Motivational Visualization for Resources-Sharing Online Communities

A Thesis Submitted to the College of

Graduate Studies and Research

in Partial Fulfillment of the Requirements

For the Degree of Master of Science

in the Department of Computer Science

University of Saskatchewan

Saskatoon, Saskatchewan

by

Lingling Sun

Permission to Use

In presenting this thesis in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or to make other use of material in this thesis in whole or part should be addressed to:

Head of the Department of Computer Science
University of Saskatchewan
Saskatoon, Saskatchewan, Canada
S7N 5A9

Abstract

As online applications such as online newsgroups, internet game-rooms, online chat-rooms, and peer-to-peer (P2P) resources-sharing systems become popular, online community visualization became a hot research topic. Different forms and metaphors of visualizations focused on various aspects of online communities have been proposed. In this thesis, I propose one prototype of online community visualization which is designed to motivate user contributions in various aspects and stimulate users to participate in the online community more actively. The uneven participation is a well known problem in human society; according to the 80-20 rule, 20% of the people make 80% of contributions, for example, 20% of the employees in a company do 80% of the work. This problem exits in all kinds of online communities, e.g. newsgroups, chat-rooms, but it is particularly crucial for P2P online resources-sharing communities. Such communities do not have a central server and rely solely on the peers not just to provide contributions, but also to ensure the infrastructure. Large P2P file-sharing communities like KaZaA and Limewire can provide the redundancy of peers and resources needed to support the infrastructure and availability of resources. However, when an online community is small, for example, the students in a class, a research group, a department, or a school, the problem of lack of users it is hard to reach a "critical mass" of user participation, leading to poor service and resource availability, which reduces users' interest in participating in the system.

To attract users and motivate them to make more contributions into an online resources-sharing community, I propose to use motivational visualization of the community and the contributions of its members. The motivational effect of the visualization is grounded on two theories in social psychology which explain how individuals align their behaviour with each other and with their group (community). In this thesis, I discuss three stages in the design of the visualization and the subsequent redesigns following results from evaluation and user feedback.

Acknowledgements

First of all, I express my sincere thanks to my supervisor, Prof. Julita Vassileva for her support, patience, guidance throughout my project and my thesis.

I would like to thank my advisory committee: Prof. Gord McCalla, Prof. David Mould, and Prof. Chris Zhang (external) for their valuable advice and suggestions. Special thanks to Prof. Winfried Grassmann and Prof. David Mould for their help on the statistical analysis.

I would also like to thank all the students and the faculty members in the Department of Computer Science, University of Saskatchewan, who participated in the experiments on the Comtella system, for their valuable feedback. Also thank you to Ms. Jan Thompson for her help and support.

Last but not least, I would like to thank my Mom for her all-time support without which I would not be able to finish my work. I would like to dedicate this thesis to my Mom.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

A community is formed by individuals. The number of the individuals in a human community and the contribution that each individual makes to the community directly determines the existence and prosperity of this society. However, Pareto pointed out an interesting phenomenon (Pareto, 1896-97), known as the 80/20 rule: in any human group or community 20% of the people contribute 80% of the resources or work. This phenomenon can be observed also in online communities and is particularly crucial for P2P online resources-sharing communities. Such communities do not have a central server and rely solely on the peers not just to provide contributions, but also to ensure the infrastructure. Large P2P file-sharing communities like KaZaA and Limewire can provide the redundancy of peers and resources needed to support the infrastructure and availability of resources. However, when an online community is small, for example, the students in a class, a research group, a department, or a school, the problem of lack of users it is hard to reach a "critical mass" of user participation, leading to poor service and resource availability, which reduces users' interest in participating in the system.

In order to attract users and encourage contributions, some motivational tool is needed in any online community. What kind of tool would be effective in motivating users to join an online community and to bring more contributions is an interesting research topic.

In this thesis, I propose a prototype of motivational visualization to encourage users to contribute resources into an online resources-sharing community and to participate more actively in the community. The motivational effect is grounded on research in social psychology. My literature survey in social psychology has led me to believe that a visualization interface which gives every user a chance to see the community may be an efficient way to motivate contributions and more active participation. According to

social psychology (Festinger, 1954), people generally want to compare their attitudes and actions with their peers and like to fit in their peer groups. Theoretically, if a user sees that most of the other users in the community behave cooperatively s/he may pay more attention to his/her own behaviour. If the user knows that other users are able to see his/her behaviour, s/he will feel more responsible for his/her actions and manners.

Encouraged by the discoveries from my literature survey, which will be described in chapter 2, I developed a prototype of motivational community visualization to encourage users to participate in an experimental online resources-sharing community more actively and motivate users to share more files with high-quality (i.e. high-quality files are considered by other users of being useful, relevant, or interesting). The system used to test the effectiveness of this visualization prototype is a P2P file-sharing application, "Comtella", developed in the MADMUC lab at the University of Saskatchewan. Through the entire research, I have completed the design, implementation, and evaluation of three versions of this visualization prototype. Chapter 3 describes the first version of the visualization which takes a static approach. Chapter 4 describes the second version of the visualization which takes a dynamic approach. Chapter 4 describes the design of the final version. Chapter 5 concludes this thesis with a summary of all the three designs and evaluations on each design as well as the suggestions on further research on similar topics.

Chapter 2

Literature Review

A human society is made of different communities and a community is formed by a group of individuals. The number of individuals in a community and the contributions that each individual makes to this community directly affect the existence and the prosperity of the community. The same logic applies in online communities. Without enough users, an online community would not even exist, so it is essential for an online community to ensure a **critical mass** of users. How large is the critical mass for a given online community? In other words, how many users are enough to sustain an online community? The answer depends on how big the community is and what is the major concern of this community: a community serving millions of members may require thousands of contributing users, and a community serving hundreds of members may require tens of contributing users. A file- or resource-sharing community may not necessarily require a very large number of contributing users but a large number of shared files or resources, and an online game room may require a large pool of users to play the game for so that it is more fun etc. Although the level of critical mass required may vary depending on the particular type of the online community, it is certain that if the number of users is under this level of critical mass, the community will decline and ultimately vanish as time goes by due to the lack of contributions and participants; and if the number of users is at or above this level of critical mass the community is likely going to grow and attract even more users because it provides a lot of resources and the activeness of its existing members. Thus online communities have a feedback loop with respect to number of participants: the more participants, the more attractive it is and the more participants it will gain.

There are two types of online communities based on the structure of the networks:

1) online communities with centralized servers, such as online newsgroups, internet chat rooms, cyber games. This type of online communities need active contributing users but users do not have to stay online very often because the central server will keep records of user information including their shared resources, if any, and make them available for other users.

2) P2P online communities. Communities of this type do not have a centralized server. Every user can be a server if s/he provides any service or resource to others. Thus, this type of online communities not only requires a large number of contributing users but also requires users to stay online for as long as possible so that their information and resources will be available to others. In P2P online communities, user participation can be classified into five different levels (Vassileva, 2002):

1. **Staying online** and having the P2P servent (Milojicic et al., 2002) connected to other peers in the P2P online community so that the shared materials are available for the community and the servent can forward queries and responses. This is the lowest level of participation which ensures the existence of the P2P network, and therefore the search infrastructure of the community.

2. **Consuming** (e.g. downloading): users download files from others and re-share the received replicates, which creates copies of popular materials and thus increases their redundancy and availability.

3. **Contributing**: users bring new materials to the P2P online community. This level of participation requires more effort but enriches the variety of materials in the P2P online community.

4. **Rating**: users give unbiased ratings on the quality of the shared materials. More effort is involved in this level of participation (reading/listening/viewing and evaluating the materials) but it benefits others by saving search time and helps to improve the quality of the shared materials.

5. **Commenting**: users give truthful and unbiased comments on each other's shared materials. This level of participation requires also a lot of effort but makes it much easier for others to find good materials and it is also effective in improving the quality of the shared materials. Besides, comments act as a sort of community feedback given to

the contributors and it makes the online community visible i.e. users can feel the existence of the virtual community through the feedback that they received from it.

