User Motivation and Persuasion Strategy for Peer-to-peer Communities

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Abstract

In recent years, peer-to-peer systems have become more and more popular, especially with some successful applications like Napster and KaZaA. However, how to motivate user participation in peer-to-peer systems remains an open question for researchers. If few users are willing to participate in the community or make contributions to it, the peer-to-peer system will never become successful. To address the problem, this paper proposes a motivation strategy based on persuasion theories of social psychology. The main idea is to introduce a set of hierarchical memberships into p2p communities and reward active users with better quality of services. We have applied this strategy to a p2p system called Comtella and launched a study to test its effectiveness. The results of the study show that our motivation strategy is capable of stimulating the users to participate more actively and make more contributions to the community.

1. Introduction

Peer-to-peer (p2p) systems have become more and more popular in recent years. Some applications have proved to be successful, for example, Napster, KaZaA, eDonkey and most recently, BitTorrent. Since peer-to-peer systems are a kind of decentralized distributed systems, their reliability is usually superior to the traditional server-oriented systems. However, in a p2p system, there are no powerful servers which provide various services or information for the clients. All the users of the system are equal peers, which act as both servers and clients. They are expected to contribute resources, enabling the system to provide benefits for individuals. If few users are willing to participate in the community or make contributions, the p2p system will never become successful no matter how excellent the technology it applies is in terms of protocol, efficiency, performance, etc. According to Preece's Online Community Framework [1] online communities (including p2p user communities), should include four key components: "people, purposes, policies and software".

A p2p application, called COMTELLA [2], has been implemented at the MADMUC Lab at the University of Saskatchewan. It is built on JTella, a Java API for the Gnutella network, and enables a community of researchers and students to share and exchange resources, such as research papers. Although the system was mature in terms of technique, it could not provide good service because the number of active participants was small. Moreover, some participants were free riders who typically started their client application only when they needed some paper and quitted immediately after finding it (or not finding it). Consequently, there were few people simultaneously online and the probability of users finding the files they looked for was very small, even where the files were shared by some of their peers. When the users realized the dysfunction of the system, they were discouraged from participating further. This situation matches the findings by Jones et al. [3]. Based on his user-population / contribution model, a "critical mass" (or a certain number of active users) will have to be reached for a virtual community to be sustained.

On the contrary, if there are a lot of participants who are willing to stay online and contribute resources, the probability that a user finds in the system what she needs would become much higher. The user who benefits from the system would perceive the system as useful and tend to log on more often, stay online longer, and make more contributions. Therefore, user participation, as well as the value of the system would increase and show the "network effect" [4].

Obviously, there exists a feedback loop in peer-to-peer systems [5]. The size of the community of users may directly determine the level of usefulness of a system and the usefulness of the system can influence the number of participants in reverse. In order to have this feedback loop work on a peer-to-peer system in a positive way, motivations are needed to attract the users to join and stimulate them to contribute.

2. Related social psychology theories

A peer-to-peer system, together with its users, creates an online community, which shares some features with real human communities. Therefore, some theories of

social psychology could be used as the foundations of the strategies to motivate users' participation and contributions.

2.1. Reciprocation theory

Reciprocation is a basic norm of human society. Simply put, appropriate rewards are needed when we ask people to do something for us [6]. Therefore, if we want people to join our p2p community and make contributions to it, they should benefit from their participation and contributions. A community is never sustainable unless it provides benefits that outweigh the costs of time, energy and resources members contribute [7]. Reciprocation is the basic of the motivation strategies of KaZaA Lite and Mojo Nation, two existing p2p systems. Both of the systems tried to reward the users who actively participated in their communities. However, their mechanisms were not very successful. To improve the effectiveness of the strategies, two key questions must be deliberated. One is how to measure the users' participation and contributions. Since the amount of reward the user receives should depend on her participation and contributions, it is important to measure them accurately. Otherwise, the users may feel that the mechanism is unfair. Another crucial question is what the rewards should be. If the users think that the rewards are useless, they would not be stimulated to contribute.

