# Self-organized Virtual Communities: Bridging the Gap between Web-based Communities and P2P Systems

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**Abstract**

*In this paper we argue for the benefits of enabling the self-organization of virtual on-line communities, which today are mainly formed and operated by centrally managed web servers. However, self-organization requires community members to contribute themselves different types of resources (e.g. bandwidth, storage, etc.), as in the case of peer-to-peer (P2P) systems. Unfortunately, this cooperation cannot be taken for granted. To address this obstacle, we introduce the notion of a cross-layer incentive mechanism. The main idea is to encourage the contribution of low-level resources using social incentives generated at a higher (social) layer. We believe that this type of incentive mechanisms will play a central role toward the realization of self-organized virtual communities and will enable users to take advantage of the attractiveness and value of Web-based communities on the one hand and the externalities and flexibility of P2P networks on the other. We make a first step toward this direction: a) we categorize the different types of social incentives applicable in this context and b) we provide insights for the design of the appropriate social software required to map the behavior of participants at the resource sharing layer with suitable rewards at the social layer.*

## 1. Introduction

Over the last decade, two types of user communities have emerged in the Internet. On the one hand, the so-called *peer-to-peer (P2P)* systems allow to form overlay networks over the Internet and exchange a variety of resources such as content, bandwidth, storage, and CPU. To date, the ones that enable users to share files stored in their computer, such as eMule, LimeWire, and BitTorrent, are the most successful attracting millions of people, mainly due to the undergoing exchange of copyrighted content. On the other hand, *on-line (virtual) communities* are becoming the killer application in the Internet. Like peer-to-peer systems, they are differentiated according to the types of resources shared, in this case at the application layer. More specifically, through their human presence members of online communities build social networks (e.g., Facebook and Myspace), share their self-generated content (YouTube, Flickr), their expertise (Slashdot, Epinions), and much

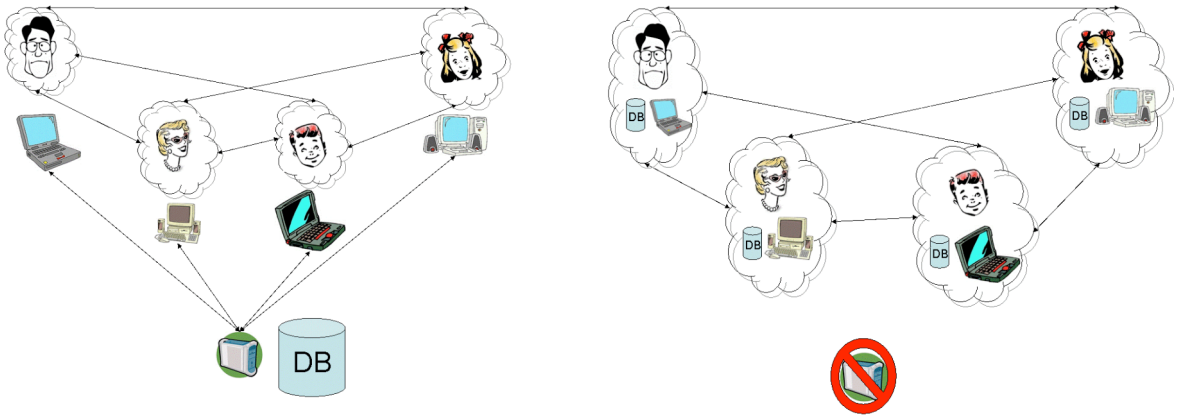
more. So, both peer-to-peer systems and virtual communities allow end-users to exchange different types of resources. However, they differ significantly in terms of service provision and community management.

