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# Group Maintenance in Technology-Supported Distributed Teams

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**Abstract**
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**Keywords:** group maintenance, distributed work, virtual teams, open source, organizational citizenship

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# GROUP MAINTENANCE IN TECHNOLOGY-SUPPORTED DISTRIBUTED TEAMS

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## ABSTRACT

Are geographically-distributed teams which exhibit high levels of group maintenance between members successful? We answer this through content analysis of emails from two Free/Libre Open Source Software (FLOSS) teams. Our results illustrate that the groups utilize low levels of organizational citizenship behaviors and high levels of positive politeness actions.

## INTRODUCTION

Small groups or teams are a mechanism for organizations to integrate diverse forms of specialized knowledge (Grant, 1996). To allow individuals to serve on multiple teams unconstrained by geography, organizations are increasingly turning to information-technology-supported or virtual teams. Members of virtual teams may come from a variety of organizations or sub-organizations; rather than being assigned to the team by a common manager, and members often voluntarily choose to participate (a form that Stark (1999) described as a "heterarchy"). As a result, these teams are often *self-organizing*, that is, they are characterized as having a "high degree of decision-making and autonomy and behavioural control at the work group level… (such that) a much greater emphasis is placed on control from within rather than outside the group" (Manz and Sims, 1987). Other examples of self-organizing teams include *ad hoc task groups* that quickly form and dissolve, *voluntary learning groups* that may be informal or semi-formal (*e.g.*, *communities of practice*, *action learning groups* or *study circles*), *self-managing work groups* within formal organizations, *cross-organizational teams* (e.g., in the context of inter-organizational alliances), and *Internet-enabled collaborations* such as Wikipedia and Free/Libre Open Source Software (FLOSS) development teams. As organizations become

increasingly knowledge-based and dependent on effective coordination of specialized knowledge for competitive advantage, these sorts of virtual teams grow in importance, making it critical to understand the factors that promote their success.

This paper is concerned with one particular element that may be a factor in the success of virtual teams, namely group maintenance behaviour. Group maintenance behaviour refers to the pro-social, discretionary, and relation-building behavior between members that maintains reciprocal trust and cooperation (Ridley, 1996). To describe group maintenance behaviour for the purpose of this paper, we draw on three theories describing closely entwined, pro-social, organizational behaviors, namely social presence (Garrison, Anderson, & Archer, 2000; Rourke, Anderson, Garrison, & Archer, 1999); face work in computer-mediated communications (CMC) (Morand and Ocker, 2003); and organizational citizenship behavior (OCB), (Organ, Podsakoff, & MacKenzie, 2006).

The purpose of this paper is to assess whether groups that exhibit higher levels of group maintenance behaviour are indeed more successful. We answer this question through a content analysis of email archives from two FLOSS teams. The two teams provide a useful contrast for our study because one continues operating today, while the other has ceased development. We also examine group maintenance in the teams within two distinct contexts: decision-making episodes, when members necessarily have to interact to accomplish a given goal; and in every-day interactions—to determine how the role of group maintenance differs in these settings.

This paper begins with a review of the theories we have leveraged to explain group maintenance. Next we present our research questions and hypotheses, followed by our method, including data collection technique and our employment of content analysis. The results are then discussed, proceeded by implications thereof. Finally we discuss the limitations of our studies, and make recommendations for future research.

## THEORY

In this section, we review the three theories that we drew on to describe group maintenance behaviour, social presence, face theory, and OCB. We then discuss our conceptualization of group success, which we hypothesize will be affected by the level of group maintenance behaviour in the teams.

### Social Presence

Social presence has often been linked to the success and cohesion of communities (Stein et al., 2007). As defined by Garrison, Anderson, & Archer (2000), social presence is the ability for participants in a community "to project their personal characteristics into the community, thereby presenting themselves to the other participants as 'real people'" (89). As individuals project themselves socially and emotionally, group interactions can potentially become more engaging and appealing, thus having more intrinsic rewards for participants (Rourke, Anderson, Garrison, & Archer, 1999). Face-to-face settings often establish social presence through visual cues, a key element that may result in unique challenges for members of computer-mediated communities (Garrison et al., 2000).

Daft and Lengel (1986) explain that various forms of media are able to present varying levels of informational cues based on their bandwidth. They assert that rich media, such as face-to-face or telephony decrease ambivalence because of participants' ability to leverage paralinguistic cues, and natural language, with face-to-face being richest because one can easily include visual cues in expressing a message. Lean media, those that are limited in the ability to

transfer multiple types of cues are less rich in the ability to convey message clarity (Yoo & Alavi, 2001).

Social presence is often more easily established in the absence of ambiguous and equivocal informational cues (Yoo & Alavi, 2001). Virtual teams communicate through computer-mediated systems, such as email, where text is often the only way to express a message. As such, it is plausible that these participants may enact strategies to compensate for those cues reduced by this lean medium (Garrison et al., 2000), hence increasing social presence. Such strategies to increase the degree of social presence within CMC include use of emoticons, humor, vocatives, phatics, inclusive pronouns, complimenting, appreciation, agreement, punctuation, and capitalization (Rourke et al., 1999).

**Face Theory**

Referring to the work of Goffman (1959, 1967, 1983), Morand explains that face is "the positive value individuals claim for the public self they present" (1996: 545). In other words, face can be viewed as an individual's public identity. Face is constructed of two wants: autonomy of action (also known as negative face) and the need for validation (also known as positive face) (Meier, 1995). Examples of each come from Duthler who writes that negative face is exemplified by want to be left alone, independence from others, self direction, and freedom from restrictions created by others; meanwhile positive face includes want of respect, membership in a valued community, and a reputation for competence and fairness (2006).

Holtgraves notes that face is held as scared to people, and is thus inherently vulnerable when engaging others in interaction (2005). Because face is emotionally charged, people strive to maintain it in social settings and communications (Morand, 1996). However, despite the identity that one claims, it can only be validated by others. As such, face is dependent on others, and thus becomes within everyone's interest to maintain the face of those they interact with (Holtgraves, 2005). Face is therefore viewed as "a social rather than a psychological construct" (Holtgraves, 1992: 142). And it's within these social situations that people continuously interact in ways that preserve, bolster, or show consideration for the face of others (Morand, 1996).