Since ensuring participation in P2P online community is harder than in other types of online communities, I will start with the discussion of P2P online communities first. Depending on the goals of a particular P2P application, it is not equally necessary to ensure all these five levels of participation. Most of the current P2P systems such as KaZaA (Sharman Networks Ltd., 2001), LimeWire (LimeWire, the Gnutella Protocol Specification v0.4), BearShare (Free Peers Inc.), and E-Donkey (MetaMachine, 2000) are mainly focusing on ensuring the first two levels of participation with some attention on the third level. In the next section the main existing P2P file-sharing applications and their approaches for motivating user participation will be reviewed.

2.1 P2P Networks vs. Client-Server Networks

Since Napster was introduced in 1999, peer-to-peer (P2P) systems have become popular and have been largely used for online resources-sharing. “Peer-to-peer” systems refer to “a class of systems and applications that employ distributed resource to perform a critical function in a decentralized manner” (Milojicic et al., 2002). Traditionally, networks were built on the client-server model. Depending on the size of the network, there can be only one server or several servers, each connecting to a group of clients. As the name indicates, servers provide resources and services and clients consume services and resources and then wait for being served by any available server upon the request. In a traditional network, every server knows at least where its clients are and usually every server also knows the services and the resources that its clients frequently ask for. There is and has to be direct communication between these clients and their server but there is no such communication between clients. Even if clients sometimes have to talk to each other, they talk via the server. Clients are free to come and leave at any time while servers have to be available all the time. Thus, a traditional client-server network needs regular maintenance and to set up and maintain the servers is generally costly.

Compared with traditional client-server networks, a P2P network is highly decentralized, unstructured, and has the advantages of low cost, improved scalability, anonymity, replication and diversity of resources (Milojicic et al., 2002). Instead of

having servers and clients in a traditional network, a P2P network only has "servents" (Klingberg & Manfredi, 2002) or "servant" (LimeWire, the Gnutella Protocol Specification v0.4) (in this context I use "servent"). The term "servent" is a "contraction from the words *SERVe*r and *cliENT*" (LimeWire, the Gnutella Protocol Specification v0.4) because a servent can act as either servers or clients or both at the same time. The servents are equal in status and role, and therefore they are called "peers". Unlike servers in traditional networks, servents enjoy the freedom of leaving and coming at any time; their privacy is well protected because of the anonymity in a P2P network. In Gnutella, probably the most elegant and fully distributed P2P protocol, every servent is directly connected to a group of other servents which form the servent's neighbourhood. When trying to locate a resource or service, a servent asks first its neighbours, and then they ask their neighbours, etc. The query is propagated until it either finds a servent that has the resource or provides the service, or its "time to live" (usually 7 hops) expires (Klingberg & Manfredi, 2002, LimeWire, the Gnutella Protocol Specification v0.4) It is clear that this type of network has many advantages: no central point of failure, equality among all participants on the network, and anonymity, to name a few. With all these advantages compared with the traditional network applications, P2P applications are considered useful and promising.

However the current P2P applications also introduce a lot of problems. Their variable topologies can cause poor performance. Their lack of fixed network structure due to the fact that everyone is a server as well as a client and everyone has the freedom to decide when to come and leave and what resource to share make it hard to organize and locate the resources and services. So P2P networks in general are inefficient in locating the requested resources.

This is especially true for Gnutella-based applications, since they are among the earliest P2P applications. Gnutella is a protocol for distributed search (LimeWire, the Gnutella Protocol Specification v0.4), but in a broader sense Gnutella has been used to refer to any decentralized peer-to-peer system (Klingberg & Manfredi, 2002) using Gnutella protocol. Gnutella-based applications often suffer from problems such as mal-organization and random location of shared resources and services, unpredictable message routing, and search delay.

Over the last five years, people have been working on alternatives to improve the performance of Gnutella-based applications. There are proposed methods to optimize the structure and successfully adapt network overlays: Chawathe et al. (Chawathe et al., 2003) proposed mechanisms to improve Gnutella's scalability while still maintaining its simplicity; the "small world model" (Kleinberg, 2001) is proposed to support efficient search based on psychologist Stanley Milgram's *Small World* phenomenon (Milgram, 1967) which indicates that people are mostly linked by "short chains of acquaintances". Based on Kleinberg's work, "an enhanced-clustering cache replacement scheme" is proposed for Freenet (Zhang et al., 2002). *BestPeer* (Ng et al, 2002) is implemented as a generic prototype P2P system, where peers learn from the success of queries where to send their next query. The notion of "Super Peers" is introduced in (Yang & Garcia-Molina, 2003) and is now adopted by a lot of P2P systems, like KaZaA or Morpheus, to speed up search and facilitate the management of heterogeneous P2P networks.

Other P2P protocols have been developed, taking the advantage of decentralization, low cost, and resource diversity, etc. For example, *Pastry* (Rowstron & Druschel, 2001) which "performs application-level routing and object location" and supports efficient message routing and object locating in various P2P applications; and *Chord* (Stoica et al., 2001) which is a "distributed lookup protocol" that targets the problem of efficiently locating certain data items.

However, all the existing approaches are on the protocol level and assume that there is a large enough pool of peers (and correspondingly, users) constantly on-line sharing materials. There are not many attempts, if any at all, focusing on the actual users' behaviours. The human factor seems to be neglected in the earlier P2P applications. In fact, all the structural improvements on the specific types of P2P applications are evaluated under the assumption that there exists a large P2P network where a massive number of users is guaranteed at almost any time. But the question is "Is this assumption always fair?", or in other words, "Are there always enough users in P2P networks at any scale?" The answer is "no"! When a P2P application is built to serve a relatively small community such as a company, a school, a newsgroup, or a research group, quite often there are not enough users and even if there are some users they may not make any contributions to their P2P community. The experiment about free riding (Adar &

Huberman, 2002) shows that in Gnutella communities, 70% of the users contribute nothing; 50% of requests are responded to by the top 1% of the contributing users (Adar & Huberman, 2002), which means 30% of the users contribute very little, if anything at all.

Without enough user contributions, there will not be enough resources available and no diversity of the resources. Without enough users staying online, there will not be enough hosts to forward requests to their destinations and not enough responders to these requests. A critical mass of users is needed for the community to exist and for the system itself, but the problem is that even in good communities most of the users do not contribute or only contribute very little.

Recently, the importance of attracting contributing users in P2P communities has been brought into focus (Vassileva, 2002, Bretzke & Vassileva, 2003). People have noticed the problem of free riding (Adar & Huberman, 2002) even though some others have argued that free riding is not always bad (Shirky, 2000) because even if people don't contribute actively, as long as they stay online, they ensure the infrastructure for passing messages, which is fundamental for P2P applications.

Various solutions have been implemented to ensure a critical mass of users on-line who re-share their downloaded materials (participation at levels 1 and 2). Most popular P2P applications, e.g. LimeWire, BearShare, E-Donkey, and KaZaA make it hard for users to exit the system. In these applications, closing the application's interface does not mean to quit the system; instead, the servent continues running in the background without the interface, but only an unnoticeable tray-icon shows the actual servent at a corner on the screen. In this way a large number of users who are either unsuspecting or too lazy to go through the effort of closing the application on the system tray will stay online for much longer time period ensuring the infrastructure and sharing their files. This trick is potentially risky because users may give up the system once they realize that they are cheated, i.e. the system does not really exit when users actually meant to do so.

Approaches have been proposed for online communities on motivating users to contribute through incorporating economic incentives (Hardy & Tribble, 1995; Ma et al., 2003) such as micro-payments (Shirky, 2003; Szabo, 1999) and service

differentiation (Ma et al., 2003) (i.e. give better or more services to users with bigger contributions). Golle et al. (2001) have proposed an algorithm for calculating credits for users based on their contributions to the online community. This algorithm pays particular attention to deal with cheating – trying to gain more credit while not actually contributing enough. However, there have been compelling arguments by Clay Shirky that micro-payments do not work in practice (Shirky, 2003), since the mental transaction cost (Zhang et al., 2002) of deciding whether to start a download when one has to pay for it, even a miniscule amount, is too high. Differentiated service, as applied in KaZaA (Sharman Networks Ltd., 2001) invoked a lot of protests among the users who in response invented numerous ways to play the system. The next section introduces some example of general forms of online communities and how they motivate user participations and contributions.

