Crowds and Communities: Light and Heavyweight Models of Peer Production

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Abstract

Two collaborative forms of organizing dominate discussion of open participation and production on the Internet: a crowdsourcing model based on micro-participation from many, unconnected individuals, and a virtual community model, based on strong connections among a committed set of connected members. This paper argues that dimensions such as task interdependence, authority control, and group focus underpin behaviors associated with participation in such open systems, resulting in contributory behaviors that can be described at one end as 'lightweight', functioning by weak-tie attachment to a common purpose, enacted through authority-determined, rule-based contribution, and at the other end as 'heavyweight', operating through strong-tie affiliation with community members and community purpose, enacted through internally-negotiated, peer-reviewed contribution. Examination and articulation of these dimensions, and the resulting patterns of contributory behavior they engender, help reconcile peer production and virtual community approaches to online collaboration, explain motivational and structural aspects of new forms of collaborative production, and inform design for building and sustaining collective contributory systems.

1. Introduction

As production turns to Internet-based collaborations – supported and often driven by movements of open source, open access and open content – there is an increasing need for more fundamental understanding of the operation of these enterprises. Questions arise such as: What are the optimal structures for contributory practices? What motivates individual contribution where the traditional rewards of creation and invention – financial reward, ownership of ideas, fame – are delayed, transferred, or foregone? What models of contribution drive these new economic and personal production mechanisms? How should social and technical systems be designed to promote contribution and participation?

The new open movements are increasingly identified with the idea of 'peer production' and in particular 'commons-based peer production' as described by Benkler [2][3][4]. Spurred on by the Free/Libre/Open movements as exemplified in open source software (FLOSS), Raymond's characterization of the cathedral and the bazaar [39], and initiatives such as Wikipedia, this perspective provides insight into the economic benefits of voluntary micro-participation by many contributors. While much attention is given to the process of crowdsourcing [25][27], i.e., gaining inputs from many, unknown and unconnected contributors, inherent in many of these collaborations is also a strong attachment to community, including the highly local community of fellow contributors, the larger community of interest around the topic and purpose of production, and the societal community of open source/open access.

This paper argues that two patterns of engagement are operating within peer production enterprises, with one pattern emerging at the crowdsourcing end, with relatively anonymous and independent contributions supporting the goals of a project organizer, and the other pattern emerging at the virtual community end, with named contributors joining and gaining status within the enterprise, participating in decision-making and agenda-setting as internal project promoters and as active co-constructors of enterprise management. While elements of both patterns will be found in existing peer production enterprises, the argument here is that the distinction between these patterns reveals insights into the organization of contributory behavior in open source environments. The paper also argues that it is the backdrop of the Internet and the open source/open access movements that have not only opened the door for these enterprises, but have also formed the foundation for trust in these voluntary enterprises.

2. Crowds and Communities

The idea of crowds and communities provides the basis for identifying two contrasting models of peer production processes. First, a crowd model can be described that is based on a simple form of peer production where contribution is defined in a way that

requires little learning or qualification for contribution. Knowledge of what to do and how to contribute are defined by authorities or owners of the enterprise in such a way that contributors can easily begin to provide input. To avoid connotations from existing ideas of peer production, this form will be referred to here as a *lightweight peer production* (LWPP), where 'weight' is used to refer to contributors' commitment and engagement with the production and with each other, not to the significance of the product.

An LWPP draws on a large set of contributors each of whom provides minimal, rule-based additions to the product as a whole. For example, they provide access to idle computer time (as in the SETI@home project), or they follow rules to identify craters on Mars (NASA Clickworkers). The lightweight peer production enterprise is oriented to independent contribution, and is not primarily designed to create or maintain relationships among contributors. Contributors do not need to make a long-term commitment to the project, the group, or its members; they can drop in and out easily with little long-term commitment to the project. Nor are contributors expected to play an ongoing role in determining the course of the enterprise as a whole. It can change or be terminated at the discretion of the owner/operators.

The power of the lightweight model is that the contribution is straightforward enough for participation by as many people as possible, with contributions independent enough to alleviate coordination among contributors or contributions. Participation can be motivated by interest in the particular endeavor (e.g., SETI's search for extraterrestrial life) and/or some minimal recognition of individual efforts such as recognition in the form of contribution statistics. Also, for many enterprises, contributors are motivated by the idea of contributing to free/libre efforts. Coorientation to ideals of peer production and open access as new economic models provide an intrinsic motivation for the donation of time or computer resources. Together the intrinsic motivations of personal interest, coorientation to free/libre goals, and minor recognitions form the reward system that stimulate and sustain contribution in lightweight peer production systems.

