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 Napter, Kazaa and edoney. 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 a successful one. To address the problem, this paper proposes a motivation strategy based on the 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 preliminary results of the study have show that the motivation strategy is capable of stimulating the users to participate more actively and make more contributions to community.

Keywords
Motivation, peer-to-peer system, social psychology, online community, hierarchical memberships

1. INTRODUCTION
Peer-to-peer systems have become more and more popular in recent years. Some applications have proved to be successful, for example, Napster, Kazaa, and edoney. 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 peer-to-peer 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. What a user can get from the system completely depends on what other users contribute to the system. If few users are willing to participate in the community or make contributions to it, the peer-to-peer system will never become a successful one no matter how excellent the technology it applies is in terms of protocol, performance, etc.

A P2P application, called COMTELLA [1] has been implemented at the Mobile and Ubiquitous Computing Lab at the University of Saskatchewan. It is a Gnutella-based peer-to-peer application which enables a community of researchers and students to share and exchange resources, such as research papers [2]. Although the system was mature in terms of technique, it can not provide good service because the number of participants was small. Moreover, some participants were actually free riders who typically entered the system, searched for what they need and then logged out. In this way there were very few people simultaneously on-line. Consequently the possibility of users finding the files they really wanted was also very small. When they realized the dysfunction of the system, they would be discouraged from making contributions to it further. On the contrary, if there are a lot of participants who are willing to keep online and contribute resources, the probability that a user finds what she really needs in the system would become much higher. The user who benefits from the system would perceive the system as useful and tend to log on more often, keep online longer, and make more contributions. Therefore, users' participation, as well as the value of the system would increase in a snowball effect.

Obviously, there exists a feedback loop in peer-to-peer systems. That is, 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 [3]. 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. PREVIOUS WORK
2.1 Related social psychology theories
How to motivate people to participate in a peer-to-peer system and make contributions to it? Generally, a peer-to-peer system, together with its users, creates an online society, which shares some features with real human societies. Therefore, some theories of social psychology could be used as the foundations of the strategies to motivate users' participation and contributions.

2.1.1 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 [4]. Therefore, if we want people to join our p2p community and make contributions to it, they should benefit from their participation and contributions. Actually, 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 and made contributions to their communities. However, their mechanisms were not very successful. To improve the effectiveness of the strategies, two key questions must be thought over. 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. We must give the users what they really need and therefore appreciate. If the users realize the uselessness of the rewards, they would not be stimulated to contribute.

2.1.2 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 [5]. 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 to the community 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.

2.1.3 Social Validation

Consider what would be your reactions 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 [4]. According to this theory, it is possible to persuade people to make contributions to p2p community by demonstrating that many people just like them have contributed a lot to the community and benefited from their contributions. In general, only a small portion of all users in a p2p system are active users. It is usually 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.

2.1.4 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]. 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 be more effective than one from a salesperson. The mechanism of Orkut.com, an online community, is based on the persuasiveness of liking. 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 and have its members realize that their invitations are the prerequisite of their friends entering the community. If we consider the action of invitation to be a kind of contributions to the system, rewarding this action may be another feasible approach.

2.1.5 Theories of discrete emotions

Discrete emotions are the emotions that have unique appraisal patterns, motivational functions, and behavioral associations [7]. Common emotions such as fear, anger, sadness, joy, etc. are discrete emotions. There are theories about each 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 [7]. 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 their 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.

2.2 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 have users make contributions. 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 tend to not 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 [8] to provide economic incentives for sharing resources. The users need to pay for each download as well. However, this approach did not effectively stimulate users to participate because act of buying anything, even if the price is very small, creates mental transaction costs, that is, the energy required to decide whether something is worth buying or not [9]. 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. But actually the users do notice, since they are being asked to buy something. 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 recorded 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 resource has been downloaded from her by other users and how much resources she has downloaded from others (in MegaByte) [2]. Actually, the basic of this strategy is reciprocation. Since the user's benefit (or privilege) is highly related to the amount of resource other users download from her, this strategy can motivate users to keep online, make more contributions, and even more,

compel them to be concerned about the quality and the potential demand of the resources they shared, because it is not rewarded to share the resources that nobody would download. However, the strategy can result in the following situation. A user who is sharing many files that are not of wide 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 varieties of files offered decreases.