2.2. Consistency theory

Consistency theory argues that after people have made a public commitment they will be more likely to act in a consistent way with their commitment [8]. Combining this theory with our goal, we can try to induce the user of the p2p community to make a commitment of making contributions to the system at the beginning. After that, she will be reminded of her commitment whenever she does not act in accord with it. According to the theory, the user would try to reduce her cognitive dissonance by making more contributions than before. The main problem is how to induce the user to make a public commitment. It is necessary to get the user's consent before we publish her words in the community. But whenever the user knows that her commitment would become a public one, she would tend to promise in a conservative way.

2.3. Social validation

Consider what your reaction would be when you realize that many people just like you have already done something. In most cases, you will do it as well even if just to try it out. Actually, one fundamental way that people decide what to do in a situation is to look at what others are doing or have done. If many individuals have decided in favor of a particular idea, more people would tend to follow this way. Moreover, a group of persons sharing some sort of similarity can influence each other's behaviors more effectively [6]. According to this theory, it is possible to persuade people to make contributions to a p2p community by demonstrating that many people just like them have contributed a lot to the community and benefited from their contributions. However, in general, merely a small portion of members are active contributors, who offer a large proportion of resources in the community [3]. So it is not a good idea to provide a user with a whole picture of the community because the behaviors of those inactive users could discourage the user from contributing. A possible motivation strategy is to show only the active users who participate in the community cooperatively, even if misrepresenting the actual level of contributions in the community.

2.4. Persuasiveness of liking

Liking is a term which frequently appears in social science literature. It means a feeling of connection between people. Social psychologists have found that people are more likely to say "yes" to those they like, such as their relatives and friends [6, 9]. This rule has been applied in the marketing domain. While a customer hesitates over whether to buy a product, a recommendation from her friend would have more impact than one from a salesperson. The mechanism of Orkut.com is based on the persuasiveness of liking as well. It provides an online meeting place for people to socialize, make new acquaintances and find others who share their interests. The members of the community are encouraged to invite their friends to join. When a person receives an invitation from her friend instead of an advertisement of Orkut.com, the chance of her joining the community would increase significantly. One key question would be how to stimulate the members to invite their friends. The approach of orkut.com is to make the community more exclusive. People cannot join it unless they get an invitation from a member of the community. Apparently exclusive, this rule compels the members to invite their friends since their invitations are the prerequisite of their friends entering the community. If we consider the act of invitation to be a kind of contribution to the system, rewarding this action may be another feasible approach.

2.5. Theories of discrete emotions

Discrete emotions are "the emotions that have unique appraisal patterns, motivational functions, and behavioral associations" [10]. Common emotions such as fear, anger, sadness, joy, etc. are discrete emotions. There are theories

about each discrete emotion. Here, we mainly focus on the theory of fear, which is more useful to us. According to the theory, people will feel fear when they perceive some threat to themselves or their properties. This fear to lose something makes the incoming messages, especially those containing reassuring information, more appealing to them [10]. Based on the theory, we can devise the following paradigm: first, we arouse the fear of the users in the p2p community, for example, by threatening to deprive them of some privileges; then information about how to avoid this problem is provided. In this case, the information would become more persuasive and will stimulate users to make contributions to the community more effectively.

3. Motivation strategies of existing p2p systems

Many existing p2p systems have their own strategies to motivate users to make contributions to the communities.

"Direct Connect" (www.neo-modus.com) and Limewire (www.limewire.com) are very similar in their strategies to make users contribute. Both of them force users to share a minimum amount of resources. If a user fails to meet the requirement, her access to the resources of the systems will be limited or completely denied. Although this method might encourage users to contribute to some extent, it failed to stimulate people to participate and even made the communities more exclusive. Most people are not willing to join the community since they are forced to do the contributions before receiving any benefits.

Mojo Nation (www.mojonation.net) attempted to introduce an electronic currency and micro-payments [11] to provide economic incentives for sharing resources. The users need to pay for each download as well. Micro-payment believers consider that if the payments are miniscule, such tiny amounts of money can be extracted from the users that they will not notice, while these payments would add up to something significant for the recipient. However, the users do notice, since they are being asked to buy something. Act of buying anything, even if the price is very small, creates mental transaction costs [12], that is, the energy required to decide whether something is worth buying or not. Mental transaction costs create a minimum level of inconvenience that cannot be removed simply by lowering the prices of goods.

