The motivational arc of massive virtual collaboration

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Abstract

Massive virtual collaborations (MVC) involve large numbers of mostly unpaid contributors collectively creating new content. Wikipedia is the most dramatic example of MVC; smaller-scale examples include contributors to blogs and discussion groups and teams of programmers and users developing free/libre open source software (FLOSS). In this paper, we propose a model of motivations for contribution to MVC that integrates various theoretical perspectives. The model extends prior work by distinguishing three different levels of contribution to projects (initial, sustained and meta) and by capturing the dynamic and recursive effects of contributions on emergent individual and project states.

Introduction

The Internet has facilitated a new era of human collaboration. Novel information and communication technologies supporting online community spaces and shared information resources have created a new mode of coordinated effort among contributors, which we call "massive virtual collaboration" (MVC). The term massive virtual collaboration highlights the following signal features of these phenomena: large numbers of contributors, commensurate with the popularity of the activity but ranging from dozens to tens of thousands; mostly unpaid contribution by contributors, for reasons subject to much speculation but little data; and jointly focused activity, in which contributors collectively create new content, structure, presentation, and/or computer software with possible value to some larger audience. Wikipedia is the most dramatic (but hardly unique) example of MVC. This online encyclopedia has expanded rapidly (over seven million articles in more than 200 languages) due to the huge number of text contributions from voluntary contributors (more than 4 million account holders) who help to develop and edit content for the site. But MVC includes also smaller-scale collaborations, such as contributors to blogs and discussion groups on a wide variety of topics and the teams of programmers and users who develop free/libre open source software (FLOSS), contributing software, documentation and bug reports.

Motivation for contribution has been a consistent topic of research in these various settings, and researchers have identified a variety of factors that motivate contribution, as we review below. In this paper, we propose a model of motivation for MVC that integrates various theoretical perspectives to make three advances over the current literature. First, we note that understanding the motivations for MVC contributions is complicated by the great diversity in levels and nature of contribution. Therefore, our model distinguishes between three different levels of contribution (in what we call the motivational arc of contribution) drawing on different theories to explain motivation at each level. Second, we note that prior attempts to theorize motivation of contributors to MVC have generally considered the problem at an individual level and taking the project as a given context. This approach is an over-simplification because it is the contributions of developers that create the project context that motivates future contributions. Therefore, our model includes propositions concerning the effects of contributions on emergent states of the project as a whole. Finally, most prior models have been static, taking the state of the contributor and the project as fixed. Again, this is problematic because contributors and projects evolve as the result of contributions, thus changing the context for future contributions.

Therefore, our model includes propositions concerning the dynamic and recursive effects of contributions on individual states and on project states, and the effects of these emergent states on motivations to further contribute.

Theory development: Contribution and motivations for contribution

In this section we present our theory of motivations for contribution to massive virtual collaborations, drawing on and integrating several streams of prior research. By contribution, we mean the effort that is given by individual volunteers to create the collective good produced by the MVC, such as articles or other text for wikis and blogs; software, documentation, bug reports or tests results for FLOSS; and even videos or other multimedia on sites such as YouTube. By motivations, we mean factors that increase the chance that an individual will make a contribution. The model is shown graphically in Figure 1 below. The three stages of contribution are in the centre of the figure, with motivations for contribution to the left, individual emergent states below, feedback effects on the project above and outputs to the right. In this section, we first distinguish between different levels of contribution, before reviewing and integrating theories for motivations at each level.