2.3 Motivation strategies of server-oriented online communities

Similar to the p2p systems, some server-oriented online communities 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, she earns karma in the system, which gives her some special privileges. For example, the user's subsequent posts begin life at a higher rating than usual. And the users with high karma are more likely to be chosen as a moderator 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 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" [10].

Orkut.com (www.orkut.com) is an online community which provides an online meeting place for people to socialize, make new acquaintances and find others who share their interests. The community is apparently exclusive since people can join it only if they receive an invitation from a member of the community. Nevertheless, the size of the community is very large. Actually, the members of the community are inclined to invite their friends to join them because they clearly know that without their invitations, their friends are ineligible to become members of Orkut. On the other hand, according to the theory of persuasiveness of liking, an invitation from a relative or a friend would have more impact on people compared to an advertisement of the Website. So, this mechanism, although apparently exclusive, can attract people to participate in the community.

3. PROPOSED SOLUTION: HIERARCHICAL MEMBERSHIPS

In this section, I would propose another motivation strategy, which is different from the ones used in the existing p2p systems. Although this strategy is devised for our p2p community, Comtella, I believe it may apply to other peer-to-peer systems as well.

3.1 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 higher the user' contribution, the higher is her membership level. The users with higher-level membership receive better services and enjoy some privileges or special rights.

Actually, rewarding active users is the substance of this strategy. In order to implement this strategy, several crucial questions need to be resolved. The way they are resolved would influence the motivation effect of this strategy to a great extent.

3.2 How to measure users' contribution

We would like that the users in the Comtella community engage in the following five cooperative activities:

1) keep 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 performances on the five activities respectively. For example, a value "*V1*" 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 (*W1*, *W2*, *W3*, *W4* and *W5*) can be introduced to describe it. In Comtella, bringing new resources is more important than the other activities. So we give its weigh "*W4*" a higher value. Finally, an overall evaluation of a user's participation "*Voe*" 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 keeps online, her contributions are almost meaningless since very few people would benefit from them. Hence, we put a ceiling value (*Ci*) in 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 (*Wi_excess*) would be much less than the original one (*Wi*). Correspondingly, the user's contribution in the criterion should be recalculated in this way (2).

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

The goal 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 *Vi* (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.

3.3 How to determine the users' memberships

First of all, we should decide how many membership levels we should have in the community? If there are too many levels in the system, the hierarchy would become so complicated that it might be difficult for the users to figure out which level is the higher one. On the other hand, if the number of the membership levels is too small, the users with different participation levels would not be differentiated precisely. When the user realize that some persons who did not made as much contribution as she did hold the same membership as hers, she would feel unfair and be discouraged from participating actively. This could impair the effect of the motivation. Then what is an appropriate number for the membership levels? Air Canada 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 seven; To distinguish the users with different participation levels, the number should not be less than three.

In Comtella, we rank all the users in the system into three levels of membership depending on their own overall evaluation *Voe*. The detail process is the following. First, the users are sorted by *Voe* in decreasing order. Then we put the top 10% of the users on the first level, gold member. The middle 60% and the bottom 30% of the users become silver members and bronze members respectively. In this way, the proportion of the users in each level will not be changed, even though most of the users' *Voe* values increase (or decrease). Nevertheless, 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. Their only possible motivation is trying to maintain their memberships according to the theory of discrete emotions. The reason we classify most of the users to silver member lies in that they have the chance to upgrade their membership and at the same time have to care 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 in the users with bronze membership. This pressure may become another kind of stimulation for these inactive users.