2.2 Online Communities

As computer technology advances, the Internet has become a new way of communication and people not only chat online but also work and play online. As a group people come together at a network place, they form an online community. There is an increasing number of computer applications that serve online communities and apply various mechanisms in motivating people to participate and bring contributions. The following are some examples of online communities in general.

The Internet Chess Club – ICC (Ginsburg & Weisband, 2002) is a successful world-wide online game community that motivates a large number of volunteers. The Club categorizes its participants based on their interests and skills. *Software contributors* are good programmers and they help with designing, improving, and maintaining the system. People who enjoy chess playing can join the tournaments and compete to win the *Titled Chess Players* and as they play, they also discover the problems with the system and give suggestions and ideas. *Helpers* are interested in socializing and their duty is to answer questions online. *Administrators* train players, organize helpers, and advertise forthcoming events etc. *Managers* organize chess tournaments and resolve conflicts. Every explicit volunteer (i.e. a volunteer known by ICC members and directly tied in with them) has a special letter appended to his/her Net ID to identify his/her

status. For example, helpers have an "H" appended to their Net IDs. To be a helper, one has to be tested for his/her qualification. Although they are not paid, helpers are rewarded with a private communication channel. Administrators chat through their own channel; most of them are volunteers except some paid consultants and a few equity holders of private ICC. It has been observed that volunteers generally worked hard to maintain or gain reputation in the Club. Chess players practice their skills in order to compete in the tournaments and gain the status of *Titled Players*; software contributors compete in inventing new features for the system, helpers compete in the quantity and quality of the messages that they post, administrators put a lot of effort in socializing new-comers and training players etc. so that they can be recognized as specialists or experts when they chat with others as well as that they gain the chance of being promoted to managers. Now ICC has thousands of members who are motivated and actively make contributions to the Club and the total social capital of the Club constantly increases (Ginsburg & Weisband, 2002).

Slashdot.org (Slashdot.org Community, http://slashdot.org/) is a widely used online news group where people post information, their own questions, as well as answers to others' questions. The Slashdot.org community motivates users' contributions by a type of digital money – "Karma". Every posting is counted as a contribution to the community from the person who posted it. By making contributions, one can gain recognition from the community in terms of ratings from the others. To avoid inflation, each user has only a limited amount of ratings to give, depending on his/her "Karma". Based on their "Karmatic level", people can attain moderator-rights for some period of time, which "increases their visibility and power in shaping the forum" (Slashdot.org Community, http://slashdot.org/). This "Karmatic level" gives the users the benefit of having more control over the discussion forum in the Slashdot.org community and causes competition among its users, who tend to not only post more information and discussions but also give more informative or instructive postings in order to get more ratings.

The ESP Game (Ahn & Dabbish, 2004) is an online electronic image tagging system. The problem of semantically tagging pictures is well known. Its goal is to create a game-like environment where the players have to tag images on the web. The goal of the game

is that players try to 'agree' on the tags for as many images as they can in 2.5 minutes (Ahn & Dabbish, 2004) and the pair of players with the highest number of agreeing tags is the winner. The game-like nature of this ESP community directly arouses competition. To intensify the competition as well as make it more interesting, ESP highlights the success of a pair of players by giving them a certain number of points each time when they agree on the tag of an image, and giving even a larger number of bonus points when they agree on a set (15) of images (Ahn & Dabbish, 2004). The experimented on ESP and the result (Ahn & Dabbish, 2004) shows that the system has attracted a substantial number of players and produced a great number of good quality tags for images on the World Wide Web.

Travel Decision Forum (Jameson et al., 2001) is a computerized system designed to help a group of friends to organize a holiday trip in the situation where they cannot meet each other in person to do the planning. Each user is represented by an animated agent who is able to show emotions as responses to the decisions and choices made by others. For example, when one person compromises his/her favorite tourist destination or holiday activity so that the group can reach an agreement, the agents representing the other users show appreciating faces. In this way, the user will be encouraged to behave cooperatively.

Orkut (Orkut Society, http://www.orkut.com/index.html) is an online "trusted community", where the members can bring up various issues and comments for discussion. The interesting feature of Orkut is "by invitation only" – one can join the Orkut community only by invitation from a friend who is already a member. As soon as one joins Orkut s/he can invite his/her friends to the community. Orkut is an example in building large social groups. As people communicate by posting discussions, comments, and suggestions, they socialize with each other and find friends with common interests. Since friends are all interested in the same common issue or a group of related common issues, they can form their own discussion group inside the Orkut community and invite more others to join them. The total postings of the Orkut community will increase in this way. In the case that someone starts disagreeing with his/her friends in a particular discussion group, s/he can either persuade his/her friends to agree with him/her by posting convincing discussions or break the relationship with these friends by leaving

the group. Even if s/he leaves a group, s/he can always switch to another group that is more agreeable to him/her or start his/her own group and invite new members to join this group. The total postings of the Orkut society will also increase in this way. The "invitation only" makes the Orkut community like a club of rich people and creates a feeling of exclusiveness and belonging to the community.

Embodied conversational agent (ECA) (Nakanishi et al., 2002) has been evaluated based on how the agent can influence human relations. They carried out an experiment with multiple pairs of subjects who mostly never met each other in person or did not know each other very well. In the experiment, each pair of subjects communicates through an automatic animated computer agent. The agent asks each subject twenty questions and shows the subject whether or not it agrees with him/her. There are three situations in the experiment, each with a particular kind of agent: agreeing agent, disagreeing agent, and unfair agent – "the agreeing agent agrees to both subjects' opinions", "the disagreeing agent disagrees with both of their opinions", and "the unfair agent agrees to one subject's opinion but disagrees with the other subject's opinion at once" (Nakanishi et al., 2002). The experiment showed that an agent would have stronger influence on the relationship of the subjects if the subjects were not allowed to communicate in any other way except through the agent, i.e. while in the situation where the subjects were allowed to communicate via a second medium such as a voice conversation or a text conversation, the agent's influence was dramatically reduced. With a second means of communication, the subjects had more opportunities to exchange opinions directly and on a wider range (not limited to the questions that the agent asked), for example, the subjects could simply agree with each other on the dumbness of the agent because they both thought "it could not understand or be aware of their conversation via the second means" (Nakanishi et al., 2002). Moreover, with a second means of communication, the unfair agent lost power to control the relationship between the subjects by picking one side against the other, because the subjects were able to express sympathy to each other through the second means of conversation when the agent disagreed with one of them. In this case, as Nakanishi stated, the social agent's behaviour is observed by a third party, i.e. as the agent showed its opinion to subject A, the other subject, B, acted as a third party, observing the agent's behaviour and would

exchange his/her idea over the agent's behaviour with A, and A and B might reach agreement on their thoughts. When designing a social agent, it is important to be aware that the agent's behaviour "is interpreted by the third person as well as the person to talk with" (Nakanishi et al., 2002), and therefore the relationship between the two persons may not always and only be influenced by the agents' opinion i.e. the agent may lose control over the relationship if it keeps giving biased or fake opinions.

The above online communities provide example of effective motivators in encouraging users to contribute and participate in an online community. In my research I focus on users' consciousness and try to arouse users' awareness of their online community and their feelings of belonging to the community so that they would be willing to participate and bring contributions. So I proposed a prototype of community visualization which makes the invisible online community visible. This idea is based on my investigation on user behaviour in human societies from the social psychologists' point of view. The next section gives an overview of two major social theories that guide my research.

2.3 Social Psychology

In order to find a fair means to reach the goal, I had to investigate user behaviour in human societies from the point of view of social psychology theory. The next section gives an overview of related work in this area.

After social psychologist Leon Festinger first published his famous paper on **social comparison** (Festinger, 1954) in 1954, interest in social comparison has been growing fast, especially in the recent decade. According to Festinger, social comparison can happen in different directions. There is *upward comparison* – when people compare with someone that they think is better than themselves, and *downward comparison* – when people compare with someone that they think is no better than themselves (Festinger, 1954). But normally, if people really want to learn about their abilities or attitudes they compare with their peer groups – a group of others that they think is similar to themselves in some way (Festinger, 1954). For example, when a student wants to know if s/he is good at math, s/he usually compares with the other students taking the

same math class, rather than with their professor. However, when there is no suitable peer group, people will compare with almost any one.