Kazaa Lite promotes users to participate and contribute by rewarding the active users with better quality of services. The system records the actions of users and maintains a numeric participation level for each user. The speed of downloads the user can get is based on this value. The participation level of a user seems to be a function of the difference between how much other users has been downloaded from her and how much she has downloaded from others (in MegaBytes). Actually, the basic of this strategy is reciprocation. Since the user's benefit (or privilege) is highly related to the amount of resources other users download from her, this strategy can motivate users to stay online and make more contributions and even more, compel them to be concerned about the quality and the potential demand of the resources they shared, since there is no reward for sharing resources that nobody downloads. However, the strategy can result in the following situation. A user who is sharing many files that are not of common interest may receive a low participation level and a low-quality service, since relatively few people, or maybe none at all will download these files. Thus users who share rare files for specific narrow interest area are disadvantaged. The Kazaa Lite approach makes such users feel frustrated and treated unfairly. They withdraw and the diversity of resources shared in the system decreases.

4. Motivation strategies of server-oriented online communities

Similar to the p2p systems, some server-oriented online communities (e.g. newsgroups) use various mechanisms to motivate people to join and contribute high quality resources (typically, posts). Although these online systems are different from p2p systems in terms of architecture, the ideas of their motivation strategies can be applied.

Slashdot (slashdot.org) is an interesting online community. To measure the users' contributions to the community, the founder of the system, Rob Malda, defined a term he called "karma". If the user's posts are highly rated by the moderators, the user earns karma in the system, which is associated with special privileges. For example, the user's subsequent posts begin life at a higher rating than usual. The users with high karma are more likely to be chosen as moderators in the future. After a user becomes a moderator, she could rate other users' posts, consuming her own karma. That means the users with high karma have more ratings to give away and therefore are more influential in the community. This strategy stimulates the members to submit high quality posts because these posts could potentially earn more karma for them. Furthermore, "it set up an environment where community leaders could naturally rise to the surface" [13].

Erickson et al. [14] pointed out that there was a lack of social cues in existing online communities and to compensate for this, community members and their activities should be visualized to enhance their mutual awareness and responsibility. Based on this idea, an online chat system named Babble was designed. In the

system, a visualization component showed in real time the presence and activities (talk, listen) of the users in current conversation. This mechanism provides the participants with more information about others in the community and therefore, makes it easier for them to engage in various interactions. This approach serves small to medium-sized groups very well, but it is hard to apply in online communities with a large population.

Millen et al. [15] suggested that an online community, although it may comprise many discussion forums, should have a common entry, where new messages and calendar items within the community are highlighted. This common space is supposed to encourage members to observe the general activities of the community. Besides, notification service was recommended, through which members will know when new information is posted in one of the community forums. Millen found that after they get a notification, for both active and inactive users the probability to visit the site doubles. To some extent, Millen's strategy is similar to Erickson's because both of them promote social awareness of community members and therefore, stimulate their engagement in the community.

5. Proposed solution: hierarchical memberships

In this section, we propose a motivation strategy, which is different from the ones used in the existing p2p systems. Although this strategy is devised for our p2p community, Comtella [2], it may apply to other online communities.

5.1. Overview of the solution

The basic idea is to introduce a set of hierarchical memberships into the community. For example, users are given different memberships, such as "bronze", "silver", "gold", and so on, depending on their own contributions to the system. The more the user's contributions, the higher is her membership level. The users with higher-level membership receive better services and enjoy some privileges or special rights. Rewarding active users is the substance of the solution. Several crucial questions need to be solved in order to implement the memberships. The way they are solved would influence to a great extent the resulting motivation effect.

5.2. How to measure users' contribution

We expect the users in the Comtella community to engage in the following five cooperative activities:

1. stay online;
2. log on the system frequently;
3. download resources and share them with others;
4. bring new resources in the system;
5. comment on the resources they have experienced.

