

# IS THE SOURCE STRONG WITH YOU? A FIT PERSPECTIVE TO PREDICT SUSTAINED PARTICIPATION OF FLOSS DEVELOPERS

*Research-in-Progress*

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## Abstract

*Despite the notable success of some Free Libre Open Source (FLOSS) projects, the overwhelming majority of FLOSS initiatives fail, mostly because of insufficient long-term participation of developers. In contrast to previous research which focuses on the individual perspective, we approach developer retention from an organizational perspective to help existing project members identify potential long-term contributors who are worth spending their time on. Methodically, we transfer two concepts from professional recruiting, Person-Job (P-J) and Person-Team (P-T) fit, to the FLOSS domain and evaluate their usage to predict FLOSS developer retention.*

*An empirical analysis reveals that both fit concepts are appropriate to explain FLOSS retention behavior. Looking at contributor retention in Google Summer of Code (GSoC) projects, we find a moderate correlation with P-J fit and a weak correlation with P-T fit.*

**Keywords:** Open source software development, Open Source Software, OSS/FLOSS, IS/IT professionals, Information systems professionals, IS personnel

## Introduction

Starting in the 1950s, the beginning of software programming was characterized by a strong sharing culture. Due to expensive hardware costs, software has usually been written by scientists and engineers who took code sharing with others for granted (von Krogh and von Hippel, 2003). With the rise of the software industry, the 1970s brought a fundamental change to this sharing practice. Software companies relied on licensing and technical restrictions to prevent their customers and competitors from accessing their programs' code (Dixon, 2004; Kavanagh, 2004). As a reaction to these restrictions developers all over the world formed programming communities to develop Free Libre Open Source Software (FLOSS) whose code could be freely studied, modified and exchanged with others (Ghosh, 2005). Today, more than 50% of American and European companies rely on FLOSS for their mission critical tasks (Gold, 2007) and software companies all over the world increasingly see FLOSS as a business opportunity. Similar to Cloud-Computing services, the ability to retain a large community of interested developers is a critical success factor for FLOSS initiatives (Vasan, 2011).

For a FLOSS project, failure to retain its developers has grave consequences. A lack of long-term contributors not only causes schedule overruns (Hosack and Sagers, 2011) and quality deficits (van Lieere, 2009) but also threatens the entire existence of a FLOSS project (Colazo and Fang, 2009). Moreover, team member turnover strongly affects the ways new contributors are welcomed and accommodated. Old project members will increasingly become weary of newcomers the more they experience that developers in whose training they have invested a lot of effort turn their back on them. This often starts a vicious circle in which progressively reserved behavior of old project members drives away younger developers and hinders new developers from becoming active, which in turn increases skepticism towards newcomers even further (Stewart and Gosain, 2006; Xu and Jones, 2010).

From an organizational perspective it is therefore imperative for a FLOSS project to identify lasting ('sustained') contributors at an early stage. In their empirical analysis, Hahn and Zhang (2005) show FLOSS projects are facing similar staffing challenges like organizations do. But while organizational research provides several approaches to assess factors indicating the retention of newcomers to their jobs early on (Weitzel et al., 2009), to our knowledge there is no similar conceptual approach for FLOSS projects. As a consequence, we evaluate two concepts from professional recruitment, Person-Job (P-J) and Person-Team (P-T) fit, to predict developer retention in FLOSS projects from an organizational perspective. P-J fit describes newcomers' suitability for a given job (Edwards, 1991) while P-T fit defines the compatibility between an individual and the existing team (Werbel and Johnson, 2001). Both P-J and P-T fit have been found reliable concepts to assess future job performance and job satisfaction (Werbel and Johnson, 2001; Tak, 2011), which at the same time are the key factors for sustained FLOSS participation. Hence, we investigate the research question: Are P-J and P-T fit appropriate concepts for a FLOSS project to predict the retention behavior of new developers?

