uses compensation plans for developers; *Communication and coordination*: Communication and coordination in OSS projects are mostly done through mailing lists or project forums; *Release management*: A successful release management results in more releases and faster releases.

5. **5.5 Network structure**

A pile of network structure related factors have been examined in OSS literature for their impact on “user interest”. They usually apply network analysis of OSS projects through project mailing lists, forums, bug systems or etc. In this regard, collaboration structure of core developers, community level structure, centrality structural holes, core/periphery fitness, network embeddedness have been already examined in “user interest” literature.
6. 5.6 Product characteristics

Product characteristics refer to software characteristics which have been studied to see whether they impact “user interest”. They include software modularity, complexity, degree of decomposition, degree of coupling, and software quality (defined through the number of bugs).

7. 5.7 Resources

The resources a project has at its disposal in order to fulfil its goals (e.g. developers, popularity in the community). The factors in this category that have been investigated in OSS “user interest” literature include: Number of developers: The more skilled developers an OSS project can attract, the more likely it will succeed; Number of administrators: The number of people who manage the project; Administrator rank: The rank of project administrators as ranked by their peers; Developers’ experience: How experienced the project developers are in terms of the skills they have or even the time span they have been writing programs; Core developers’ effort: the number of CVS reports done by the project developers.

6. 6. Discussions

This paper has investigated antecedents of user interest in OSS projects through a literature survey. The result of our systematic review is depicted in Figure 1. Having come up with 43 distinguishable determinants of user interest, this paper has classified them into 7 main categories: project status, project characteristics, community contribution, process, network structure, product characteristics, and resources. A brief explanation of each antecedent is provided in Section 5.

The current study gives critical recommendations for future studies by creating a new model of OSS success. We also introduce four important gaps in user interest literature. Firstly, existing studies lack attention to the influence of the “development processes” on user interest. Secondly, the current literature suffers from a lack of research focusing on the impact of project management practices on user interest. Thirdly, existing research lacks empirical work on the influence of “user contribution” on project success. Fourthly, the impact of communication quality and quantity, as well as communication media that an OSS project uses, should be investigated too.

Findings of this research inform OSS project managers about the factors that influence user interest in their projects. Firstly certain decisions that project managers have to make before launching the project have a direct impact on user interest in their project. Hence they should take such decisions very seriously. For example which licence to choose, what audience category to select, or what programming language(s) to adopt. Secondly, software characteristics should be also taken into
account. For example, how modular a piece of software is or its complexity can directly impact on user interest. Finally, process management is of critical importance to OSS success. Thus project administrators should processes such as release management, promoting project, and communication with great care.

7. Conclusion

This paper sought to review and advance the literature on OSS success through a survey of the current literature. It overviews various aspects of OSS success in the literature and investigates user interest as one of the key aspects of OSS success. Definitions and examples are provided for user interest through a literature review, as well as introducing indicators to measure this phenomenon. More importantly, based on the results of our literature survey, we introduce a taxonomy for representing antecedents of user interest in OSS projects. This taxonomy includes 43 factors categorized into 7 clusters including: project status, project characteristics, community contribution, process, network structure, product characteristics, and resources.

Finally, we call on future research to fill the gaps found in the literature by this research. This recommendation includes conducting a meta-analysis to investigate the impact significance of each antecedent found in this research on user interest using systematic literature review.

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Hahn, J., and Zhang, C. (2005). An exploratory study of open source projects from a project management perspective. paper presented at MIS Research Workshop, Purdue University, West Lafayette, IN.