Based on these goals, our approach is the following: first, maintain five separate numeric values for each user to represent her performance on the five activities respectively. For example, a value "V_1" may account for how long the user stays online per time unit (e.g. one week). Moreover, since the importance of the five items for the system is different, five different weights (W_1, W_2, W_3, W_4 and W_5) are introduced. In Comtella, bringing new resources is more important than the other activities. So we give its weigh "W_4" a higher value. Finally, an overall evaluation of a user's participation "V_{oe}" should be calculated in the following way (1).

$$Voe = \sum_{i=1}^{5} W_i * V_i \quad (1)$$

Although in most cases this formula is able to calculate the users' contributions accurately, there is a detail that deserves mentioning. We hope that users engage in all the five activities. In other words, they should not keep doing one of them and skip others. For instance, if a user shares many new resources but seldom stays online, her contributions are almost meaningless since very few people would benefit from them. Hence, we put a ceiling value (C_i) for each criterion. If a user's performance value of a certain activity is greater than the ceiling value of that activity, the weight for the excess part (W_{i_excess}) would be much less than the original one (W_i). Correspondingly, the user's contribution in the criterion should be recalculated in the following way (2).

$$W_i * C_i + W_{i\_excess} * (V_i - C_i) \quad (2)$$

The intent of introducing the ceiling values is to stimulate users to perform the five cooperative activities with the same effort. It ensures that the users who always do one thing and ignore others would not get a high-level membership. Probably a more elegant approach would be to model a user's contribution in each criterion as a logarithmic function of V_i (see formula 3). Here, b_i is a parameter, which may different for each criterion.

$$W_i * \log_{b_i} V_i \quad (3)$$

But for now, the formula (2) would be enough.

5.3. How to determine the users' memberships

First of all, we have to decide how many membership levels we should have in the community. If the number of the membership levels is too small, the users with different participation levels would not be differentiated well. When the user realizes that some persons who hold the same membership as hers did not made as much contribution as she did, she would feel treated unfairly and will be discouraged from participating actively. On

the other hand, too many membership levels would complicate the hierarchy, hereby bringing difficulties for the users in figuring out which level is the higher one. What is an appropriate number for the membership levels? Aeroplan®, Air Canada's frequent flyer branch devised four different memberships to distinguish their customers: super elite, elite, prestige and regular. The exact number of the memberships could be different in particular systems, depending on the size (or expected size) of the community. Generally, to ensure that people will not be confused by the hierarchy of the memberships, the number of the membership levels should not be greater than six; to distinguish the users with different participation levels, the number should not be less than three.

In Comtella, we ranked all the users in the system into three levels of membership depending on the overall evaluation V_{oe} of their participation. First, the users were sorted by V_{oe} in decreasing order. Then we put the top 10% of them on the first level, and those users got gold membership. The middle 60% and the bottom 30% of the users became silver members and bronze members respectively. In this way, even though the users' V_{oe} values increased or decreased, the proportion of the users in each level would not be changed. Yet the three proportions may be adjusted in terms of the contribution level of the whole community.

In general, the number of the gold members in the community should be relatively small, because gold members, representing the highest participation level in the community, are not easy to be stimulated further. According to the theory of discrete emotions, their only motivation is trying to maintain their memberships. The reason we classified most of the users into the silver member category is that these users have the chance to upgrade their membership and at the same time have the fear about being degraded. Both of the two possibilities could become their motivation to make more contributions to the community. In addition, according to the social validation theory, the fact that most of the users in the community are in the first two levels would bring a pressure and stimulation for the inactive the users with bronze membership.

5.4. What should the rewards be

When a user has managed to upgrade her membership, it is very important to have her realize that the system does reward her participation and contributions in some ways. Otherwise, the user would feel it is useless to obtain a high level in the membership hierarchy and may stop participating and contributing. What should be the reward for the cooperative users? First, the membership itself is a sort of reward. Since users' memberships are public and shown in the Comtella community visualization [16], they serve as a kind of recognition from the virtual society. Gold members would gain a status of celebrities of the community. Silver members would receive some social attention as well. However, offering only this reward is not enough since not all users are motivated by status and social comparison. Therefore, we provide better services for active users. For example, in Comtella, some additional functions that facilitate the search for resources are used as the rewards for silver and gold members. The definition of a "better service" may be different in different systems. Generally, what is offered as better services should be what users really need in the system. The reward should deserve or outweigh the users' effort to upgrade their memberships.