Our work has important theoretical contributions for FLOSS research and the recruitment literature. We intend to extend FLOSS research by transferring concepts from professional recruitment. Moreover, our research complements existing recruitment literature by evaluating the applicability of P-J and P-T fit within a context where workers work voluntary. Considering that knowledge workers should be treated as volunteers (Drucker, 2002) our evaluation thereby contributes to research on staffing in general. In particular, our work complements existing literature in Computer Personnel Research (CPR) which focuses on the motivation and retention of IT-workers (Joseph et al., 2007; Beecham et al., 2008; Hall et al., 2008; Allen et al., 2009; Mourmant et al., 2009). Beside these theoretical contributions our research is relevant for most FLOSS initiatives, 80 percent of which fail due to insufficient long-term contributors (Colazo and Fang, 2009). Based on our insights, project members will be able to identify new developers who are likely to become long-term contributors so that they can concentrate their training efforts rather on them than on developers with only a short-term interest.

The remainder of this paper is organized as follows: Next, we will review existing research on sustained participation of FLOSS developers and introduce the organizational concepts our research is based on. Then, the research model and the corresponding research hypotheses are developed. After presenting preliminary results of a first study in which we evaluate the research hypotheses based on the retention

behavior of former Google Summer of Code (GSoC) students to the KDE project, implications, limitations and next research steps are discussed.

## Research Background

### *FLOSS research*

Previous research has shown that it is vital for the management of FLOSS projects to identify and retain long-term contributors. According to Hahn and Zhang (2005) a FLOSS project's chances to succeed depend significantly on its ability to acquire the right developers early on. This is supported by Long (2006) who shows the crucial role of long-term contributors to a FLOSS project. Yet, there is neither consistent theoretical knowledge nor practitioner advice on how to identify team members for FLOSS projects that are likely to stay. Instead, existing research has examined the retention behavior of FLOSS developers primarily from an individual perspective (von Hippel and von Krogh, 2003; Ghosh, 2005; Midha and Palvia, 2007) and used three main approaches to explain developers' project permanence: intrinsic motivation, socialization and project specific properties.

Studying FLOSS developers' motivation, Ghosh (2005) finds that, as one might expect, most long-term contributors are intrinsically motivated to contribute. They stay active because they enjoy contributing to the FLOSS project. Short-term contributors, in contrast, are predominantly stimulated by extrinsic motives such as an immediate personal need. In their longitudinal study, Fang and Neufeld (2009) show that long-term contributors also start contributing extrinsically motivated, yet through social interactions with the project's community and successful code contributions this motivation becomes intrinsic. These findings are supported by Bagozzi and Dholakia (2006). Another approach used to explain developers' retention is proposed by von Hippel and von Krogh (2003). They argue that the momentum for developers' sustained commitment originates from their social interactions with the project members. Socializing with the project's community, team members continue contributing to demonstrate their programming knowledge to others. Fang and Neufeld (2009) support this socialization theory and show that especially newcomers' retention behavior depends strongly on situated learning and identity construction. For this socialization process to happen, previous research emphasizes a developer's like-mindedness and past interactions with the project members. Besides these motivational and social drivers for continued commitment, FLOSS research has revealed that FLOSS developers are stimulated by project specific properties. Midha and Palvia (2007) show that the complexity and modularity of a project's codebase have a strong influence on developer retention and FLOSS developers will leave as soon as they feel that the quality of the project's codebase lowers their productivity. Another influencing characteristic of a FLOSS project is the restrictiveness of the chosen software license (Colazo and Fang, 2009).

Although these three perspectives emphasize a novice's familiarity with the project's codebase and social interactions, there is to our knowledge no embracing framework for FLOSS projects to assess newcomers concerning these characteristics. In their early work Pratyush et al. (2010) suggest the usage of fit concepts to explain developer turnover in FLOSS projects. However, the authors focus solely on the perceived fit of the newcomers, making it inapplicable for their assessment from the project's perspective. In contrast, our research aims at using measures for predicting novices' retention behavior from an organizational perspective. Following Crowston et al. (2007) who suggest that FLOSS projects are compatible with organizational practices to identify and retain talent, we use two concepts from the organizational staff recruitment literature to predict newcomers' project permanence.

