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EMERGENT DECISION-MAKING PRACTICES IN TECHNOLOGY-SUPPORTED SELF-ORGANIZING DISTRIBUTED TEAMS

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Abstract

We seek to identify work practices that make technology-supported, self-organizing, distributed (or virtual) teams (TSSODT for short) effective in producing outputs satisfactory to their sponsors, meeting the needs of their members, and continuing to function. A particularly important practice for team effectiveness is decision making: are the right decisions made at the right time to get the work done in a way that satisfies team sponsors, keeps contributors happy and engaged, and enables continued team success? In this research-in-progress paper, we report on an inductive qualitative analysis of 120 decision episodes taken by two Free/Libre Open Source Software development teams. Our analysis revealed differences in decision-making practices that seem to be related to differences in overall team effectiveness.

Keywords: Decision-making practices, technology-supported teams, distributed teams, self-organizing teams, virtual teams, Free/Libre Open Source Software development teams, team effectiveness, leadership

Introduction

We seek to identify work practices that make technology-supported, self-organizing, distributed teams (TSSODT for short) effective in producing outputs, meeting member needs, and continuing to function. A particularly important practice for team effectiveness is decision making: are the right decisions made at the right time to get the work done in a way that satisfies team sponsors, keeps contributors happy and engaged, and enables continued team success? We examine this question in the context of TSSODT because the decision-making practices of these teams emerge from the interactions of the team members rather than from organizational context. However, discontinuities between team members make such emergence and indeed any kind of consistent decision process harder to attain. Since TSSODT are increasingly used in a variety of settings, it is important that we understand how to make them effective.

In this paper, we have two primary objectives. First, we present a descriptive analysis of the range and evolution of decision-making practices in TSSODT based on longitudinal observation of 120 decision episodes that took place over time in two naturally occurring teams. We present this description in the form of a comparative case study that highlights differences in decision-making practices. Second, we begin the process of relating differences in these work practices to team effectiveness. Because we compare two teams that differ in success but are similar in other ways, we provide suggestions for future research on the relationship between decision-making practices and team effectiveness.

We examine in particular the decision-making practices of Free/Libre and Open Source Software (FLOSS) development project teams. Core FLOSS developers comprise a TSSODT because they have a shared goal of developing and maintaining a software product, are interdependent in terms of tasks and roles, and have a user base to satisfy, in addition to having to attract and maintain members. Developers contribute from around the world, meet face-to-face infrequently (some not at all), and coordinate their activity primarily by means of ICT (Raymond 1998b; Wayner 2000). Team members typically contribute to projects without being employed by a common organization. Although we focus on FLOSS teams, our findings will have implications for understanding all kinds of TSSODT because FLOSS development is an example of self-organized distributed work.

Literature Review

In this section, we very briefly review literature relevant to our study of decision-making practices in TSSODT. We consider as a team decision a commitment to particular course of future action that binds the team as a whole (versus individual decisions that bind just a single team member). Many kinds of decisions have to be made collectively by a FLOSS development team, ranging from procedural questions, such as which patches to accept, when to release a new version and with what content (e.g. Erenkrantz 2003), to strategic questions such as overall direction for development or system architectures, to group maintenance questions, such as whom to accept as a developer. We have identified these decisions as team decisions, since they affect and bind the entire group and the software they produce.

Of course, there is a huge literature on decision making in teams that is potentially relevant to our research but to which it is impossible to do justice within the space limitations of a research-in-progress paper. Broadly speaking though, these studies underscore the close tie between effective decision making and overall team effectiveness and the importance of understanding the practices by which decisions are actually made in teams. In the information systems literature more particularly, there have been numerous studies of ICT support for group decision making (e.g. DeSanctis et al. 1987; Fjermestad et al. 1998/1999; Turoff et al. 1993). Many of these studies have been design focused, offering important suggestions for systems to improve the process and quality of team decisions. For example, many studies have examined the value of structuring decision-making processes using software tools. Studies of groups in action have tended to adopt experimental methods and to focus on single episodes of decision making rather than on practices over life of an intact team (though there are exceptions, such as (Eden et al. 2001)). Broadly speaking, there is a relative lack of studies that examine what kinds of decision processes emerge in intact self-organizing teams, how these practices evolve over time, and how they contribute to overall team effectiveness.

Decision making is complex process involving a series of interrelated steps. A number of decision-making models have been proposed, both normative and descriptive (Vazsonyi 1990). Normative models suggest how people should

make decisions given stated considerations. Descriptive models, on the other hand, attempt to describe how decisions are actually made in real settings.