Yet, despite the need to support the face of others, there are instances when one may have to "make requests, disagree, and offer advice or criticism to others" (Duthler, 2006: 3). These instances are known as face threatening acts (FTAs), and can either be directed toward the speaker or the hearer, and can threaten both types of face (Meier, 1995). As members of groups communicate to achieve shared goals, face becomes potentially important to maintaining cooperation, cohesion, and success. The tactics with which participants manage face is thus a key element in the understanding of group maintenance.

Politeness is a tool that individuals can use to moderate any face threats in communicating with others (Morand, 1996). Politeness, as adapted for the purposes of this paper, is conceived of as a linguistic act that can take the form of positive tactics (to encourage positive face) and negative tactics (to encourage negative face) (Morand and Oaker, 2003). Examples of positive politeness tactics include use of colloquialisms or slang, vocatives, agreement, inclusive pronouns, and sympathy. Examples of negative politeness include use of hedges, indirect inquiries, subjunctives, honorifics, apologies, formal verbiage, passive voice, and rationale for FTAs (Morand, 1996; Morand and Oaker, 2003).

**Organizational Citizenship Behavior**

Organizational citizenship behavior (OCB) is defined as "individual behavior that is discretionary, not directly or explicitly recognized by the formal reward system, and in the aggregate promotes the efficient and effective functioning of the organization" (Organ, Podsakoff, & MacKenzie, 2006: 3). Examples of such behaviors range from assisting a co-worker even when it is not required to sporting a company logo on one's clothes (Moorman and Blakley, 1995). Moorman and Blakely (1995) note that OCBs are expected to be performed by those who support the collective; as such behaviors promote the group while subordinating the individual. It is for precisely this reason that we would expect to see these manifested in self-organizing teams. The voluntary work performed by members suggests that they have a commitment to the group, or at least the group's purposes. Such collective commitments have been shown to be strongly linked to the performance of OCBs (Williams and Anderson, 1991).

There are a number of different OCB actions identified across the literature. Of note, this literature has focused on face-to-face settings in traditional organizations, where leadership is clear, and group members, while not rewarded directly for their OCBs, do receive paychecks for their work. As such, only those actions identified as most transferrable to a virtual team were considered for this paper. This consisted of helping, courtesy, peacemaking, cheerleading, and sportsmanship.

In terms of OCB, helping is considered to be a behavior in which one voluntarily helps a specific individual within the same organization with a work-related problem (Ridley, 1996). Those who exhibit this behavior are often ready to lend assistance to those around them (Padsakoff, MacKenzie, Mooreman, & Fetter, 1990). Courtesy is the avoidance of practices that creates difficulties for others, or at least giving them advanced notice of difficulties such as extra tasks or work loads (Organ, 1988). One who embodies courtesy is likely to be mindful of how he or she affects others, taking steps to prevent problems (Padsakoff et al., 1990). Peacemaking refers to the actions of one who steps in to resolve conflict between two or more parties (Organ et al., 2006). A peacemaker in a group is often a stabilizing influence amidst dissention (Podsakoff and MacKenzie, 1994). Cheerleading "involves the celebration of coworkers' accomplishments (be they grand or humble)" (Organ, Podsakoff, & MacKenzie, 2006: 25). This action may be demonstrated by encouraging others through recognition for hard work (Podsakoff and MacKenzie, 1994). Sportsmanship is a willingness to tolerate the inconvenience and impositions without registering complaints (Organ et al., 2006). Those who exhibit sportsmanship can be recognized by their lack of complaining or by their focus on the positive aspects of situations (Padsakoff et al., 1990).

**Team success**

In many studies the effectiveness of a virtual team is measured either by an experiment bound task-level measure, such as decision quality, or an overall business impact measure, such as revenue or profit produced. However, measuring only task output is inadequate for long-lived teams with voluntary and fluid memberships. Drawing on models of group effectiveness proposed by Hackman and McGrath (IPO), we assess success in three ways: acceptability of task outputs to others, attractiveness of the project to participants and ability of the team to sustain itself over time. We as well as assessed the vitality of the team processes (as process vs. output measure) as an indication of the success of the project.

Group maintenance is expected to influence each of these measures in a positive direction over time. Acceptability of the task output is linked to group maintenance indirectly: appropriate

group maintenance behaviors will increase the quality of the output produced, which ought to in turn increase its acceptability. Participant attraction is linked to group maintenance because a group which works to appropriately respect participant's face and in which participants support each other through organizational citizenship behaviors will support individual motivations and therefore be successful in attracting and retaining participants. The result of these two effects should also be a team that is able to sustain itself over time as it gains participants and external support. Process vitality is linked to group maintenance for similar reasons but has the additional ability to measure the contribution of active-users engaged in highlighting bugs, suggesting features and supporting each other.

## METHOD

In this section, we discuss our research design and data collection and analysis methods. This study employs a multiple case study method. We chose to compare two FLOSS projects that developed Instant Messaging (IM) clients: Gaim and Fire. The two projects were similar in terms of their project goals, nature of tasks, and potential users, making the comparison meaningful. Both projects sought to deliver a unified platform for those who typically used multiple IM clients. Rather than be logged onto several clients at once, a user of either Gaim or Fire could log onto a single program and have access to users across the other clients. However Gaim has been more effective as a project, based on Crowston et al's multivariate measure of effectiveness in FLOSS contexts [17, 18]. Evidence of Gaim's success can also be seen in that the project is still going strong (although it is now known as Pidgin), while Fire ceased active development in early 2007.

### Success Measure for FLOSS teams

In order to understand the impact of group maintenance behaviors in FLOSS teams it is necessary to measure understand the meaning of success in the FLOSS environment. In many studies the effectiveness of a virtual team is measured either by an experiment bound task-level measure, such as decision quality, or an overall business impact measure, such as revenue or profit produced. The FLOSS environment, consisting of long-lived teams with voluntary and fluid memberships existing outside traditional organizational structures offers neither of these traditional measures[1]. Crowston et al reviewed the construct of success in FLOSS teams in detail and, drawing on models of group effectiveness discussed above, propose that studies interested in FLOSS effectiveness should measure success in multiple ways linked to three aspects of group work: Inputs, Processes and Outputs. The particular measures chosen should be theoretically linked to the specific research question of interest. Accordingly this paper adopts three measures: developer attraction and retention (Inputs), communication participation (Process) and popularity (Outputs).