### *Theoretical Concepts*

Employee retention is a critical issue for organizations. As shown by Allen et al. (2010) the direct costs associated with the compensation of an employee leaving the organization can range in total from 90% to 200% of the annual salary. Considering that there are also indirect costs of staff loss for organizations, such as knowledge losses, employee retention is of vital interest to employers. To avoid hiring employees who are likely to leave soon, Allen et al. (2010) recommend the usage of fit constructs during recruitment. In particular, the two sub-constructs Person-Job (P-J) and Person-Team (P-T) fit have been found valuable predictors for employee retention (Werbel and Johnson, 2001; Tak, 2011). P-J and P-T fit belong

to the overarching concept of Person-Environment (P-E) fit. This originates from the interactionist theory of behavior which assumes that behavior is a function of the person and the surrounding environment (Schneider et al., 1997). P-E fit defines the degree of congruence between the characteristics of the individual and the characteristics of the environment she has to act in.

### **Person-Job (P-J) fit**

The concept of Person-Job fit is traditionally used in the recruitment process for selecting applicants for jobs. A common definition for P-J fit by Edwards (1991) uses a twofold description. The first aspect is the match between an individual's desires and the job supplies. A person's desires consist of preferences and goals (Pryor, 1987; Lee et al., 1989). Complementary to these desires, the supplies of a job refer to attributes of the working environment such as pay and participation in decision making (Alutto and Belasco, 1972). The second aspect for P-J fit is the congruence between the required demands for a job and a person's abilities. The job demands are commonly derived using a detailed analysis of the required tasks an employee has to fulfill (Sekiguchi, 2004). Based on this analysis, the demands for a job are specified by the necessary skills and knowledge. Correspondingly, a person's abilities are described by the level of education, previous job knowledge and relevant working experience (Drexler, 1981; French et al., 1984). Organizational research repeatedly found positive effects from both aspects of P-J fit. The demands-ability match guarantees employers that a recruit possesses the required abilities, while simultaneously increasing individual's job productivity and satisfaction. Driven by these effects, persons with a high demands-ability match also show, from the beginning, a stronger intention to retain (Kristof-Brown et al., 2005). A better match between an individual's needs and a job's supplies makes an employee happier and more satisfied with one's work which increases the intention to stay at that employer in the long term.

### **Person-Team (P-T) fit**

For effective teamwork, smooth collaboration and effective communication between team members is vital. According to organizational research it is often the compatibility between members that determines the success or failure of a project (Hollenbeck et al., 2004), emphasizing the consideration of P-T fit for team staffing decisions. P-T fit describes the compatibility among team members. Defining P-T fit, researchers differentiate between supplementary and complementary fit (Werbel and Johnson, 2001). Supplementary fit occurs when an individual shares attributes, skills and abilities with others in the team ('is similar') (Muchinsky and Monahan, 1987). Complementary fit, in contrast, requires an individual to possess skills or characteristics that differentiate him or her from the existing team ('has what we lack') (Watson et al., 1993). Both forms of P-T fit have advantages and disadvantages when considered alone. A high complementary fit leads to tighter group cohesion and increases members' willingness to remain in the team but could reduce the groups' overall creativity and innovativeness. Similarly, a high supplementary fit increases team's creativity but might lead to dysfunctional teams due to a lack of shared beliefs or values among team members. As a consequence, Werbel and Johnson (2001) recommend considering both sub-forms for assessing newcomers' P-T fit as only. The assessment of both, supplementary and complementary fit, leads to teams in which members can compensate the deficiencies of one another and also interact effectively.

## **Research Hypotheses**

Because of their generic applicability, P-J and P-T fit have been successfully used for team-staffing decisions in various organizational contexts (Malinowski et al., 2008). Applying the fit concepts to the FLOSS context hence might be an opportunity to better understand and foster developer retention. Despite the differences in terms of regulatory and remuneration, newcomers' intrinsic motivation and the socialization with project members have been found key drivers for sustained participation in both the organizational and the FLOSS domain. Based on this similarity, we transfer in the following P-J and P-T fit to the FLOSS domain to identify long-term contributors from an organizational perspective.

To be applicable to the special relationship between FLOSS projects and their contributors the definition of P-J fit needs to be adjusted. In contrast to organizational contexts, FLOSS developers are usually not

attracted to projects because of their monetary rewards but because of specific work aspects. Hence FLOSS developers' needs are much more focused towards specific implementation and contribution conditions (Ke and Zhang, 2010). Consequently, the supplies of a project are much more characterized by its provided working environment, like the quality and documentation of the existing codebase. Beside the needs-supply match of P-J fit, the demands-abilities match has to be adjusted. Although most FLOSS projects do not have a detailed demands description for novices, a general familiarity with the used development practices and the existing codebase have been found advantageous. The relevant abilities of newcomers are therefore described by previous experiences with the FLOSS project and their level of existing expertise.