Several descriptive decision-making style typologies have been developed in the last forty years. Broadly speaking, they can be divided into two closely related categories. The first category, *Member Involvement Typologies*, is based on the extent of involvement by group members in the decision making process (e.g. Holloman & Hendrick 1972; Miller & Anderson 1979; Kameda 1991; Schwartz 1994; Rebori 1998). The second category, *Leader-centric Typologies*, also focuses on the extent of member participation but differs from the first category by virtue of a premise that assumes that a formal leader determines the degree to which participation occurs (e.g. Blankenship & Miles 1968; Vroom & Yetton 1973; U.S. Army Handbook 1973). Typologies in both categories describe styles that range from a single, autocratic decider (e.g. Dictatorship Rule, Assigned Decision) to broad participation (e.g. Consensus). Examples of these typologies are given in Table 1, below.

Table 1. Typologies of Decision-Making Style

Member involvement typologies					Leader-centric typologies		
Holloman & Hendrick (1972)	Miller & Anderson (1979)	Kameda (1991)	Schwartz (1994)	Rebori (1998)	Blankenship & Miles (1968)	Vroom & Yetton (1973)	U.S. Army Handbook (1973)
Leader decision	Dictatorship rule	Assigned decision rule	Decision by authority rule	Assigned decision - maker	Personal initiation	Autocratic-I	Authoritarian or autocratic
Committee decision	Majority rule	Deliberation style	Decision by minority rule	Minority rule	Autonomy from superiors	Consultive-I	Participative or democratic
Majority vote	Unanimity rule		Decision by majority rule	Majority rule	Perceived influence on superiors	Consultive-II	Delegative or Free Reign
Consensus			Decision by lack of response	Consensus	Reliance on subordinates	Group process	
Consensus after majority vote				No decision	Final Choice		
Averaged decision							

Decision making has been examined in several studies of FLOSS teams. Similar to studies of Group Decision Support Systems, some authors have noted the possibility of using software to encode and enforce particular work practices (Halloran et al. 2002). One common concern has been participation in decision making. At one extreme is a style where decisions are taken primarily by a few central participants, even a single individual, as in Linux, where Linus Torvalds originally made most of the decisions for the team (Moon et al. 2000). Such a decision style has been characterized as a “benevolent dictatorship” (Raymond 1998a). On the other extreme are teams with a decentralized communications structure and more consultative decision-making style. Some teams even settle decisions by voting (Fielding 1999). Of course, the decision style might be different for different kinds of decisions (e.g. decentralized for patches but centralized for strategic decisions). As well, the style might evolve over time as the project evolves. Fitzgerald (2006) suggests that a small group will control decision making early in the life of a project, but as the project grows, more developers will be involved. German (2003) documents such a transition in the case of the Gnome project. What is not yet clear is which of these styles is most effective and in what situations. Our study attempts to address this question, and this paper reports progress to date.

Methods and Data

To analyze the decision-making norms and processes of open-source projects, our research employs a comparative case study methodology, depending primarily on content analysis of the decision-making discussions. Because the team members interact primarily via ICT, to find these discussions, we analyzed the email discourse between

administrators, developers, and users that takes place on the developers' e-mail lists. Archives of these lists are available on project Web sites and from repositories such as Sourceforge.net¹.

Case SiteSelection

We picked two FLOSS projects to examine in detail, Fire and aMSN. We selected these projects by considering several dimensions to balance between maximization of variability and control of unwanted systematic variance. First, we controlled for topic. We picked two projects that both develop Instant Messenger (IM) clients, so the projects are essentially competitors, making comparisons of outcomes such as downloads or interest between these projects valid. Second, the projects are roughly similar in age and status (production/stable.) Finally, they are both hosted on SourceForge, providing some control for potential differences in development tools (which, as noted, could be used to structure decision making).

On the other hand, the two projects that we chose varied in their effectiveness. Project effectiveness is a multi-dimensional construct, including success of the project's outputs, team member satisfaction, and continued project activities (Hackman 1987). We therefore applied the multivariate approach to success suggested by Crowston et al. (2006) and looked at downloads as an indication of project output, as well as the number of developers and users attracted to the product over time as indications of member satisfaction and continued team performance. The array of measures presented in Table 2 and Figure 1, which use data collected by the FLOSSmole project (Howison et al, 2006) from the project birth until the end of 2004, suggests that aMSN has become a more successful project than Fire.