In fully-decentralized peer-to-peer applications, e.g., file sharing, both service provision (i.e., content distribution) and management are distributed. This means that users should contribute a significant amount of upload bandwidth for the distribution of available content, but they should also participate in the management of the system (e.g. the implementation of content search). Note that although a centralized entity could handle more efficiently part of this functionality (e.g. content search), it could be subject to legal threats in the case of copyrighted multimedia content sharing (as in the case of Napster) and this was probably one of the driving forces for the research on the design of fully distributed peer-to-peer systems. In such systems, the participating users are responsible themselves for the core system's management functionality. Additionally, there are cases where even lower level resources (i.e. network) are required to be contributed by the participants in order for the basic communication to be feasible in the first place; this is the case of ad-hoc mesh networks formed through wireless user-owned mobile devices (e.g. spontaneous ad-hoc applications [2]) or access points (e.g. neighborhood wireless communities [5]). The fact that end-users should contribute a significant amount of resources for the system to operate harms the efficiency of the system (for the sake of scalability and independence from central servers), but also raises important incentive issues (e.g., free riding). There is significant research work toward this end, studying different types of incentive mechanisms, relying on the basic assumptions of the economic theory (i.e. rationality) and using game-theoretical tools for evaluation purposes; we summarize the main types of such mechanisms in the next section.

On the other hand, in communities where non-copyrighted content or expertise is shared (e.g. Wikipedia, Flickr, etc.) or the objective is pure socializing (e.g. MySpace, Facebook, Orkut, etc.) the current model consists of a central entity taking care of all the low-level functionalities, even multimedia content hosting itself (e.g. Flickr, YouTube). In this case, contributions at the application/social level are motivated by members' desire to disseminate their own content. However, this incentive is not always adequate [24] and the active participation of users in virtual communities could be further stimulated through social incentives incorporated in the system's design (see [9][16][32] and references therein). Notice that although there are still copyright infringement issues in these systems, since users do upload copyrighted content (as in YouTube for example), the legal threats are directed mainly toward the site owners (who make a significant effort to eliminate them since the sharing of copyrighted content is not the main service provided)[1]. However, the existence of a central server being responsible for hosting all the content generated by participants' interactions in a virtual community raises some significant issues related to privacy, censorship, and independence, which we discuss in the next section.

[1] Notice also that even when the content shared is copyrighted, it is attributed to a certain user who takes somehow the credit and, since she is not responsible for distributing it, does have the incentive to share it; this is not the case in P2P applications which are more anonymous in terms of contribution, for obvious reasons. Additionally, in P2P systems there are limited ways of personal communication between end-users. In online communities, users participate as human beings and they often disclose personal information. Although they may use nicknames for privacy, their participation necessarily reflects "something" about them, be it hobbies, personal or professional relationships, behavior, mood, etc. Thus, the benefits of participation to an online community are often longer-term benefits than those of a P2P system, where people act more like consumers rather than members of a community.

So, both types of existing communities (P2P and web-based) have limitations, either in terms of incentives or architecture. In this context, our objective is to provide them with the ability to self-organize at all levels. One could follow two directions toward this goal. First, a social layer may be added to P2P systems to increase users' incentive to participate and contribute their resources without the need for "strict" incentive mechanisms to be in place. On the other hand, the second direction consists in enhancing existing virtual communities by allowing them to be formed independently of central servers as illustrated on Figure 1 [6]. However, going closer to a P2P architecture, new issues arise regarding the incentives for resource sharing (for the distributed implementation of the functionality handled by the central entity) and the reliability of the community information (e.g. rating, content popularity, etc.).




1a) Web-based architecture

1b) Decentralized architecture

**Figure 1: Centralized vs. Peer-to-peer community management**

Notice that socially-enhanced P2P systems have already been implemented [31] [39] or envisioned in the context of neighborhood wireless mesh networks [5]. However, there is still a lot of room for research toward exploiting their full capabilities. Until today the obstacle of the copyright issues gives an advantage to "anonymous" incentive mechanisms such as BitTorrent [14] and the current research is still focused on this area. Note that motivations for contribution are in many cases inherent (intrinsic) when for example there is an *ideal* involved in the community activity and objectives. For example Free and open software is the motivation of FLOSS (Free/Libre and Open Source Software) community and knowledge is the incentive of SETI@home. Fighting the system can be another one as illustrated in P2P file sharing systems, and so on. But these incentives cannot be always taken for granted, especially when low-level (possibly costly) resources need to be contributed by end-users. The existence of a social layer on top of a P2P system will enable their provision to a wider range of participants (for which such motivations need some sort of stimulation) through the design of the appropriate technology-aware social software.