Consistent with organizational literature we assume that P-J fit has positive effects for the newcomer and the FLOSS project. Previous FLOSS research has shown that new entrants, in particular, are stimulated to stay with the project by the need to demonstrate their expertise to other developers (von Hippel and von Krogh, 2003; Fang and Neufeld, 2009) and by the wish to extend their knowledge. We therefore expect that a high needs-supply fit motivates newcomers not only to commit themselves intensively to coding but also to continue working in the FLOSS project after their initial contributions. Further, a needs-supply match ensures that a developer complies with the surrounding characteristics of a FLOSS project, which is another relevant preliminary for project retention (Midha and Palvia, 2007; Colazo and Fang, 2009). Beside the importance of a needs-supply match, existing literature supports the importance of the demands-ability match in the FLOSS context. Developers with relevant project experience are sooner recognized and valued within the project's community which in turn stimulates them to continue contributing. Existing project experience also helps developers in successfully accomplishing their coding activities which in turn drives their retention intention. Similar to the organizational domain, we therefore expect that FLOSS developers' level of P-J fit influences their retention behavior and hypothesize that:

**Hypothesis 1:** *The assessed level of P-J fit between a developer and a FLOSS project is positively associated with his or her retention.*

Besides their fit with the FLOSS project we also consider newcomers' compatibility with existing team members a relevant predictor for sustained participation. Drawing on Werbel and Johnson (2001), we define P-T fit as a combination of supplementary and complementary fit. For supplementary fit, we consider the similarity of values, interests and skills between project novices and the existing developers. Consistent with organizational literature we assume that a high level of supplementary fit will result in tighter group cohesion which in turn accelerates newcomers' socialization and team-identification. As demonstrated by Fang and Neufeld (2009) and von Hippel and von Krogh (2003) these two effects strongly influence FLOSS developers to stay with the project. Consequently, we assume FLOSS developers' supplementary fit to affect their continued commitment for the project. In contrast, complementary fit requires newcomers to have personal or technical skills the project team lacks. Following organizational literature, team members with a high complementary fit are much more likely to propose solutions which others have not thought of. As a result, newcomers will get the attention and recognition by other team members which in turn motivates them to continue contributing (Fang and Neufeld, 2009). Based on the assumed positive effects of both supplementary and complementary fit we hypothesize that P-T fit will positively influence FLOSS developers' retention behavior.

**Hypothesis 2:** *The assessed level of P-T fit between a developer and the team members of a FLOSS project is positively associated with his or her retention.*

## Research Methodology

To test our hypotheses, we analyze the retention behavior of 80 former Google Summer of Code (GSoC) students to their KDE subprojects. GSoC is an annual program in which Google offers students a 3-month developer stipend to contribute to open source projects during their summer break. When applying, students have to choose one of the participating organizations and their coding project. Next, all organizations have to evaluate the corresponding applications and decide which candidates to accept. One of the top organizations students choose for their GSoC contributions is KDE, the default desktop environment on many Linux distributions. It has been shown that many developers contribute to KDE's more than 150 subprojects for rather short periods (Studer et al., 2007). One of KDE's main interests

when evaluating GSoC candidates is therefore to predict their future commitment. Next, we describe the measures used to assess GSoC students' P-J and P-T fit and present preliminary results.

## Measurement

Assessing **P-J fit** we concentrate on students' demands-ability match. Given that students freely choose their organizations and customize their project proposals to their individual needs, we assume needs-supply fit to be high. Following recruitment practices we consider the amount of practical development experience students have already acquired to be a suitable measure for their relevant abilities. Having already contributed to the corresponding subproject, students are already familiar with the structure and quality of the existing codebase and the use of the necessary development tools. Hence students with existing project experience satisfy the general two demands of their FLOSS project. Following van Liere (2009) and Hu and Zhao (2008) we use the number of students' code commits to their subprojects prior to GSoC for evaluating their level of practical development experience. To identify all of a student's prior code contributions we use the special mailing list *kde.cvs.commit* in which all commits of all KDE subprojects get propagated. Querying the online service *markmail.org* which indexes all posts of this mailing list, we were able to extract all of students' code commits to their KDE subprojects before GSoC.