Table 2. Effectiveness Measures for aMSN and Fire			
Criteria		aMSN	Fire
Popularity	Average number of download/ per month (Figs 1a & 1b)	91,415 (Increasing)	18,066 (Decreasing)
	Number and range of spin-offs projects	Ported to Mac OS X	Not ported
Activity	Sourceforge Activity Percentile (Fig. 1e) (100 th means most active)	99th	94th
	Average number of tracker items /month (Figs 1c & 1d)	Opened: 56 Closed: 42	Opened: 47 Closed: 30
	Average number of developer mailing list posts/month (Fig. 1f)	542	93
Ability to attract and retain members	Tendency of change in number of community members (Fig. 1g) and developers (Fig. 1h)	Always Increasing	Stagnant or falling

¹ Because postings to lists are intended to be publicly accessible, our human subjects review board considers them public behavior, and so does not require formal consent to study them.

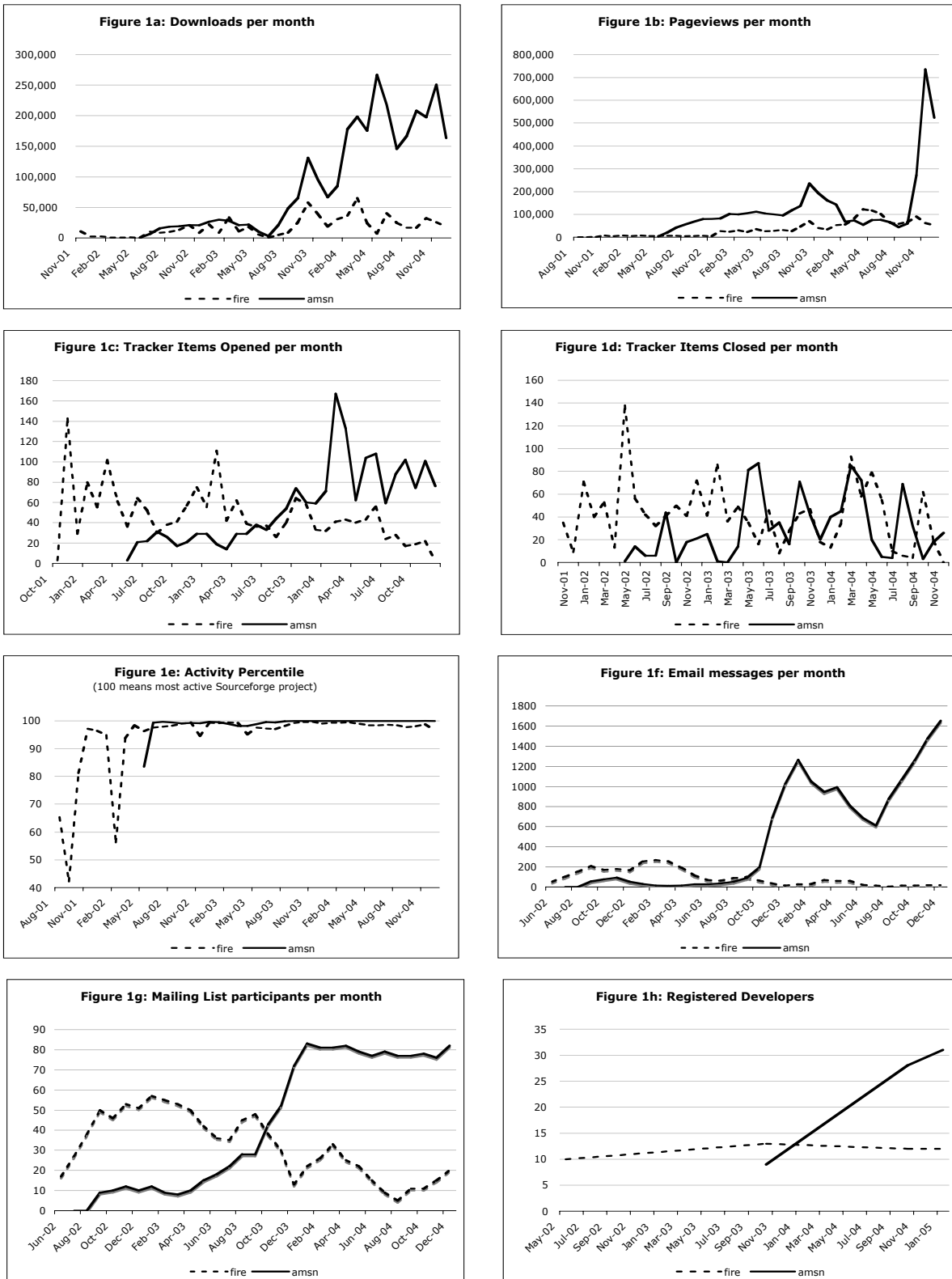


Figure 1. Comparison of Success Measures Between aMSN and Fire.