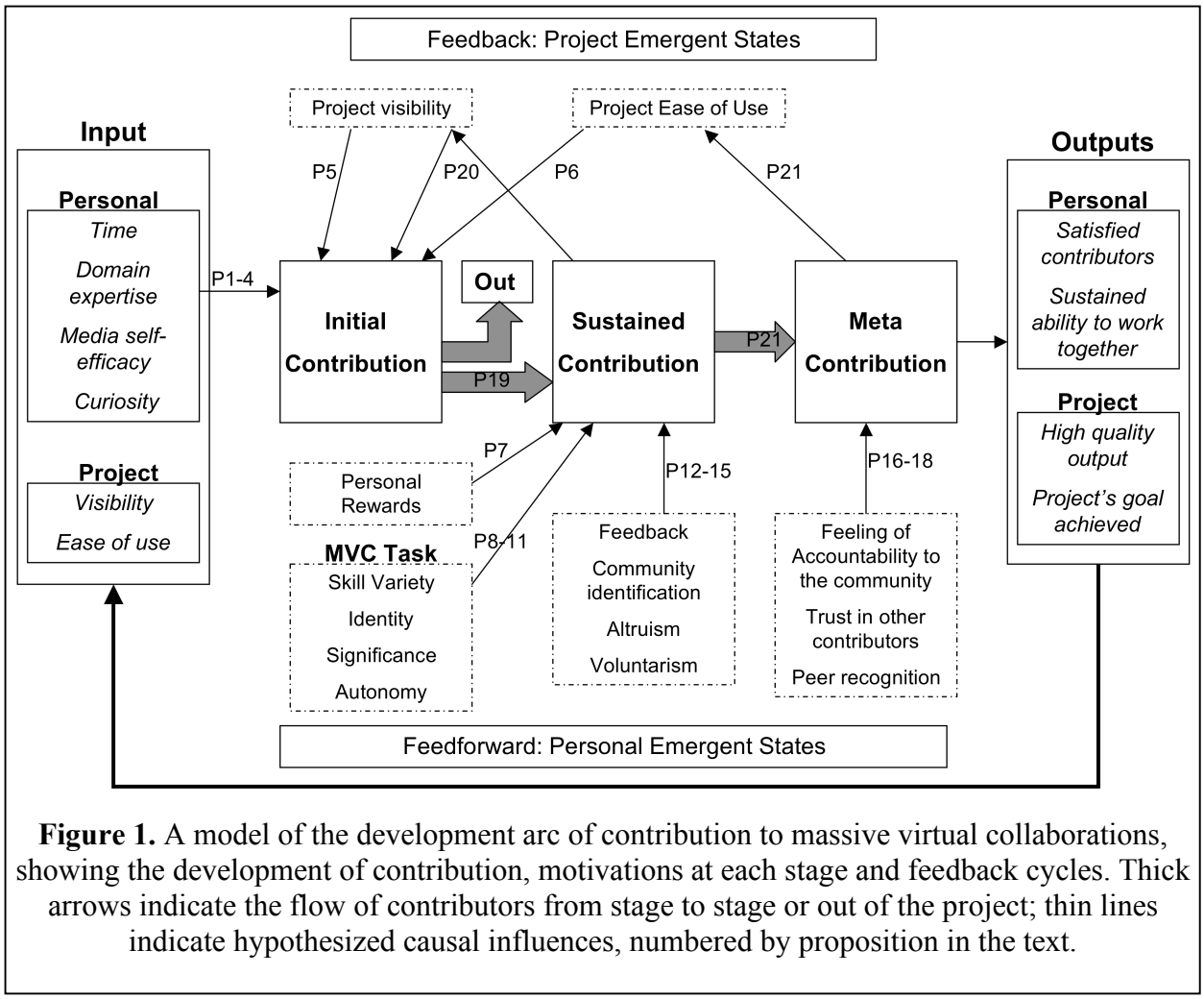

Figure 1. A model of the development arc of contribution to massive virtual collaborations, showing the development of contribution, motivations at each stage and feedback cycles. Thick arrows indicate the flow of contributors from stage to stage or out of the project; thin lines indicate hypothesized causal influences, numbered by proposition in the text.