To evaluate students' **P-T fit** we rely on a recruitment practice that was originally described by Klimoski and Jones (1995). Newcomers are asked to work for a short period together with the existing developer team. Next, the level of P-T fit is derived based on project members' feedback regarding the novices' supplementary and complementary fit characteristics. Similar to this practice, for the evaluation of GSoC candidates KDE requires that all corresponding subprojects rank the applicants based on their compatibility with the team and the need for their proposed contributions in descending order. Because team members' rankings consider applicants supplementary and complementary fit characteristics we use it in the following for assessing the students' P-T fit.

Like regular FLOSS developers, GSoC students have no formal obligation to continue contributing to their KDE subprojects after the event. Therefore, we measure students' **retention behavior** based on the period they continued in their subprojects' development after GSoC. Consistent with previous FLOSS research by Colazo and Fang (2009) we calculate this time by the difference in days between the end of GSoC and the date of their latest code contribution to the corresponding KDE subproject. In their analysis of developers' retention behavior, Ortega and Izquierdo-Cortazar (2009) show that most developers stay up to 1000 days active in their projects. To calculate the retention period we queried on August 26<sup>th</sup> 2011 the online service *markmail.org* to find the timestamps of students' latest code commits for their corresponding subprojects using the mailing list *kde.cvs.commit*. Because this mailing list aggregates all commits of all KDE subprojects, we were able to identify the time of students' latest code contribution to their subprojects and compute the resulting time difference in days to the end of their GSoC.

## Preliminary Results

With exception of 8 students whose username could not be determined in retrospect, we analyzed the retention behavior of all students who contributed to KDE in the last two GSoC events. Our dataset consists in total of 80 students; 34 participated in GSoC 09 and 46 participated in GSoC 10. As a first step of our statistical analysis we calculated Pearson's parametric correlation coefficient and found a weak (0.230) and significant ( $p < 0.05$ ) linear correlation between the number of previous code commits and the number of days students stay at their KDE subproject after GSoC. Because Pearson's correlation coefficient measures only the linear relationship between metrically scaled variables we cannot apply it to test other forms of correlation. Therefore, we calculated Kendall's rank coefficient, which is a non-parametric test, and found a much stronger (0.353) and significant ( $p < 0.01$ ) correlation between prior commits and students' project permanence. The visual representation of this correlation in Figure 1 suggests that it is logarithmical. The data hence support H1. Kendall's correlation coefficient requires the analyzed variables only to be ordinal. Applying it to test the correlation between candidates' ranking and their continued commitment reveals a significant ( $p < 0.05$ ) weak negative correlation (-0.163). This negative correlation implies that students who are rated with a higher rank (expressed by a lower numerical number) tend to stay longer in the project, supporting H2. As visualized in Figure 1, there is a strong representation of top rankings, 84% of all assigned priorities where top 3 rankings.