A useful side effect of social comparison is that when people know that they will be taken as the benchmark by others, they will act more responsibly. Generally speaking, people feel happy to be positively recognized in their social communities and are willing to make an effort to gain social reputation, provided that the effort is affordable and worthwhile compared with the potential benefit of the reputation. Usually people also want to maintain their good reputation once they have gained it. Another outcome of social comparison is the appreciation from the community. When a person spends efforts and resources for the benefit of his/her community, if s/he receives appreciation from the community s/he knows that compared with others, his/her effort is positively recognized and so s/he would be encouraged to continuously act cooperatively.

Hornstein (1968) did an experiment to prove that social comparison commonly existed in human society. They dropped many times a wallet in Manhattan and watched people's reaction when they picked it and how many of them would actually return the wallet. The wallet contained nothing expensive or special, only a return address, $2, and a letter. The variations were different in the letters. Some letters were clearly from an English-speaker (native of Manhattan) while others were clearly from a foreigner; the letters had different tones: positive, neutral, and negative. 30% of the wallets with a letter from a foreigner were returned, 65% of the wallets containing letters from a English-speaker with positive or neutral tone were returned, and only 10% of the wallets from the "English-speaker" with negative tone were returned. The explanation of Hornstein's experiment is that when people picked the wallet, read the letter and felt they were similar to the letter writer they were more likely to return the letter, but when they felt that the letter writer was similar to them but spoke negatively, they were discouraged from returning the wallet.

Since it has been shown that social comparison exists, the next question is why it exists? The answer is people want to "fit in" to a group. Fitting in at an interpersonal level happens; for example, when someone sees a friend doing or believing in something and starts believing or doing the same thing. Fitting in at a collective level happens, for example, when one sees trends in the behaviour of others, e.g. the style in dressing, and

changes his/her own style of dressing to fit in, even if only for a particular occasion. In order to fit, people compare with each other and the result of comparison is changing opinions and behaviours to fit in the majority. Asch's conformity study (Asch, 1951) demonstrates this. In this experiment the subjects were asked to compare the length of three lines against a reference line and give the opinions on whether each of the three lines was longer, shorter, or equal to the length of the reference line. They were allowed to discuss with each other but everyone had to come up with his/her own decision. A small portion of the group was the experimenters, who were known just as regular users by other subjects, and these experimenters deliberately gave wrong opinions while they were chatting with the other subjects in order to test how their opinions would influence the rest of the subjects. The result was that 33% of all the answers were wrong and most subjects gave at least one wrong choice.

Computer scientists (Cosley et al., 2003) did another experiment for online movie rating systems which also showed that people generally want to "fit in" their group. In this experiment subjects were divided into four groups, A, B, C, and D. Each group was seated in a separate room so that they would not influence each other. Before they started rating the given movies, group A, B, and C were given some predicted ratings and group D was not. The results showed that a significant proportion of the participants from groups A, B, and C were influenced by the given predictions in their ratings (Cosley et al., 2003).

The fitting in behaviours can also be explained by the balance theory (Kogan & Tagiuri, 1958). The theory states that when two acquainted persons are involved with the same social issue, if they have the same opinion towards this issue (e.g. they both agree (figure 1a) or they both disagree (figure 1b)), they build or maintain a positive relationship; if they have different opinions then their positive relationship breaks (figure 1c, d), or in order to maintain the positive relationship, one of them has to persuade the other to change his/her opinion so that they get back to the pattern of either figure 1a or figure 1b.

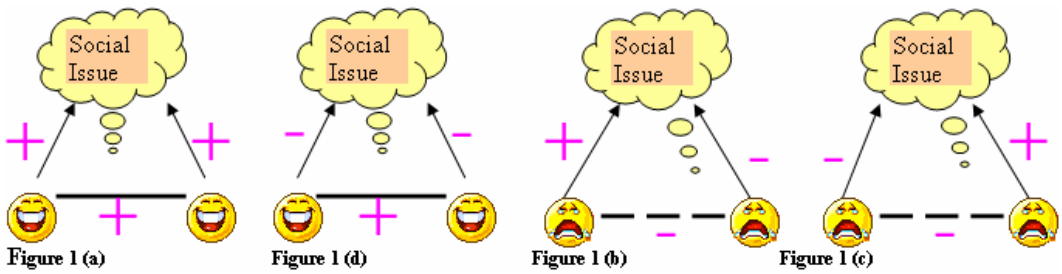

Figure 1. Balance Theory

The "Social Issue" in figure 1a to figure 1d can be instantiated to anything of importance in a community, such as a person, a topic, an object, a problem, an event, or a political cause etc. An arrow with a "+" sign represents a positive attitude, an arrow with a "—" sign represents a negative attitude, a line with a "+" sign stands for a positive relationship between two persons, and a dashed line with a "—" sign stands for a negative relationship between two persons in which case the relationship is broken. For a triangular structure (figure 1) to be stable, in other words to be balanced, the dot product of the three signs in this triangle has to be positive (Kogan & Tagiuri, 1958), which means there has to be either three positive signs (figure 1a) or two negative signs and one positive sign (figure 1b,c,d). A configuration with one negative sign and two positive signs or with three negative signs is unstable and will evolve into a stable configuration by changing one of the signs. Thus, when we build group collaboration, we can group users according to their preferences and interests. When the group members agree with each other, their relationships will be stronger and the so is the stability of the group. **Embodied conversational agent (ECA)** (Nakanishi et al., 2002) is a system applying the balance theory in building relationships between users.

To provide encourage participation, many online communities use community visualizations. Some well-known work in this area will be presented in the next section and their success indicates that a visually attractive representation of an online community will arouse users' interest in using the system, therefore, will stimulate active participation.

2.4 Community Visualizations

There are good techniques in making information-compact visualizations for large networks from the HCI (i.e. Computer-Human Interaction) point of view, and there are

also different graphical representation used to create the visualization. As computer becomes faster and memory becomes cheaper, more complicated metaphors such as palace, garden, and city are applied in visualization interfaces.

2.4.1 Techniques in Designing Information-Compact Visualizations

The following is a list of known techniques in designing large-scale visualizations:

Hierarchical structure: online communities may vary a lot in size and some can be very big, containing hundreds or even thousands of nodes. Applying hierarchical structure will facilitate organizing the layout of a large number of nodes (Eick & Wills, 1993, Sprenger et al., 2000). The major difficulties in creating reasonable hierarchies are finding a suitable clustering algorithm and choosing a proper scale. The clustering algorithm should not only focus on "optimizing the computation and spatial grouping" (Sprenger et al., 2000). It should also make each cluster meaningful and self-explanatory. A proper scale should help generate enough levels in the hierarchy to map the levels of significance; hence, there should neither be too many levels to confuse users nor too few to blur the difference between levels. Eick et al. (Eick & Wills, 1993) presented a visualization showing the email interaction in their company. Their visualization was aimed at large and complex networks where each connection of a pair of nodes had a strength or weight attached to it. Their visualization also made use of "any hierarchy present on the nodes to aid the investigation of large networks" (Eick & Wills, 1993). H-BLOB is another type of hierarchical visualization (Sprenger et al., 2000). It focuses on visualization at multiple levels of detail. The major idea about H-BLOB is a new hierarchical visual clustering method which uses isosurfaces and completes the visualization construction in two stages.

Composable Layout and Visual Sets (Pattison et al., 2001) is introduced as the "novel Composable Layouts and Visual Sets class of views", abbreviated into CLOVIS, which is an application of "graph drawing and information visualization techniques to the visualizations of information which can be modelled as an attributed graph" (Pattison et al., 2001). Pattison argued that it would be easier and more convenient for both the designers and the users if the visualization did not have to show all the information at once. In other words, decomposing the information into sub visual sets

will be a good design for large and information-complex visualizations. This will help solving many interaction problems such as navigation, filtering, details on demands (Pattison et al., 2001).