Contrast this discrete-unit contribution system with building and sustaining virtual communities. These collective enterprises require peer interactions that make and sustain the community. This will be referred to here as *heavyweight peer production* (HWPP). The heavyweight model involves not only contributions to the product, but also attention to the actions and contributions of others, and a commitment to maintaining and sustaining the direction and viability of the community. Its 'weight' reflects the commitment to the enterprise as a whole, including internal processes as well as products, the social and emotional experience of the community, and its continued existence.

Heavyweight enterprises depend on a critical mass of contributors who give significant portions of their time and energy toward defining and maintaining the rules of operation. Such involvement requires engagement with others, encouraging contribution from all members, building internal structures and norms collectively and collaboratively. Learned norms of interaction, conversation and participation are highly important for signaling membership in the whole, and lack of proper behavior marks the contributor as an outsider or apprentice in the community. Contributors design and operate this kind of virtual enterprise; it is by their contribution that the enterprise grows, changes, responds to change, and survives.

The power of the heavyweight model is that peer production applies equally to the product and the operation of the enterprise, potentially creating more sustainable long term activity. As for lightweight models, contributors in heavyweight enterprises can be motivated by interest in the particular endeavor and a coorientation to peer production and open access. However, recognition extends to include not only quantity of contribution, but also quality (peer-rated). Recognition also extends to evaluation of the contributors themselves, e.g., in the quality of contributor's personal conduct, interpersonal behavior, helpfulness and support, or efforts in support of communal goals.

Considering existing peer production enterprises, it is possible to see some as essentially lightweight models, and others as essentially heavyweight. However, problems arise immediately as it becomes evident that purportedly lightweight enterprises actually entail considerable attachment to community operations and members. The argument here is that the usefulness of the light to heavyweight distinction is in identification of *two overlapping patterns of collaborative, contributory behavior* rather than as a classification of existing enterprises. Thus, it is possible to find that lightweight practices emphasizing discrete contributions from a large number of individuals may dominate or co-exist with heavyweight practices associated with the products and process of the peer production, coordinated among a limited set of engaged participants. A few examples will help illustrate where light and heavyweight practices dominate in collaborative production systems.

2.1. Examples at the lightweight end

At the extreme lightweight end are distributed computing applications such as SETI@home (http://setiathome.berkeley.edu/). This distributed computing effort uses idle computer time on volunteers' computers to search for radio signals that may indicate extraterrestrial life. Originally developed for SETI (Search for Extraterrestial Intelligence), the Berkeley Open Infrastructure for Network Computing (BOINC)

now supports a number of similar applications using time on volunteers computers (see http://boinc.berkeley.edu/projects.php). The participant's obligation is to download the BOINC program and provide access to their computer for SETI use. At present the SETI site also provides information about the project, message boards and profiles for users, and statistics on use. Participation is recognized by statistical summaries of contributions of computing time ('credits'). Individuals, teams and regions of participants can see their number of recent and total earned credits in comparison with others. Aggregator sites can give totals across various BOINC applications, or across these and other non-BOINC, distributed computing applications. Statistics on contribution are a visible sign adopted by contributors for competitive status, and provide an important motivator for contribution [26]. As described on the DC-Vault site (http://www.dc-vault.com/):

> "The DC [Distributed Computing] Vault is the place to compare your team's performance against others, the place to look out for when you plan your next taunting fest, the place you can refer others to and brag about how devilishly high ranked your team is ... or not."

Another form of lightweight collaboration is exemplified by NASA's Clickworkers project (http://clickworkers.arc.nasa.gov/). This crowdsourcing project relied on human perception to complete a task not easily programmed into computers. As the site says,

> "There are many scientific tasks that require human perception and common sense, but may not require a lot of scientific training. Identifying craters on Mars is something almost anyone can do".

The participant's obligation was to take the online training session, then access images of Mars and mark craters where appropriate. The application was experimental, but proved to be a success. Results are available in documents reporting on overall results, but not for individual participation. Projects following the same idea are being implemented for determination of geographic features (AfricaMap), and identification of hominid fossils (http://www.planetary. org/programs/projects/setiathome/setiathome_20080115.html.) In these applications, some training is needed, but it is kept simple enough for many to be able to participate.

Other collaborations involve greater complexity in the rules to follow, but still encourage contribution from as many people as possible. For example, the Mozilla site encourages bug reporting from those with both low and high technical expertise (http://www.mozilla.org/contribute/). With higher technical competence, participants are encouraged to use newly released software and all are asked to follow guidelines for entering software bug reports (e.g., http://www.mozilla.org/bugs/bug-reporting.html). Other kinds of projects require more screening of participants. For example, the Flora of North America project (www.fna.org/FNA) accepts submissions only from expert participants approved by the editor, with these also evaluated by approved reviewers. Detailed guidelines are provided for the proper formulation of contributions of plant descriptions.