A clear research objective in this context is to formalize the notion of a social incentive mechanism (as for example in [35]) according to which users do not participate in a community only as human entities but also as low-level resource contributors. In this case, they will have to bring in the community, not only their human presence, but also their computing and networking capabilities, making them somehow a part of their "social

image". We propose to exploit this fact in order to provide social, cross-layer, incentives that will encourage users to share their low-level resources and cooperate.

This document is a position paper, which argues for the benefits of a distributed implementation of on-line communities and the provision of social, instead of economic, incentives for encouraging the contribution of resources from the participants. Our goal is to provide a suitable framework for researchers from the computer and social sciences to cooperate and contribute toward enhancing our understanding of human motivations in this context and design successful self-organized on-line communities as described in the following. More specifically, in Section 2 we discuss the trade-offs involved in the design of self-organized virtual communities, in particular regarding efficiency vs. independence and trust vs. privacy. In Section 3 we present a literature review about economic motivations and we propose to take into account social motivations for resource sharing in self-organized communities. Finally, in Section 4, we propose insights toward a cross-layer incentive mechanism, which allows to reflect users' "technical" contribution at the social level and vice versa.

# 2. Web-based vs. self-organized virtual communities

Today on-line communities are mainly web-based for some good reasons such as robustness, efficient content distribution or trust. However, we believe that certain drawbacks of this centralized approach justify the extra effort required for the design and implementation of sustainable and attractive self-organized virtual communities. We analyze in the following the trade-offs between the current centralized and a potential distributed approach for the management of a virtual (online) community.

### *2.1. Efficiency vs. independence*

One of the main arguments in favor of P2P systems is the increased scalability they offer, which makes them good candidates for supporting demanding applications such as streaming. When a central server is used to support the management of an online community and content distribution, all traffic necessarily goes through this single node, which may become a bottleneck if the community is large and/or members participate a lot. In this case, the performance may decrease. On the other hand, fully decentralized P2P networks distribute the traffic load on many different links of the network. This should lead to better performances in case of congestion. Moreover, self-organized networks are also more robust as the failure of a node does not compromise the operation of the whole network.

However, practice has shown that centralized web-based communities can support a very high load through investments on infrastructure (multiple servers, disk space, bandwidth capacity, CDNs). YouTube and Flickr are the best example since they host and serve an enormous amount of content with pretty good performance. It is doubtful whether a P2P system would manage to achieve this level of performance (both in terms of content search and distribution). An additional reason for this is that in online communities the majority of the distributed content belongs to the long tail [1]. This means that with voluntary content distribution, there would not be enough copies of each content item available in the system to ensure their availability and efficient distribution.

But in order to sustain this impressive quality of service, the owners of web-based communities must invest a huge amount of money. And this means that they should find a way for their investments to pay-off. Some possible approaches toward this end are advertising, exploiting members' personal information and content, or placing entry fees. However, such strategies are in most cases decreasing the value for the end-user (sometimes significantly). Moreover, the central management makes web-based communities vulnerable to other types of legal issues such as governmental censorship [13][22].

Finally, companies controlling such web-based communities prevent users from deciding on the rules of their own community or can change without notice the existing (and accepted) ones according to their own objectives, which could in general be different from those of the users. Independence is also important in terms of flexibility, which can play a critical role. Indeed, the needs of communities depend on various cultural and socioeconomic aspects but also evolve over time and it would be highly beneficial for them to be able to adjust their rules and supported functionality accordingly. A characteristic conflict of interest between members of a community and the community owner is the so-called "stickiness", which is typically achieved through the provision of a high rate of events that attract the interest of the participants (e.g. Facebook's news feed). Although such policies could increase activity (and eventually socialization), they could also cause addiction and build unhealthy communities (e.g. with a gossiping culture).

### *2.2. Trust vs. Privacy*

In the case of web-based communities privacy concerns arise as all personal information and on-going social interactions are not only stored in central databases but also visible to the outside world (potentially the whole Internet) [9]. Data could also be exploited commercially (e.g. for targeted advertisement) or in many other possible ways, which are not acceptable by the participants [10][20]. Most importantly, information that was meant to be visible only to users' selected audience (e.g., their family) could be exposed to the Internet due to software bugs. This issue is becoming increasingly important as big online communities (e.g., Facebook) are not always respecting the privacy of their members. [18]. For many users this is a critical requirement and a good reason for them not to participate in communities that put their private information into danger. In a self-organized community they have the ability to share sensitive personal information only with people they trust, by using encryption. As for their "public" personal information, they still face theoretically privacy threats, since someone could collect "manually" and exploit this information, but there is no way to avoid this possibility anyway. In any case, one should inform participants about such threats through the community interface and let them take their decisions according to their own requirements. Web-based communities do not act toward protecting users to that respect.