Unit of Analysis: Decision Episodes

To analyze the email discussions, we selected the decision episode as our primary unit of analysis. We chose episodes rather than words, sentences, paragraphs, messages, or thematic units because the decision process we wish to understand is at its essence a process of interaction, making it important to capture the full interaction. In FLOSS projects, decision making occurs as a process that unfolds when project administrators, developers, and users interactively respond to triggers that present opportunities for the group to choose. Thus, to analyze decisions, we examined the group of email messages that reflect as complete picture as possible of the process of decision making related to an issue. More specifically, we defined a decision episode as a sequence of messages that begins with a message containing a trigger that presents an opportunity for choice (such as a feature request, a software bug report, or a presentation of a strategic problem). It includes discussion related to the issue and a decision concerning the stated opportunity.

In order to observe potential changes in decision-making processes and norms over time, we sampled 20 decision episodes from three similar time periods from each project. The *Beginning* period for each project consisted of the first 20 decision episodes observable on the developer mailing list. The *Ending* period for each project consisted of the last 20 decision episodes observable on the developer mailing list. The *Middle* period for each project consisted of 20 episodes surrounding a major code release approximately halfway between the *Beginning* and *Ending* periods. Table 3 shows the specific time periods sampled for each project. Note that differences in mailing list activity meant that the 20 episodes selected span different time periods in the two projects.

	Beginning period	Middle period	Ending period
Fire	6 months (2002/07-2002/12)	11 months (2003/09-2004/07)	13 months (2004/07-2005/08)
aMSN	7 months (2002/07-2003/01)	1 months (2004/01-2004/01)	2 months (2005/12-2006/01)

Analysis and Coding of Episodes

We began analysis of decision episodes by coding observable, manifest elements of content that would provide consistent descriptions of episodes. We coded: *number of messages per episode*, *duration of the episode* (in days), *total number of participants in the episode*, and the *role of each message's sender* (project administrator, listed developer, or user, according to the project Web page on SourceForge). We chose these manifest elements because they are directly related to the decision-making typologies described in the literature above.

Subsequent coding was inductive, with three independent analysts (PhD students, members of the research team, and co-authors of this paper) reading the episodes in order to understand the salient features of the decision process. Through several iterations, these independent coders identified and agreed upon five additional latent variables that were important to the decision process. Each episode was then formally coded by two analysts, with all disagreements discussed and reconciled to achieve essentially complete agreement. The latent variables identified and coded are: *decision type*, *decision trigger type*, *decision process complexity*, *decision announcement*, and *decision style*.

Decision Type. Initial inspection of the discourse in developer mailing lists suggested that two types of choice opportunities might be fruitful to systematically observe: CODE decisions, and Non-CODE decisions. The first type of episode involves decisions about the code itself: bug fixes, additions of new features, or enhancement of the final product through a change in code. The second type (Non-CODE) were those that involve other kinds of decisions such as choices about strategic direction, infrastructure, alliances and partnerships, etc., that do not result in changed code. While this distinction may seem straightforward, it is not always easy to identify when a decision — a

commitment to a future course of action — has been made. This deceptively simple dichotomy captures two basic types of decision that we believe will prove fruitful for much future analysis.

Decision Trigger Type. One goal of our inductive content analysis was to understand the types of triggers that presented opportunities for the group to choose. Thus, our coding has developed a preliminary and partial typology of triggers. Decision episodes about CODE are triggered by: (1) bug reports, (2) feature requests, (3) problem reports, (4) patch submissions, (5) release to-do lists, and (6) mixed (bug and feature) lists not specifically associated with releases. We have not yet systematically identified the trigger types for Non-CODE episodes, and have thus far coded them as “Other.”