Developer attraction is linked to group maintenance because a group which works to appropriately respect participant's face and which supports each other through organizational

[1] Popularity, it should be noted, is not a direct analog to market share or revenue in a general business context since 'shipping units' is not the overarching goal of the development team, a team is highly unlikely to stop building a multi-protocol instant messaging client and start building an multi-player gaming world because they feel it has the potential to ship more copies. The motivations of the team are much more diverse and directly linked to the product.

citizenship behaviors ought to support developer's individual motivations and therefore be successful in attracting and retaining developers. Communication participation is linked to group maintenance for similar reasons but has the additional ability to measure the contribution of active-users engaged in highlighting bugs, suggesting features and supporting each other. Popularity, on the other hand, is linked to group maintenance more indirectly; appropriate group maintenance behaviors ought to increase the quality and functionality of the software produced, which ought to in turn increase the popularity of the software in the wider user community. These measures also align with other detailed work on success in the FLOSS context, such as Stewart and Ammeter . Group maintenance should be expected to influence each of these measures in a positive direction over time. The time needed for these effects (the lag) will vary according to the measure, with the shortest lag expected for community participation, followed by developer attraction and finally the more indirect measure of popularity.

**Data Collection**

The nature of FLOSS teams provides unique opportunities to observe group maintenance behavior since most FLOSS activities (if not all) are archived. We collected messages sent to the projects' email lists by all contributors. To reach the 95% confidence level, we decided to randomly pick up about 300 messages from each project. There were periods when large amounts of junk mails were sent to the lists. To rule out the influence of this condition, we decided to select 360 messages from each project. We sampled the lists over time by dividing the list into 360 sequential groups and selecting a random message from each group. Each group represents a calendar period with the same density of messages, as the original list. During the coding we replaced messages identified as automated or spam with the nearest appropriate message. If all the messages in a period were junk mails, then this period was removed from analysis. As a result, 360 messages were selected from Gaim mailing lists. These messages spread from June 2002 to February 2006, covering 45 months. A total of 337 messages were selected from Fire mailing lists, from June 2002 to December 2005 over a period of 43 months.

Data on team success were gathered from existing public research repositories of FLOSS data, specifically FLOSSmole. Where new data was collected they have been made available through the FLOSSmole project.

**Analysis**

We conducted content analysis to examine group maintenance behavior in the two projects. We adopted a thematic measure as our unit of analysis: "a single thought unit or idea unit that conveys a single item of information extracted from a segment of content" or the "unit of meaning" (Budd, Thorpe, & Donohue, 1967). Such units vary in size from an emoticon or punctuation to a word, a phrase, a part of a sentence, a sentence, or even a few sentences when appropriate.

The coding scheme was initially created deductively from the literature reviewed in the Theory section. Then it was used to code a small number of messages in both projects. Based on that, the scheme was revised and then used to code more messages and revised again. The iteration process repeated until a relatively solid coding scheme was achieved. About 400 messages from Gaim and Fire mailing lists were used to refine the scheme. These messages may or may not be drawn as sampled messages in this study because we utilized a random sampling technique. Table 1 shows the category, definition and examples of each group maintenance indicator. Two authors of this paper have been trained to code independently and then discuss to

reach consensus during the scheme development process. Their inter-rater reliability has reached .80 in the second half of the training process and .85 in the last 1/5 process. Therefore they were allowed to code messages independently for this study.

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Insert Table 1 about here

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Developer attraction was operationalized as the number of developers listed as such by the project over time, these data were collected from copies of the project homepage stored by the Wayback Machine of the web archive. Communication participation was operationalized by analyzing the mailing lists used for content analysis in two ways: counting the total number of messages sent and counting the unique senders per month. Popularity was operationalized through the download and pageview statistics published by Sourceforge and available through the FLOSSmole project. It makes sense to use these statistics for comparative popularity only because the projects, as multi-protocol instant messaging clients, are direct competitors.

Since each variable was measured across the life span of the projects, we have time series for each variable, allowing us to assess causality more directly. The time needed for these effects (the lag) will vary according to the measure, with the shortest lag expected for the effect of group maintenance on Community participation, followed by Developer attraction and finally the more indirect measure of Popularity.

## FINDINGS

### Descriptive Measures

#### *Success*

Fire and Gaim differ in success across all three concepts: inputs, as measured by developer counts, process, as measured by unique mail participants and outputs, as measured by downloads and pageviews. Overall it is possible to see both projects moving to an initially successful position from a low starting point. Around February 2004, however, the patterns diverge with Gaim continuing to grow, and even accelerate, while Fire stagnates and in fact on some measures, actually declines. Figure 1 compares developer counts. It shows initial growth for both followed by stagnation for Fire and continued addition of new developers by Gaim. It is likely that projects are slow to remove inactive developers, Fire may never have done so, while it appears that Gaim did so in November 2005, but quickly grew again. Figure 2 shows our two Communication participation measures. Both projects grow, with Fire outpacing Gaim until Feb '04. From that point on Fire displays a declining trend until the end of the project in early 2006, while Gaim shows much higher levels, even if somewhat varied, through to the end of data collection in Apr '07. Finally Figure 3 shows our popularity measures, downloads and pageviews, with a logarithmic Y axis, due to the disparity between Gaim and Fire. Both projects display substantial initial growth, which continues for Gaim, while Fire achieves it's highest levels in early 2004 and does not grow further. Although not displayed it is interesting that Fire continues to receive many downloads to this day even though the program has not been updated since early 2006.

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Insert figures 1-3 about here

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### *Group maintenance*

The 360 Gaim messages received a total of 3748 group maintenance codes; while the 337 Fire messages received 2861 codes. It is reasonable to suspect that messages containing more words tend to reveal more group maintenance behaviors, so comparison between the groups on frequencies may be misleading. Therefore we calculated the densities of group maintenance behaviors by looking at how many codes are assigned to every 1000 words. Thus we define density as the number of codes in a message/number of words in the message*1000. Table 2 shows the densities of each code and each category in both groups. The average densities across 4 categories of group maintenance behaviors are 91.66 and 88.95 for Gaim and Fire, respectively.

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Insert Table 2 about here
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Positive politeness behaviors have been widely observed in the two projects. The densities are 68.52 and 67.15 for Fire and Gaim, respectively. Specifically, group-specific jargon/metaphor have been appearing the most, 39.73 for Fire and 47.59 for Gaim. Following it, vocatives (Fire = 8.74, Gaim = 6.38), inclusive pronouns (Fire = 7.06, Gaim = 5.09), and colloquialism/slang (Fire = 3.61, Gaim = 3.20) have been used frequently.