These collaborative ventures all have in common the description of rules by authorities beyond the individual participants and contributions of similar, often scripted, form. Although contributions may range from passive to active, and simple to complex, how and what to contribute is clearly defined. In terms from organization theory, the tasks involve *uncertainty*, in the Perrow [34] sense of lack of information, rather than *equivocality*, where there is a need to negotiate an interpretation.

2.2. Examples at the heavyweight end

Heavyweight collaborations contain some form of equivocality such that the participants themselves determine and enact the goals, purposes and processes for the enterprise. Instead of appealing to written rules and procedures, participants turn to other participants and others' contributions to determine their own contribution. Instead of crowds, HWPPs involve a smaller set of contributors who give more significant portions of their time and energy, and add contributions of different shapes and sizes. Most listservs supporting communities of inquiry operate in this way. Individuals read and respond to others' posts, get to know others through their posts, get to know the norms of participation and enact this through conformity to norms in their own submissions and policing of the contributions and behaviors of others. Norms are continuously emergent from group behaviors. (For more on virtual communities, see [12][20][22][23][28][32][36][37][49]). Since each contribution can differ, the need to negotiate what constitutes a contribution arises, and thus heavyweight enterprises turn to qualitative judgments and forms of peer review in assessing contributions (see below).

One of the most long-standing and (apparently) successful models of peer production is that of the *academic community* [48], and it is an example that will be referred to throughout this paper. Academic communities and their 'invisible colleges' [11] exemplify heavyweight collaborations, with community influence evident in the intense intra-disciplinary focus on practices and the peer review processes that form strongly-tied communities of interest ([10][29][48]). There are several further aspects of contemporary academic work that make it a particularly good example for consideration in connection with open source projects. First, academia is more than just a model of virtual community because academic contributors are also strongly motivated by principles of openness, including a commitment to ideas of open science stemming from the 17th century [48]. Second, the Internet

has stimulated new means of achieving such openness, marrying the principle of open science with the reward of visibility of individual's work. The open access/open science movement in academia is gaining momentum, exemplified by the creation of institutional repositories, open publishing in blogs, websites and webpages, and open access journals. The backdrop of commitment to a open movement situates this collaborative effort in a separate realm from proprietary virtual community efforts, and thus provides an ideal example of heavyweight peer production stimulated and motivated by an open movement.

2.3. Examples of dual weight enterprises

As noted, the caveat in considering peer production enterprises as situated on the light or heavyweight end of a spectrum is that many enterprises exhibit characteristics of both. Although the examples above fall more or less clearly at one or other end of the behavioral spectrum, many on-the-ground peer production enterprises entail both a crowd and a community. Also, it can be expected that behaviors in new communities or by new community members may more closely resemble that of crowds than of communities as norms are learned and established.

Wikipedia provides an interesting model that demonstrates both light and heavyweight behaviors: lightweight from the crowds who enter, edit and update entries; heavyweight from the inner circle of editors who determine such things as what is a "keeper" article [15] and the "Wikipedians" for whom "Wikipedia as a whole becomes more important than any single article or set of articles" ([8], p.4). Consonant with a heavyweight endeavor, Wikipedia stresses "a very strong buy-in to consensus decision-making":

> "Consensus is not the same as majority, it signifies that the concerns and views of minorities should be taken into account in the attempt to gain a decision which reflects community values and which most can live by to some extent or other."

Significant for community efforts is that this 'consensus-based ethos' applies to both content and process. The entry on Editorial oversight continues: "Most policies and procedures also develop and become refined in this same manner" (http:// en.wikipedia.org/ wiki/Wikipedia:Editorial_oversight_and_control).

3. Articulating Dimensions

Building from the examples above, it is possible to articulate dimensions of collaborative activity along which light and heavyweight productions vary (summarized in Table 1). As introduced above, a primary dimension distinguishing light and heavyweight peer production relates to the ***contribution type, granularity and authentication***. In lightweight enterprises the contribution is straightforward, with easy to learn rules, coordinated by pooled interdependence of similar contributions; heavyweight contributions require greater learning, with contributions evaluated by other participants in a peer review process, and the overall product coordinated through reciprocal interdependence. The second dimension relates to ***individual to group focus***. This affects the extent to which the enterprise can, or must, depend on the attention that participants give to other contributors and others' contributions. These two dimensions form the basis of the third dimension: the ***recognition, reputation, and reward***. Together these dimensions provide insight for individual motivation for contribution. The next sections discuss these dimensions further with particular attention to consequences for contributor motivations.

