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A Longitudinal Study on Member Contributions in Open Source User Oriented Community

Yuan Long
Colorado State University - Pueblo, yoanna.long@colostate-pueblo.edu

Leigh Jin
San Francisco State University, jinlei@sfsu.edu

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Yuan Long
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Yoanna.long@colostate-pueblo.edu

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jinlei@sfsu.edu

ABSTRACT

A longitudinal study was conducted in this research to examine member contributions in an Open Source Software User-Oriented Community (OSSUOC). Data were collected from both mailing-list archives and meeting minutes of a local Linux user group over a six-year period. Social Network Analysis and Web archive analysis were used to identify core contributors of activities in different categories. Member contributions were then measured based on the intensity, the breadth, and the continuance of participation across activities and years. The results suggest the importance of a balance between online and offline activities in an OSSUOC. Additionally, offline outreach activities play a more crucial role in stimulating the overall participation of an OSSUOC. The research contributes to the understanding of individual contributions and overall performance in an OSSUOC.

KEYWORDS

Open Source Software, Open Source Software User-Oriented Community (OSSUOC), Longitudinal Study, Social Network Analysis

INTRODUCTION

Open Source Software (OSS) refers to "software whose source code is openly published, is often developed by voluntary efforts and is usually available at no charge" (UK Cabinet Office, 2002). While proprietary software is usually sold in compiled binary format and with various restrictions on ownership and use (Feller et al. 2000), OSS grants its users the freedom to access, modify and distribute the source code, provided that they would not redistribute the derived work under a more restrictive license (Open Source Initiative, 2009).

The past decade has witnessed an extraordinary proliferation on OSS development activities, which in turn have inspired various innovative business models that are built upon OSS solutions. As suggested by Kim Polese (2005), the OSS movement is leading this age of Software Renaissance, providing entrepreneurs and ordinary users unprecedented access to software products, thus leading to new opportunities for creation and growth.

Although OSS has attracted substantial interest from the researchers in the area of Information Systems, the majority of the studies have focused on OSS *development* rather than *use* (Fitzgerald and Kenny, 2003). Various researches have targeted the developer communities of OSS projects such as Linux, Apache, Mozilla, and GNOME studied their development processes and the incentives for developers. Only few researches have focused on the *use* of OSS, for instance, the motivation of participants of OSS user group (Bagozzi and Dholakia, 2006). However, as OSS enters the mainstream, more and more non-technical users who have no interest or capability to program the source code are increasingly involved in the OSS movement. It is argued that more research attention should be drawn to OSS *use* (Jin et al, 2005; Waring and Maddocks, 2005). To address this research issue, our study aims to examine community activities and member contributions in a user-oriented OSS community.

OSS Development-Oriented Community

An OSS Development-Oriented Community (OSSDOC) is defined as an OSS community that is mainly dedicated to develop, support, and maintain a single or multiple open source project(s). Communities surrounding Linux, Apache, and Mozilla are examples of such communities. The participants in a development-oriented community can be generally categorized into four different groups: project owners/core developers, patch submitters, bug reporters, and end users. Project owner/core developers are a small group who contribute most of the source code and ultimately control the software releases. In a case of the Apache project, for example, the core developers accounted for over 80% of the coding (Mockus et al, 2000). Patch submitters involve a slightly larger group who improve the source code by submitting small feature patches or bug-fixing patches. Bug reporters are comprised of an even larger group who download and compile the source code, test new features, and report bugs. End users, on the other hand, are non-technical members who are mostly interested in using pre-compiled binary software, not the source code per se.

Notice that the composition of an OSSDOC could vary significantly depending on which stage the project is in. While the end user involvement could be very limited during the early development stage, it's the community size will increase, and more non-technical members will join as end users as the project becomes more functional and mature. Indeed, the number of users (in addition to the developers) has been identified as one important indicator of OSS project success (Crowston et al 2003). However, because the end users tend to be less technical and may not actively participate in feature discussion forums and bug report databases, they become "silent majority" whose usability needs may not be appropriately addressed. It is suggested that in order to sustain a dynamic community, it is important for OSS leaders to stimulate interest and create a sense of participation and belonging among technically inexperienced users within the community (Jin and Robertson, 2008).

OSS User-Oriented Community

Though the OSSDOC is probably the most well known and well studied OSS community, it is worth noting that many OSS local user groups also play important roles in OSS movement. We classify those user communities that are committed to promoting OSS advocacy, adoption, education, and outreach as OSS User-Oriented Community (OSSUOC) (Moen, 2007). Apparently, the majority of the participants of these communities are end users.