Negative politeness tactics densities for Fire and Gaim are 14.99 and 18.10 respectively. The most dense code found was hedges/hesitation/subjunctives (Fire = 12.12, Gaim = 15.60).

Emotional expressions have been employed to a moderate extent with densities for Fire and Gaim at 5.19 and 6.31 respectively. Within this category, both groups used punctuation most often to express emotions or emphasis (Fire = 3.48, Gaim = 2.42). Emoticons were often used to express emotions in both teams (Fire = 1.03, Gaim = 1.44). Gaim employed capitalization and humor much more than Fire.

On the other hand, organizational citizenship behaviors (OCB) were very rarely seen, with an average density of only 0.25 and 0.10 for Fire and Gaim.

Figures 4-7 show the comparison between the two projects on each group maintenance category (emotional expression, positive politeness, negative politeness, and organizational citizenship behaviors) over time by month. For each category, the trends in both projects are similar, fluctuating from month to month in a relatively stable range. There are a few outliers in the graphs, mainly due to small numbers of messages in those months. In September 2004, for example, only one message was drawn for analysis in Fire. That message happen to have a high density in emotional expression. To maintain the integrity of data, we keep and present these several outliers in the graphs.

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Insert Figures 4-7 about here
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**Comparison between Fire and Gaim**

To compare the difference between Fire and Gaim, we conducted independent-samples t-tests on each group maintenance category and individual indicator. To rule out random factors that individual messages may bring in, we aggregated density data monthly. That is, density was fined as and were conducted based on monthly density as the number of codes in all the sample messages in a month/number of words in these messages x 1000.

The last column of Table 2 shows the t-tests results. Most group maintenance behaviors demonstrated similar patterns without significant differences revealed. Several type of behaviors have been found to be used very differently in Fire and Gaim. Gaim used humor ($t = -3.349$, $p < .001$) and apology ($t = 2.401$, $p < .05$) significantly more than Fire. But Fire shows much more frequent usage of inclusive pronouns ($t = 2.214$, $p < .05$), phatics ($t = 2.243$, $p < .05$), complimenting ($t = 2.214$, $p < .05$), and expressing appreciation ($t = 4.401$, $p < .001$).

**Relationship between Group Maintenance and Success**

To explore the relationship between group maintenance behaviors and team success, linear regressions were conducted to reveal salient predictors of team input (measured by developer count), communication participation (measured by message count and mail participant count), and team output (measured by download count and pageview count). Below we describe preliminary results, which look promising. In the Future Work section, we discuss how to improve the analysis.

Each of the five team success measures was treated as a dependent variable individually. In each regression, all group maintenance indicators were used as independent variables in a BACKWARD manner so that important contributors of the dependent variable could be identified. These contributors were then used to predict the dependent variable in a regression using the ENTER method. We allow one month lag for group maintenance behaviors to be reflected in success measures. For example, success measures in Feb. 2005 corresponded to group maintenance behaviors in Jan. 2005 in data analysis. Regression results are presented in this section summarized in Table 3.

***Group Maintenance and Team Input***

79.6% variance in Gaim developer counts was explained by the usage of Helping, Vocative, Punctuation, Colloqualism/Slang, Formal Verbiage, Agreement, Rationale for FTA, Phatics, and Complimenting ($F = 10.54$, $p < .001$).

Due to the limited availability of developer numbers, we could run a meaningful regression using it as the dependent variable for Fire.

***Group Maintenance and Communication Participation***

For Fire, 38.9% variance in mail participants was explained by Capitalization, Colloqualism/Slang, Vocative, Phatics, Apologies, Expressing Appreciation, and Disclaimers/Self-depreciation ($F = 4.37$, $p < .01$). For Gaim, 49.5% variance in mail participants was explained by the usage of Formal Verbiage, Phatics, Humor, Complimenting, Rationale for FTA, and Hedges/Hesitation/Subjunctive ($F = 8.03$, $p < .001$).

34.5% variance in the number of messages sent to the Fire lists was explained by Vocative, Apologies, Disclaimers/Self-depreciation and helping behaviors ($F = 5.87$, $p < .001$).40.5% variance in the number of messages sent to the Gaim lists was explained by the usage of Formal Verbiage, Phatics, Humor, Complimenting, Rationale for FTA, and Hedges/Hesitation/Subjunctive ($F = 5.88$, $p < .001$).

***Group Maintenance and Team Output***

18.6% variance in Fire download counts was explained by the usage of Emoticon, Empathy/Sympathy, Complimenting, Agreement and Formal Verbiage ($F = 2.88$, $p < .05$). 43.5% variance in Gaim download counts was explained by the usage of Formal Verbiage, Apologies, Disclaimers/Self-depreciation, Vocative, Hedges/Hesitation/Subjunctive, Rationale for FTA, Complimenting, Emoticon, and Group Jargon or Metaphor ($F = 4.77$, $p < .001$). 33.0% variance in Fire page view counts was explained by the usage of Formal Verbiage, Group Jargon or Metaphor, Humor, Apologies, Disclaimers/Self-depreciation, Complimenting, and Colloqualism/Slang ($F = 3.88$, $p < .01$). 37.9% variance in Gaim page view counts was explained by the usage of Formal Verbiage, Humor, Rational for FTA, and Emoticon ($F = 7.72$, $p < .001$).

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Insert Table 3 about here

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## DISCUSSION

The strongest results of this research are the overall patterns observed with group maintenance behaviors.

Positive politeness behaviors have been widely observed in the two projects. This suggests that members view their team as a cohesive group that has its own culture that bonds its members together.

The frequent use of hedges/hesitation/subjunctives as a negative politeness tactic suggests that team members are somewhat careful to respect the autonomy of others despite the casual atmosphere.

The low rate of organizational citizenship behaviors (OCB) may reflect the fact that OCB theory was developed in traditional organizations, where member responsibilities are clearly defined. Under this condition, it is easy to identify behaviors such as helping or courtesy that go beyond what is required. In the FLOSS setting, however, most members contribute to the projects voluntarily and it is hard to distinguish the line between fulfilling one's own responsibility and helping others.