On the other hand, a valid argument in favor of the centralized approach is the trustworthy authentication; the fact that allows for trustworthy authentication; the high certainty that a user acting under a certain pseudonym is always the same. This is important for addressing malicious behavior consisting in stealing identities, disreputing others, etc. Again using encryption techniques and assuming a set of trusted nodes could provide some security toward this end, but in a distributed environment ensuring trust is always a challenging and costly task. Additional costs will be also necessary in order to ensure the validity of ratings and reviews/comments of

content items, since participants would have the incentive to alter them in order to increase their popularity. For example, a simple but costly way to do this is to store the ratings/comments on the computer of the user who issued them and download them from there each time a content item is viewed. However, the big emphasis given on this type of information in communities like Flickr, creates "addiction" effects and reciprocal behavior in terms of popularity (e.g. users favoring each other's photos). In a self-organized community the truly most popular content will be replicated among computers, and thus will become more easily accessible. This would be a "technological" means to filter content items and give more visibility to the most popular ones, similarly to Flickr's Explore page which presents the most popular photos among all photos posted by its members.

### *2.3. Discussion*

According to the aforementioned trade-offs, we believe that web-based and self-organized communities should not be treated as substitutes but rather as complements. Web-based communities are probably the only way to manage global scale online communities of millions of users, while self-organized communities would be a good alternative for more medium sized communities with a sufficient number of pre-existing trust relationships to ensure a trustworthy distributed management functionality. But since there are not necessarily pre-existing trust relationships (e.g. from real life) between community members in this context, the bootstrapping of a fully distributed virtual community is a rather challenging task.

One way to solve this problem could be to rely on existing social networks (maintained by current popular social software) to create our distributed cross-layer communities –and benefit both from the social ties between members and from the independence and flexibility of a decentralized architecture. For example, a group of Flickr users' could decide to create their own P2P network within the overall Flickr community in order to be independent from any centralized management or rules and operate in parallel as a self-organizing P2P community. So, this way web-based and self-organized could co-exist expressing somehow the "going out" and "staying at home with friends" choices for one's entertainment.

## 3. Incentive Mechanisms

As analyzed above, the two most important aspects for moving from web-based communities to self-organized ones is independence. But in order to achieve independence one has to provide the required incentives to users to contribute their resources. We propose to do exactly this through the social context provided by a virtual community. In the following we make an overview of the existing approaches for providing incentives in P2P systems and the social incentives created in on-line communities. Then in the next section we will make a first step toward designing our proposed cross-layer incentive mechanisms.

### *3.1 P2P systems and economics*

One possible way of defining an incentive mechanism is to consider it as a system rule, whose goal is to influence participating agents into behaving in a certain manner, by rewarding or punishing them according to their actions. For example, in a traditional market, a price is a monetary reward for production and a punishment

(a charge) for consumption. The system designer's task is to decide on the mechanism to compute and set prices in order to reach a specific goal.

The two most common objectives considered in economics are social welfare maximization (also called economic efficiency) and fairness. The social welfare maximization approach considers two, private, people's characteristics (namely their utility and cost for consuming and contributing resources, respectively). It aims at maximizing the total utility minus the total cost, assuming people are rational (i.e. they seek to maximize their own benefit: their utility minus their cost). For example, in a resource allocation problem, setting the price at a level where demand equals supply, ensures that the participants with the highest utility will be the ones that will choose to pay the price and have access to the resource. On the other hand, the fairness approach treats all agents in the same way either in principle or acknowledging the inability to convey this information. Thus in our resource allocation example, the resource would have to be shared equally among them, which would result in an inefficient outcome in general.