5.5. The foundation of this motivation strategy

The main foundation of this motivation strategy lies in two social psychology theories, discussed in section 2. The first one is the reciprocation theory and the other one is the theory of discrete emotions (fear).

According to the reciprocation theory, appropriate rewards are needed when we ask people to do something for us [6]. In the proposed strategy, we reward the users' contributions with the hierarchical memberships and the better quality of service bound with the memberships. These two kinds of rewards are intended to satisfy different kinds of users. For instance, some users prefer glory or recognition but others want material benefit (better quality of service).

The theories of discrete emotions imply that people will feel fear when they perceive some threat to themselves or their properties. This fear to lose something makes them more receptive to the incoming messages, especially those about how to avoid the threat. Therefore, these messages become more persuasive to them [10]. If a silver member or a gold member of the community, who holds relatively high-level membership and enjoys some better services, stops participating in the community or contributes less than before, the system will show that the evaluation of her contributions is decreasing, which may arouse her fear of her membership being degraded. At this time, a message related to the actions that she can take in order to avoid demotion (e.g. the five cooperative activities listed before) might provide more effective persuasion.

6. The case study

We have implemented the proposed motivation strategy in the Comtella system. A study of the effectiveness of the strategy was carried out for ten weeks. We collected feedback from the participants and analyzed their activity-logs in the system. In this section, we describe how the proposed strategy was implemented in the Comtella system and how the data was collected. Then, the actual results of the study will be presented.

6.1. The motivation interface of Comtella

To apply the proposed strategy to the Comtella system, we introduced a set of three memberships into the system: gold, silver and bronze. All users are grouped into these three levels according to their own contributions to the community. The main feature of the user interface is providing different but analogous GUI to the users with different memberships. Figure 1 shows the GUI for the gold members of the community.

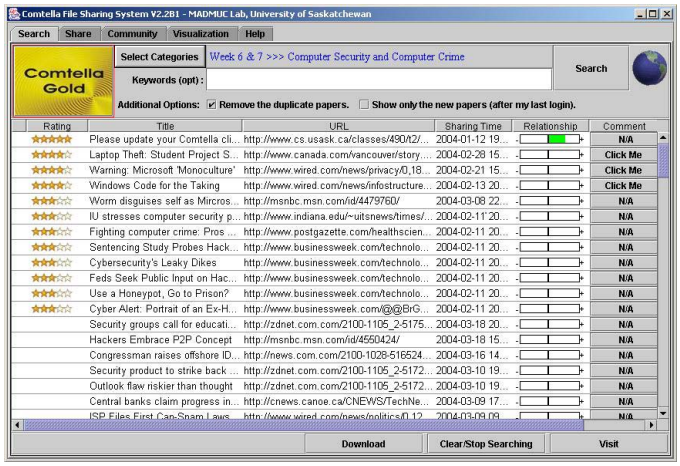

Figure 1. The GUI for the gold members

On the search panel (default panel when a user logs on the system) of the interface a symbolic membership card is displayed (see upper left corner in Figure 1), which clearly shows the user's current membership level. If the user clicks on the card, a new window would pop up and show the user' contributions during previous week (Figure 2). The window describes the proportion of the user's contribution to that of the top contributor in each category (each cooperative activity) instead of the absolute value. This information explains why the user is in the current membership class.

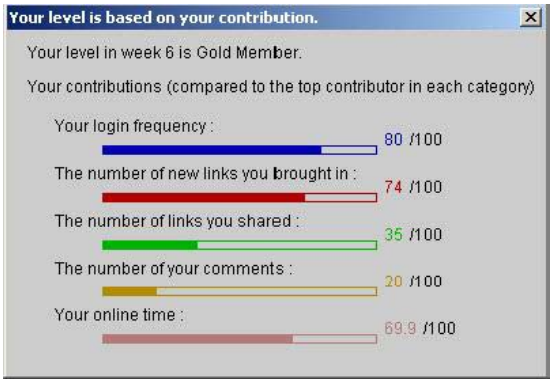

Figure 2. The window showing user's contribution

The users' overall contributions are calculated using formulae (1) and (2) in section 5.2. According to the importance of the five cooperative activities, we set the values of the five weights ($W_{i,\ i=1,2,3,4,5}$) shown in Table 1. In the latest version of Comtella, each user has a servant program which is always running in the server side. This servant program has the copies of all the resources the user has shared. Therefore, even though the user is not online, her resources are still available for others in the community. Since the basic level of participation (staying online and duplicating resources to ensure redundancy) are ensured in this way, we give the corresponding activities (staying online and downloading resources) relatively small weights; these forms of participation have become less significant for the Comtella community. Bringing new resources is very important for most p2p systems, so is it for Comtella. Besides, we encourage users to comment on the resources they have experienced.