3.4 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 therefore 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 in the community, they serve as a kind of recognition from the virtual society. Gold members would gain the status of celebrities of the community. Silver members would receive some social attention as well. However, offering only this social comparison 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 members and gold members. The better services may be different in different systems. Generally, what we offer as better services should be what users really need in the system. The reward should deserve the users' effort to upgrade their memberships.

3.5 The foundation of this motivation strategy

The main foundation of this motivation strategy lies in two social psychology theories, which have been discussed in section 2.3. The first one is the reciprocation theory and the other one is the theories of discrete emotions (fear).

According to the reciprocation theory, appropriate rewards are needed when we ask people to do something for us [4]. 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 [7]. 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.

4. THE EFFECTIVENESS STUDY

We have applied the proposed motivation strategy into our Comtella community. Based on it, a study on the effectiveness of this strategy is currently under way. Up to now, we have obtained some feedbacks from the participants and also some preliminary results of the study. In this section, I will first describe how the proposed strategy was implemented in the Comtella system and how the data was collected. Then, the actual results of the study are presented.

4.1 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 is the GUI for the gold members of the community.

On the search panel of the interface (it is the default panel when a

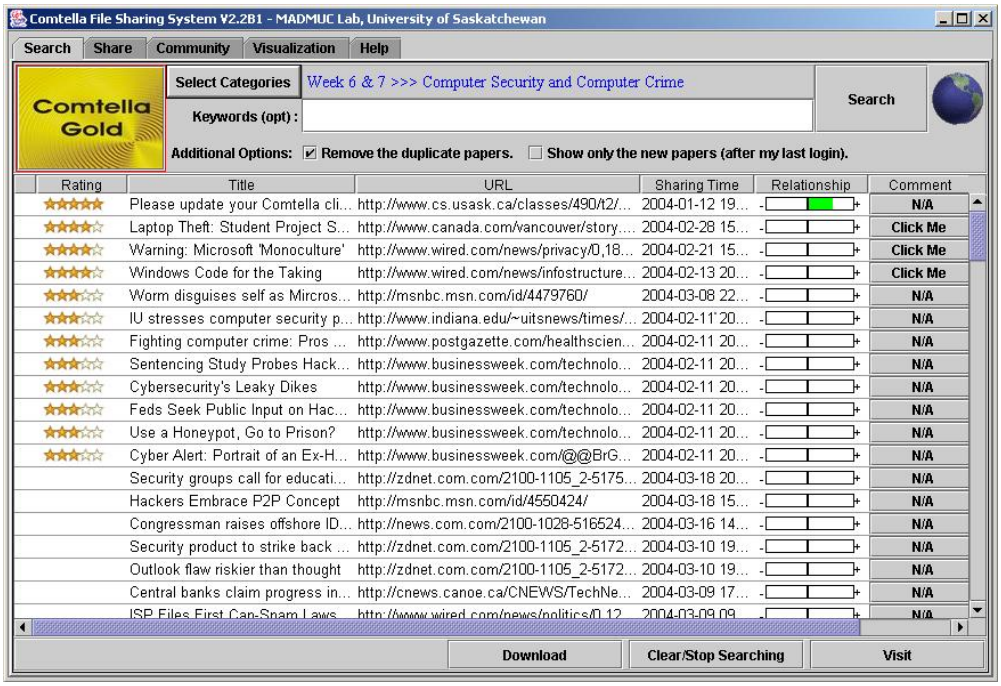

Figure 1. The GUI for the gold members

user logs on the system.) 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' contribution during previous time unit (one week) (Figure 2). The window describes the proportion of the target user's contribution to that of the top contributor in each category (each cooperative activity) instead of the absolute value. We anticipate this information could answer the user' questions about why she is in the current membership class.