Although the choice between these two objectives is the subject of endless debates between scientists from several disciplines such as political philosophy, sociology, and economics, the selection of an approach rather than another is not always due to the philosophical dimension of the problem. The complexity of computing optimal prices in many economic problems and/or the required information, the difficulty of implementing micro-payments in a distributed system and the mental burden that they require from the user, and the non-rivalry of certain resources (e.g. content), are some of the reasons why pricing mechanisms proposed in the literature for addressing many of the aforementioned problems [23][25] are not implemented in practice despite their nice theoretical properties.

| Mechanism | Incentives | Users' Decision |
|---|---|---|
| Pricing | Charges, Payments for consumption / contribution | Level of consumption and / or contribution |
| Entry Fees | Fixed contribution, Fair resource allocation | Participate or not |
| Reciprocity | Consumption = contribution | Level of consumption |
| Reputation | Resource allocation based on past behaviour | Level of contribution, Quality of experience |

**Table 1: Summary of economic incentive mechanisms**

Thus, in many cases simple fixed contribution [3][4] or reciprocity-based approaches [19] are being considered, which treat all participants as equals. For example, reciprocity-based ones dictate that all users should contribute the same amount of resources they consume. But although this is a theoretically very simple incentive mechanism, its enforcement is not trivial in a distributed environment, since it requires the existence of some kind of virtual currency, except in cases where a direct exchange of resources is possible, as in the case

of BitTorrent. However, this is usually not the case; additionally, it still puts a significant mental burden on users, and it could discourage altruistic behavior, which seems to play an important role in the context of P2P applications.

Acknowledging the above issues, reputation mechanisms [15][29], originally introduced in distributed marketplaces (such as eBay), have also been considered as candidate incentive mechanisms in the context of all types of P2P applications providing a more qualitative (than quantitative) way to reward and punish good and bad behaviors respectively. More specifically, a user's reputation could be seen as a way to aggregate her past behavior into a single value. This value is in general a function of other users' ratings based on this user's observed behavior. Then rewarding people with high reputation (e.g. giving them priority in case of congestion) and/or punishing the ones with low reputation (e.g. denying service to those with reputation values lower than a specific threshold) would ideally provide the suitable incentives for participants to maintain high values of reputation and thus behave correctly.

However, the "freedom" offered by this approach in terms of rewards and punishments makes it difficult to evaluate formally the outcome of a specific mechanism and compare it with other possible ones since there is currently no sound theoretical framework for their description and evaluation; this may explain why a plethora of reputation mechanisms have been proposed for all the aforementioned incentive problems [29].

Another important challenge in this context is to ensure that the reputation values are computed correctly (i.e. based on truthful ratings [30]). This is particularly critical when users may easily create a new identity/pseudonym and when information regarding exerted effort as a function of the outcome of a transaction is hidden. So, the fact that users are treated as both the selfish agents who wish to maximize their net benefit and the ones responsible for sustaining collaboration (having to rate other peers and rewarding/punishing peers according to the rules of the reputation mechanism) creates complex theoretical games.

However, all above mechanisms summarized in Table 1 concern a single "cooperation layer". Moreover, they assume that humans behave rationally, which is actually another highly debatable assumption of the theory of economics. Indeed, there are many cases where people seem to actually contribute "for free" (e.g. in on-line communities some members always answer questions whereas they never ask questions themselves, in P2P file sharing applications some peers provide a huge amount of content although no explicit incentive mechanisms exist.

### *3.2. Social incentives*

But what is the main motivation of such an altruistic behavior? The main motivation could be inherent or rely on more subtle, immaterial, rewards related to feelings such as affection, respect, happiness, satisfaction etc. In other words, even seemingly altruistic *behaviors* do not necessarily arise from altruistic *intentions*; according to several theories, altruistic behavior could be motivated by self-interest (e.g., reciprocal altruism as described by Trivers [41] –see also [7]).

These motivations are related to some core human needs, based on which humans decide how much effort, time, and resources to invest toward a collective outcome. A well-established general theory trying to analyze the drivers of human behavior is Maslow's [27]. According to Maslow, human needs can be categorized hierarchically into 5 levels, from basic physiological needs to personal growth objectives. This classification is

very often represented as a pyramid, where the 5 layers correspond respectively –from bottom to top– to physiological, safety, social, esteem and self-actualization needs. According to this theory, humans try to satisfy specific needs only if the lower-level needs have already been fulfilled.