Table 1. Dimensions of light and heavyweight collaborative activity

LIGHT	HEAVY
Contribution Type, Granularity and Authentication	
• Atomistic, independent • Addressing uncertainty, explicit knowledge • Rule-based contribution • Delimited contribution attributes • Single form defined by authority/owner, authenticated by formula • Pooled interdependence	• Connected, revised, negotiated • Addressing equivocality, tacit knowledge • Negotiated contribution • Variable contribution attributes • Multiple forms defined and authenticated by group consensus, norms • Reciprocal interdependence
Individual to Group Focus	
• Anonymous • History of contribution unnecessary • Open membership; low effort to enter • Two-tier hierarchy: authority, contributor • Independent, repetitive, discrete contributions	• Attributed • History of contribution important for group • Review, gatekeeping to join; high effort for membership • Multi-tier hierarchy: novice to expert, newbie to experienced • Continuing, contingent, norms-based contribution to product and process
Recognition, Reputation, Reward	
• Quantitative recognition mechanisms, e.g., contribution rate • Internally relevant to the individual application or the arena of contribution • Quantitative measures of contribution to product	• Qualitative recognition • Internally relevant, permeable to field of interest • Internal: judgments of contribution quality, expertise • External: judgment of contribution quality, expertise re field of interest • Peer review (qualitative) judgments of contribution to product and process

3.1. Contribution type, granularity and authentication of contributions

Lightweight peer productions operate by garnering discrete contributions to a greater whole. Because they

operate by contributions from unconnected individuals, the overall enterprise is created and operated by an authoritative set of individuals who are external to the contributors. These authorities enact rules and implement technologies that support the easy deposit of individual contributions, and their integration into a whole. Thus, lightweight production is an *enterprise of coordination,* with each contributed unit finitely defined. Systems that operate on discrete contributions have a *pooled interdependence* [44]: each piece of work contributes to the whole but is not contingent on other pieces.

Lightweight enterprises are likely to work best where the contributory unit is of a size that fits contributors' time, energy and attention. As Benkler [3, p. 9-10] writes, peer productions require a "basic unit of contribution that is sufficiently coherent to form a significant enough contribution to advance the project":

> "Once the cost of participating in the production of something useful is lowered sufficiently, the question of motivation becomes trivial. Someone, somewhere, will have a few minutes or an hour to perform an act, if that act can be performed … in a way that creates a persistent and useful object." ([3], p. 9-10)

Yet, how much time something takes, and how easily it can be dealt with as one coherent unit, depends as much on the *experience and expertise of the contributor* as of the unit size of the contribution. "The larger the granules the more is required of each contributor, the smaller the set of agents who will be willing and able to take a crack at the work" ([3], p. 22). For example, it is easier for someone familiar with the technical structures of a wiki to make a contribution, and for someone familiar with the norms of publishing to get published.

Because commitment to the lightweight system is 'lightweight', it is easy for individuals to drop in to contribute, thereby harnessing the power of the maximum size crowd – no need to pre-qualify, no social network to belong to beforehand, no invitation required, no daunting user manual to digest. Note also that the social overhead to leave is also low – no long-term commitment is either required or necessary. This atomization of task, individual, and contribution puts the individual's commitment to the whole at a very weak level. At best, they have some attachment to the overall purpose of the particular project or its mode of action (e.g., open source), but their attachment is not to the group or its members. Thus lightweight, in this description, represents a weak tie association among contributors or with organizers, best described as a *coorientation* [9] to a common enterprise. In such cases, motivations for contribution are likely to focus on the purpose or goal of the enterprise rather than the experience within the enterprise, e.g., to an interest in extraterrestrial life, programming, or an encyclopedia topic, or to the goal of enhancing understanding of the universe or promoting access to information.

By contrast heavyweight peer productions – online communities, invisible colleges, communities of practice, learning communities, epistemic communities – are *enterprises of collaboration*. They function by internal negotiation of purpose and form (genre), derivation of rules and procedures, development and maintenance of practices, creation of norms and use of language that emerge through a community's history and life course. In a heavyweight enterprise, the concern can be as much about the commune or group's character and survival as it is about the task (see [21][31]), and as much about community process as it is about the community product. Indeed, in some cases the commune *is* the product, such as a field of research. Work on virtual communities and organizations shows these function through discussion, knowledge sharing, derivation of practice, co-evolution of technology and practice, and situated cognition. Their product is emergent, potentially unexpected, subject to change in process and outcome over time, but tempered in volatility by a history of purpose, membership, and goals. Communities function with a more generalized reciprocity: contributions are not only exchanged in a one-to-one manner, but are also distributed and received more generally throughout the community.