Table 1. Different weights for five cooperative activities

i	**Cooperative activities**	***Wi***
1	Stay online	1
2	log on the system frequently	1
3	download resources and share them	0.5
4	bring new resources	5.5
5	comment on the resources	2

In Comtella, the users' memberships are public inside the community. If the user switches to the visualization panel, the system would show a hierarchical representation of all the users' nicknames together with their memberships (see Figure 3). This representation is supposed to trigger social comparison and thus stimulate the user to contribute more to measure up with her peers.

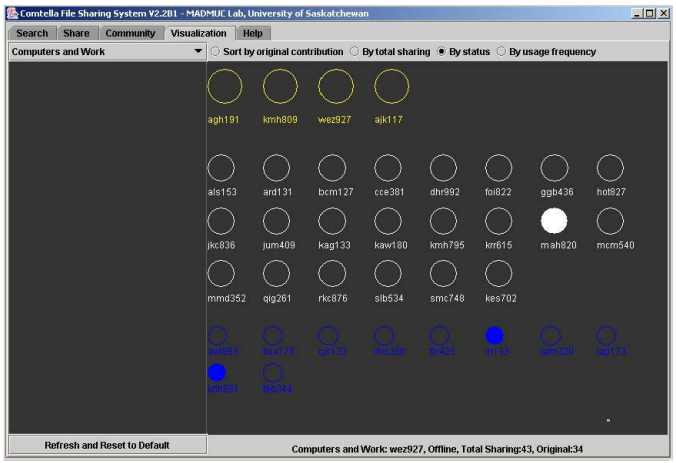

Figure 3. Visualization panel

Based on their status, we reward the active users with some useful extra functionality to facilitate their search. In the previous version of Comtella, it was difficult for users to find the target resources because the search results are usually numerous and there are many duplicate

resources which are returned from different peers. Therefore, we provide some useful extra-functions for the users with high-level memberships as better services, listed in table 2.

Table 2. Rewards for different members

Users	Addition Functions
Bronze member	✓ Sort search result by resource title
Silver member	✓ Sort search result by resource title ✓ Remove duplicate resource
Gold member	✓ Sort search result by resource title ✓ Remove duplicate resource ✓ Show only the new paper after my last logon ✓ Sort search result by rating, share time, or provider

6.2. The study on the effectiveness of the proposed strategy

To evaluate the effectiveness of the proposed strategy, we invited 35 fourth-year students of the Computer Science Department at the University of Saskatchewan to use the Comtella system while taking a course on Ethics and Information Technology. The students were encouraged to share class-related web articles with the community.

The study was performed for ten weeks. In the first six weeks, we did not apply the proposed strategy. At beginning of the 7th week we introduced the hierarchical memberships into the community and updated each user' membership status weekly, based on her participation and contribution level in the previous week.

The study was aimed to answer the following questions.

- ✓ Whether the strategy succeeded in stimulating the users to do the five cooperative activities?
- ✓ To what extent the users were stimulated?
- ✓ Did the users really care about their membership levels?
- ✓ Whether the addition functions were really useful? How often did the users use them?

To collect the data to answer the above four questions, the client program of Comtella was programmed to trace the users' actions in the system and report the data to a central database. The following data were recorded during the study.

- ✓ Whenever the user logged on the system, the logon time, logout time, and the user's identification were recorded.
- ✓ Whenever the user shared or downloaded a resource, the action, the resource and the user's identification as well as the time were recorded.
- ✓ Whenever the user clicked on her membership card, the action and the user's identification as well as the time were recorded.
- ✓ Whenever the user used the additional functions, the time, the function being used and the user's identification were recorded.
- ✓ All the users' actions on the visualization panel were recorded [16].