The motivational arc of contribution

A key feature of our model is that we theorize separately about contributors with differing levels of contribution. Researchers have noted that the distribution of contributions to MVC is typically quite skewed, with a few people doing the majority of work, and the majority doing only a little (or none at all). For example, Mockus et al. (2000), in their study of the Apache community, observed that the top 15 contributors (out of 388 total) contributed over 83% of modification requests and 66% of problem reports. Crowston et al. (2006) found that the median size of the core group of 120 SourceForge teams was only 3 persons (about 5% of the total contributors). Similarly skewed distributions of contribution characterize other forms of MVC. On Wikipedia, only 25% of registered users have edited 10 times or more, and 2.4% of users have contributed 80% of the edits (Zachte, 2007). However, this inequality of contribution seems not to have been considered in work on motivations, which instead tacitly assumes that all contributors are alike, either in theorizing about motivations or in empirical study.

In our model, we distinguish three distinct levels of contributors, which we label initial, sustained and meta-contributors, each with particular motivations. Contributors begin their involvement with a project with an initial contribution and potentially evolve to further levels depending on personal and project factors, as we review below. Of course, the level of contribution varies continuously across members of a project, so any grouping into distinct categories is a theoretical abstraction. However, we argue that these groups do exhibit distinct patterns of involvement with different motivations, making the theoretical abstraction meaningful. While the details differ from project to project, we suggest that these different levels of contribution can be found across most MVCs.

The first and largest group we consider is the *initial contributors*. In most MVC, only a small fraction of users of a system actually contribute. For example, as of January 2007, Wikipedia was reportedly the 6th most popular website, visited regularly by an estimated 189 million users ("Awareness", 2008), but had only roughly 6 million registered accounts ("Statistics", 2008). Comparable ratios are reported for other MVC. We hypothesize that the move from consumers of the products of an MVC to contributors is largely curiosity driven and enabled by a low barrier to entry ("testing the waters"). It is striking that the majority of contributors do not participate past this initial trial. For example, numerous studies of FLOSS teams have found large numbers of contributors, but most contributors provide only a single contribution, such as a bug report or modification request (Howison *et al.*, 2006). Similarly, among the 6+ million Wikipedia accounts, the median number of edits is only 1. As a result, this stage includes the bulk of contributors, but since each makes at most a few contributions, the overall volume of their contributions is low. Still, because all contributors must initially pass through this stage, it is important to understand their motivations.

From the constant stream of initial contributors, perhaps 1–10% continue to participate regularly, thus becoming *sustained contributors*, the second group in our model. These contributors account for the bulk of contributions, as noted above, even though they are a small proportion of the total number of contributors. Finally, a very few sustained contributors, perhaps only 1% of sustained contributors, shift their focus from substantive contributions to become what we label "*meta-contributor*s," whose work structures and enables further contributions. For example, on Wikipedia, a few meta-contributors structure large sections of the encyclopedia, to

check that the style of articles is consistent or to administer the Wikipedia rules. Indeed, we suggest that the presence of such structuring and the resulting coordination amongst contributors is what makes MVCs collaborations. Comparable roles in FLOSS are members of a consortium that oversees projects, such as the Apache Software Foundation.

Motivations for initial contribution

We now consider motivations for each type of contribution in turn, starting with motivations for initial contribution. In each case, we consider both personal and project level factors that may be motivating, shown respectively to the left and below in Figure 1, reserving discussion of project feedback loops to the end. To explain initial contribution, we first draw on two theories, basic cost/benefit and expectancy theory. First, following early research on motivations for contribution to FLOSS, we suggest that a key factor for understanding how individuals first decide to contribute to a MVC project is the perceived comparison between barriers to entry and available personal resources, specifically time, since contribution often does not require other resources. Considering the later first, we propose:

Prop 1.	The more available time someone has, the more likely someone is to initially contribute to an MVC project.

To understand how an initial contribution might provide benefit, we draw on expectancy theory (Vroom, 1964), which hypothesizes an effect on motivation from the perceived link between expected effort and performance, and between performance and outcomes, as shown in Figure 2. We consider each in turn. First, factors that increase the perceived likelihood of the initial effort achieving a positive performance will increase motivations. Specifically, we propose:

Prop 2.	The more domain expertise someone has, the more likely s/he is to initially contribute to an MVC project.
Prop 3.	The more media self-efficacy someone has, the more likely s/he is to initially contribute to an MVC project.

