The Impact of Project Leaders on Open Source Software Development Team Composition

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Abstract. We report on results of a study examining the formation of teams around newly registered open source software development projects on SourceForge.Net. We found that project leaders affected the likelihood of attracting developer interest through project management involving early code release and maintaining high levels of development activity. Project leaders exhibited varying levels of openness towards new volunteer developers joining their projects. Leaders' decisions regarding developer joining had a direct impact on project team size – an important factor determining a project's likelihood of attracting new developers.

1   Introduction

Interest in open source software development (OSSD) as a viable alternative to the conventional proprietary model of producing software has grown as a result of the success of some notable projects such as the Apache web server and the Linux operating system kernel [10, 11]. In OSSD, individuals form voluntary online communities around projects and engage in a collaborative development process. Open source project communities usually have an onion-shaped structure consisting of project leaders, developers, and users [2, 9]. At the onion's center are the project leaders who are often project founders. Surrounding the project leaders are core developers and co-developers. Core developers are usually formally listed as project members and allowed commit privileges into the source code repository whereas co-developers contribute code to the project but do not have commit privileges. Around core developers and co-developers are active users who contribute by submitting feedback or writing documentations and passive users who do not contribute to the development.

In the past decade, recognizing the importance of developers' voluntary participation to the existence and success of open source software (OSS) projects, scholars and practitioners have intensively investigated the motivations and

incentives of OSS developers for contributing to OSS projects [4, 6, 7, 12]. Overall, most accounts of the OSSD process tend to emphasize the open, voluntary nature of participation in OSSD where individuals freely join and leave projects.

While these accounts may reflect the nature of participation at the periphery of OSS projects such as co-developers and users contributing code or submitting feedback regarding the software, they do not fully capture the reality of volunteers joining the core development team of an OSS project mainly due to the role played by project leaders. Although we acknowledge that the success of an OSS project to some extent depends on its ability to attract interest and contribution from developers and users, we argue that leadership also plays a key role in the OSSD process, thus deserves closer examination.

Many OSSD observers [11, 14] emphasize the important role of project leaders despite the fact that leaders cannot mandate and enforce the activities of developers through monetary incentives or legal authorities. Besides providing project visions and delegating tasks to other developers [8], more importantly, OSS project leaders need to know how to "lead without coercion" and how to recruit and sustain community members [11].

Not every OSS project can survive and prosper. To date, a vast majority of OSS projects have failed to take off and become abandoned [1] due to a lack of individuals attracted to them. Unlike software development groups in organizational settings whose members are unilaterally assigned by project managers based on members' experiences and skills, OSS project teams are formed as a result of the bilateral choice of both project leaders and volunteer developers. In short, the formation of the core development team of OSS projects depends not only on developers' voluntary choices but also on actions and predispositions of project leaders, who not only influence a project's potential to attract developer interest but may also exercise discretion regarding which external developers to accept into the core development team.[1] Therefore, this study examines the direct and indirect influences of OSS project leaders on attracting and managing the boundary of their project teams.

2   How Project Leaders Indirectly Attract Developers by Project Design

We conducted a study examining new OSS project team formation within SourceForge.net, the largest open source software project hosting site [5]. In this research we studied the growth in development team size of a sample of 2349 new OSS projects hosted on SourceForge.net in order to determine factors that influenced developer choice of new projects to join.

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[1]   In most OSS projects, the administrators at the outset are the owners of the project code – those who start the project by writing and releasing the goals and blueprint of the project and (in most cases) the initial version of the software as well.

At SourceForge.net, a developer interested in initiating a new project submits a request to the SourceForge.net staff. After the project is approved for hosting, the developer becomes the project administrator or leader who can start utilizing the services and tools provided by the site and upload contents to the project site. External developers wishing to become a member of the project must first contact the project leader. The leader then either rejects the joining request or approves the request and adds the requester to the project membership. A joining event occurs when a developer is added to the project membership list by the project leader. Project leaders may also send out invitations to targeted developers to become involved in the project.