The comparison between Gaim, as the most successful project, and Fire as the least successful project indicate that they exhibit quite similar patterns of group maintenance behaviors, with differences only between a few lower level categories. We think this primarily reflects the similarity between the projects as self-organizing, volunteer and distributed software development teams. Despite Fire eventually folding as a project the patterns of behavior established early on do not seem to change as the project declines in productivity.

Finally we presented preliminary results of an analysis relating the group maintenance measures to the success measures. The results are promising in that our measures are able to explain substantial variance in the dependent variables, but the interpretation is complicated because the models for each project selected different predictors and some of the relationships were the inverse of what we expected to find. We discuss improvements to this analysis below.

**Conclusions and future work**

The existence of server outliers in our time-series data is a concern, and it is caused, in part, by some months having very spares communications and therefore being only represented

by a small number of messages. On reflection we have options for improving that situation. The first is to simply drop months with very low sample-sizes (perhaps 10 months overall). The second is to reorganize the analysis into event-time rather than calendar time, producing periods defined by equally sized sequential buckets of messages. Such periods would be of irregular length, but would, perhaps, more closely reflect equal amounts of "project time"; after all these groups are voluntary and part time. Finally it would be possible to compare two larger time periods for the projects, one while Fire was successful and one when it was less so (Jun. 02–Dec. 03 vs Jun. 04–Mar. 06). Each period would then be represented by a large (but different) number of messages (~150).

Further, we are concerned that there may be substantial auto-correlation and cycles in some of our time-series, which would affect the validity of the regression analysis. For example the downloads series is made up of both new users and those continuing to use the software, meaning that a download in an earlier period makes one more likely in a later period. The extreme "saw tooth" structures in the mail participation series (one month up and one month down) suggest that there are periods of high activity and periods of low activity, perhaps entrained to the release cycle of the project. Again this fits with the unequal effort to be expected in a self-organizing voluntary team environment.

Finally the regression analysis can be improved by taking the analysis up a conceptual level and ensuring that the individual indicators do in fact validly measure the higher level concepts such as social presence, possibly through a factor analysis. This should also be done with the success measures. This will reduce the variables in both sides of the regression analysis.

Nonetheless, the analysis presented in this paper highlights a number of very interesting findings. Firstly the groups showed no evidence of organizational citizenship behavior. We speculate, above, that this could be an effect of considering the entire project, including the full spectrum of commitment, core, peripheral developers and simple users. Indeed Howison et al (2006) suggests that there is a power law in participation tenure, with just a few central members having long tenures and the majority of participants only getting involved for a single period. It would therefore be more telling to compare the behaviors of core, or long standing, members with those of irregular or one-time participants, and to observe patterns over time for long standing members. This comparison may also throw light on the dominance of positive politeness behaviors, which indicate group cohesion and may have been concentrated amongst the core developers.

As technology-supported distributed teams increase in importance throughout organizations and the economy, an understanding of the role of group maintenance behaviors should facilitate group success.

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## APPENDIX

### Tables

**Table 1. Coding Scheme of Group Maintenance Behavior**

| Category | Indicator | Definition | Example |
|---|---|---|---|
| **Emotional Expression** | Expressions of emotion using emoticons. | Expressions of emotion or emphasis using emoticons. | : )<br>;-) |
| | Expressions of emotion or emphasis using conspicuous capitalization. | Expressions of emotion or emphasis using conspicuous capitalization. | "EVERYONE ON THE LIST"<br>"THINK" |
| | Expressions of emotion or emphasis using (repetitious) punctuation | Expressions of emotion or emphasis using (repetitious) punctuation, exclamation point, underlining, italic fonts, or any other | "!!!"<br>Underline<br>"!" |
| | Use of humor | Teasing, cajoling, irony, understatements, sarcasm.<br>So we will code every repeated signature, but not coded text. | "'The only way to keep your health is to eat what you don"t want, drink what you don"t like, and do what you"d rather not'. -- Mark Twain" |
| **Positive Politeness** | Colloquialisms or slang | Spelling out phonological slurring, using colloquialisms or slang; beyond group specific; used to show familiarity. | "Saturdayish"<br>"BTW" |
| | Group-specific jargon or metaphors | Use of group-specific jargon, language, or metaphors. | "Why is this a .mm file? what is .mm again? I know .m is ObjC" |
| | Vocatives | Referring to participants by name, or specifically addressing part of a message to an individual. Name used as the second or third or even first person. If there is a "you" or "your" specifically referring to a particular single person, we'll code it. | "As sean said"<br>"Martin," |
| | Inclusive pronouns | Incorporating writer and recipient(s) | "we", "us", "let's", "our" |
| | Phatics | Personal greetings and closures, including communication for purely social reasons | "Hi", "regards", |
| | Raising/presupposing commonalities | Assuming a stance that is in agreement with other group members – attributes of things that we share. | "If you have two patches that modify the same file, it is best to separate them. I know this is a pain, but I go through this |

| Category | Indicator | Definition | Example |
|---|---|---|---|
| | | | every time I submit something to the gaim guys since we use their library." |
| | Expressing empathy/sympathy | Expressing empathy and/or understanding | "I know this is a pain" |
| | Complimenting | Complimenting others or message content. It can go beyond agreement. | "The temporary message is a good idea" "You guys have done an awesome job" |
| | Expressing agreement | Expressing agreement with others previous statement | "Agreed" "I suppose." "Correct." |
| | Apology; Admitting Mistake/Fault | Apologizing for one's own personal mistakes | "Sorry again if I stepped on any toes" "Sorry if I touched a nerve there Sean" "Sorry about that..." "I am sorry" "Sorry for the inconveniences" |
| | Encouraging participation | Encouraging all the members of the group to participate | "Any comments welcome." |
| | Expressing appreciation | | "Thanks for the help." "Well thanks a lot for you hard work!" |
| **Negative Politeness** | Disclaimers; Self-depreciation | Use of disclaimers prior to an FTA; self-depreciation as a distancing tool; may include apologies as explanations | "dumb fire question#1: which MSNService.nib "file" is the real one?" "Sorry if I'm terribly ignorant somehow... I'm just getting into this stuff." |
| | Stating rational for FTA (State FTA as general rule + explanation) | Stating an FTA as a general rule to minimize impact or as to not single out an individual; Explaining the reasons behind an action that might threat someone's face. | "In general we want to avoid forking the MSN library with our own changes so |