In addition, we used a post-experiment questionnaire to collect more information from the users at the end of the study.

6.3. Results of the study and analyses

Through analyzing these raw data, we obtained the following results.

✓ **Users' contributions and participations increased.**

According to the statistics, the users' contributions and participation began to dramatically increase since the 7th week of the study, the same time we introduced the hierarchical memberships into the community. Figure 4 shows the change of the sum of the new resources shared by the users per week. In the first six weeks, there were no membership levels, extra functionality or community visualization in the system. All users had the basic bronze-level functionality. It is evident that the average of the numbers of new resources in the last four weeks is greater than that in the first six weeks. Although there is a decrement in the last week, it is primarily due to the heavier workload of the students at the end of the term. Besides, other kinds of contributions, such as comments, increased as well after the motivation strategy was introduced in the 7th week.

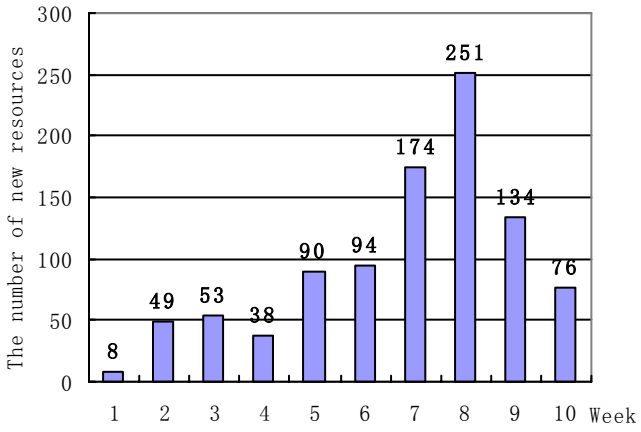

Figure 4. The change of the sum of new shares

We saw the same effect with the users' participation. As can be seen in Figure 5, the total times of the users logging on the system per week increased since the 7th week. Moreover, we found that the users tended to stay online longer than before. The average online time for each logon became longer since the 7th week.

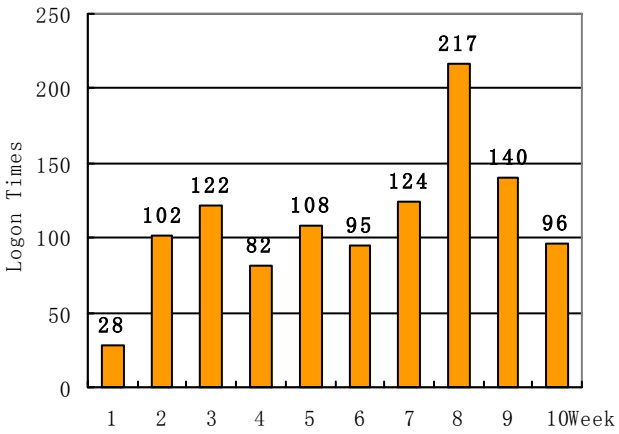

Figure 5. The change of logon times

✓ **Nearly half of the users checked weekly the evaluation of their contributions.**

According to the usage data collected, all the participants clicked their membership cards at least once to check the details about their levels of participation in comparison with the top contributor in each aspect. On average, since it was introduced in week 7, the membership card was clicked 10.8 times per user. Although the users might click their cards by mistake, the probability is small. Most of those who clicked the cards did this to check the evaluation of their contributions. Besides, the results of the questionnaires showed that 48% of the users indicated that they clicked the cards every week to check their participation and contribution levels.

✓ **The users who paid more attention to their membership status were more inclined to upgrade their membership intentionally.**

We found this pattern through analyzing the results of the questionnaires. Of all the participants, 58% indicated that they have tried to upgrade their memberships. However, of those who indicated that they had checked their membership status in each of the four weeks, 93% tried to upgrade their memberships. We noticed as well that the users who never paid attention to their membership status never attempted to earn higher-level membership. These users were not motivated by the proposed strategy. So obviously, there was a correlation between the efforts students made to upgrade their membership and the regularity with which they checked their participation measures.