3.2. Individual to group focus

While contribution to a LWPP may be based on coorientation to an overall project, the basic nature of such enterprises is individual contribution, submitted independently from others' actions. By contrast, in HWPPs, commitment becomes oriented to the enterprise as a whole, its internal processes as well as its products. Involvement in HWPPs requires engaging with others, encouraging contribution by all members, and building internal structures and norms collectively and collaboratively. Adhering to agreed norms is important for signaling commitment to the group separately from commitment to its product. The expertise needed to join these communities may be low, particularly in those that accept apprentices, but the social overhead is high, entailing learning and adhering to norms, keeping up with community knowledge and practice, and forming strong, persistent social ties with other members.

While small scale contribution may be founded on coorientation to an area of interest, motivation for larger efforts seems to require a stronger orientation than casual interest. Raymond [39], Benkler [3], and Willinsky [48] all point to the dual motivation of a *personal-but-shared everyday need* as motivation for contribution to peer collaborations. As Raymond ([39], online) describes it, "the best hacks start out as personal solutions to the author's everyday problems, and spread because the problem turns out to be typical for a large class of users." Moreover, while "[e]very good work of software starts by scratching a developer's personal itch" ([39], online):

> "The interesting point, the point that the histories of Linux and fetchmail seem to demand we focus on, is the next stage – the evolution of software in the presence of a large and active community of users and co-developers."

Thus, the problems that suit – that motivate – peer collaborations are personal, but in the world, and in that worldly focus they find community.

This is not limited to software development. Benkler (([3], p.16) also addresses the 'personal but shared need' in discussing the potential development of shared curricular resources for teachers:

> "They may be teachers, parents, academics, or hobbyists, but they are all likely to be unusually committed as a common project to producing materials that are useful to teachers and students."

And Willinsky ([48], online) discusses how the environmental movement worked to leverage local concern into a common cause:

> "With time many of those involved in what we now call the environmental movement come [sic] to realize the common cause among all of their different efforts. Through such a realization, they were able to build … environmentalism into a popular movement and an everyday reality, and this served, of course, to further all of the original goals."

A similar move is evident in academia, in response to the high costs of publications and an increasing attention toward open access [41]. Universities face an 'everyday need' – to provide cheaper, easier access to academic work – that affects a 'large class of users', a class that includes the university, their libraries, faculty, and students as well as the general public. These constituents have come together around the long-standing idea of open science, now newly combined with online practices. Many signs exist of a general academic movement to open access. These include organized efforts, such as the Scholarly Publishing and Academic Resources Coalition (SPARC), Public Knowledge Project (PKP), and university repositories (e.g., Michigan's Scholarly Publishing Office http://spo.umdl.umich.edu/, [5]). It also includes changes in individual practice. For example, faculty and students posting drafts and papers online; choosing online, open-access journals as publication venues; starting open-access journals; developing open-source software to support open-access journals; and engaging with publishers in amending the copyright agreements to allow open access.

These trends suggest that while individual need may start an activity, it is group focus that sustains a larger movement. This suggests that collaborative contributions develop when an individual (or institution) can see the benefit of their effort reflected in a larger enterprise, and that visibility of contribution and benefit to the larger enterprise are important motivators that stimulate further effort to contribute and sustain the movement.

3.2.1. Weak and strong ties. Underpinning this individual to group distinction between LWPP and HWPP collaborations are the attributes of *social network ties*. In social network analysis, ties are defined to exist where there is any connection between actors in a network, including ties of direct interaction (one-mode, actor-actor networks), and ties created by co-participation in an event where the actors themselves do not necessarily interact (two-mode, actor-event networks). The latter are important ties for the current discussion as they place actors in the same milieu, exposed to the same ideas and actions, and thus tied by common experience. Moreover, individuals' independent decisions to become involved in a peer production suggest they share a common orientation to the purpose or goals of the event or project, which forms another basis for a tie. This has application as a potential antecedent condition for joining and participating in open source productions.

Ties based on direct interaction range from weak to strong. The literature on social networks shows that weak ties between actors are based on one or only a few kinds of interactions usually of an impersonal type, maintained through few means of communication, and with little commitment to the continued existence of the tie. By contrast, strong ties are predicated on a variety of interactions, particularly personal interaction and self-disclosure, the use of many media, and a commitment to the continuation of the tie ([18][19][21][45]).