The Self-Determination Theory [36] distinguishes between extrinsic (external) and intrinsic (internal) motivations. It suggests that people experience more self-determined (or internally controlled) types of motivation when the activities they participate in make them feel that they have *autonomy* (the power to make their own choices), *competence* (the ability to effectively perform their task), and *relatedness* (authentic social connections with others). More self-determined types of motivation are desirable because they are associated with more positive experiences and continued motivation to participate. So, depending on the pressure and control imposed to the user, on a scale going from amotivation to intrinsic motivation, we can find 1) external regulation, that is, the least autonomous forms of extrinsic motivation. Then 2) introjected regulation, which is still quite controlling but involves the ego e.g. in terms of self-esteem or feeling of worth, 3) regulation through identification, where there is a more personal endorsement and finally 4) the integrated regulation where people have a feeling of choice. The "ideal" extrinsic incentive is the one, which is fully accepted –integrated- by the human being and which almost becomes natural –intrinsic.

As already discussed, the economic theory focuses on extrinsic motivations (e.g., monetary rewards or resource exchange) assuming that users actions aim to maximize the difference of their utility of consuming resources minus the cost of the required contribution. Notably, intrinsic motivations are very difficult to model formally and thus such (often dominant) aspects determining users decisions regarding participation and resource sharing are ignored by the existing game-theoretic approaches. Clearly, this leads to somehow conservative models concerning the alternatives of a system designer to encourage participants to collaborate.

There is a large variety of predominantly intrinsic motivations, derived by users themselves and the community as a whole that could be exploited toward this end. Self-esteem, self-efficacy, community spirit, emotional connections, social norms, interest, and fun are only some of them. Numerous theories focus on a subset of such motivations. For example, the expectancy theory [42] calculates humans' motivation as a function of their belief in their success (expectancy) of the reward they expect to get from it (instrumentation) and of the value they place on this reward (valence). The Sense of Community (SOC) [28] highlights the importance of the community for encouraging people to contribute. More specifically, it identifies four important attributes that contribute toward this end: feelings of membership, feelings of influence, integration and fulfillment of needs, and shared emotional connections.

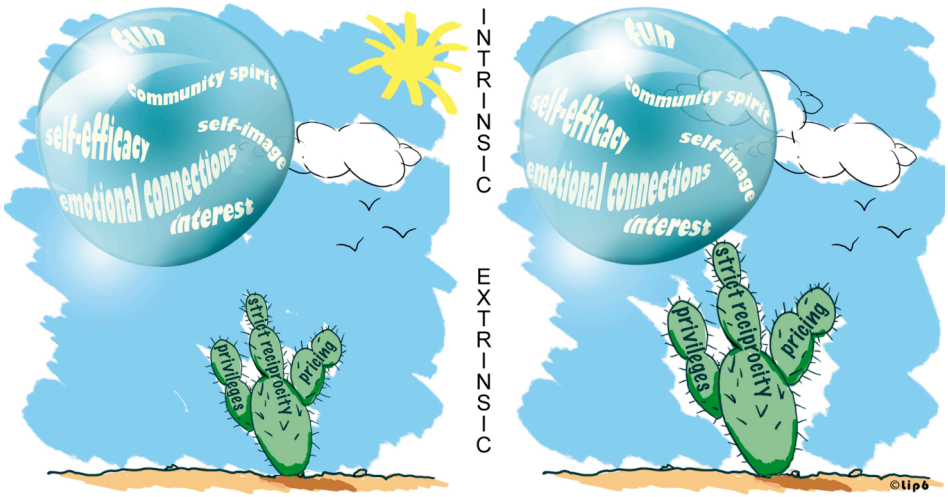



**Figure 2 : Extrinsic vs. Instrinsic motivation and the crowding out effect**

But how one could stimulate these motivations? Some possible mechanisms discussed in the social sciences literature include feedback, goal setting, social recognition, interest, socializing opportunities, community identity, personal responsibility (accountability) (see [40] and references therein). Interestingly, in the case of online communities the means to provide this type of incentives are restricted to the interface offered by the corresponding software. Hence, this has been the subject of extensive research in the field of Computer Supported Cooperative Work (CSCW) [12], while the term *social software* has recently been established (extending the scope from collaborative work environments to more general communities).