Decision Process Complexity. Inductive analysis also indicated that some episodes required more complex decision choices than others. For example, some episodes involve a single choice that responds to a single straightforward trigger. These were coded as “Single.” Others responded in a linear, straightforward fashion to a trigger that contained multiple opportunities for choice (e.g. a release to-do list.) These were coded as “Multiple-Simple.” The most complex episodes were not straightforward or linear in nature. Regardless of the nature of the initial trigger, in these episode new, sometimes unrelated triggers created additional opportunities for choice throughout the episode. The initial problem(s) might be solved or remain unsolved, and the new problems introduced might also remain unsolved. These episodes, coded “Multiple-Complex,” closely resemble the garbage can decision opportunities described by Cohen et al (1972) in that a straightforward, sequential “problem-resolution” decision process was not observed.

Decision Announcement. In order to reliably determine that a decision had truly been reached, our independent coders coded the statement(s) that confirmed that a decision had been reached.

Decision Style. We are in the process of developing a typology of decision styles. The decision style will be coded for each episode. We will thus be able to determine if a project uses a single style, multiple styles, a predominant style, etc. (We plan to present these findings at the conference.)

This initial typology of latent variables provides the ability to concisely describe multiple characteristics of the decision-making process and allows us to measure the participation of various members in decision making, thus contributing to our first objective, providing a rich description of the evolution of decision-making practices over time and the connection between decision making and TSSODT effectiveness.

Findings

We have completed preliminary analysis of 120 episodes, 60 each from two projects. In this section, we present several elements of that analysis.

Duration, Length, and Participation in Decision Episodes

Figure 2 shows how decision episodes evolved in terms of duration and length. In Fire, the average decision episode lasted for 3.5 days in the early sampling period. Duration steadily grew until the average episode lasted 5.2 days during the final sampling interval. The number of messages, however, in a Fire decision episode decreased from 7.6 to 5.1 over the same time frame.

In aMSN, duration and length evolved differently. The average decision episode lasted only 2.6 days in the earliest sampling period. Duration rose slightly in the middle period, then fell to 2.2 days in the final period. Unlike Fire, the number of messages in a decision episode steadily increased over time, increasing to 16 messages per episode by the final sampling period.

A one-way ANOVA showed that differences between periods were not statistically significant in Fire. (Duration: $F=1.35$, $df=2$; $p=.27$; Number of messages: $F=2.15$; $df=2$; $p=.13$). Though duration in aMSN is relatively consistent ($F=.17$, $df=2$; $p=.84$), the number of messages in decision episodes in the later periods is significantly greater ($F=11.96$, $df=2$; $p<.01$).

A contrast between the two projects is also evident when we compare participation in decision episodes. Figure 3 shows that in Fire the average number of individuals participating in a decision episode shrinks from 3.4 to 3.2 over time. It is apparent that this drop in participation occurs in core members (administrators) rather than in users.

In MSN, on the other hand, average participation steadily increases over time. In this project, the growth in participation is attributable to developers and users, while participation by administrators remains relatively constant.

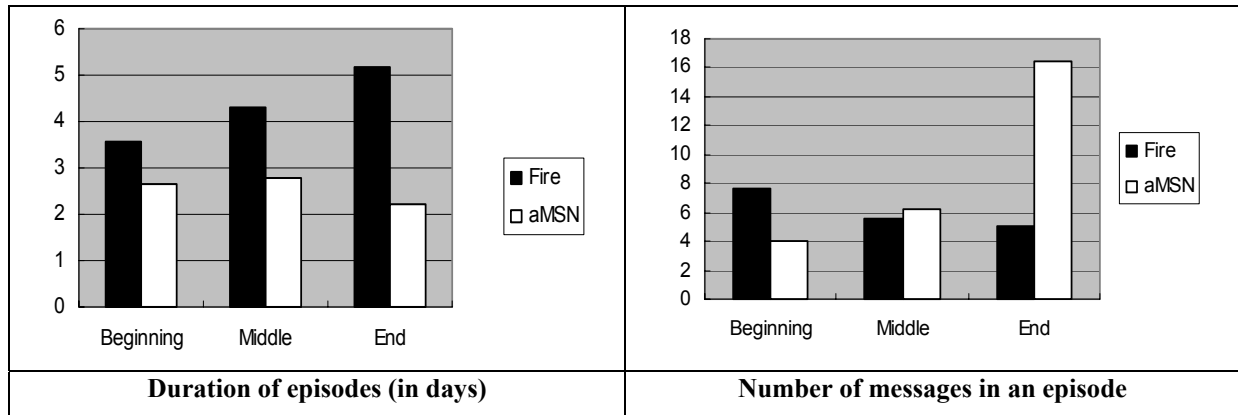


Figure 2. Average Duration and Number of Messages in a Decision Episode for Fire and aMSN across the Different Sampling Periods. Note differences in scales.