Attracting Visual Attention: people usually do not pay attention to everything they see (Lamme, 2003). The advantages of graphical presentation over plain text are that 1) human eyes are more sensitive to colourful pictures than black-and-white text and 2) human brains are better at memorizing patterns than words (Lamme, 2003). Effective means of emphasizing something to stimulate visual attention can be one or a combination of the following: highlighting with a particular color, locating at a special place (e.g. center of the picture), using different drawing patterns, etc. These means are aimed at creating contrast to the surroundings.

Reusability: since "richly expressive information visualization is difficult to design and rarely found" (Humphrey, 2000), it is beneficial that once a useful visualization is created, it can be re-applied in similar situations.

Apart from the above techniques in designing community visualization from the technical point of view, there are also some good suggestions (Erickson, 2003) in creating different types of online community visualizations (Erickson et al., 2002; Erickson et al., 2004; Erickson & Kellogg, 2003) and they also investigated their effect on the users in the online communities and came up with the following suggestions for designing online community visualization:

1. Everyone sees the same thing: no customization – when one sees something s/he knows that all the others see it as well, and the others also know that s/he knows this. Thus, people would pay more attention to what they do and be more responsible for their actions by the feelings of obligation and peer pressure.

2. Portray actions, not interpretation – the system may often be used in ways that the designer has never expected, so the interpretation provided by the designer in the expected situation would more often be incorrect or even misleading to the users in the real situation. Therefore portraying objectively the actions will be more useful and practical than interpretation of the actions.

3. Allow deception – people commonly want to hide their true feelings or actions in social situations; hence for a social visualization to completely and truthfully represent a

social activity is impossible and even undesirable. For instance, when a person appears offline in MSN (MicroSoft MSN Messenger), s/he may actually be online but does not want to be disturbed and so has switched off his/her MSN interface. Designers generally have no options but to allow deception or to allow for a certain level of ambiguity.

4. Support micro/macro readings – social visualization should be made of many small, consistent components so that as time goes by, they will be self-organized into certain readable patterns. For example, Task Proxy (Erickson et al., 2004), which will be introduced in detail in the following section, each user is represented by a very small hexagon and a group of users is visualized to be a group of hexagons. As time goes by, people can figure out that the color of a user's hexagon shows progress in his/her work, and so does the color of a group of hexagons (figure 2 in Appendix 1).

5. Suggest rather than inform – since it is not possible to completely eliminate ambiguity in social visualization, the visualization should give suggestions rather than information, in other words illustrate social translucence (Erickson et al., 2002, Erickson & Kellogg, 2003) instead of providing complete transparency, but the ambiguity has to be made clear to all the users i.e. all the users understand there is a certain degree of ambiguity in the visualization (as guideline 3 claims). For example, everyone knows MSN's ambiguity in displaying a person's status and the truth is left up to the users to infer from both the visualized information and their personal experiences.

6. Use a third-person point of view – although users may know what they are doing, it is still necessary for them to see some feedback for their own activities so that they are assured that their actions take effect and the system works as they expect. More importantly, it provides the users a better chance to learn how the social visualization system works if they are able to see their own actions reflected (Erickson, 2003). The feedback does not have to be very detailed. A minimum amount of reflection is enough. For example, in the case of MSN, when a user sets his/her status to be offline, his/her icon in the MSN interface turns to red from green and the system will not allow this person to send any instant messages unless s/he switches to be online, but the details such as the exact time when this user turns to be offline, why s/he is offline, how long s/he will be offline, and when s/he will be available again etc. are omitted.

The above are all techniques and suggestions on how to develop intuitive, informative, and useful community visualizations. When we get to the details, there is an important question: what specific metaphor do we want to use to represent a P2P online community? In other words, what particular graphical representation do we want use to visualize the online community? There are numerous alternatives. The following section is going to introduce a group of existing metaphors that other types of online communities have applied. My research topic is not on testing the difference in the effectiveness of different types of metaphor; instead it is on finding out given a specific visualization prototype if it could motivate users to make more contributions.

2.4.2 Various Metaphors in Online Community Visualizations

Erickson et al. developed a social visualization system applying the guidelines listed in the previous section – the **Babble System** (Erickson & Kellogg, 2003; Erickson et al., 2002) (figure 1 in Appendix 1), which was "designed to serve the communication needs of small to medium sized corporate groups" (Erickson & Kellogg, 2003; Erickson et al., 2002). In the Babble user interface there is a pie representing the current chatting community. A dot on this pie represents a participant in the community. When a dot moves closer to the center of the pie, it means that person is becoming more active; if a dot is further away from the center of the pie, that person is not quite active; and if a dot goes on the edge or even outside of the pie, that person is idle. However, when a dot moves close to the center, it is hard to tell whether that person is really paying attention, talking frequently with someone, or just pretends to be typing meaningless input. Social translucence applies here and the truth is left up to the user to guess. People, seeing the clustering of dots, will draw the conclusion that a hot debate is going on there, and may choose to join the debate or at least to be there listening. So the system is generally "engaging and informative" (Erickson & Kellogg; 2003, Erickson et al., 2002). Babble uses a pie-dots metaphor. It does not explicitly apply any hierarchical structure but it does group users into different chat rooms based on the topics of discussion. When a user joins into a particular topic, his/her "pie" will visualize the situation of the selected chat room. This avoids all the users crowding into one "pie" and also helps with organizing the view of different chat rooms. The movement of a dot closer to the center

of away from the center is expected to be an intuitively understandable representation of the participant becoming more active or less active and is a way of attracting attention to an individual's activities. This visualization has mostly informative role, and the main purpose is to create user awareness of the activities in the community. Such visualizations may also have a behaviour changing role. For example, if a user realizes that s/he is overly active and monopolizes the conversation, but this is more a side-effect than an intention in the visualization design.

The Task Proxy (Erickson et al., 2004) (figure 2 in Appendix 1) is a visualization using "a packed set of hexagons", looking like a honeycomb, where each hexagon represents a person involved in a particular task, and a group of hexagons attached side-by-side to each other represents a group of people involved n the same task. The color of a hexagon shows the status of the sub-task undertaken by the represented person e.g. the darker the color, the closer the person is to completing his/her part of the task. The group manager's hexagon is located at the upper left corner with a hat on top, and the current user's hexagon has an asterisk on it. The entire target, e.g. a company, may have multiple tasks carried out by different groups of people. Each group is displayed in the Proxy as a packed set of hexagons. Color differentiation makes it easier for viewers to pick up which task is at an early stage and which one is going to be completed, since the overall color of a nearly-done task will be much darker than the rest and a newly-started task will have a very light color, almost white. It is also trivial to detect who is the "slowpoke" in a task since that person's hexagon color will always be much lighter than the rest of the group. As a result of this, the slowpoke will be pushed to work harder and catch up quickly with his/her colleagues. This task proxy gives clear information but it gives users room for interpretation; it does not show exactly what each person is currently doing, and if a person is obviously slower than the others, the task proxy does not clearly say whether it is because that person's task is more difficult or because that person is lazy. Yet, one can view this visualization as one that creates very explicit conditions for social comparison and can thus be used for influencing users' future behaviour.

Robert Savage created **VisitorVille** (Savage, http://www.visitorville.com) (figure 3 in Appendix 1), which is a visualization tool for web server traffic analysis. He used a

metaphor of buildings and buses in a city, where the entire city is the domain, the buildings are the web pages, and buses display the source (a searching engine or an external link) from which visitors are coming to the webpage. For example, if a visualization built with VisitorVille is to represent the websites of business companies, then this will be the domain – the definition of the city in this particular case. Users using Google to find the website "http://www.visitorville.com/" open it, and from there will be represented as taking a bus named Google to get to a building named "VisitorVille". The more visitors to a certain webpage, the higher is the building representing that webpage and the lighter are the windows in that building. The difference of height and the brightness are effective means to cause visual attention. Viewers immediately notice the major websites that have a lot of visitors as well as the minor ones which are rarely visited by anybody. Visualizations created with VisitorVille are able to generate a clear overview of the popularity of each website enclosed in its domain which can be any range of websites engaged in any subjects.