Second, we consider the link from performance to outcomes. In the case of MVC, outcomes rarely include direct monetary benefit. We argue instead that in the case of an initial contributor, the result is simply satisfaction of curiosity about the project. Therefore, we propose:

Prop 4.	The more curious someone is about a project, the more likely s/he is to initially contribute to an MVC project.

We next consider project level factors that might influence an individual's decision to participate. A basic factor is simply having heard of the project at all. Specifically, we propose:

Prop 5.	The more visible the project, the more likely someone is to initially contribute

Furthermore, drawing again on expectancy theory, we suggest that projects that reduce needed effort or increase likelihood of effort leading to desired performance will increase motivations. Specifically, we propose:

Prop 6.	The easier it is to contribute to a project, the more likely someone is to contribute.

Motivations for sustained contribution

We next consider factors that might cause an initial contributor to go on to become a sustained contributor. Again, we begin with personal factors. In discussing motivations for initial contribution, we hypothesized that satisfaction of curiosity could be a motivation. However, such an outcome is unlikely to be motivating past the initial stage, which may explain why so few individuals go on to become sustained contributors. Drawing again on expectancy theory, we suggest that motivations for sustained contribution will come from anticipation of some other personal gain, beyond simple curiosity. For instance, for FLOSS developers, reward motivations appear to include factors such as personal interest, enjoyment of programming and development of knowledge or programming skills (Ljungberg, 2000; Ye & Kishida, 2003). Researchers have also suggested that contribution could be signaling for future employers leading to anticipated salary gains. Specifically, we propose:

Prop 7.	The more personally rewarding someone finds contributing, the more likely s/he is to become a sustained contributor.

We note that many of the rewards mentioned above are intrinsic rather than external. To better understand why making MVC contributions could be intrinsically rewarding for sustained contributors, we draw on Hackman and Oldham's (1980) model of work motivations. They identify five job dimensions—skill variety, task identity, task significance, autonomy and feedback—that they suggest create positive psychological states about the work and thus lead to work motivation. Based on this model, we first suggest:

Prop 8.	The greater the perceived skill variety of the MVC task, the more likely a contributor is to become a sustained contributor.
Prop 9.	The greater the perceived identity of the MVC task, the more likely a contributor is to become a sustained contributor.
Prop 10.	The greater the perceived significance of the MVC task, the more likely a contributor is to become a sustained contributor.

Because MVC relies on voluntary contributions, we believe that it is generally high in autonomy, but projects may adopt different practices in how much autonomy they allow individuals.

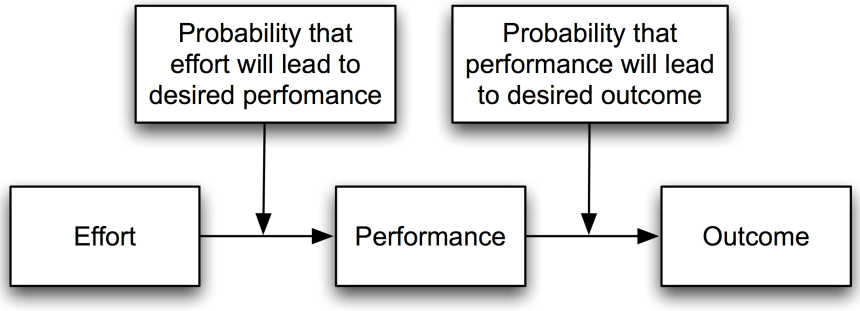

Figure 2. Major elements of expectancy theory.

Therefore, we suggest:

> Prop 11. The greater the autonomy of the MVC task, the more likely a contributor is to become a sustained contributor.