Linux User Groups (LUGs) are excellent examples of OSSUOCs. There are currently around 800 registered LUGs in 105 countries, including 250 or so in the United States (www.linux.org). Besides online media such as websites and discussion forums, LUGs also organize regular face-to-face meetings and invite guest speakers to present topics related to OSS use. In addition, Installfests and demos are held to help new users configure Linux systems and diagnose problems. According to Moen (2007), LUGs are vital to the Linux movement, taking on many of the same roles that a regional office does for a large organization.

RESEARCH QUESTIONS

Since little research has been done about the OSSUOC such as local LUGs, we anchor our study in this context to address the OSS user perspective. In particular, we intend to investigate the following research questions:

- How could member contributions in an OSSUOC be classified?
- Given the hybrid nature of the community, what are the different ways to measure member contributions?
- What is the optimal structure of an OSSUOC that potentially cultivates member participation as well as sustainability of the community?

RESEARCH FRAMEWORK

In August 2002, one of the authors began regularly attending monthly face-to-face meetings in five LUGs around Silicon Valley and the San Francisco Bay Area. As a participant observer, the author actively engaged in OSS related activities both online and offline, including subscribing to the mailing lists of different LUGs, attending monthly meetings, recording presentations, interviewing LUG members and presenters, and attending social gatherings at local restaurants. Based on the tremendous field experience, we propose the following research framework (Figure 1) to classify member contributions in an OSSUOC.

Figure 1. Research Framework

As illustrated in Figure 1, member contribution could be classified based on whether the media of contribution is made online or offline, and whether the nature of contribution is technical oriented or outreach oriented. In terms of the media of contribution, the offline contributions include attending and organizing events that involve face-to-face interactions, while the online contributions consist of participation in computer-mediated activities, such as responding to questions on mailing lists or updating information on community websites. In terms of the nature of contribution, the technical-oriented contributions, on one hand, tend to be task specific and problem solving in nature, for example, Installfest volunteers offer one-on-one help to address the specific problem that belongs to a particular user's computer. The outreach-oriented contributions, on the other hand, cultivate OSS advocacy and education that target the general public, for example, setting up computer demos at a local farmers' market to raise public awareness on OSS use.

RESEARCH METHODS

Site Selection

The site selection is crucial in pursuit of our research goal. After comparing several LUGs, we decided to choose Linux Users' Group of Davis (LUGOD) as our research site. Located about 70 miles north east of San Francisco and within the proximity of UC Davis campus and the city of Sacramento, LUGOD is one of the well-organized LUGs in the bay area. Because of the efforts made by its dedicated volunteers and officers, LUGOD currently consists of 450 members, and holds monthly face-to-face meetings that feature various OSS related presentations.

Besides the well-organized physical events, LUGOD also boasts well-archived mailing lists, its own IRC (Internet Relay Chat) channel, and most importantly, an informative website – www.lugod.org. The website records and publishes the details of the community activities and member contributions. Since our data collection primarily draws upon online resources, apparently, the rich content provided by its website is the number one factor that drives our decision to select LUGOD as our research site. In particular, the website publishes the list of members who attended each of their face to face meetings. This meeting attendance data is very valuable in reflecting offline activities of members, at the same time, is unique to LUGOD since hardly any other LUG website publish details as such. Longitudinal Study

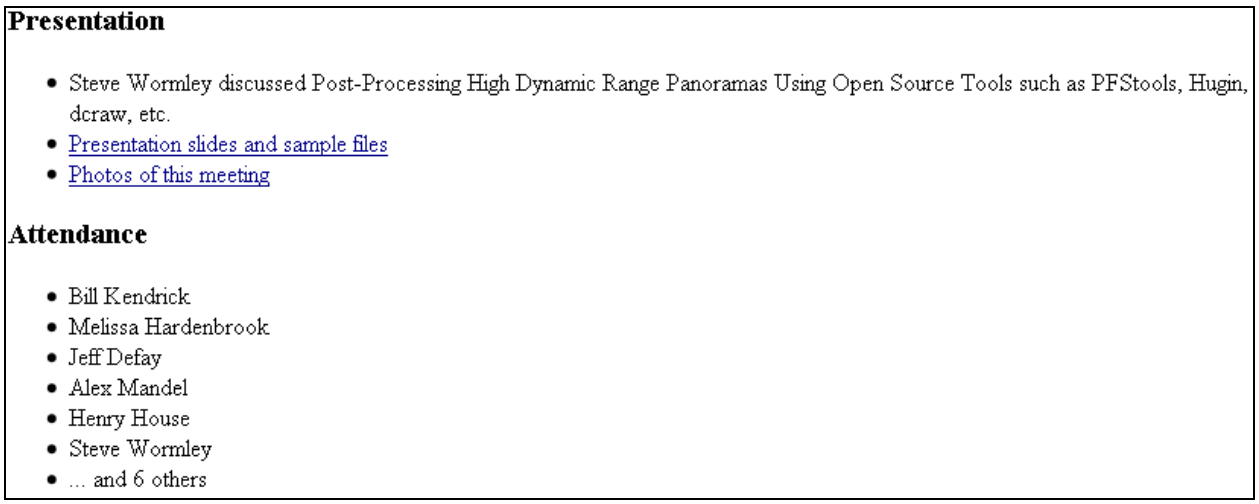
To effectively address our research questions about user-oriented OSS community, we would like to investigate member contributions to both online and offline activities over a period of time. To accomplish this, we collected data from multiple sources on LUGOD.org, including meeting minutes as well as mailing lists of technical Q&A, events planning and outreach, and intallfest. Moreover, we are not only interested in community activities in a snapshot fashion but rather observing how the community structure evolves over time. Therefore we conducted a longitudinal study and collected data across a six-year period from 2003 to 2008.