Where voluntary, collaborative production systems are implemented to operate on a lightweight, weak-tie model – instrumental additions to a corpus, no interpersonal connection, minimal commitment to the purpose of the group – they can expect to reflect weak tie behaviors, with high turnover in contribution, and fleeting and intermittent attention to production. In such cases, the power of crowds is vital, and pooled contribution of minimally sized and minimally complex units is essential for success. The advantage is that the simplicity of contribution affords easy entry and exit, but the disadvantage is lack of continuity. Reward systems can help strengthen participation (beyond intrinsic motivation), but where contribution is minimal, rewards cannot change the essential weak-tie characteristic of the collaboration.

By contrast, a heavyweight, strong-tie model can be expected to follow strong tie behaviors, with long-term commitment to group goals, repeat participation, and a willingness to learn norms and procedures. Contributors can be expected to exhibit a greater willingness to commit effort despite deferred or delayed 'return on investment', and a willingness to accept different kinds of returns for their effort (e.g., a generalized reciprocity). The advantage is commitment, and intrinsic motivation to achieve the goal. The downside can be an over-emphasis on the group (network) to the detriment of the product – e.g., a group may become more concerned with its internal processes or survival than about meeting its original goals.

As noted above, light and heavyweight features are models of collaborative behavior which can combine in collaborative enterprises. So too, weak and strong-tie behaviors can combine in collective enterprises. Although LWPPs only need weak tie associations to function, it often happens that contributors or other agents may build a stronger-tie association on top of or alongside the LWPP. Examples of such behavior include the kind of association that grows up around competition over contribution statistics, e.g., as in the DC-Vault site noted above. However, such association is not a necessary part of the LWPP enterprise. More familiar is the presence of weak-tie associations in heavyweight, strongly-tied communities, e.g., lurkers, occasional participants, and newcomers. The distinction is that the heavyweight operation as a whole will not operate successfully if there is not at least a critical mass of voluntary participants sufficiently committed to care about, create, and police communal norms and contributory behavior. It is when such core participants fade from communal enterprises that previously successful online groups disappear and dissolve (e.g., see Bruckman and Jensen's account of the 'Death of MediaMoo' [7]).

At present, while there is a wealth of information on group behaviors at the strong, virtual community end of this spectrum (e.g., how groups and communities of practice function [31][35][46], the nature of cooperation [1], how to engage participation in virtual communities [28][36][37]), there is far less on harnessing weak ties for production, and on understanding the tremendous reach of the Internet for creating weak tie initiatives [19]. This is, of course, where research and observations on crowdsourcing [27], commons-based peer production [3], smartmobs [40], and social software [13] becomes so important.

3.3. Recognition, reputation and reward

The two dimensions discussed so far provide the basis for the dimension of recognition, reputation and reward. For the purposes of discussion here, it is useful to make a distinction between *recognition*, a visible summation of contribution, *reputation*, a value-added commentary about contribution, and *reward*, the outcome of a recognition and reputation system. Recognitions include visible tallies of computing cycles [26], web linkages [33][43], page hits, citation statistics, or lists of publications. Reputation is gained or lost by the attention given to these recognitions from community members; it is an indicator of whether one has conformed sufficiently to production standards and community norms to deserve the attention of one's peers. Reputation is a network effect. It is a form of social capital, that emerges from the actions of members of a social network [30][47]. Rather than being something possessed by an individual, reputation results from the social network ties to and from individuals in the network. Rewards result from reputation and are benefits that accrue to the individual, such as status, fame or wealth.

Reputation becomes more salient the more heavyweight the collaboration. At the lightweight end of the spectrum, where individuals contribute with discrete units, quantitative measures are the basis of reputation, and are likely to be the only form of visibility a system can generate (unless contributors or other outside agents build an adjunct reputation systems; again, as per the DC-Vault example). At the heavyweight end, qualitative measures of the value of a contribution become integrated with the recognition and reputation system. Such judgments are made by peers (e.g., academic peer review), or through a community's designees (e.g., awards committees; for an interesting take on the importance of award systems even to those who disdain them, see [16]). Open source developers gain reputations based on coding expertise as judged by other contributors; academics gain reputation through commentary on their publications as well as successful navigation of the peer review system. Reward in the form of status accrues to those with good reputations: Slashdot reviewers are vetted and promoted; in a community of teachers known as MirandaNet, participants become 'fellows' as contributions increase [38]; and academics gain higher ranks. Of course, infamy also accrues to those who behave badly, e.g. 'trolls' in online discussions, or 'griefers' in gaming environments as the reputation systems work to sanction as well as praise.