We selected all public OSS projects registered between September 30 and November 11, 2005 (N = 2349) as our study sample. The sample projects spanned 19 top-level domain categories such as Software Development and Internet. A software agent visited these projects' web pages and kept track of their membership information on a daily basis. This daily data collection process allowed us to identify when joining events occurred and when important project events occurred (e.g., release of code, updating of project description). Data collection ended in early January 2006.

We then identified the factors that external developers may consider when making their joining decisions and conducted logistic regression analysis to test the influences of these factors. Fig. 1 presents an overall summary of the factors significantly influencing the likelihood of developers joining a new OSS project in this study of newly-created SourceForge.net projects.
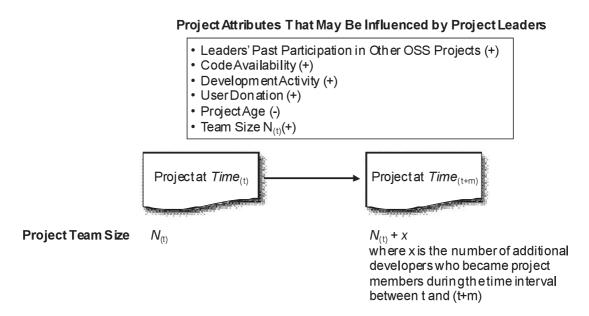
Project Attributes That May Be Influenced by Project Leaders

• Leaders' Past Participation in Other OSS Projects (+)
• Code Availability (+)
• Development Activity (+)
• User Donation (+)
• Project Age (-)
• Team Size $N_{(t)}$ (+)

| Project at $Time_{(t)}$ | → | Project at $Time_{(t+m)}$ |

Project Team Size $N_{(t)}$

$N_{(t)} + x$
where x is the number of additional developers who became project members during the time interval between t and $(t+m)$

Fig. 1. How OSS Team Leaders Influence Team Formation

.Our findings show that project leaders can influence the perceived attractiveness of OSS projects by setting the overall project direction and coordinating the development efforts of project members, thus indirectly influencing the likelihood that developers voluntarily join the projects. Project leaders' past participation in other OSS projects and their connections with other OSS developers also affect who is likely to join the project.

Each of the major factors influencing OSS team formation is summarized below.

2.1   Code Release

An OSS project is typically registered and initiated by a single developer within SourceForge.net who becomes the de facto leader of the project. The leader may decide whether and when some initial working code will be released to the public. Developers were more likely to join a project that had released some initial software code outlining the functionalities envisioned by the project administrator and demonstrating the potential merits of the project. This is consistent with the argument that some minimal code needs to be assembled in order for the project to receive reaction from the OSSD community [8, 11].

2.2   Development Activity

Evidence of active development in the project increased the likelihood that developers would join the new project. Developers tend to consider a project that exhibited a higher level of development activity more favorably and are more likely to be attracted to the project because it may have a higher probability of success. Although project leaders are unable to mandate or enforce the activities of their team members due to the lack of monetary incentives or legal authorities, they may encourage and facilitate team development activities by achieving a more modular software design and delegating tasks to developers [8].

2.3   Donation Acceptance

Project leaders usually have the administrative right to enable projects to accept monetary donations. Our results suggested that projects that were set up to accept donations from users were more likely to attract developers.

2.4   Project Leaders' Past Participation in Other OSS Projects

We found that project leaders' prior history with developers in the overall open source community also had an impact on attracting developers to join OSS projects. A developer is more likely to join a new project whose administrator had collaborated with him in past OSS projects than a project whose administrator is a

stranger to him. In short, project leaders launching new OSS projects may increase the chances that developers contribute to and join their projects early on (i.e., Time(t+m) in Figure 1) by first establishing strong collaborative relationships with other developers through participation in existing OSS projects.

2.5   Development Team Size and Importance of Early Momentum

Our study findings also indicated that developers were more likely to join a new project earlier rather than later. They were more likely to join a new project that had already been successful at attracting additional developers – a unit increase in project team size increased the likelihood that an additional developer joined almost twelve-fold.

Taken together these findings suggest that project leaders can indirectly influence the assembly of project teams through their past participation history with others and through project administrative decisions made early in the project development process – releasing working code "early and often" and instituting a means of procuring external financial resources (e.g., accepting user donations in the case of projects hosted on SourceForge.net).