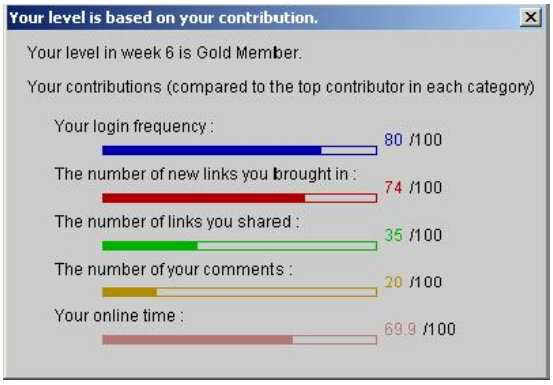

Figure 2. The window showing user's contribution

The users' overall contributions are calculated using formulae (1) and (2) in section 3.2. According to the importance of the five cooperative activities, we set the values of the five weights (*Wi, i=1,2,3,4,5*) as the ones 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. That is why we give the activities such as keeping online and downloading resources relatively light weights. They 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	Keep online	1
2	log on the system frequently	1
3	download resources	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.

Beside status, we reward the active users with some useful functions as well. These addition functions can facilitate their search for the resources they want. In the previous version of Comtella, it is difficult for users to find the target resources because the search results are usually numerous and there are

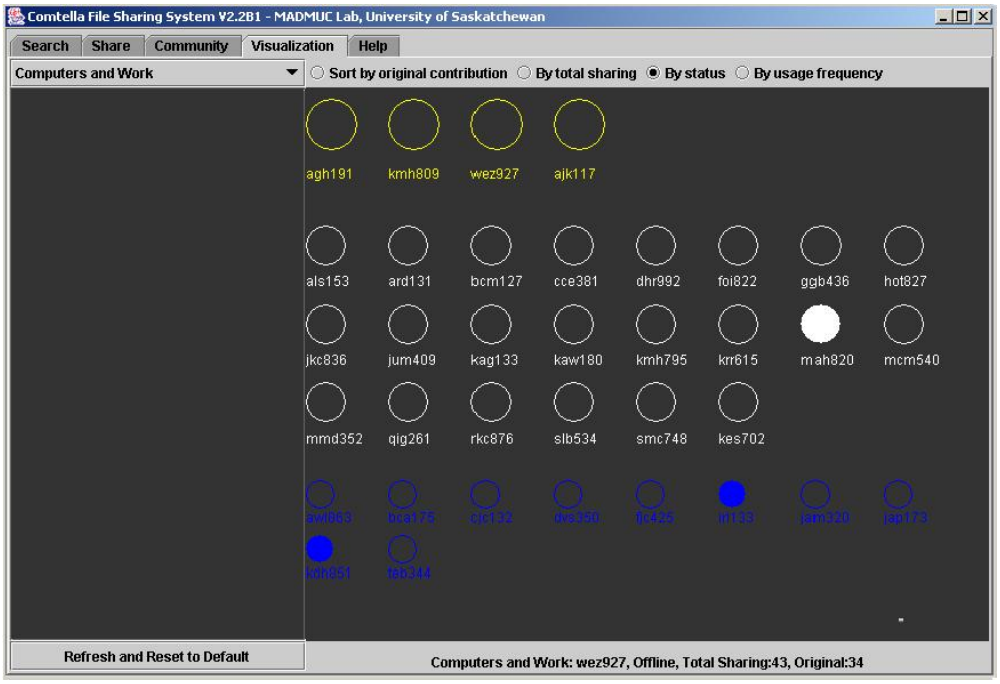

Figure 3. Visualization panel

many duplicate resources which are returned from different peers. Therefore, we provide some very useful functions for the users with high-level memberships as better services. What we offer different members is listed in the following table (table 1). We expect that these functions would be the motivation of users to upgrade their membership levels.

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

4.2 The study on the effectiveness of the proposed strategy

To prove the effectiveness of the proposed strategy, we have launched a study on it. We invited 35 fourth-year undergraduate 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 bring class-related articles into the community.