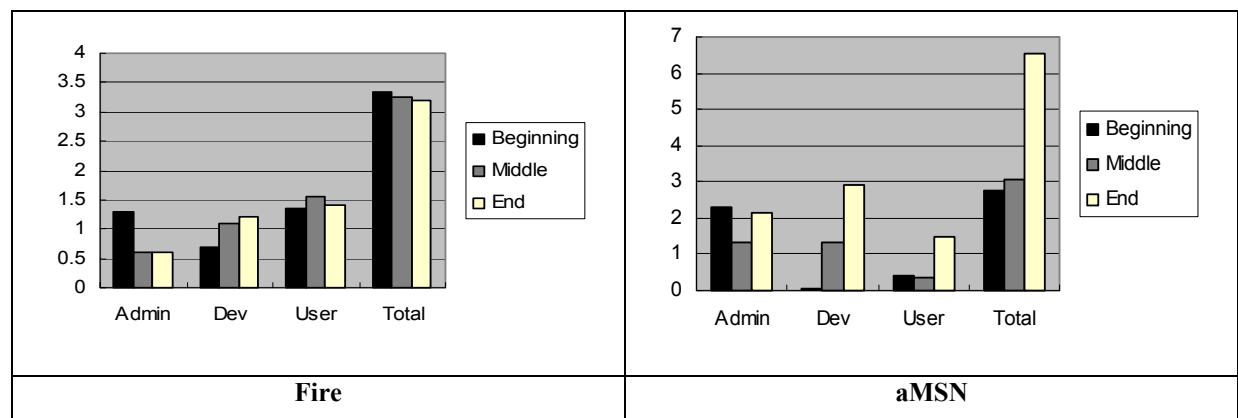


Figure 3. Comparison of Average Number of Administrators, Developers, and Users Participating in Decision Episodes across the Different Sampling Periods. Note differences in scales.

One-way ANOVA shows that the involvement of participants is relatively level overall in Fire over time (Number of total participants: $F=0.05$, $df=2$; $p=.95$) although participation by Administrators shrinks and participation by developers rises (Number of Administrator: $F=13.49$, $df=2$; $p<.001$, Number of developer: $F=2.04$, $df=2$; $p=.14$; Number of user: $F=.22$, $df=2$, $p=.80$.)

However, in aMSN, the total number of participants in decision-making episodes increased dramatically ($F=14.536$, $df=2$; $p<.001$), mainly due to increasing involvement of developers and users (Developer: $F=29.21$, $df=2$; $p<.001$; user: $F=6.62$, $df=2$; $p<.01$). Administrator involvement decreased in the middle period but remained relatively constant in Beginning and Ending periods.

These comparisons suggest that the two projects' decision processes (a) had significant differences, and (b) evolved differently over the sampling intervals. Over time, Fire's decision episodes gradually began to take longer, contain fewer messages, and include fewer participants, especially fewer Administrators. aMSN on the other hand made decisions relatively faster, even when the participation of developers and users was growing. These patterns indicate increasing interest, energy, and inclusiveness in the decision processes at MSN, while Fire's patterns indicate a leveling off of interest and energy, especially among Administrators.

Who Triggers Decision Episodes and Announces Decisions?

In order to better understand the role played by core and peripheral members of the projects in creating decision opportunities for the group, we examined who sent the message that triggered decision episodes, and who sent the message(s) that announced decisions. Figure 4 shows that all three groups played a role in triggering decision opportunities, but that there were differences between projects, and from time period to time period.