Data Collection and Data Analysis

Offline Activities: Web archive analysis

Two primary offline activities conducted by LUGOD include regular meetings and Installfests. Web archives were analyzed to identify the core contributors of each category over a six-year period.

LUGOD holds face-to-face meetings on a regular basis and keeps a detailed record of each meeting. Meeting minutes were published on the LUGOD website including presentation slides, meeting attendees, and even pictures taken during each meeting. Figure 2 captures a part of the meeting minute published on the LUGOD website.



Presentation

- Steve Wormley discussed Post-Processing High Dynamic Range Panoramas Using Open Source Tools such as PFStools, Hugin, dcraw, etc.
- Presentation slides and sample files
- Photos of this meeting

Attendance

- Bill Kendrick
- Melissa Hardenbrook
- Jeff Defay
- Alex Mandel
- Henry House
- Steve Wormley
- ... and 6 others

Figure 2. Example of LUGOD Meeting Record

In this research, we collected LUGOD meeting attendance information over the six-year period between January 2003 and December 2008. For each year, we ranked members based on the number of times they attended meetings. We counted those members who attended over 33% of the meetings as the core contributors who made contributions in the offline outreach category. Table 1summarizes the number of core members identified for each year.

	2003	2004	2005	2006	2007	2008
Held Meetings	26	25	17	12	12	12
Meetings with Attendance Recorded	20	19	12	8	8	12
Number of Core Members Attending over 33% of the Meetings	19	19	11	8	7	10

Table 1. Number of Core Participants of Offline Meetings

Besides regular meetings, LUGOD holds free Installfest workshops at least once a month in the neighborhood of UC Davis to help users solve technical problems regarding Linux installation and configuration. The organizers and volunteers use the Installfest mailing list to plan for the events. The majority people posted in this mailing list are those who physically participated in the Installfest workshops. Therefore we used this mailing list as the data source to identify the core participants of Installfests.

We first counted the total number of posts for each individual member in the Installfest mailing list; we then manually checked the relevance of the messages to delete the members who posted few messages and irrelevant information from the core-contributor list. Finally we generated Installfest core-member lists for each year from 2003 to 2008.

Online Activities: Social Network Analysis

In addition to attending face-to-face meetings and Installfest workshops, LUGOD members use online mailing lists to seek help for technical problems and plan for outreach events. Data were collected from two mailing lists: Technical Q&A as well as Event Planning and Outreach to investigate member contributions in online technical activities and online outreach activities, respectively.

LUGOD members use the mailing list of Technical Q&A (Tech. Q&A afterwards) to help each other solve technical problems such as Linux installation, device configuration, and hardware trouble shooting. Additionally, LUGOD members use the mailing list of Event Planning and Outreach (Event Planning afterwards) to prepare and plan for community outreach projects such as conferences, festivals, demos and classes. Maintaining a high traffic of these two mailing lists contributes to the primary goals of LUGs: support and educate users, advocate Linux as a computing solution, and socialize with Linux users (Moen, 2007). Obviously, the more messages the individuals send and reply in these two mailing lists, the more likely they become core contributors to online technical activities and online outreach activities.

Both Tech. Q&A and Event Planning have high traffic and a large number of subscribers. Those subscribers form a virtual social network through which they interact and collaborate with each other. We therefore used Social Network Analysis to identify core participants of these two mailing lists.

Social Network Analysis

Social Network Analysis (SNA) is characterized as a distinctive methodology encompassing techniques for data collection, statistical analysis, and visual representation (Katz, 2004). Through a structural analysis of a social network diagram (i.e., a map depicting actors as well as ties that connect them together), SNA reveals the patterns of relationships and the relative position of individuals in a specific social setting. This approach has been effectively used in social support, diffusion of information, and collaboration in online communities (Long and Siau, 2008; Freeman, 2004).

To identify the core participants of online Tech. Q&A and Event Planning, we followed a three-step procedure to collect and analyze data (Table 2).