In the first six weeks, we did not apply the proposed strategy to Comtella. At beginning of the 7th week, we introduced the hierarchical memberships into the community and updated each user' membership status every week, based on her participation and contribution level in the previous week.

Summarily, the study was aimed to answer the following questions.

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

To collect the data which are useful to answer the above four questions, the client program of Comtella was programmed to traced users' actions in the system. 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 resources, 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.

4.3 Actual results of the study and analyses

Up to now, the study has been carried out for nine weeks. In the process, many data have been collected from the 35 participants. Through analyzing these raw data, we obtained the following results.

4.3.1 Users' contributions and participations increased

In order to evaluate the effectiveness of the strategy, we applied it to Comtalla six weeks after we started the study. So in the first six weeks, no motivation existed in the community. According to the statistic of the data collected, the users' contributions and participation increased 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. It is evident that the numbers of new resources in the last three weeks are greater than those in the first six weeks. Although there is a decrement in the last week, new resources shared increased in the long run. Besides, other kinds of contributions, such as comments, increased as well after the motivation strategy was introduced in the 7th week.

We saw the same effect with the users' participations. 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 keep online longer than before. The average online time for each logon became longer since the 7th week.

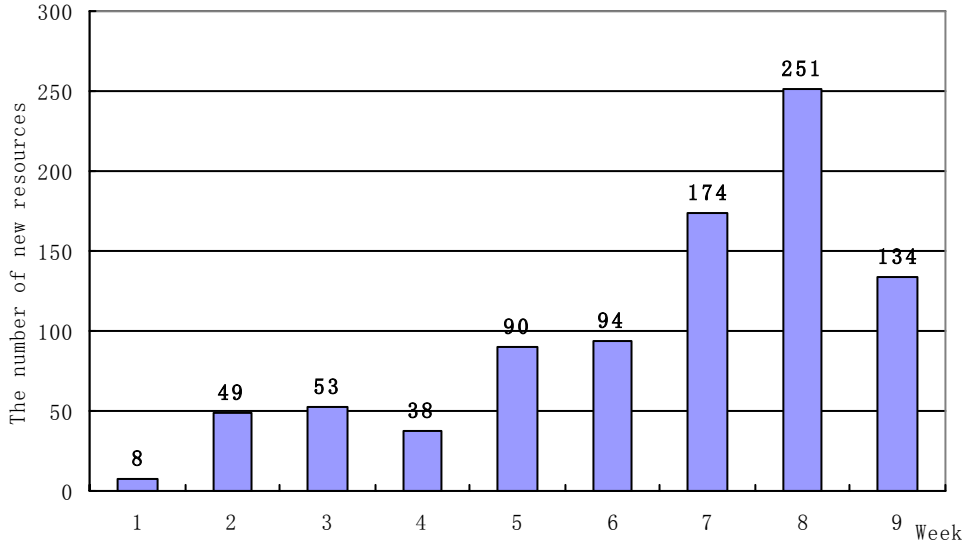

Figure 4. The change of the sum of new shares

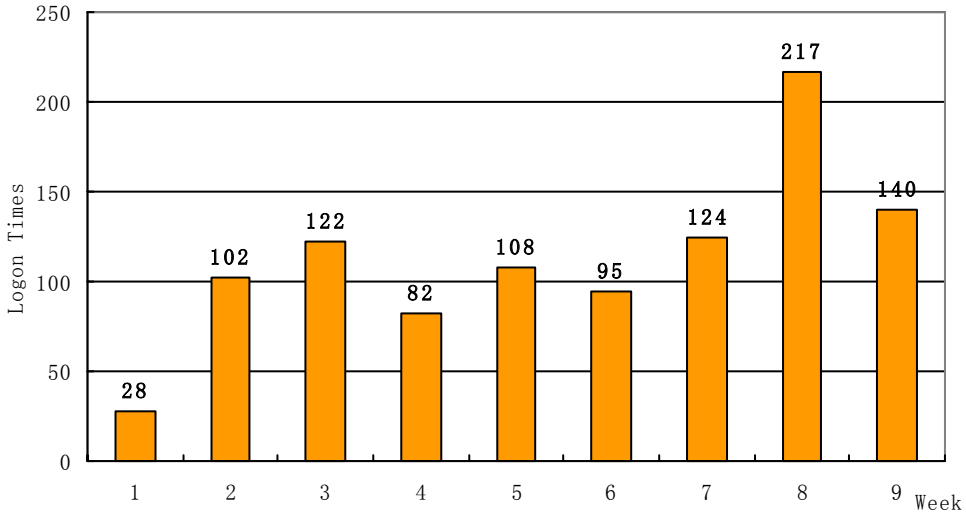

Figure 5. The change of logon times

4.3.2 The majority of the users checked weekly the evaluation of their contribution

According to our records, all the participants who have downloaded the new version of Comtella clicked at least once their membership cards on the search panel, which showed their levels of participation in comparison with the top contributor in the respective aspect of participation. On average, in the last tree weeks, the membership card was clicked 9.56 times per user. Moreover, 60.0% of the users clicked the cards every week since the 7th week. Although users might click the membership cards by mistake, the probability is small. Most of the users who clicked the cards did this to check the evaluation of their contributions, especially those who did that every week.

4.3.3 Some of the additional ("reward") functions were used frequently, others were not

Totally, we provided six additional functions for the different membership levels in terms of rewarding with better services. Based on the data collected in the last three 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 results of the calculations are listed in Table 3.