VIUM (Uther & Kay, 2003) (figure 4 in Appendix 1) is a visualization tool showing a graph of related concepts to help students' learning online. The tool lists all the titles to the left of the webpage that the student is currently reading. The title that the student selects to be the focus will be displayed in larger font with more space around to distinguish it from the rest. Other titles, according to their relevancy to this one, will be displayed in smaller fonts and with less space around. Those that hardly relate to the focus will appear in a mass because they are in very small font and with almost no space around to separate them from each other. The differentiation in font size and spacing makes it easy for the student to recognize the most related titles to what s/he is learning, as well as to see how many of them exist. Color differentiation is also used in *VIUM* to show how much the student has learned on different topics. *VIUM* provides users a slider to specify a standard e.g. how much has to be learned on a topic is considered as "known enough". All the topics that a student has known enough will appear in green (as the traffic light for passing permit) and the rest, in red, and the "saturation of the color indicates the degree" (Uther & Kay, 2003). According to the standard set by the student, a topic that s/he has mastered will appear in pure green, the topics that s/he has learned about but not considered as "known enough" yet will appear in a color less

green but a bit reddish, and those s/he has not learned yet, will be in pure red. With a higher standard, the student has to learn more to make a topic appear green and there will be fewer topics in green, and vice versa. *VlUM* uses color and space to attract visual attention and persuade users to learn more. There are no explicit hierarchies applied in *VlUM*; however, the differentiation in font size and color gives an implicit hierarchical effect since more relevant topics are easier to be recognized. Users have great control over the visualization by selecting titles and setting standards.

Chat Circles (Viegas & Donath, 1999) (figure 5 in Appendix 1) is "a graphical interface for synchronous communication that uses abstract shapes to convey identity and activity". Instead of the commonly used text-based chat rooms, Chat Circles, as the name indicates, uses circles representing users on a black background. Circles representing the users engaged in the same discussion are placed close to each other. At login time, each user is asked to pick a color of his/her circle and to specify a name for it. The name will be displayed beside its circle. The color is purely a user preference, carrying no special meaning. However, both the color and the size of a circle changes as messages are posted. When a user sends a message, his/her circle becomes bigger and brighter, containing the message in it. Depending on the length of the message, if this user does not post any new messages for a while, his/her circle will become smaller and less bright. The longer the user stays silent, the more his/her circle fades into the background, but as long as s/he is still connected to the chat server, his/her circle will not completely disappear from the interface. *Chat Circles* give users an overview of the chat group, e.g. the total number of people in this group, how active they are, what the newly posted messages, etc. At the same time, it is the easy for users to pick up more recent conversations and the conversations they are currently involved in.

2.5 Summary of the Literature Review

It is essential for an online community to maintain a certain number of contributing users. This issue is even more serious with P2P online resources-sharing communities which target smaller scale, local area networks such a company, a school, a research group other than the World-Wide-Web (WWW) because these local networks do not have as many potential users as the WWW. My research focused on finding an effective

way to motivate users to participate and volunteer contributions in a resources-sharing online community.

The social comparison and the balance theory introduced by social psychologists provide possible approaches to arouse people's interest in participating in social activities. One can see examples of methods and mechanisms for encouraging participation in online communities such as newsgroups, chat rooms, and game rooms. Visualization brings an online community closer to its members by making it more visible. The hypothesis is that a specially designed visualization to encourage social comparison and fitting in with the community (according to the balance theory) may help to increase the participation and contributions in P2P applications.

Thus, my research project is to design a motivational visualization, applying the social comparison and balance theories for a resources-sharing online community. The expected result is that with this motivation visualization, the users will be encouraged to participate in their resources-sharing online community by competing in their contributions and the total amount of contributions of the community will be increased. To my best knowledge, there are no applications using community visualization based on social psychology to encourage participation in resources-sharing online community.

Chapter 3

First Design of the Visualization for Comtella

During my work at the MADMUC lab, I participated in the development of several versions of a Gnutella-based file-sharing P2P system called *Comtella*, which stands for "*Community Gnutella*". Comtella is used for sharing research papers. To share or search for a file, a user has to specify under which category/topic the file should be classified (by selecting a category from a pre-defined list in a menu). The user can also add keywords to specify the topic more or to narrow down the search by giving extra keywords. By modifying the list of categories/topics, Comtella can serve different communities of users who are interested in different areas.

Comtella is intended to serve a closed community such as a research group, a lab, a department, a company or a class of students to share files containing articles or web links. As discussed early in chapter 2, when an online community does not have enough potential users, encouraging participation is very important. In other words, when an online community is not large enough to guarantee that there are always enough users making enough contributions to serve the community, we need to find a way to encourage users to participate so that the community can survive. In order to motivate the users to actively participate in their Comtella community, a prototype of community visualization was proposed. It serves two purposes:

- to facilitate social comparison. According to the theory of social comparison in social psychology, people tend to compare with their peers from time to time and will act to fit into their peer group.
- to create a feeling of belonging to a community and educate in people a positive attitude towards contribution. The balance theory states that people involved positive relationship tend to have similar attitudes to issues of common interest and vice-versa. In Comtella, the social issue under

discussion is whether or not making contributions to an online community, one of the social agents is a community of users, and the other is an individual. If a community of users generally makes a lot of contributions to the online community, a new user wants to join this community will be urged to make contributions as well (figure 2a); as this user contributes, s/he will feel more and more related to the community (figure 2b), and thus the relationship between him/her and the community is strengthened. However, there may also be negative influences. When a community of users in general does not contribute, a user who is in that community will be negatively influenced and become less contributing or not contributing at all (figure 2c). The visualization helps with applying the balance theory by making the community members and their contributions visible, but has to be carefully designed to avoid or decrease the effect of the negative case.

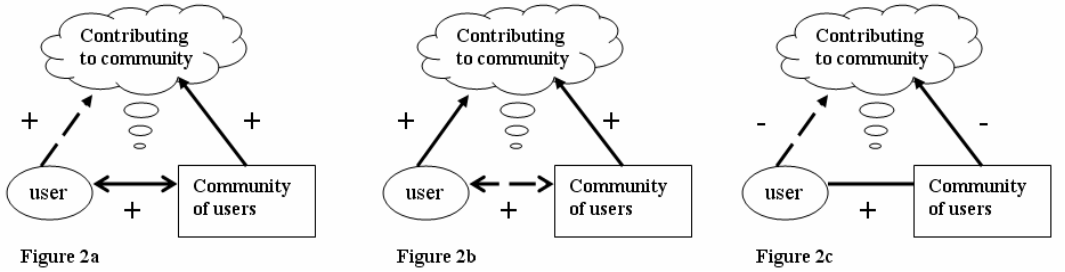

Figure 2. The Balance Theory as applied in Comtella

The application of social comparison in the Comtella visualization is for encouraging the competition among users so that the total resources provided by the Comtella community will increase. The application of the balance theory is for strengthening the feeling of belonging to the community and the attitude of cooperativeness among the members.

The Comtella visualization has evolved through three versions. In the following sections of this chapter will introduce the design rationale, the experimental results, and the user feedback for the first version. Chapter 4 will introduce the design and evaluation of the second version and the final version is presented in Chapter 5. The focus of my work is not on comparing different metaphors or different types of visualizations, but to investigate if my proposed prototype of visualization has any effect

on encouraging social comparison and simulating users to bring more contributions. The metaphor chosen is a picture of a star-studded night sky, because it allows representing a range of semantic dimensions and to the best of my knowledge, there is no similar metaphor deployed in any existing online community visualizations.

3.1 Design Rationale

The first version of the Comtella visualization was designed as a static webpage, showing the same community view to all the users. This design follows Erickson's first suggestion "everyone sees the same thing: no customization" (Erickson, 2003). A non-customized view is easier to implement, and most importantly, when a user sees the non-customized Comtella visualization s/he knows that all the other users see the same thing and they know that s/he knows this and the user will feel more responsible for his/her behaviours in the community. The visualization, written in PHP and HTML, is generated on a web server using the data stored in a MySQL database. The data storage is separated from the graph generation so that the visualization can be used to serve any online communities of a similar type and size with minimum modification on data fetching. The database is updated constantly with the information reported by each user's Comtella servent. The information includes each user's identification and his/her activity (shared files, uploads, downloads, and interrupts etc.) in the Comtella community. Users have consented to allow this data to be collected and used for research purposes. The client-reporting protocol needed for the visualization server is separated from the regular Comtella protocol to eliminate any possible interference with the main Comtella functionality. To see the Comtella community, one can either visit the website without running a Comtella servent, if s/he knew the web address, or s/he can use a button on the interface of his/her servent to open a browser window with the pre-coded web address.