Steps	Summary	Software	Input	Output
Step 1. Download mailing-list archives	Download mailing-list archives from both Tech. Q&A and Event Planning	Web spider program[1]	Mailing-list archives published on LUGOD website from 2003-2008	Mailing-list Web pages
Step 2. Generate social network matrix	Generate a matrix revealing the interaction among users (An example showed in Figure 3)	Web parsing program[1]	Mailing-list Web pages	A matrix for each year from 2003-2008 for both Tech Q &A and Event Planning
Step 3. Identify core	Calculate the core of each year for two mailing lists	Ucinet[2]	Social network matrixes	A list of core members of each year from 2003-2008 for two mailing lists

[1] Programs were developed by one of the author using Java.
[2] Software was developed by Borgatti, Everett, and Freeman (2002)

Table 2. Data Analysis Using Social Network Analysis

Step 1 Download Mailing Lists

A Web spider program was developed (using Java) by one of the author to download all the archived mailing lists for both Tech. Q&A and Event Planning from 2003 to 2008. The downloaded Web pages were then served as the data source for the following analyses.

Step 2 Generate Social Network Matrix

To generate a social network matrix, we first identified the receiver and sender of each email, second counted the number of interactions (i.e. replying emails) between each pair of members in the mailing list, and third aggregated all the interactions happened within one year to generate an interactive matrix on a year base. A Web parsing program was developed by one of the author to generate such matrix. Figure 3 shows part of the social network matrix for Tech Q&A in 2005. In this matrix, the rows and the columns represent each individual user in the mailing list, which were determined by the unique email address. The cells represent the interactions between the pairs of users, which were determined by the number of replies from user A to user B.

		1 2 3 4 5 6 7 8 9 10
		a k a b n s j b b c
		- - - - - - - - - -
1	allo@novozymes.com	0 0 0 0 0 0 0 0 0 0
2	king@tiem.utk.edu	0 0 0 0 0 0 0 0 0 0
3	aaron.king@umich.edu	0 0 0 0 0 1 0 0 0 0
4	bill@cse.ucdavis.edu	1 0 0 1 0 0 0 0 0 1
5	nbs@sonic.net	0 0 1 0 6 3 2 0 0 1
6	scofield@omsoft.com	0 0 1 0 1 3 0 0 0 0
7	jeremic@ucdavis.edu	0 0 0 0 0 0 1 0 0 0
8	bawolk@ucdavis.edu	0 0 0 0 0 0 0 0 0 0
9	btrichter@ucdavis.edu	0 0 0 0 0 1 0 0 1 0
10	cmclaughlin@ucdavis.edu	0 0 0 0 0 0 0 0 0 1

User #4 replied #10 for 1 time

Figure 3. Example of Social Network Matrix

Step3. Identify Cores

UCINET (Borgatti, 2002), a SNA software, was used to identify the core participants in the social network matrix generated from step 2. The software uses an algorithm to fit the input data set to a core/periphery model in order to distinguish core members from periphery members (UCINET reference, 2008). Figure 4 shows the social network diagram for Tech Q& A in 2007. Those nodes in the center of the diagram represent the core contributors who send and reply messages frequently to other users. A list of core members was then identified for each year (from 2003 to 2008) for both Tech. Q& A and Event Planning.