Hackman and Oldham's (1980) suggestion of feedback has been echoed in prior research. For instance, Bandura & Schunk (1981) claim that "consistent positive feedback should encourage high collective efficacy". FLOSS researchers often suggest that contributions to FLOSS projects are rewarded by recognition by peers and enhancement of reputation within the project or the OSS community more generally (Bezroukov, 1999; Markus *et al.*, 2000). We note the possibility of a virtuous cycle here: as an individual contributes, they become more visible, which increases the likelihood of feedback and thus further contributions. Therefore, we propose:

> Prop 12. The more feedback someone receives, the more likely s/he is to become a sustained contributor.

The above propositions have taken an individual perspective on the work. However, a key characteristic of MVC is that they are group activities. For example, some individuals may contribute because they enjoy teaching others or participating with others in a worldwide project. To understand the group nature of this work, we draw from research on communities of practice (CoPs). A motivating factor identified in this work is shared ideology. For example, Hodkinson and Hodkinson (2004) found that groups of teachers coalesced around shared ideologies of members of their CoPs (cf., Barab *et al.*, 2002; Hodkinson, 2004). This finding reveals an idea that may have application to the emergent social values of an MVC project. If members self-select and remain contributors in the MVC project on the basis of a belief in the similarity of their personal ideologies to those represented by the project, this may ensure a cascade effect on membership similar to what would be predicted by Schneider's attraction-selection-attrition framework (e.g., Schneider *et al.*, 1995; Schneider *et al.*, 2000). The attraction-selection-attrition framework provides a multi-level explanation of why large groups often become more homogenous over time with respect to the values or ideologies embodied in the group's mission and operations. According to Schneider, individuals join and leave organizations based on the degree of perceived alignment between their own personal value systems and those apparently espoused by the organization. Combining the attraction-selection-attrition framework with CoP perspectives on joining and staying suggests that the level of variation in ideologies represented among the contributors to an MVC project will decline over time as the identity of the group stabilizes. Therefore, we propose:

> Prop 13. The more a contributor identifies with the community, the more likely s/he is to become a sustained contributor.

Finally, because only a small percentage of individuals do go on to become sustained contributors, we consider that there may be personality factors that differ between contributors and others. For example, Clary et al. (1998) suggested that individuals contribute on an unselfish basis, springing from what Clary et al. (1998) identify as a combination of altruistic and humanitarian values. Therefore, we propose:

Prop 14.	The greater someone's feelings of altruism, the more likely s/he is to be a sustained contributor.
Prop 15.	The greater someone's feelings of voluntarism, the more likely s/he is to be a sustained contributor.

Motivations for meta-contributions

Finally, we turn to consideration of motivations for meta-contributors. Unlike regular contributions, we suggest that individuals receive little direct personal benefit from this type of contribution. As a result, we need to look beyond expectancy theory for an explanation for these motivations. We suggest that for a contributor to be motivated to provide this level of contribution, they must have feeling of accountability and trust towards the other community members. To explicate these motivations, we draw on the literature on Social Movement. Marshall (1998) defined a social movement as an organized effort by a group of people to effect societal change. Sociologists and political scientists have studied social movements almost since the birth of these disciplines, so a rich research literature has emerged containing explanations of popular and political movements, how they form, how they influence societies and governments, and how they decline. Because many or most social movements coalesce around a shared ideology, some of the literature in this area may apply to massive voluntary collaboration projects, to the extent that some of these projects also amalgamate on the basis of the shared values or goals of the contributors (e.g., Elliot & Scacchi, 2003), as discussed above.