| Category | Indicator | Definition | Example |
|---|---|---|---|
| | | | any changes there need to be sent on to Meredydd." |
| | Hedges; Hesitation; subjunctives | Use of words/phrases/subjunctives to diminish force of act; Use of hesitation in disagreement (ie. "well…") | "um..." "I"m not sure what the problem is..." "it would be nice to at least…" |
| | Honorifics | Use of honorifics | Mr., Miss., Dr., Prof., etc. |
| | Formal verbiage | Using formal wording choices | "please send the file to …"; "please" |
| | Passive voice used to create distance | Use of passive voice to create distance between the object from the performer | "What is it that isn"t handled properly?" "Is it being worked on?" |
| **Organizational Citizenship Behaviors** | Helping | Behavior involving voluntarily helping others with a work problem. The immediate beneficiary is a specific individual person. | "I"ll look into that." |
| | Courtesy | Subsumes all of those foresightful gestures that help someone else prevent a problem; avoiding practices that make other people's work harder. | "Note that, after applying this patch the SILC Toolkit 1.0.1 must be installed in the system in order to be able to compile." |
| | Peacemaking | Actions that help to prevent, resolve, or mitigate unconstructive interpersonal conflict. | "A compromise could be to…" |
| | Cheerleading | The words and gestures of encouragement and reinforcement of coworkers' accomplishments and professional development. | "You will be honored for contributing your time and skill to a worthy cause." |
| | Sportsmanship | A willingness to tolerate the inevitable inconvenience and impositions of work without complaining. | |

**Table 2. Group Maintenance Behavior Density**

| Category | Indicator | Density in Fire | Density in Gaim | t value |
|---|---|---|---|---|
| **Emotional Expression** | | **5.19** | **6.31** | -.025 |
| | Expressions of emotion using emoticons. | 1.03 | 1.44 | -.546 |
| | Expressions of emotion or emphasis using conspicuous capitalization. | 0.25 | 1.08 | -1.789 |
| | Expressions of emotion or emphasis using (repetitious) punctuation | 3.48 | 2.42 | 1.467 |
| | Use of humor | 0.44 | 1.37 | **-3.349*****|
| **Positive Politeness** | | **68.52** | **67.15** | 1.652 |
| | Colloquialisms or slang | 3.61 | 3.20 | 1.035 |
| | Group-specific jargon or metaphors | 39.73 | 47.59 | .106 |
| | Vocatives | 8.74 | 6.38 | 1.085 |
| | Inclusive pronouns | 7.06 | 5.09 | **2.214*** |
| | Phatics | 3.73 | 2.37 | **2.243*** |
| | Raising/presupposing commonalities | 0.00 | 0.00 | n/a |
| | Expressing empathy/sympathy | 0.06 | 0.02 | .938 |
| | Complimenting | 1.34 | 0.27 | **2.214*** |
| | Expressing agreement | 0.25 | 0.44 | -1.519 |
| | Apology; Admitting Mistake/Fault | 0.22 | 0.37 | **-2.401*** |
| | Encouraging participation | 0.53 | 0.49 | .304 |
| | Expressing appreciation | 3.26 | 0.93 | **4.041***** |
| **Negative Politeness** | | **14.99** | **18.10** | -.857 |
| | Disclaimers; Self-depreciation | 0.84 | 1.17 | -.260 |
| | Stating rational for FTA | 0.90 | 0.76 | -.302 |
| | Hedges; Hesitation; subjunctives | 12.12 | 15.60 | -1.462 |
| | Honorifics | 0.03 | 0.00 | 1.000 |
| | Formal verbiage | 1.09 | 0.51 | 1.955 |
| | Passive voice used to create distance | 0.00 | 0.05 | -1.388 |
| **Organizational Citizenship Behaviors** | | **0.25** | **0.10** | .858 |
| | Helping | 0.09 | 0.07 | -1.020 |
| | Courtesy | 0.00 | 0.00 | n/a |
| | Peacemaking | 0.00 | 0.02 | -1.000 |
| | Cheerleading | 0.16 | 0.00 | 1.237 |
| | Sportsmanship | 0.00 | 0.00 | n/a |

*Note: *p < .05, **p < .01, ***p < .001.*

**Table 3. Regression Results**

| | Fire (Predictors) | Gaim (Predictors) |
|---|---|---|
| Developer Count | n/a | Adjusted $R^2$ = 79.6% |
| | | Helping<br>Vocative<br>Punctuation<br>Colloqualism/Slang<br>Formal Verbiage<br>Agreement<br>Rationale for FTA<br>Phatics<br>Complimenting |
| Mail Participant Count | Adjusted $R^2$ = 38.9% | Adjusted $R^2$ = 49.5% |
| | Capitalization<br>Colloqualism/Slang<br>Vocative<br>Phatics<br>Apologies<br>Expressing Appreciation<br>Disclaimers/Self-depreciation | Formal Verbiage<br>Phatics<br>Humor<br>Complimenting<br>Rationale for FTA<br>Hedges/Hesitation/Subjunctive |
| Message Count | Adjusted $R^2$ = 34.5% | Adjusted $R^2$ = 40.5% |
| | Vocative<br>Apologies<br>Disclaimers/Self-depreciation<br>Helping | Formal Verbiage<br>Phatics<br>Humor<br>Complimenting<br>Rationale for FTA<br>Hedges/Hesitation/Subjunctive |
| Download Count | Adjusted $R^2$ = 18.6% | Adjusted $R^2$ = 43.5% |
| | Emoticon<br>Empathy/Sympathy<br>Complimenting<br>Agreement<br>Formal Verbiage | Formal Verbiage<br>Apologies<br>Disclaimers/Self-depreciation<br>Vocative<br>Hedges/Hesitation/Subjunctive<br>Rationale for FTA<br>Complimenting<br>Emoticon<br>Group Jargon or Metaphor |
| Pageview Count | Adjusted $R^2$ = 33.0% | Adjusted $R^2$ = 37.9% |
| | Formal Verbiage<br>Group Jargon or Metaphor<br>Humor<br>Apologies<br>Disclaimers/Self-depreciation<br>Complimenting<br>Colloqualism/Slang | Formal Verbiage<br>Humor<br>Rational for FTA<br>Emoticon |