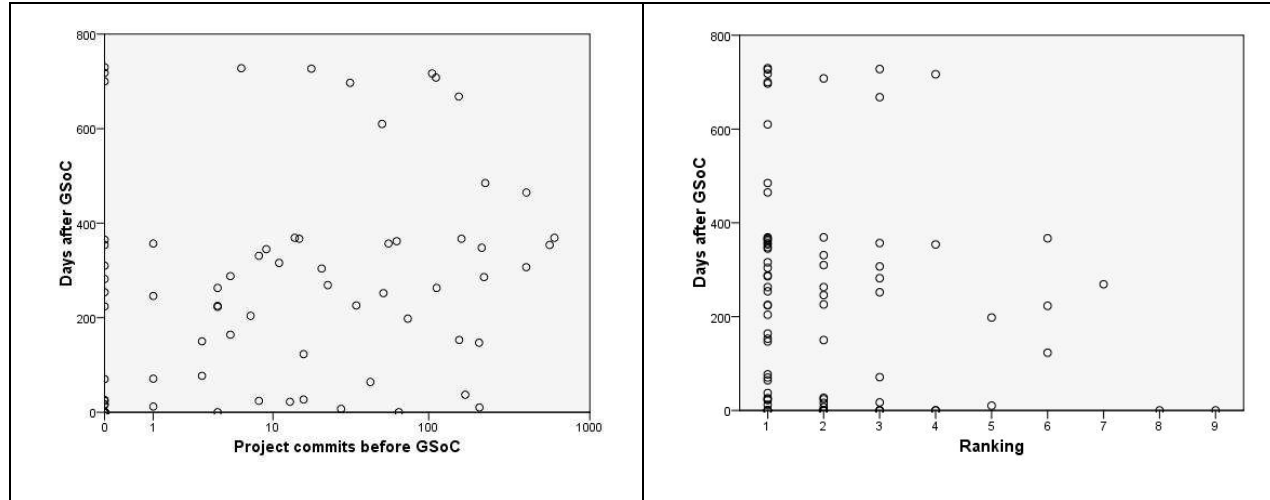


Figure 1: Visualization of the correlation between prior commits and team ranking on developer retention

## Discussion and Future Research

### Discussion

Although our research is at an early stage, the preliminary results presented above offer some interesting implications. We could demonstrate how successful recruitment concepts from traditional firms can be transferred to the FLOSS domain and be used to select novice contributors and predict their future long-term participation. The correlation between prior contributions and ongoing commitment supports and extends existing FLOSS research. The assumed logarithmic relationship suggests that developers only need to have a given level of experience on the development practices of the FLOSS project to successfully contribute, which in turn stimulates them to continue in the project. This is consistent with the findings of Fang and Neufeld (2009), who showed that project novices' ongoing participation is driven by their "situated learning". At the same time, however, this logarithmic relationship indicates that development experience above a given level only results in marginal increases of developers' continued project permanence. Combined with the theory of "situated learning" our results could indicate that experienced FLOSS developers are likely to leave their project as soon as they experience that their contributions no longer satisfy their learning needs. To our surprise we found only a weak correlation between the team ranking and GSoC students' continued project commitment. Based on the previous research of Bagozzi and Dholakia (2006) and von Hippel and von Krogh (2003) we expected to observe a much stronger correlation between these two constructs. A possible explanation could be the used measurement. Previous research on organizational recruitment practices showed that the subjective assessment of candidates' P-T fit is often inaccurate (Cable and Judge, 1997). It is possible that only few project members took a closer look at the candidates' supplementary fit. The remaining team members might then rely on this initial judgment and focus their prioritization on students' complementary fit because they like to see some proposed projects implemented sooner than others. Another explanation for this moderate correlation could be the frequent classification of candidates' proposals as top priority and the under representation of low rankings.

### Limitations

This study is subject to several limitations. First, we only analyzed the retention behavior of former GSoC students at KDE, thus our findings might not apply to other FLOSS projects and newcomers to these. Further, GSoC students also receive direct monetary rewards for their contributions so that extrinsics might play a higher role than in most other settings. Another limitation is the underrepresentation of low rankings in the sample, which is caused by KDE's consideration of the teams' ranking for the assignment

of GSoC slots. Finally, we like to stress that only 732 days passed since the end of GSoC 2009 and 371 days since the end of GSoC 2010 to the date of our data extraction. This period marks the upper bound of retention we could possibly measure for the corresponding GSoC students.

### Future Research

Based on our first findings we will carry on our evaluation for the usage of P-J and P-T fit to predict the retention behavior of newcomers to FLOSS projects. Next we analyze the correlations found in our dataset further by performing regression analysis and by combining both fit models to predict long-term participation. In addition, we will address several limitations of our current analysis by refining our measurement of P-J and P-T fit. For the assessment of P-J fit we are planning to consider the code quantity newcomers' contributed before participating in GSoC as well. As outlined above, this measure could allow us to specify the minimal level of project experience necessary for students to contribute successfully and continue in the project. Further, this extended contribution analysis could also identify the threshold level for project members to no longer regard their contributions as opportunities to learn. These two levels of contribution expertise are eminent for FLOSS projects, giving them the opportunity to build early-warning systems for experienced developers who might leave the project in the near future and early-identification systems for newcomers who are likely to become future long-term contributors. To refine our assessment of P-T fit, we will complement our dataset with conversational data from KDE's mailing lists. With this information we will be able to validate if students only talked to few or all team members and in addition how much they communicated before they began GSoC. Besides refining our measurement we will compare the retention behavior of the analyzed students with average newcomers to FLOSS projects and the behavior of other GSoC students to evaluate the generalizability of our findings.