✓ **Some of the extra ("reward") functions were used frequently, others were not.**

We provided six extra functions for the different membership levels to reward users with better services. Based on the data collected in the last four weeks, some of these functions were often used by the users, but some were not. For each of the functions, we calculated the following values to evaluate its usefulness:

✓ The number of the users who were eligible to use it (*NE*);

✓ The number of the users who used it (*NU*);

✓ The total times of the users using it (*T*);

✓ The percentage of the users who used it (*P=NU / NE*);

✓ The average times of using it per user (*A=T / NE*).

The data about how the extra functions were used are listed in Table 3. We found that sorting search results by title and removing duplicate resources were used most by the participants. Sorting by provider and sorting by rank were used as well and some participants used them frequently. However, the other two functions were used seldom. The function of showing only new resources was used less than once by each user on average. These functions are probably not what users really need. Generally speaking, the reward functions we provided for gold and silver members are not attractive enough. More useful functions are needed to stimulate users to upgrade their membership levels.

✓ **The quality of users' contributions declined.**

With the increment of the quantity of users' contributions, the quality of the contributions decreased. Some users shared a lot of articles not related directly to the topics of the class just to raise the evaluation of their contributions and gain a higher membership level or maintain their gold level. Since the hierarchical memberships were introduced into the community, the quantity of the users' comments increased but the length of the comments became short on average. Some students even plagiarized others' comments. In summary, after the

Table 3. The use of additional functions

Addition functions	The members who can use it	*NE*	*NU*	*T*	*P*	*A*
Remove Duplicate Resources	Gold; Silver.	32	20	167	62.5%	5.22
Show only new resources	Gold.	13	5	12	38.5%	0.92
Sort by rank	Gold.	13	4	37	30.8%	2.85
Sort by title	Gold; Silver; Bronze	35	15	343	42.9%	9.80
Sort by share time	Gold.	13	3	13	23.1%	1.00
Sort by provider	Gold.	13	8	34	61.5%	2.62

motivation strategy was introduced, users' contributions increased in number but at the same time declined somewhat in terms of quality.

7. Conclusions

The results of the case study demonstrate that the proposed strategy is capable of motivating users to participate in the p2p community and make contributions to it. After the hierarchical memberships were introduced into the Comtella community, the users began participating in the system more actively and contributing more resources than before. The questionnaires showed that 58% of the users tried to upgrade their membership and among them, 60% succeeded in doing it. In other words, the strategy successfully stimulated more than half of the users to participate and contribute. Besides, most of the users were concerned about their membership levels. The study showed that nearly half of the users checked the membership to see their participation details and the reason they held certain memberships weekly. In the process of the study, some participants even requested us to publish the mechanism we used to determine their memberships so that they can optimize their strategies to earn higher level memberships.

Some of the additional functions that we provided as rewards for the active users seem not attractive enough because they were seldom used by the participants. To improve the effect of the motivation, we should devise more functions that users really need to reward users' contributions.

The quality issue of the users' contributions deserves further research. The study has shown that after the motivation strategy was applied in Comtella, the users' contributions increased in quantity but declined in quality. The cause of this situation partly lies in the approach we used to measure users' contributions. The evaluation of a user's contributions is purely based on how much the user has done on each kind of five cooperative activities. The quality of the contributions was not taken into account. Our study shows that the user' performance in some of the cooperative activities (such as sharing new resources and commenting on resources) should be measured based on both quantity and quality. However, how to evaluate the quality of users' contributions is a question that doesn't have a straightforward answer. One possible solution could be measuring the quality of a resource by the times it was downloaded by other users, similar to the notion of "impact factor" (the number of references to one's papers) in determining the prominence of researchers. Another promising idea is introducing a stronger rating system, where ratings available to give depend on the users' participation level (similar to Slashdot's mechanism of computing users' "Karma"). It may encourage users to rate the papers and reward them with feeling of power. The problem is that such mechanisms may have an even stronger attraction for cheaters. In general, we believe that every effective incentive system attracts a certain percentage of cheaters and probably not having any cheating is a sign that the incentives are not attractive enough. Our research in developing mechanisms to encourage users to submit high-quality papers and discourage cheating is currently underway.

8. Acknowledgement

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http://bistrica.usask.ca/madmuc/peer-motivation.htm

9. References

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