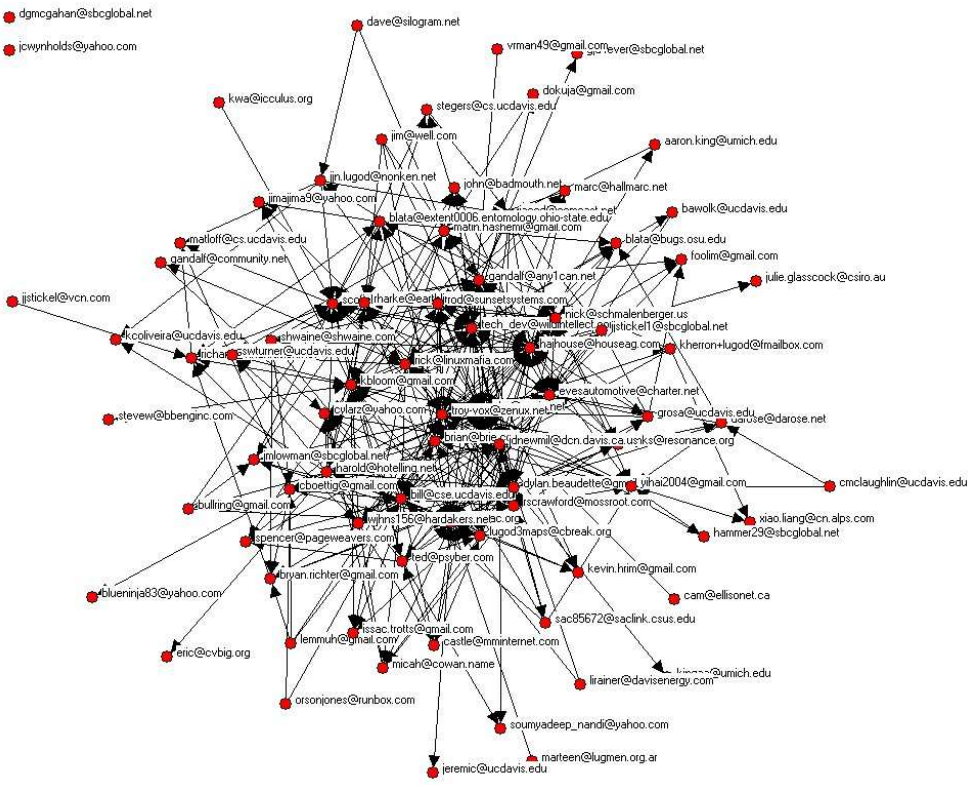


Figure 4. Social Network Graph for Tech Q& A in 2007

Summary of Data Analysis

To gain a comprehensive view of LUGs activities, we collected data from multiple sources including meeting minutes and mailing-list archives on Technical Q&A, Events Planning, and Installfest over a six-year period. Table 3 summarizes the data collection and analysis.

Activities	Online Activities		Offline Activities	
	Technical Q&A	Event Planning and Outreach	Meetings and Presentations	Installfests
Data resource	Tech. Q&A mailing list	Event Planning mailing list	Meeting minutes	Installfest mailing list
Research methods	Social Network Analysis		Web archive analysis	
Explanation	A group of core members were identified in terms of their interaction with other members; the more messages they send and reply to others, the more likely they become core contributors		A group of core members were identified in terms of their attendance of the meetings, presentations, and Installfests. The more meetings and Installfests they attend, the more likely they become core contributors.	

Table 3. Summary of Data Analysis

RESEARCH RESULTS AND DISCUSSION

Measurement of Member Contributions in LUGOD

One of the major purposes of this research is to measure member contributions in an OSS User-Oriented Community (OSSUOC). Based on the data collected from multiple activities across years, we propose three measurements to evaluate member contributions: the intensity, the breadth, and the continuance of participation across different categories and different years.

Intensity of Member Contributions

Table 4 lists the number of core contributors in four categories across six years, which were visually presented in Figure 5

	2003		2004		2005		2006		2007		2008		Average	
	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%
Online_Tech[1]	22	55%	16	42%	27	77%	18	60%	13	57%	8	38%	17	55%
Online_EventPlanning	8	20%	9	24%	4	11%	9	30%	6	26%	6	29%	7	23%
Offline_Installfest	8	20%	13	34%	9	26%	10	33%	8	35%	6	29%	9	29%
Offline_Meeting	23	58%	19	50%	11	31%	8	27%	7	30%	10	48%	13	41%
Total[2]	40		38		35		30		23		21		31	

1. The number of core members for online Tech. Q&A, online Event Planning, offline Meeting, and offline Installfest. For instance, there are 22 members serving in a core role for online Tech. Q&A in 2003, which is 55% of the total of 40 core members in that year.

2. The total of core members in the specific year.

Table 4. Number of Core Participants in Different Categories

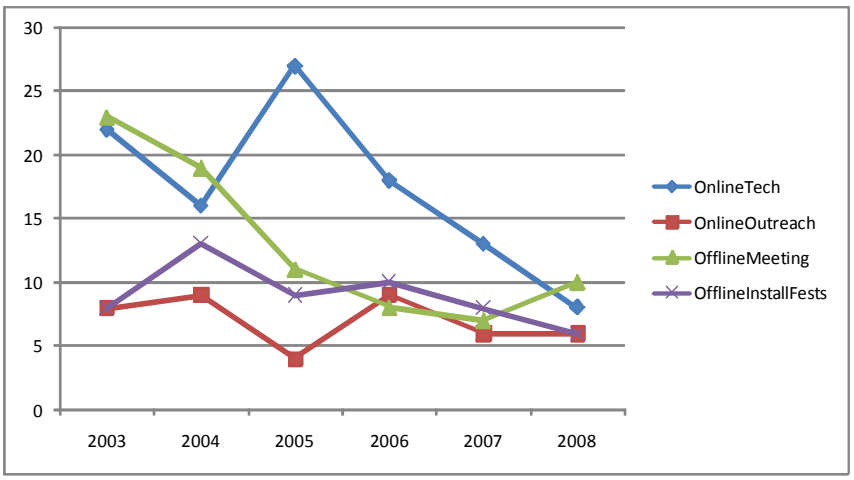


Figure 5. Trend of Number of Core Participants in LUGOD Activities

The following observations are based on Table 4 and Figure 5:

First, online Tech. Q&A and offline meetings have a relatively larger number of core participants than online Event Planning and offline Installfest. Online Tech. Q&A is the major tool for Linux User Groups to attract new members and educate Linux users. Additionally, because of the convenience of the Internet, even non-local users can use the mailing list to seek help with Linux use. Offline meetings are the major gatherings for the local Linux users. They attended the face-to-face meetings on a regular basis not only to socialize within the local Linux user community but also to advocate Open Source movement to the new members outside of the community. Therefore, we could consider the overall participation of online Tech. Q&A and offline meetings as the primary indicators of the performance of a Linux User Group as a whole.

Second, though there are a relatively small number of core participants in offline Installfests and online Event Planning, those members are the real organizers of LUGOD activities.

Continuance of Member Contributions

As indicated in Figure 6, it seems that LUGOD has been consistently losing core contributors over the years. Given its location as a college town in the center of a farming area, it is not surprising that the community suffers slightly high member turnover, which makes it particularly challenging for LUGOD to sustain its community.

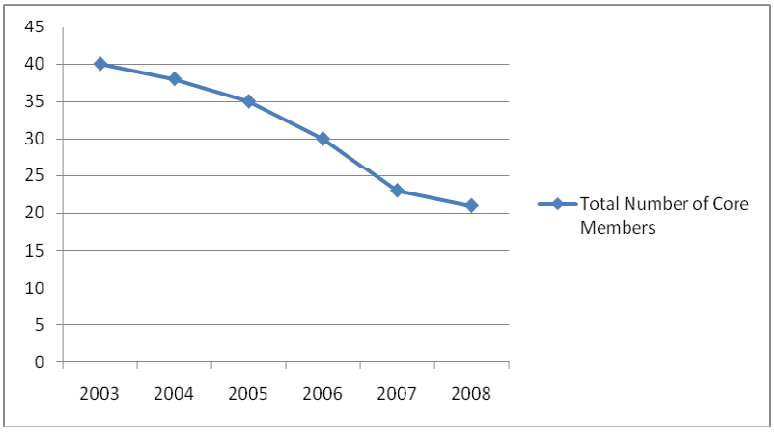


Figure 6. Total Number of Core Members over Years

Under this context, those members who are able to make continuous contributions over the years are particularly valuable for LUGOD and should be recognized as high contributors. Therefore, we propose the second way to measure the degree of member contributions based on how many years they have been core contributors to the community. Table 5 shows the result of our findings. During the six year period, 54% of the core members had been actively participating for two years or more. Out of 79 core members, only 4 had actively participated in all 6 years; they are certainly the key leadership that LUGOD cannot afford to lose.

Number of years[1]	Number of members[2]	Percentage[3]
1	36	46%
2	13	16%
3	10	13%
4	11	14%
5	5	6%
6	4	5%
Total	79	

1. "Number of years" refers to the number of years the member served a core role
2. "Number of members" refers to the number of members served a core role for how many years
3. "Percentage" refers to the corresponding percentage of the number of core members to the total. For instance, 0.46 means 46% of the 79 core members served as core contributors for only one year.

Table 5. Overlap of Core Member across Years

Breadth of Member Contributions

Table 6 and Figure 7 illustrate the numbers of core participants of either one category or at least two categories (including two categories, three categories, and all four categories). Obviously, the more categories the individual member served in a core role, the more he /she was involved in the LUGOD community. We therefore propose the third way to measure the degree of member contributions based on how many categories they served in a core role. The following observations are based on Table 6 and Figure 7.

First, most of the members (73% on average) are core contributors for merely one category (Table 6). Less than 30% of the members (28% on average) are core contributors across at least two categories. This group of members was involved in more community activities; they are actually the core of the core members. Therefore, the stability of this group of members is crucial to the sustainability of the whole Linux user group.

Second, if we compare the percentage of the core members for one category and the percentage of the core members for at least two categories (Figure 7), we find that the percentage of core contributors for one category increased while the percentage of core contributors for at least two categories decreased from 2003 to 2008. As we discussed earlier, LUGOD lost a few core members between 2005 and 2007, and the whole community experienced a decline in the past four years. The decreasing of the percentage of the core of the core members (those being core across at least two categories) demonstrates this trend.