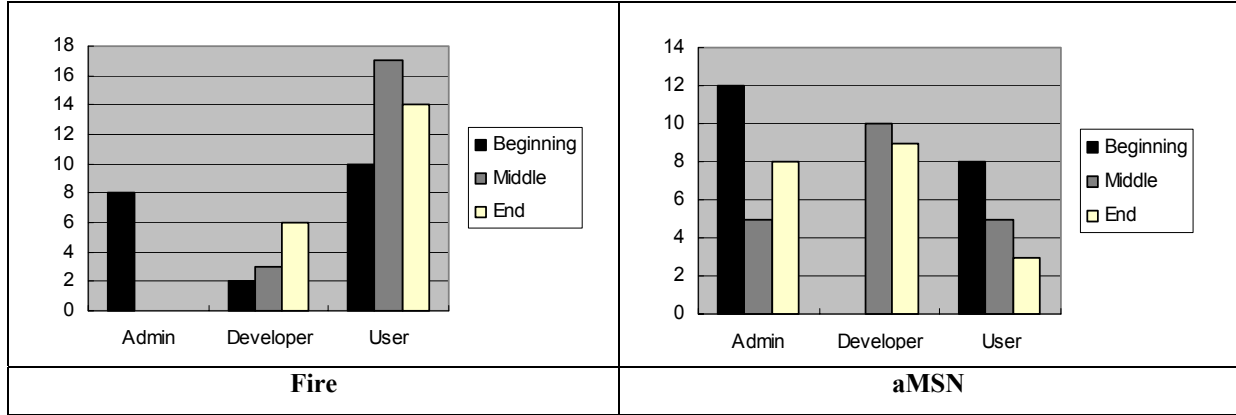


Figure 4. Comparison of the Role of the Sender Triggering a Decision Episode across the Different Sampling Periods. Note differences in scales.

There are significant relationships between sampling period and the person triggering episode in both cases (aMSN: $X^2=14.91$, $df=4$, $p<.01$; Fire: $X^2=20.17$, $df=4$, $p<.01$) The opportunities for decision-making in aMSN were originally initiated by Administrators and Users. In later periods, administrators and users decreased their activities and more developers became involved in this process, suggesting the growth of an energized core of developers.

In Fire, Administrators originally triggered opportunities but dropped out later. Users continued to play a very important role in identifying problems and creating opportunities for decision-making, while Developers took up some of the slack for Administrators.

Figure 5 shows that users rarely announce decisions in either project. There are significant relationships between sampling period and the person announcing decision in both cases (aMSN: $X^2=22.04$, $df=6$, $p<.01$; Fire: $X^2=19.90$, $df=6$, $p<.01$), suggesting that change was taking place in both, primarily due to increasing activity by developers. In aMSN, administrators remained active, while in Fire they did not.

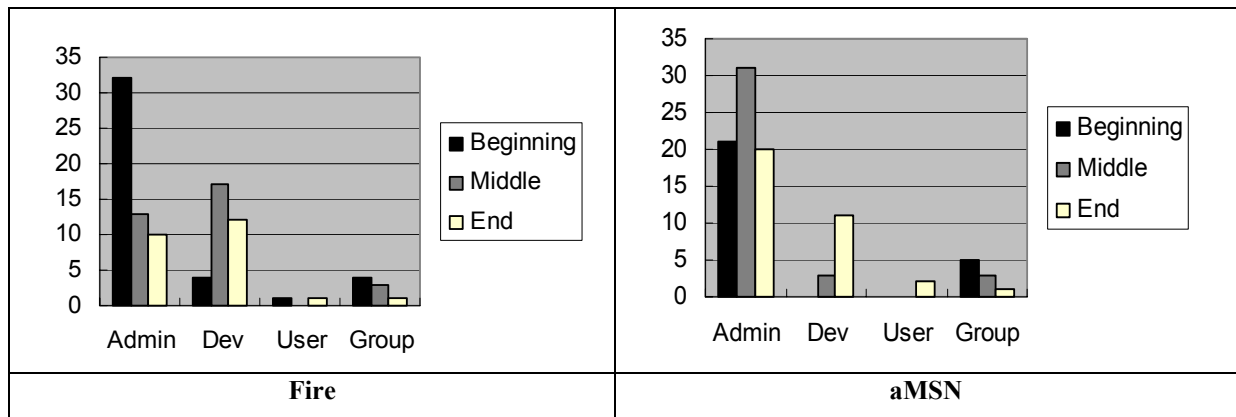


Figure 5. Comparison of Status of Individual Posting Message Announcing a decision across the Different Sampling Periods.

Decision Process Complexity

We are especially interested in episodes that are not straightforward or linear in nature. These “Multiple-complex” episodes appear to unravel in ways that are consistent with the garbage-can decisions modeled by Cohen et al. (1972) in that some original problems (triggers) remain unresolved while a variety of new triggers arrive late in an episode and attach themselves to existing decisions that seem to be waiting for them to appear.