3   How Project Leaders Directly Affect Project Membership

In addition to affecting the likelihood of developers seeking to join their project, OSS project leaders also play a more proactive role in delineating the boundaries of development team membership, i.e., they serve as gatekeepers and exert direct influence over who should be allowed to join the project. Once they receive the joining requests from external developers, their predisposition towards accepting these requests directly influences the boundary of their teams.

To further investigate project leaders' openness toward joining requests from external developers, we administered a survey of the leaders of the sample projects obtained in our previous study.

A week prior to the start of the survey, we emailed personalized invitations to participate in the online survey to the administrators in our project sample (N=2349). In the invitation, we outlined the purpose of the survey, ensured anonymity and reporting of results in aggregate form only, and gave the respondents the option to opt out by following a link in the email invitation. All respondents were also offered an executive summary of the research findings and to be entered into a drawing to win a US$200 gift certificate. A total of 125 respondents opted out of the survey. All administrators who had not opted out were sent a link to the web-based survey. Survey responses were collected from December 6 to December 16, 2007. The survey generated 384 valid responses (response rate of 16.3% (384/2349) or effective response rate of 17.3% (384 / (2349 − 125)).

The survey included both closed-ended and open-ended questions asking project administrators about the specific projects, whether developers had requested to join their projects, and their usual administrative practices regarding accepting and rejecting joining requests. Because many individuals are involved in multiple open source projects, the first set of questions in the survey instructed the project administrators to respond with reference to the particular OSSD project that was in our project sample. The second set of questions asked the respondents to answer with reference to their general administrative practices in all the OSSD projects that they had been in charge of.

We checked for non-response bias by comparing the responses received in the first five days (December 6 – December 10) with those received in the last five days (December 11 – December 16) of the survey. Results showed that there was no significant difference between the early responses and the late responses.

Of the leaders we surveyed, sixty (15.6%) actively invited other developers to join their project. Eighty-six (22.4%) of the leaders we surveyed had received and granted at least one joining request from other developers during the first three months of the sample projects. Only 6 (1.6%) of them have ever actually rejected joining requests.

How open, in general, are OSS project leaders to requests for joining? When asked how likely the project leaders are to refuse other developers' joining requests in the early phase of their projects, 41.1% expressed they were unlikely to do so; 30.6% of the respondents expressed a neutral attitude; 28.3% indicated they were likely to reject such requests. The leaders gave similar responses when asked about their attitude toward requests in the later stage and mature stage of projects.

We further examined the antecedents of their predisposition towards accepting or rejecting others' joining requests, i.e., we estimated the possible factors that influence the likelihood of project leaders rejecting the joining requests they may receive from other developers.[2] Our findings suggested the following patterns of project administrator decisions regarding requests to participate as developers in their teams.

First, the existence of past interactions between the administrator and the requesting developer positively influenced the tendency of leaders to accept the joining request. In open source software development, due to the lack of opportunities for face-to-face interaction, developers need to overcome greater barriers to effective communication and coordination and are more likely to be concerned about these issues. Hence, project leaders were more likely to allow developers with whom they have interacted in the past into the development team.

> *"I recruited people I knew in person to join the project team, and they sent requests to join if they believed they were qualified."*

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[2] Using a proportional odds model for ordinal logistic regression, we estimated the possible factors that influence the likelihood of project administrators rejecting the joining requests they may receive from other developers. The predictors explained 31.4% of the variation in the dependent variable, indicating a reasonable level of model fit.

– *Project Administrator (Firewall Domain), SF.net Member since 2005*
"*It was more a matter of me asking developers, than developers asking me.*"
– *Project Administrator (Database Engine/Server Domain), SF.net Member since 2000*

Second, the project administrator's general attitude about the openness of OSS projects also significantly impacts their decisions to accept requests from other developers. Although some project leaders expressed their concerns about potential developers' skills and willingness to contribute to projects, most leaders were more concerned about attracting additional developers, and hence were more receptive of external developers' joining requests. Over 30% of the survey respondents indicated they usually approved all joining requests that they received.