Klandermans' (1997) model of motivations (as augmented by Simon *et al.*, 1998) suggests four distinct areas of motivation: reward motives, collective motives, social motives, and the identification with the group or a subgroup. Most of these motives overlap previously discussed motivations. Reward motivations are the personal gains realized by individual contributors. Collective motivations come from the individual's evaluation of the group's goals or ideology. Social motives are based on the direct social reinforcement provided others (e.g., praise, cf. our discussion above of the importance of feedback). Group or community identification means that individuals join a movement because of their feelings of being part of or wanting to contribute to a valued group. Group identification differs from social motives in that the latter arise directly from interactions with other people—whether group members or not—while the former is a preferred state of mind based on a sense of belongingness. Moreover, we argue that contributors who feel accountable to the group and have trust in other members will be more likely to become meta-contributors to a MVC project. Therefore, we propose:

Prop 16.	The more accountable someone feels for the community, the more likely s/he is to become a meta-contributor.
Prop 17.	The greater someone's trust in other contributors, the more likely s/he is to become a meta-contributor.
Prop 18.	The greater someone's recognition from peers, the more likely s/he is to become a meta-contributor.

Effects of contributions on emergent project states (and vice versa)

Finally, we consider how the contributions discussed above change the state of the project, and thus the motivations for future contributions (the top section of Figure 1). These

linkages are important because they provide a dynamic aspect to the model. Specifically, we propose:

Prop 19.	A higher level of initial contributions leads to more sustained contributions by increasing the flow of new members.
Prop 20.	A higher level of sustained contribution leads to more initial contributions by increasing project visibility.
Prop 21.	A higher level of meta-contribution increases sustained contribution by making it easier and more rewarding.

The interaction of these feedback loops is what drives the exponential growth experienced by successful MVC: as they attract contributors and contributions, their ability to attract further contributions is multiplied.

Example: Motivations in FLOSS development teams

As an example of the need for our model, we review prior work on motivation in a particular type of MVC, namely FLOSS development. FLOSS is developed by a globally distributed developer base and released under a license allowing further distribution and modification of the source. Characterized by a rapid and reliable software development process, effective FLOSS development teams somehow profit from the advantages and overcome the disadvantages of distributed work. FLOSS teams are nothing without participants and the question of what motivates participation has been a perennial issue in studies of FLOSS. Before examining the findings in this area, it is important to note that some developers work on FLOSS projects as part of their jobs. For example, Hertel, Niedner & Herrmann (2003) and Lakhani and Wolf (2003) both found that 40% of respondents were paid—not directly by the projects themselves, but by organizations who valued the project outputs. Still, many other developers contribute without formal compensation and even many of those who are paid still choose themselves the projects and nature of their contributions, making their motivations relevant to our theorizing.

The approaches adopted in this research and the findings are generally consistent with the theorizing developed above. In their study of FLOSS developers, Hertel et al. (2003) adopted the social movement perspectives of Simon et al. (1998), distinguishing reward, collective, social and group identification motivations. For OSS developers, reward motivations appear to include factors such as personal interest, enjoyment of programming and development of knowledge or programming skills (Ljungberg, 2000; Ye & Kishida, 2003). These motivations may have an indirect economic aspect, if increased skills are rewarded later by better job opportunities. On the other hand, empirical work on motivations has found little evidence for this motivations. This lack may be the result of methodological flaws, as surveys and interviews may be subject to reporting bias, or individuals may be driven by unexpressed motivations. Hann et al. (2002) surveyed Apache developers and found that greater open source participation, as measured in number of contributions made, was not associated with wage increases, suggesting that employers do not directly reward participants for their efforts.

Collective motivations for OSS developers include valuing the capabilities of the software (though some authors (e.g., Raymond, 1998) argue that this may be an individual

motivations), or ideological commitment to the development of Free Software. With respect to social motives, OSS researchers often suggest that contributions to OSS projects are rewarded by recognition by peers and enhancement of reputation within the project or the OSS community more generally (Bezroukov, 1999; Markus et al., 2000). Note, however, that self-perceived reputation within the community might be better conceptualized as an outcome of group identification (Dalle *et al.*, 2004). Other researchers have suggested the OSS functions as a gift economy, where contributions made are expected to be reciprocated (Raymond, 1998b) or even as a kind of kinship unit to which contributions are expected without keeping track of equity (Zeitlyn, 2003).