Figure 6 shows the evolution of decision complexity in Fire and aMSN. A marginally significant relationship existed between sampling period and process type in both cases (Fire: $X^2= 8.00, df=4, p=.09$; aMSN: $X^2= 8.44, df=4, p=.08$). Fire apparently became more single focused, while aMSN became more of a “garbage can,” with the number of Multiple-Complex episodes increasing. Future analysis will look for causes of this increase.

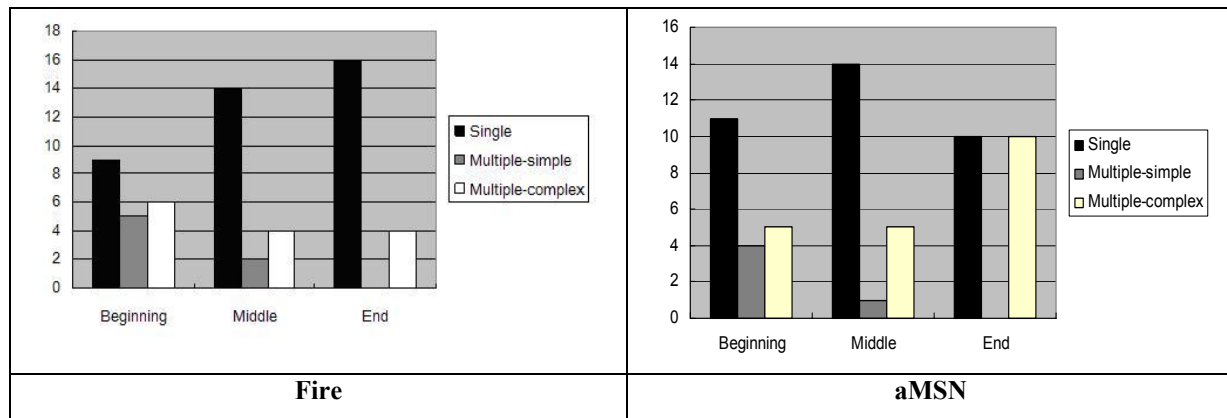


Figure 6. Comparison of Decision Complexity across the Different Sampling Periods. Note differences in scales.

Discussion and Conclusion

We have presented preliminary findings from a long-term research project that seeks to identify work practices that make technology-supported, self-organizing, distributed teams effective in producing outputs, meeting member needs, and continuing to function. This paper compared decision-making practices from two open source project teams. Preliminary findings suggest that there are significant differences in their practices. By sampling decision episodes over time, we have been able to demonstrate that each project presents an identifiable trajectory. In aMSN, that trajectory connotes acceleration and energy (growth in number of participants, shorter decision time, more inclusive participation, and richer and more complex decision-making episodes). Fire’s evolution, on the other hand, shows signs of deceleration and entropy (shrinking participation, disappearing administrators, longer decision cycles, and increasingly simple and less complex decision-making episodes).

These differences correspond to differences in a multivariate measure of project success that includes not only downloads but also development activity, spin-offs, and ability to attract and retain members. As Fire’s decision-making practices showed increasing entropy over time, the indicators of team effectiveness also showed signs of decline. Conversely, as aMSN’s decision-making practices showed increased energy, the indicators of team effectiveness showed improvement.

Because this research is in its early stages, we are reluctant to make strong assertions about the meaning of these correspondences. Based on this comparative case study, we can only point out the differences in decision-making practices, and hypothesize that they may be related to the differences in effectiveness, but we emphasize that any causal or even correlational claim would be premature. In the future, a more detailed longitudinal analysis of this data may permit stronger claims.

In order to further explore this potential relationship, we will next analyze a third IM project that also has been successful in order to see if the correspondences observed here are present. We plan to next analyze three Enterprise

Resource Planning (ERP) software projects to provide further generalization for our study. ERP projects are fundamentally different in the scope of the user universe they represent: while IM clients are more or less contained within the world of a server protocol and represent the world of a single user, enterprise software may be spread across multiple servers, and the system data represent an entire organization and its transactions. Within each topic, we plan to analyze projects that are essentially competitors, ensuring that comparisons between these projects are valid. This analysis plan will help us to better understand if the results observed here are generalizable to a wider universe of FLOSS projects, and ultimately to other types of TSSODTs.

While there is still much to be done, we believe that the variables and relationships we have identified provide the foundation for deeper exploration and potentially richer explanations of the relationships this quantitative content analysis reveals. By presenting this comparative descriptive analysis of the range and evolution of decision-making practices, we begin the process of relating differences in these work practices to team effectiveness.

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