Interestingly, many successful on-line communities owe their success to some clever details incorporated in their software to reward cooperative behavior [16]. For example, the way people can create relationships and interact with one another, the means they have to represent themselves, the feedback they have concerning their popularity and activity, exposing their level of participation to the community, their elasticity to decide which part of their activity is made public or private, community rules, the definition of different privileges/characterizations according to their behavior, user ratings for other users and/or content, are some of the functionality whose details could significantly affect the behavior of the participants and the success of the corresponding community [38].

Note that these theories have been developed in different contexts than the one we are considering: we wish to motivate members to contribute their resources for supporting the operation of their virtual community and make these resources part of their identity, their social image. We do not aim to devise a new theory of human motivation but get inspired by the ones that are close to our approach, and implement a set of practical mechanisms. Experimenting with real users will hopefully give us insights on the various trade-offs that exist in this context, especially the one related to the extrinsic/controlling vs. intrinsic/informative motivations. In particular, as illustrated in Figure 2, extrinsic motivations might create a “crowding out” effect resulting in decreasing intrinsic motivations.

## 4. Cross-Layer Incentive Mechanisms

We will now develop our early ideas concerning the design of cross-layer incentive mechanisms. Since these mechanisms highly depend on the specific context we will use as an example the functionality of content sharing communities like YouTube and Flickr, but hopefully we will be able to generalize some of the main attributes identified in order to apply them to other contexts as well, such as spontaneous network creation [5]. As mentioned previously, in these communities users have a personal incentive to share content since it will attract other users and increase their popularity and their social network, and this is actually a social incentive for them to do so. However, the distribution of this content is handled by the site owner, and as already motivated in the introduction there are cases when it would be attractive for members to manage their community themselves.

But if users were responsible themselves for the content distribution functionality, they would have to help each other. Otherwise, it would not be efficient (or even feasible) for each one of them to serve all the possible customers of her own content (especially for popular ones). Then the main contributions of a participant in terms of low-level resources include storage, bandwidth, and uptime (availability) for hosting the content of other users and participating in the distributed protocol that will ensure the reliability of information (content ratings, user comments, etc.).

### *4.1 Technology-aware social software*

We will make a first step by building on the existing mechanisms encoded in the social software of successful communities of different types, summarized in Table 2. So, in the following, we categorize these mechanisms and we imagine possible ways to extend them for the design of a self-organized virtual community: ways to motivate users to contribute their resources instead of (or in addition to) their presence, content, expertise, etc. This process will help us to evaluate and weight the different mechanisms (an example of a similar approach is the MovieLens project [8][35]).

**Roles and privileges.** Expertise sharing communities like Slashdot rank members according to the usefulness or interestingness of their contributions and give them specific characterizations. High rated users acquire also extra privileges (e.g. in terms of moderation of other participants' contributions). This approach stimulates the motivation related to the self-image and self-efficacy but also sometimes constitutes an extrinsic reward. In our case, we could directly apply such rewards for the “top contributors” of the community, which could also materialize in advanced roles in the community management functionality.

**User home page.** A critical component of an online community is a user's home page. This is her personal image to the community. Members' behavior highly depends on what information the community designer decided to place on this page (and where). The different choices of various communities toward this end are an indication of its importance - compare for example Slashdot, Flickr, MySpace, and Facebook. In our case, it is critical to decide how the infrastructure (and its capabilities) of each user and the corresponding contribution

and feedback are displayed in her profile page. This will build the technologically-enhanced social image of a user.

| Social Software Attributes | Related Social Incentives | Examples of Design Choices |
|---|---|---|
| Roles and privileges | Self-Image, Self-Efficacy | Moderator, priorities |
| User Home Page | Self-Image | Status characterization, page organization, profile information, content management |
| Feedback | Self-Efficacy | Private messages, thank you messages, statistics, visualization |
| Information Management | Socialization, Sense of Community, Self-Image | Privacy management, community activity, accountability |
| Community Identity | Sense of Community, Self-Efficacy, Interest, Fun | Community vision and outcome, content filtering, public spaces |
| Social Networks | Sense of Community, Emotional Connections, Interest | Types of relationships, people searching, group management, interest matching |

**Table 2: Social incentive mechanisms in social software design**

**Feedback.** In order to stimulate users' sense of efficacy, it is critical to provide them with meaningful personal feedback concerning their contribution (in addition to possible explicit rewards for high contributors as described above). Text messages produced by the system (MovieLens), encoded "thank you" messages (Jango), history (wikipedia), and comparisons between users (Facebook quiz) are some examples of feedback that could stimulate the self-efficacy and competence motivations. A particularly interesting mechanism in our context is visualization [17].