	2003		2004		2005		2006		2007		2008		Average	
	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%
One category[1]	27	68%	26	68%	24	69%	22	73%	18	78%	17	81%	22	73%
>= 2 categories	13	33%	12	32%	11	31%	8	27%	5	22%	4	19%	9	28%
Total	40		38		35		30		23		21		31	

1. The number (and the percentage) of core members for one category or for at least two categories

Table 6. Number of Core Members for One Category or at least Two Categories

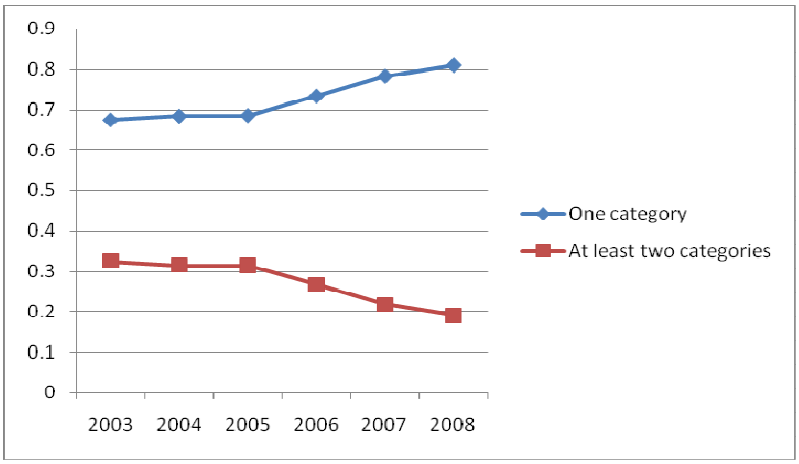


Figure 7. Comparison of Number of Categories Core Members Participated

Structure of Core Member Composition

In addition to the measurement of member contributions in an OSSUOC, we are also interested in the structure of core member composition. Table 7 lists our findings in a six-year period, which are visually presented in Figure 8.

	2003		2004		2005		2006		2007		2008		Average	
	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%	Num.	%
Online Total[1]	25	63%	21	55%	29	83%	23	77%	15	65%	11	52%	21	66%
Offline Total[2]	26	65%	25	66%	14	40%	15	50%	12	52%	13	62%	18	56%
Outreach Total[3]	27	68%	24	63%	13	37%	13	43%	10	43%	13	62%	17	53%
Tech Total[4]	26	65%	25	66%	32	91%	24	80%	18	78%	12	57%	23	73%
Total	40		38		35		30		23		21		31	

Notes: The total number (and the percentage) of core members who contributed to 1. online activities (online Tech Q&A and online Event Planning), 2. offline activities (offline Meeting and offline Installfests), 3. outreach activities (online Event Planning and offline Meeting), and 4. technical activates(online Tech Q&A and offline Installfest).

Table 7. Structure of Core Members

As indicated in Figure 8, both year 2003 and year 2004 witnessed a relative balanced structure in terms of core contributors across four categories. Additionally, these are the only two years that offline contributors surpassed online contributors in number. In 2005, LUGOD experienced a significant decline in the number of offline contributors, while the number of its online contributors surged to the highest level. This may be because some offline core contributors left the area but migrated to the online category. Between 2005 and 2008, however, the number of offline core contributors remains low but relatively stable, while the number of online core contributors consistently shrinks by about 10% per year. This may suggest that the number of offline core members is a very important indicator of overall community performance. It seems that the online core contributors could not sustain at the same level after the reduction of the offline core team. The similar trends also apply to outreach vs. technical category. Overall, the data suggests that in order to improve community performance, it is particularly important for LUGOD to stimulate participation in the offline and outreach categories.

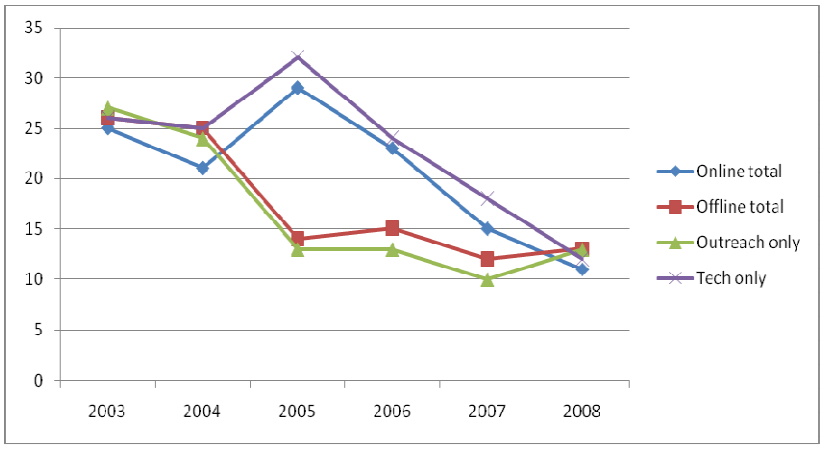


Figure 8. Core Member Aggregation Based on Media and Nature of Contributions

CONCLUSION

In this research, we conducted a longitudinal study to examine the member contributions in an OSS User-Oriented Community (OSSUOC). Based on the field experience, we first proposed a research framework to categorize individual contributions in an OSSUOC in terms of two dimensions: the media of contribution (online vs. offline) and the nature of contribution (technical-oriented vs. outreach-oriented contribution). We then collected data from the mailing-list archives and the meeting minutes of different activities—online Technical Q&A, online Event Planning, offline Meeting, and offline Installfest— from LUGOD, a local Linux user group. After that, we combined both social network analysis and Web archive analysis methods to identify core contributors in each category over a six-year period. We further measured member contributions in terms of the intensity, the breadth, and the continuance of participation across categories and years. Finally, we discussed the structure change of the core contributors in this particular OSSUOC over the years.