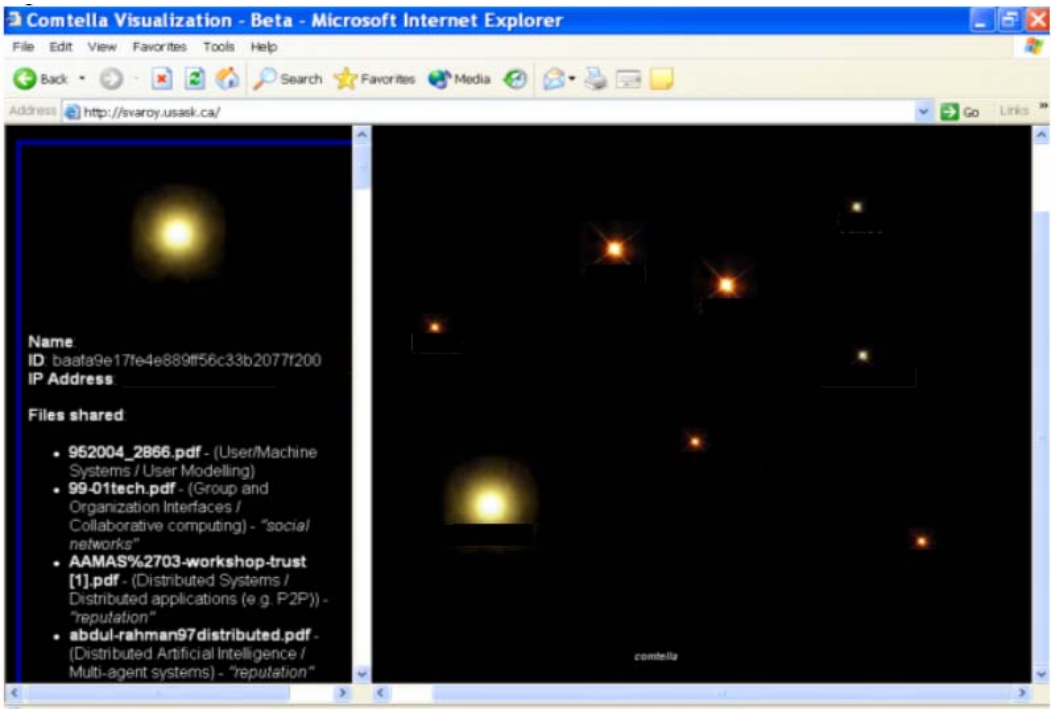

Figure 3. Motivational Visualization - first design (user names and IP address are blocked off with black rectangles to preserve the privacy of the participants).

Figure 3 shows the first version of the visualization which shows a somewhat realistic view of a mid-summer night sky. This metaphor was first proposed by Bretzke and Vassileva (Bretzke & Vassileva, 2003) for Comtella, where each star represents a user that is currently online. The size of a star is determined by the user's contributions i.e. the number of files that the user shares in the Comtella community: those who share more than the average number of files shared per user in the community have larger stars, those who share roughly the same as the average will have medium-sized stars, and those who share less than the average will have small stars. The color of a star may be either red or yellow depending on how generous a user is. Red (warm) stars represent users who give more than they take, i.e. who download from others less than what others download from them. Yellow (cold) stars represent users who download more from others than what others have downloaded from them. The largest star is the sun representing the best user among all the users. The best user in the network is determined by the number of files s/he shares and his/her balance with other hosts, in other words, to be represented as the best user one has to share more than everyone else and take less than most of the others. All sizes and colours of stars are relative,

depending on who on line at the moment when the visualization is generated (e.g. when the user clicks on the web-link "Community view"). The usability test showed, however, that this decision to compute relative sizes and colours was not a good choice as explained in the next section.

The small text, "Comtella", at the bottom of the right window frame of the visualization (figure 3), is a link to the user manual page. By clicking on this text link, users see the legend of the visualization displayed at the left side of the visualization interface. Clicking on any star or the sun shows details about the represented user at the left side, including his/her user name (may be an alias chosen by the user), IP address, list of shared files, areas of interests, and the relationships with other directly connected peers (the peer neighbourhood). The relationships are computed by considering the balance between taken and given files as explained in (Bretzke & Vassileva, 2003).

3.2 Usability Study

In the first experiment, since the subjects were graduate students, researchers and faculty in the department, the areas of interests, i.e. the topic list provided by Comtella, was predefined by extracting a subset from the ACM category index. To initiate a search, a user had to select a topic from this pre-defined list, which was inconvenient. Due to very low usage of the system, there was no possibility to sufficiently evaluate the first version of the visualization to verify its effectiveness. However, I did collect some raw data as well as feedback and suggestions from the interviews with most of the users. There were 16 users who used the system and approximately 10 of them used the system for more than one month. Most of the users accessed the visualization webpage at least once in each log-in session. About two hundred unique papers were shared in the Comtella community. The feedback from the users revealed the following problems:

1. The visualization did not provide enough interactivity. One example was that users always tended to click on the listed files shared by other peers displayed in the left visualization frame, hoping that they could download or open those files, but the visualization did not support this function.
2. The graphical location of each star was random. Most of the users tried to interpret both the absolute location and the relative location of a star in the interface as the

representations of some logical relationships, e.g. closeness in interest between users, but there wasn't any such relationship.

3. The motivational effect was not strong enough. Some users suggested that people with different levels of participation should be treated differently and the visualization should show the distinction with more details and in a more intuitive way.
4. Some users were only interested in one category and were active in contributing papers in this category but they appeared as very small and cold stars because the visualization considered the overall contribution made by each peer. Users whose area of interest wasn't shared by others couldn't download easily papers from others, and very few people downloaded from them, resulting in a low participation ranking overall. This actually discouraged the users who had strong interest in a narrow topic. It was suggested that since shared files in Comtella were classified by "categories of interest", users should also be able to see classified views i.e. the different views of the community in different "categories of interest" which would allow users who contribute a lot in one narrow area to feel rewarded.
5. The visualization's user calibration was misleading by showing only the peers currently online. When a user saw his/her star being the brightest, s/he concluded that s/he was the most contributive peer in the community so far. However, this was not necessarily true, because there might be better peers who were not online at that moment. Thus, the next time when peers who contributed more were also online, this peer might see his/her star as a smaller one, even if in the meantime s/he contributed more papers. Such sudden and apparently illogical change was reported by users as bewildering and discouraging.
6. The displayed information about each user was unnecessarily detailed. Information that does not relate to the goal of the visualization should not be shown. For example, the user's IP, which has nothing to do with motivating users, should not be shown. Users are already identifiable by their aliases so there is no need to show the IP; besides it may bring security issues. The numerical value computed by the system in the background to determine the size and the color of the stars should not be shown either. Users generally felt confused after reading these numbers as they did not care about them.

7. The visualization was not self-explanatory. It needed a legend to explain the meanings of the stars with different sizes and colors. This was not a good design because users were generally not willing to spend extra effort to read more than they wanted.

There was no evidence showing that the first version of the visualization encouraged participation. The users generally liked the idea of having this community visualization, provided that the above listed problems were solved properly. Users indicated in their feedback that an enhanced version of this visualization would be useful in quickly discovering what their colleagues were working on, easily finding out the hot topics, and that such a visualization could facilitate building online communities by raising the users' awareness of their community. The next design of the visualization was improved taking the user feedback into consideration.

Chapter 4

Second Design of the Visualization for Comtella

The second version of the Comtella visualization was decentralized and dynamic. To allow for customization (according to the user feedback described in the previous section, but against Tom Erickson's suggestion), it was implemented as a graph-generating application embedded in the actual Comtella servent interface instead of a webpage generated on a server. In this way, a customized view could be generated very quickly according to the user's choice, based on the data sent from the database on a central server. The users selected the desired view by using the Comtella servent interface and did not have to open an extra web browser window to view the community. The visualization was written in java using the java 2D technique embedded in the Comtella java-swing interface.