**Information management.** Which part of users activity is private or public could affect dramatically the way people behave both socially and in terms of resource sharing. Increased visibility strengthens the personal responsibility and the opportunities for social interactions (Facebook). In the case of social interactions, increased transparency raises privacy issues. In our context, information concerning a user's contribution should also be carefully exposed focusing on promoting/rewarding positive behavior rather than punishing small levels of contribution.

**Community identity.** The description of the community and its purpose, the identification of its members, the assessment of the overall activity and value provided are also critical aspects of the software design. These aspects will stimulate the community spirit, help the establishment of norms for guiding user behavior, and provide a well-defined goal to be achieved. So, in our context, it is very important to highlight the independence and collaborative aspect of the community.

**Social networks.** Finally, the types of relationships supported between users (e.g. friends vs. contacts), the protocols for their establishment (e.g. symmetric vs. asymmetric), the types of interactions supported, and the ability to create private groups affect the way people socialize in an online community. Moreover, one could introduce the notion of a resource sharing community. That is, the users that often exchange resources would form internal sub-communities, which would further encourage the resource sharing among them. These could be formed in an either bottom-up or top-down way. For example, a social sub-community could be bootstrapped either based on existing resource sharing relationships (members who often exchange resources create social relationships), or alternatively already formed social sub-groups could enable and organize resource sharing amongst their members (e.g. create copies of my content to the PCs of my "friends"), which is an attractive scenario when trust and privacy are high priorities. Finally, identifying the users with which one shares resources (or just feel their presence) would be by itself an important motivation for them to contribute [34].

### *4.2. Trade-offs*

However, certain trade-offs have to be made concerning the various decisions that one could take to this end. For example, the need for social visibility (both for encouraging acceptable behavior and contributing to the community spirit) contradicts with the requirement for privacy. Moreover, rewarding users by assigning them high status and/or privileges could discourage new members to contribute. Also, the more demanding and restrictive the incentives mechanisms the more intense are often the efforts to bypass them [37], which is a similar effect with the trade-off between extrinsic and intrinsic motivations already analyzed.

This trade-off is notably the most challenging in this context. A community designer should always keep in mind that incentive mechanisms do not act in an additive fashion and choose only the ones that are more appropriate according to the cultural characteristics of a community and its purpose. Also note that the chosen incentive mechanisms' detailed configuration will strongly depend on the specific environment and they will often evolve over time according to the dynamics of the community.

So, how to find the optimal point between motivation and control/overloading of the participants is not an easy task, because it is very difficult to formalize such incentives and assess their effect on users analytically. Our goal is to define the notion of the efficiency of a virtual community (the on-line equivalent of social capital) taking into account the activities at all levels of members' interactions and trust relationships and identify some basic types of incentive mechanisms that could potentially improve this efficiency, as presented in the previous section. Then one could design a set of simple rules that will tune some attributes of these mechanisms based on measurements of the system activity with the goal to improve or maintain the same satisfactory levels of efficiency over time. Additionally, this process will help us to understand the interdependencies between different types of motivations and their effect in terms of encouraging users to contribute and/or crowding out other existing motivations.

## 6. Conclusion

The main objective of this position paper was to highlight the importance of self-organized virtual communities in the Internet and propose the design of suitable cross-layer social incentive mechanisms to address the resource sharing issues that arise when community members are responsible themselves for implementing all the required community management functionality and content hosting. Exposing the resource sharing activity of a user at the social level, through the design of suitable social software, opens new directions for providing users with incentives to contribute, based on social rather than economic motivations. And in the opposite direction, such a cross-layer approach regarding incentives could make resource sharing an incentive by itself for participants to socialize and build healthy communities.

However, the design of the appropriate mechanisms for different types of communities is a challenging task that requires the collaboration of researchers from many disciplines and extensive experimentation with real users. This work is just a first step toward this direction.

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