## Figures

**Figure 1 Success in attracting developers (counts over time)**

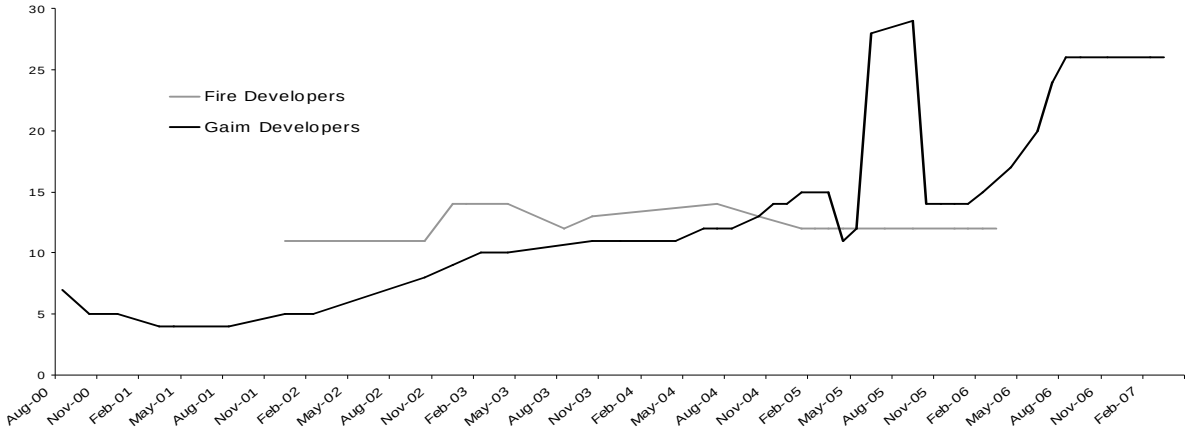



**Figure 2 Success in communication participation (unique mail participants and traffic)**

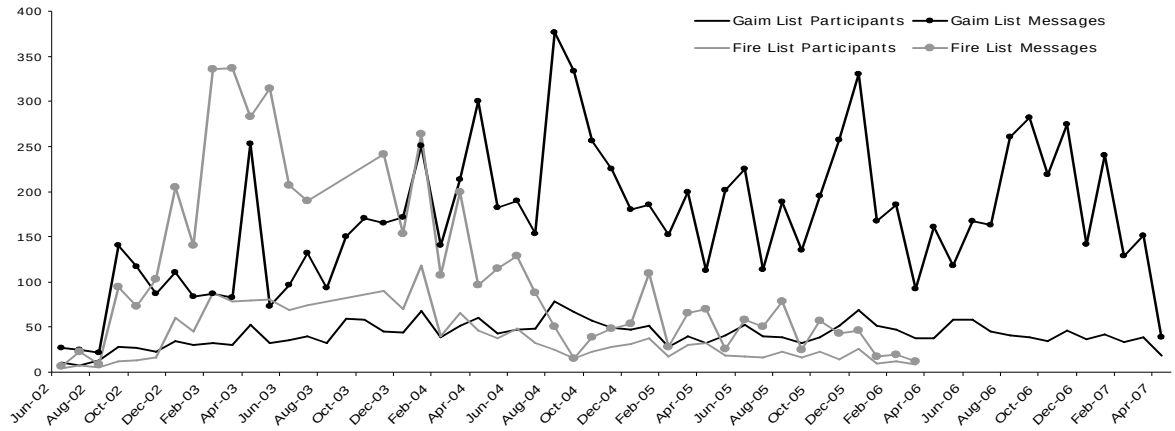


**Figure 3: Success in achieving popularity: downloads and pageviews**

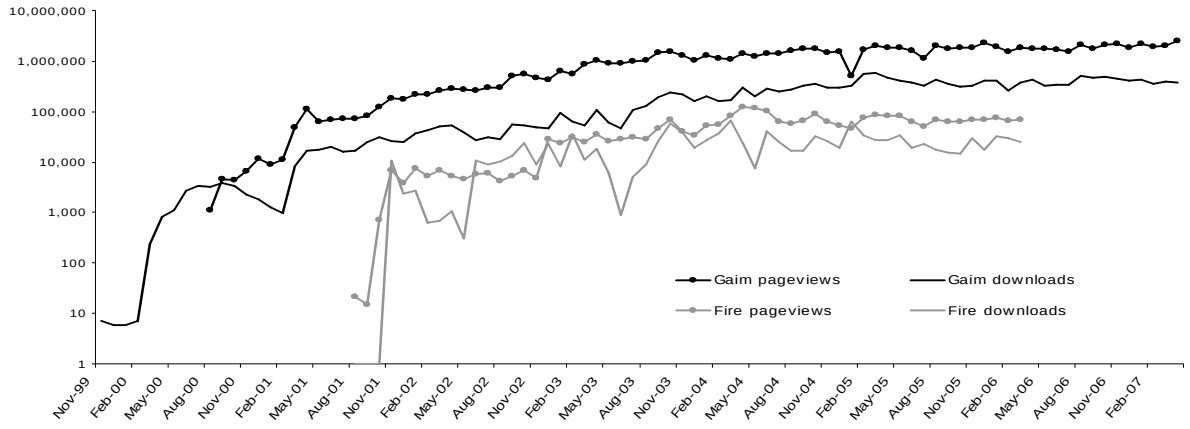