One major difference between LWPP and HWPP reward systems is that for the lightweight end, primarily impersonal, system-based calculations provide reputation statistics, but for these to exist, they must be designed into the system by the organizers. Thus, recognition and reputation are under the control of authorities beyond the individual contributor. At the community end, it is human, collegial (aka peer) evaluation of contribution that provides the most relevant feedback, with evaluations carried out with attention to community-based values. Thus, while both lightweight and heavyweight production require contribution by peers, the reward system for LWPP contribution operates *outside* the control of the peer group, while for HWPP the system operates *inside* the peer group. This suggests, somewhat counter intuitively, that individuals' motivation to larger movements may need to be *stronger* the lighter the peer production, since community-driven monitoring and control are not in operation.

In an HWPP, it can also matter *who* finds the contribution and comments on or uses it. The more heavyweight the system, the more important reputation is to community members, and the more nuance there is in reputation indicators, even quantitative ones. In HWPP, reputation depends not only on instrumental (countable)

aspects of recognition, e.g., being published, cited or linked to, but also on *who is recognizing whom*. Recognition from a high-ranking member of a network about a novice enhances the reputation of the novice beyond the value of a straightforward count of citations, whereas a cite from a low-ranking member to a high-ranking one adds very little to the latter's existing reputation. Links among low-ranking members may carry no more significance than a quantitative measure of contribution. To have members distinguished by ranks sufficient enough to make their attributions have relevance to fellow contributors requires a long-term, heavyweight commitment – it takes a community. Lightweight systems only have the option of using rank-free ties, because no basis for rank can exist in a truly lightweight production system.

Thus, in LWPP, recognition, reputation and reward reflect the discrete-unit contribution system: each contribution is the same and counts the same. In HWPP, contributions can also be counted, but variation in quality is acknowledged and becomes part of the recognition and reputation system. Network effects also come into play as who references whom affects the importance given to the contribution, and even on the importance of the reference itself. Overall, LWPPs recognition systems can only address *contributions*, whereas HWPP systems can address both *contributions* and *contributors* (see also [14]), and the *networks* they form.

3.3.1. Visibility and access. A major impact of in-group peer assessment is that individual contributions to such systems must be visible and accessible in order for ratings to be applied and reputations to be built. Thus, while Stewart Brand's often quoted saying begins that "information wants to be free", in fact, *information wants to be found*: it wants to be taken up, cited, used and linked to by friends, colleagues and readers; and producers of such information want the same thing. If we substitute 'contribution' for 'information', then we may have a more general principle that applies to peer production enterprises – that *contributions want to be found*: they want to be visible, used, examined, cited, linked to in HWPP enterprise, and at least entered into a counting system in a LWPP enterprise.

The importance of being found is clearly evident in current academic publishing trends and in how individual academics decide on how to contribute to the academic peer production process. Each academic now performs their own kind of calculus to weigh the costs and benefits of publishing in traditional, journal based venues versus posting on the web. The cost of the often long publication cycle (submission, review, revision, review, acceptance, appearance in print or online) is weighed against the benefits of quickly making material available to others online; the benefit of appearing in a community refereed and reputed journal is weighed against the opportunity of being found, read, and cited by anyone from anywhere, and of providing open access to the work. The importance of pre-publication vetting by community authorities is weighed against the post-publication vetting of crowds of readers. Currently, heavyweight community values and reputation tend to take precedence, particularly for those beginning academic careers. However, motivations for open access are also slowly modifying what forms gain community attention, including the increasing acceptance of online journals as well as open publishing on the web.

Of course, the rise of independent, individually based internet-based publishing is not confined to academic interests. Bloggers, citizen journalists, and democracy advocates create and sustain the web as a peer production enterprise. Contributions of news, commentary, photos, etc., can be unbundled from cost (given access to a computer and network account), knowledge of production (given mastery of increasingly simple means of producing digital documents), and gatekeeping (by publishers, or entrenched members of communities). Nearly anyone, from nearly anywhere can contribute to this stream of information. However, the resultant mass of documents, blogs, data sources, etc. now available online has a further impact on the issue of 'being found'. Gatekeeping of information resources *shifts from contribution to retrieval*. When 'anyone' can post to the web, the value is in being retrieved. The effect can be seen across many domains. Commons-based peer production is tipping the balance of power from contributors and the intervening systems on the contributor side – publishers, journal editors, peer reviewers, software companies – to retrievers and the systems that intervene on the retriever side. Retrieval systems – whether library catalogs, online journal access, Google's PageRank, or Amazon's search engines – become an integral part of the ecology of contribution and reward systems. Academic peer review structures are particularly challenged now because traditional publication venues and practices are unable to keep up with the easy, fast, and cheap distribution of texts and instant fame which seems to accrue to Internet-based publication. Not only is the physical artifact that bound costs and production together with copyright and selling rights no longer an essential component of scholarly dissemination, but also the reputation system that bound recognition and reward to the community is being eroded by retrieval and commentary by crowds of readers.