In our future research we will continue our approach to use P-J and P-T fit for identifying long-term contributors from an organizational perspective as illustrated in Figure 2. P-J and P-T fit are important concepts for both FLOSS developers and FLOSS projects. However, perceived and actual fits depend on different attributes of the project as well as of the developer. As a consequence our future research aims at identifying these attributes and developing a measurement model to control for FLOSS developers' perceived and actual fit in order to predict their retention. To do so we will accompany this year's GSoC students at KDE together with their mentors and conduct interviews with them before, during and after their participation in GSoC. This gives us the possibility to evaluate perceived P-J and P-T fit from an individual perspective and identify if other concepts from organizational research can be applied to explain long-term participation. At the same time, this gives us the opportunity to develop alternative approaches how P-J and P-T fit can be objectively assessed from an organizational perspective and feed back some insights from FLOSS to organizational research.

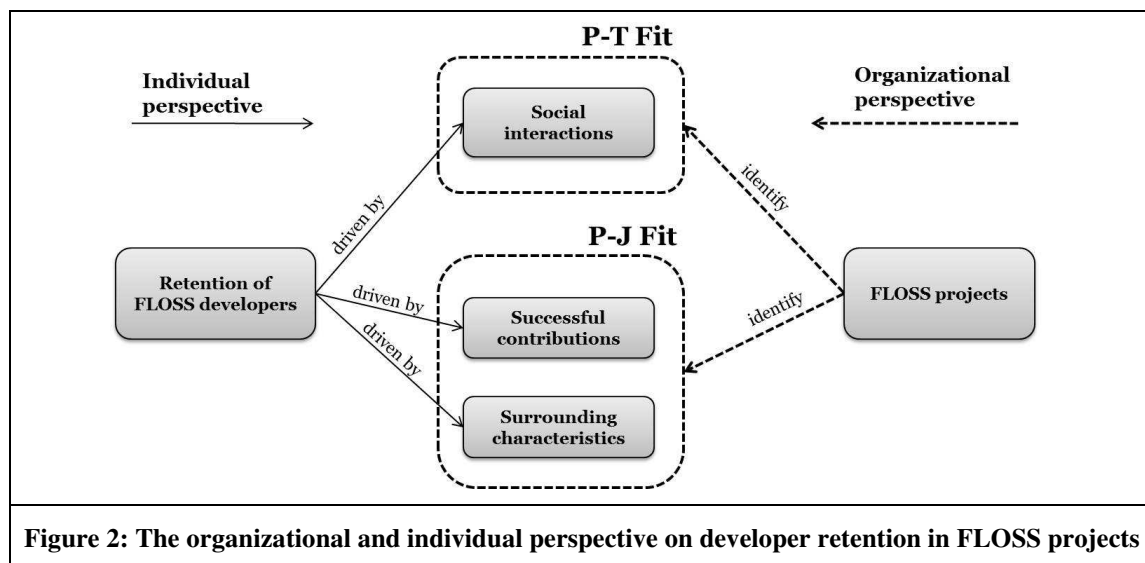


Figure 2: The organizational and individual perspective on developer retention in FLOSS projects



The evaluation of P-J and P-T fit and especially the identification of suitable measures indicating a newcomer's long-term commitment are of special relevance for FLOSS projects. By identifying developers who are likely to stay, members of FLOSS projects are able to concentrate their training efforts on promising novices instead of those with only a short-term interest in the project. Our research provides a first step towards an understanding of FLOSS developers' retention from an organizational perspective. The hypotheses indicate that both P-J and P-T fit are well established concepts that can also be used by FLOSS projects. However, our research marks only a first step towards an extended conceptualization of objective and perceptual measures that can be used for identifying P-J and P-T fit within FLOSS projects. As described above we intend to continue our research based on these preliminary results to help FLOSS projects with their challenges in identifying and retaining the most appropriate developers.

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