**Figure 4 Density of social presence over time**

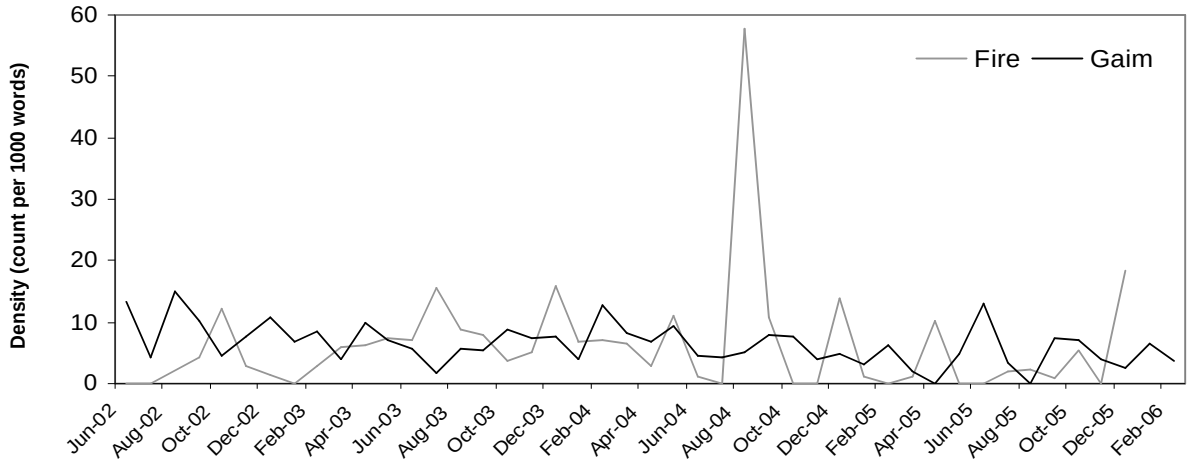



**Figure 5 Density of positive politeness over time**

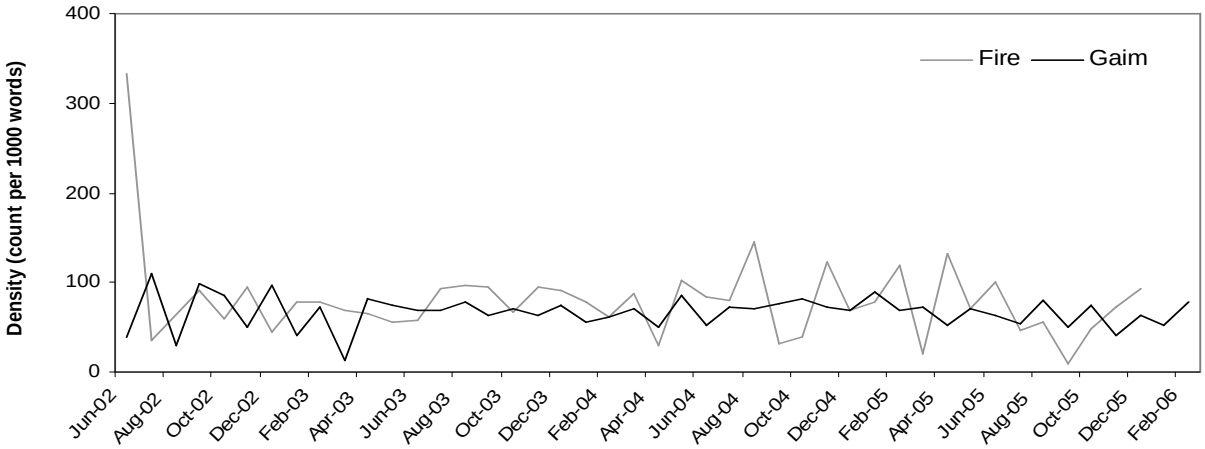


**Figure 6 Density of negative politeness over time**

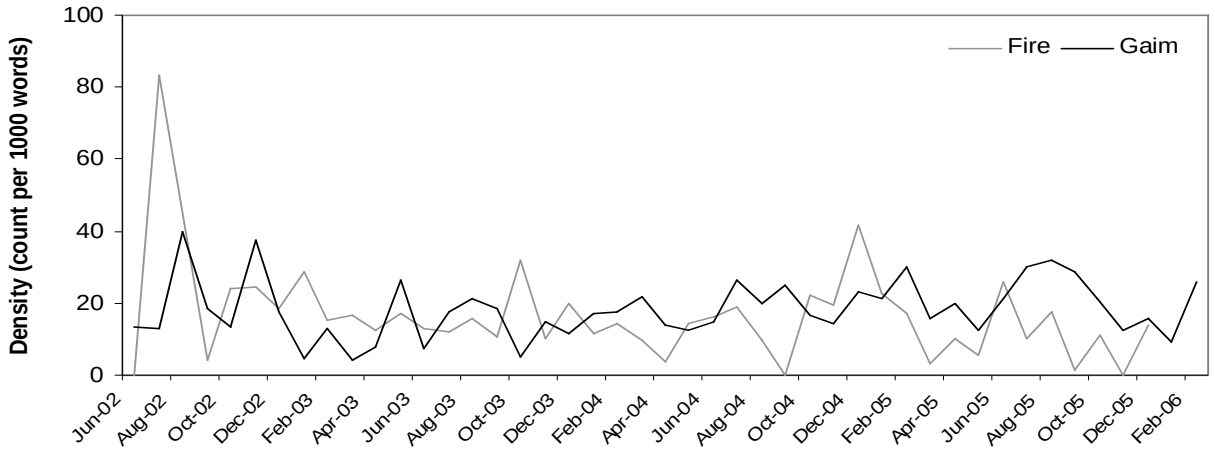
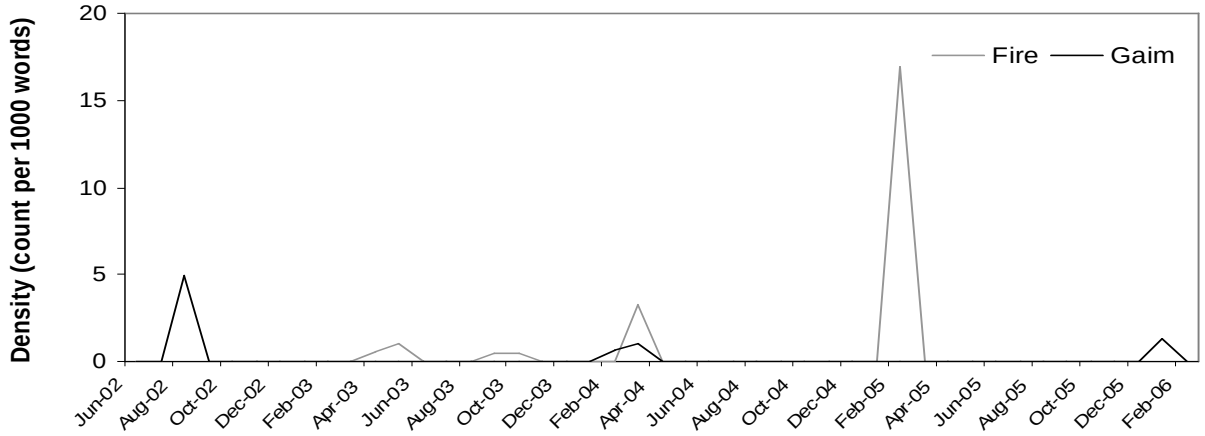



**Figure 7 Density of organizational citizenship behavior over time**



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