According to the results, we found that removing duplicate resources and sorting search results by title were usually used by the participants. They are the most useful of all the additional functions. Sorting by provider and sorting by rank are usable as well since some participants often used them. However, the other two functions were used seldom. The function of showing only new resources were used only once by each user on average. These functions are probably not what users really need. Generally speaking, the reward functions we provided for gold members and silver members are not useful and attractive enough. More useful functions are needed to stimulate users to upgrade their membership levels.

4.3.4 The quality of users' contributions declined

With the increment of the quantity of users' contributions, the quality of the contributions decreased. Some users shared lots 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 a word, after the motivation strategy was introduced, users' contributions increased in number but at the same time declined somewhat in terms of quality.

5. CONCLUSIONS

According to preliminary results of the effectiveness study, 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. Besides, most of the users seemed to be concerned about their membership levels. The study has showed that more than half of the users checked the reason they held certain memberships every week. In the process of the study, some participants even requested us to publish the mechanism we used to determine their membership so that they can optimize their strategy to earn a higher membership. Nevertheless, the effectiveness of the motivation strategy needs to be tested further since currently the study was carried out for only nine weeks and the results were still preliminary.

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 figure out more functions that users really need to reward users' contributions.

The quality issue of users' contributions deserves further research. The study has showed that after the motivation strategy was applied in Comtella, the users' contributions increased in quantity but declined in quality. The cause of this situation lies in the approach we used to measure users' contributions. The evaluation of a user's contributions is based purely on how much the user has done on each kind of five cooperative activities. The quality of the contribution 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

Table 3. The use of additional functions

Additional functions	**The members who can use it**	***NE***	***NU***	***T***	***P***	***A***
Remove duplicate resources	Gold; Silver.	31	20	153	64.5%	4.94
Show only new resources	Gold.	11	4	11	36.4%	1.00
Sort by rank	Gold.	11	4	32	36.4%	2.91
Sort by title	Gold; Silver; Bronze.	35	15	309	42.9%	8.83
Sort by share time	Gold.	11	3	13	27.3%	1.18
Sort by provider	Gold.	11	7	33	63.6%	3.00

measured based on both quantity and quality. However, how to evaluate the quality of users' contributions is a question that deserves future research. One possible solution could be measuring the quality of a resource by the times it is 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. Besides, the mechanism of computing users' "Karma" in Slashdot.org is also a promising idea. According to that, the quality could be based on the ratings the other users have given to the resources.

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