"*Everyone should be allowed to participate in open source. ... That is the nature of open source.*"
– *Project Administrator (Domain Not Listed), SF.net Member since 2004*
"*I would refuse if the developer has nothing useful to contribute or produces no results and just has the idea that they want to be a developer on the project with no specific ideas.*"
– *Project Administrator (Communications Domain), SF.net Member since 2000*

Third, when projects have had enough participating members, project leaders are less likely to accept additional developers. Although the decentralized nature of the OSS development process has been regarded as a key feature of this software production model, successful projects rely on the effective coordination efforts of leaders. As more developers join the project and the project grows larger in scale, the risk of administrator information overload and burnout also increases. Consequently, there may be a limit on the team size depending on how much effort the administrator is willing to invest in the project as well as the intended scope of the software. Our survey results also suggested that 90.1% of the leaders had an intended size for the project membership given the original scope of the project. When the intended team size is reached, project leaders were more reluctant to accept further joining requests.

"*If I had received request in the early stage of the project I surely would reject them because I want to keep the dev group small in that stage.*"
– *Project Administrator (Games/Entertainment Domain), SF.net Member since 2005*

We expected that project leaders would consider different factors depending on the software development phase. For example, some may be more open to joining requests during the early phase of the project in order to gain early momentum. At the mature stage, the increased code complexity would become an entry barrier to

new developers, and would require little additional development effort as the project is likely to have met the original project objectives. Hence, we expected that leaders would be less likely to accept joining requests after the project has reached a mature stage. However, contrary to what we expected, we did not find development phase to have any significant effect on whether they were likely to reject volunteer requests to join the development team.

4   Conclusion

In this paper we report on the implications to be drawn from the results of examining new OSS project team formation within SourceForge.net. Specifically we empirically investigated OSS developers' project joining behavior and conducted a survey of project leaders about their openness toward developers' joining requests. This study represents a first step toward understanding the bilateral nature of open source software project development team formation.

Overall our findings confirmed the influence that project leaders can exert on attracting developers to participate in core project teams as well as on managing the boundary of their teams. While we acknowledge the importance of volunteer developers' willingness to participate, project leaders can also directly influence project team formation by actively recruiting developers and declining joining requests from volunteer developers, and indirectly influence team formation through their past participation in OSS projects and their decisions related to the project that affect the project's visibility and attractiveness to prospective project members.

Our key findings suggest that project leaders may increase the probability of attracting additional developers by releasing code early, maintaining a high level of development activity, and instituting a means of procuring external financial resources. In addition, we found that open source software projects, while open in terms of source availability, were not always open with respect to participation. Project leaders exhibited varying levels of openness towards developers expressing an interest to contribute to their projects. While one-third of the surveyed project leaders maintained a favorable attitude toward developers interested in participating in their projects, and were likely to accept most developers into the development team, others were less inclined to favor open participation. These project leaders were less likely to accept participation from developers with whom they had no prior interactions, and were less receptive of new developer participation when the project already had enough developers working on it. This may be due to the increasing difficulty in assessing the true quality of developers volunteering to become part of the development team and leaders' concerns about coordination and control in the development process.

One area worthy of further exploration is the impact of project leaders' attitudes regarding open participation in the development team and the criteria used to evaluate requests to join on the subsequent performance of the OSS project. Would a more receptive attitude lead to a larger number of participating developers and a

more sustainable project? Or, would project leaders favoring developers whom they already know be more likely to have a more cohesive and high-performing group? Another direction that warrants further exploration involves the changes of project leaders in their predispositions over time as they administer more projects and acquire more experience in managing open source projects. In this paper, we present findings from an exploratory survey of leaders of OSSD projects that were hosted on one project foundry. We do not suggest that these findings are representative of all OSSD project team administration practices, but rather offer an alternative view of how OSSD project team leaders may influence project outcomes based on a sample of newly formed teams. The study is limited in that it does not provide a full account of project leaders – we base our observations on observable project attributes, and supplement these with a survey of team member request decisions. Our focus in short in this paper was to examine the role that project leaders play in initial project team formation – through both initial project design as well as decisions regarding project team membership. Future research should more fully examine the role of leaders in ongoing management of the OSSD projects.

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