Available empirical evidence suggests that all four factors play a role in developers' decisions to participate. Ghosh et al. (2002) carried out a number of surveys of OSS developers: The most commonly given reason for participation was development of individual skills (almost 80% of developers), though the other three reasons were also endorsed by many. Hann et al. (2004), in a survey Apache developers, found five factors underlying participation: use value of software, reputation, career concerns, normative values and recreation. The dominant motivations (from a conjoint analysis) included increasing the contributor's use value of the software (27%) followed by the recreational value of the task (19%) and the potential career impacts from participation (12%). Lakhani and Wolf (2003) found that enjoyment and related "intrinsic" motivations were the strongest participation drivers. Chin & Cooke (2004) found that "aspects of the project that allowed for the development of technical skills, intrinsic and extrinsic motivation factors, and trust all correlated with intrinsic satisfaction." On the other hand, Hertel et al. (2003) found that level of self-identification as a "Linux Developer" was most predictive of time spent on that project.

In terms of our model, most of the research reviewed above has attempted to focus on sustained contributors though without making this focus explicit. We suggest that part of the reason for a lack of cumulation in prior work is the failure to distinguish these groups. In particular, we believe that responses from initial contributors likely dominate empirical results from surveys, since initial participants make up the bulk of contributors. Theoretical work, on the other hand, has mostly focused attention on motivations of sustained contributors. In terms of factors for initial contributors, Hertel et al. (2003) reported that active contributors to the Linux kernel reported "considerable tolerance of time investments on issues related to the Linux kernel." Aigrain (2003) suggested that lowering the costs of becoming an active contributor would prove to be an essential factor for the success of "open information communities" such as Wikipedia or Slashdot. As far as we know, no research has examined the role of meta-contributors.

Conclusions

In summary, we suggest that a cost/benefit perspective on contributing to MVC projects may help to explain individuals' initial decisions to contribute to a particular project (c.f., Ciffolilli, 2003), but other theories, including work satisfaction and social movements are needed to explain more intensive levels of involvement. By merging these different theoretical perspectives, we can understand the phenomenon of Massive Virtual Collaboration at multiple levels. We can use this information to help understand these efforts and eventually develop and provide the tools to a variety of organizations to run successful MVC projects.

This research has implications for both the academic and the practitioner communities. To the academic community, the proposed framework of research could guide future studies of motivations. In particular, following the framework, such studies ought to consider different kinds of contribution separately rather than treating them all the same. Looking at teams in varying stages of progression can help us understand the phases of development, growth and maturity of a Massive Voluntary Collaborative effort and help us refine the model as needed.

To the practitioner community, the framework provides an explanation of the motivations behind those who join Massive Virtual Collaboration projects and their existing efforts. By looking at these efforts in a broader context and at two levels—personal and project levels—we can understand how to make these efforts more fruitful which then can assist organizations as they work through development and implementation of virtual teams in their work practices. This would in turn result in more satisfied contributors with a sustained ability to work together and enhance the work product. Increasingly, many organizations with multiple locations use the Internet to facilitate communication and coordinate business operations. The potential appears to exist for massive voluntary collaboration (MVC) projects to uproot a variety of existing business models in the information sector (Carnevale, 1995; Castells, 1996; Pink, 2005). Not only does MVC appear to provide a novel basis for developing large scale information products in a decentralized, non-commercial manner, but it also may give rise to a new "amateur class" of information product developers who short circuit the standard paths of education, hiring, supervision, and professional attainment that have played a role in supporting the existence of traditional organizational forms. Major software development companies have already lost market share to open source software, some consumer products manufacturers have felt the blows of poor reviews from collaborative online reputation systems, and encyclopedia developers must have at least a small taste of fear about the rise of Wikipedia.

As organizations become more dependent on technology to facilitate collaborative efforts, it becomes important to understand the lifecycle of such events. This paper provides a framework for understanding the motivations behind those who join such efforts, the use of technology and how efforts become a part of the fabric of society. By looking at these efforts in a broader context, we can understand how to make these efforts more fruitful for contributors and for those who benefit from their voluntary efforts.

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