3.3.2. Trust. The 'calculus' between cost and benefit is also not confined to the realms of academe. Each individual contributor in a peer production enterprise makes choices about where and whether to put their effort and work, with attention to what will become of that work when contributed. In making this decision they place a lot of trust in the operators of the peer production

enterprise, particularly so for lightweight enterprises where they have no say about operations.

Trust is important for initiating and sustaining participation in open source enterprises. Trust is required that the contribution will be used in a way that fits the original contract. Whether that entails cost-free distribution, peer evaluation, or proper accounting of contributions, the social contract must be honored. If not, individuals will defect, potentially leading to collapse of the critical mass needed to sustain the enterprise. For example, contributors to social networking sites may defect if they find their personal information being used in ways they neither expect nor agree to.

This highlights longer term issues about trust and responsibility in collaborative production: e.g., What is the responsibility of the enterprise to a contributor who has *given* the work – freely, openly, for its entire life? What is the long-term obligation of enterprises such as Wikipedia to their original, open access, peer production model? What is the responsibility of the enterprise to the employer who has made it possible for employees to give their work away? How is this relationship affected by the size, longevity, and ownership associated with the contribution? How does trust in a common cause (coorientation) influence time spent contributing?

3.3.3. Engagement. The previous sections have indicated a number of intrinsic motivators for contribution, from coorientation to common purpose in LWPPs to the establishment of reputation and receipt of rewards in HWPPs. But there are some further motivators that have not been addressed – those that address the experience of being active in a peer production enterprise. *Engagement* is important as a design and management concept for peer productions, and as an area for further consideration under the heading of reward systems.

Engaging in a peer production, at least in ones that entail more than small-grained, instrumental deposits, requires attention to the social aspects of contribution: engaging with others, watching the progress of one's work within the collective enterprise, feeling part of the enterprise, and being stimulated by participation. Raymond introduces these aspect briefly at the end of his discussion of open source. He notes how Linus Torvalds kept the open-source Linux programmers "constantly stimulated and rewarded - stimulated by the prospect of having an ego-satisfying piece of the action, rewarded by the sight of constant (even daily) improvement in their work" [39, online].

His description of the "Linus development model" and the discussion of the social context highlight what others have referred to as "presence". Contribution, participation, satisfaction and engagement have all been found to be augmented by increasing the sense of social presence [42], of 'being there' with others [24], particularly others who share similar experiences [6][22], and being cognitively involved in the action [17]. Presence of a leader, community driver, teacher [17] or "bazaar project coordinator or leader" [39] is also important for maintaining participation.

Stimulation may also come from working with the technologies themselves, learning and being active with new ways of working and interacting, including playing roles in online worlds, and engaging in play online. With many platforms now competing for peer particiation, we may now need to see how stimulation and play can advance engagement in both LWPPs (e.g., in gathering data through game-like interfaces), and HWPPs (such as World of Warcraft or Second Life). (See also [50].)

4. Summary and Conclusion

This paper presented two models of collaborative behavior, one a lightweight model of peer production based on individual, discrete, pooled contributions, and recognized based on equally lightweight, quantitative assessment of equally valued contributions, and the other end a heavyweight model, characterized by long-term commitment to common cause and community functions, with contributions differentially valued through member assessments. New Internet-based systems present new opportunities for production based on a multitude of individuals, working in a *lightweight* peer production, contributing small units of time and effort toward a common cause, as well as for groups of select individuals to work together in a *heavyweight* peer production, contributing repeat amounts of time and energy toward a negotiated outcome in support of a common cause, but also in support of their group and its membership. Future work includes examining existing open source and peer production enterprises for conformity to these patterns, and consideration of how these models apply to other open source variants such as corporate sponsored projects and other collaborative projects.

For now, these models point to structures and motivators that operate on different aspects of peer productions, and provide input for design of systems that follow the light and/or heavyweight model. As Raymond [25, online] has said about open source:

> "I think the future of open-source software will increasingly belong to people who know how to play Linus' game, people who leave behind the cathedral and embrace the bazaar… And perhaps not only the future of *open-source* software."

So, too, the future belongs to those who recognize in both the cathedral and the bazaar the enduring, but different nature of each to motivate, sustain, and reward human contribution.

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