The results suggest the importance of a balance between online and offline activities in an OSSUOC, more specifically, the significance of offline outreach activities in stimulating the overall participation of an OSSUOC. Comparing to an OSS Development-Oriented Community (OSSDOC) which mainly focuses on software development, OSSUOC aims to educate Linux users, socialize with local users, and advocate Open Source movement. To achieve these purposes and attract local members, an OSSUOC needs to put more emphasis in organizing physical outreach activities.

This research contributes to the OSS research and practice in three-folds. First, it fills the gap of understanding the community activities and member contributions in an OSSUOC. Second, it proposes a research framework to categorize member contributions in terms of both the media and the nature of the activities. Third, it provides an insight to measure the degree of member contributions based on the intensity, the breadth, and the continuance of participation across activities and years.

In terms of future research, we would like to verify our research results in other OSSUOCs. We would also like to evaluate the overall group performance of different OSSUOCs. Additionally, we intend to further compare the structure of an OSSUOC with an OSSDOC.

REFERENCE

1. Bagozzi, R.P., and Dholakia, U.M., (2006) "Open Source Software User Communities: A Study of Participation in Linux User Groups," Management Science, 52(7), pp.1099-1115.
2. Borgatti, S. P., Everett, M.G. and Freeman, L.C. (2002) *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA, Analytic Technologies.
3. Crowston, K., Annabi, H., and Howison J. (2003) "Defining Open Source Software Project Success." *The Twenty-Four International Conference on Information Systems*.
4. Katz, N., Lazer, D., Arrow, H. and Contractor, N. (2004) "Network Theory and Small Groups." *Small Group Research*, 35(3): 307-332.
5. Feller, J. and Fitzgerald, B. (2000) "A framework analysis of the open source software development paradigm," *Proceedings of the International Conference on Information Systems,* pp 58-69.
6. Fitzgerald, B. and Kenny, T. (2003) "Open Source Software in the Trenches: Lessons from a Large-Scale OSS Implementation." *Proceedings of the International Conference on Information Systems,* 24, pp 316-326.
7. Freeman, L. C. (2004) The Development of Social Network Analysis: A Study in the Sociology of Science. Vancouver, Empirical Press.
8. Jin, L., Robey, D. and Boudreau, M. (2005) "Beyond Development: A Research Agenda for Investigating Open Source Software User Communities, "*The 16th Information Resources Management Association International Conference,* San Diego, CA.
9. Jin, L. and Robertson, B. (2008) "Lessons Learned from the Development and Marketing of Mozilla Firefox Browser," *the 14th. Americas Conference on Information Systems,* August 14-17, Toronto, ON, Canada.
10. Polese, Kim (2005) CEO, SpikeSource, Keynote Speech, "Open Source in the Enterprise: Coping with Commodities in the New IT Marketplace," *Open Source Business Conference*, April 5-6, San Francisco, CA.
11. Long, Yuan, and Siau, K. (2008) "Impacts of Social Network Structure on Knowledge Sharing in Open Source Software Development Teams", *the 14th. Americas Conference on Information Systems,* August 14-17, Toronto, ON, Canada.
12. Mockus, A., Fielding, E. and Hersleb, J. (2000) "A Case Study of Open Source Software Development: The Apache Server," *Proceedings of International Conference on Software Engineering (ICSE),* Limerick, Ireland.
13. Moen, R. (2007) Linux User Group HOWTO, http://www.linux.org/docs/ldp/howto/User-Group-HOWTO.html, accessed in Feb. 2009.
14. Open Source Initiative, (2006) "The Open Source Definition", http://www.opensource.org/docs/osd, Accessed in Feb. 2009.
15. UK Cabinet Office, (2002) "Open Source Software Use within UK Government." Accessed in Feb. 2009, http://www.softwarelivre.citiap.gov.pt/Documentacao/legislacao/OSS-policy.pdf
16. Waring, Teresa and Maddocks, P. (2005) "Open Source Software Implementation in the UK Public sector: Evidence from the Field and Implications for the Future," *International Journal of Information Management,* 25, pp 411-428.