4.1 Design Rational

The second design provides the possibility for user interaction: instead of every user seeing just one view, users are able to specify how they want to view the community by selecting areas of interests (topics) and selecting among several contribution criteria. The view is generated on the client upon request with the latest data about the community from the server database (to maintain this database, each Comtella servent reports regularly participation data to a central server). Although, this customization conflicts with Erickson's first suggestion in designing community visualization, it is a response to the user feedback from the experiment on the previous first design of the visualization. Some users have only one or very few areas of interests, and some users only want to compete in one particular aspect such as sharing more files, giving more comments, or rating other users' shared files, but in not all of these activities. Therefore, this design gives users the option to customize their community views and see views

that are of interest to them and show them more favourably. However, at the design stage it wasn't clear if the possibility to create customized views would actually be used to fit the users' needs without creating other problems. One major concern regarding was that it takes some user effort i.e. users have to make a few extra clicks to select their criteria in order to see their customized community views.

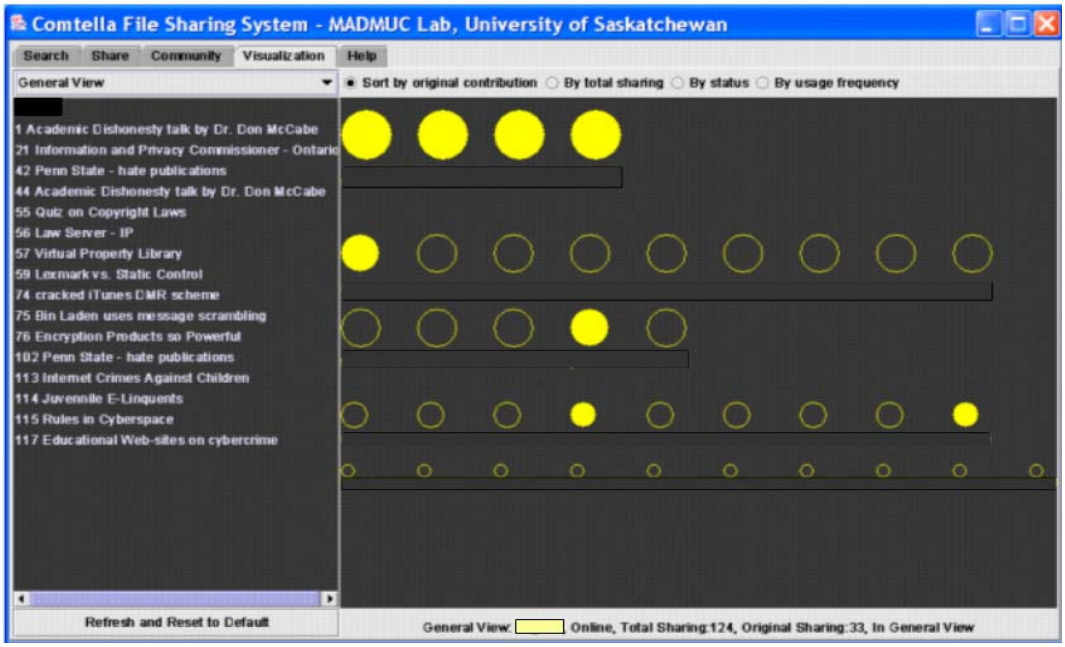

Figure 4. Motivational Visualization – second design. The left frame displays the files commented by the selected user. The user names are masked by black rectangles to preserve user privacy.

Figure 5. Topic (area of interest) Selection Box

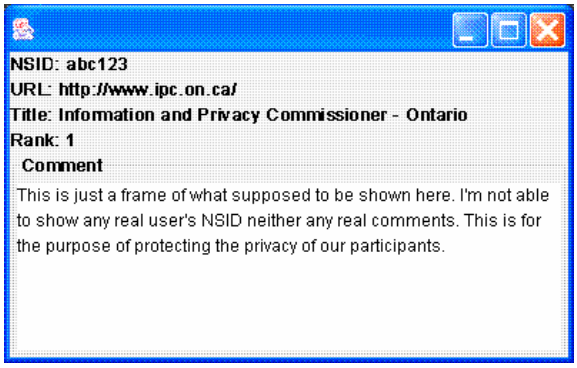

Figure 6. An Example of a Comment Window

As figure 4 shows, the metaphor used in this design is a group of nodes i.e. bright circle on a black background (a simplified version of a night sky). The first version of the visualization, taking the advantage of the web browser and HTML, was able to display the stars which are pictures of real stars saved as .JPG image files. However, in

this second version the system had to draw every component of the visualization. It is easier and faster for the system to draw the primitive geometry of a circle and a dot than complicated shapes such as the star images used in the first design.

Each user is represented by a yellow node, which is a yellow circle either filled or empty, on a black background. The visualization shows all the users, no matter if they are online or offline. A filled circle represents a user who is currently online and an empty circle represents a user who is not online. This avoids one of the problems discovered from the user feedback of the first version (see problem 5 above in section 3.2), i.e. the sizes of stars are not relative anymore to who is currently online, but they truthfully represent the ranking of contributions in the whole community of users.

This design allows the visualization to be translucent rather than transparent. When a user appears online, it is not certain whether s/he is doing something in the Comtella community or doing something else with his/her Comtella servent running at the background. Everyone is aware of this uncertainty and it is up to the user to draw his/her conclusion. This design follows one of Erickson's (2003) rules for designing good community visualization.

The sizes of the nodes are defined by the contributions of the users in a particular area of interest (selected from a menu on the left top) and under a certain participation criterion (selected by the user through clicking on one of four radio-buttons arranged horizontally, on the top of the screen). The Hierarchical location of a node depends on its size. It is important to note that in figure 4 the nodes are not randomly located. Instead they are laid out hierarchically at four levels in descending order of size. According to Erickson's rules for designing good community visualizations (Erickson, 2003), it is not necessary to always visualize the exact difference (in this context this means: the exact difference in the numbers of articles shared by two different users). Instead, a certain amount of approximation is helpful and is more realistic most of the time. So instead of determining the size of a node by the exact contributions, I classified the numbers of contributions into four levels and users within the same level of contributions, having nodes of the same size. The following is the algorithm according to which the classification is done.

The largest possible size *largest_size* that a node can have is pre-defined and there also is a decrement factor *decr_f*. The choices of the *largest_size* and the *decr_f* depend on the total available space for drawing and the total number of nodes to be drawn. After sorting the nodes in descending order of their size, the visualization assigns the *largest_size* to the top X nodes in the sorted list and draws them at the top most level in the graph. Among the remaining nodes the visualization takes the top Y and assigns them a size of *2_size*, where *2_size = largest_size*decr_f*, and draws these nodes at the second-top-most level in the graph but not necessarily to be the second line from the top because sometimes there may be too many nodes to be put in one line. The next level of nodes is always started at a new line after the last node at the previous level. For instance, in figure 4 nodes at line 2 and line 3 are all at the second level since they are of the same size – the second largest. The top Z of the remaining nodes after the second level will be drawn at the third level, each with a size of *3_size = 2_size*decr_f*, and the rest will be put at the fourth level with a size of *3_size*decr_f*. In this way, the position of a node changes only depending on how the represented user's contribution compared with that of other users. The filled nodes in figure 4 are users who happened to be online when the screen shot was taken and the empty nodes are users who happened to be offline at that moment. In this version of the visualization the cooperativeness of users decreased vertically from the top to the bottom and horizontally from the left to the right. There are many ways of classifying users into various hierarchical levels. In this implementation, these sizes of the classes were selected as follows, supposing the total number of users is **N**:

X = 10% * N → the number of nodes at Level One,

Y = 40% * (N - X) = 36%*N → the number of nodes at Level Two,

Z = 50% * (N - X - Y) = 27% *N → the number of nodes at Level Three,

The rest = 27%N → the number of nodes at Level Four.

An obvious alternative to this set of classes is to select four classes of equal size, i.e. to divide the total number of users into equal-sized groups. This method will not generate noticeable gaps between different levels and therefore may reduce the motivational effect. To be more specific, if there is the same number of users at the highest level as there is at other levels, then the best contributors will not be able to feel

the exclusiveness of their high social status as much as they would do if they see themselves being one of the few at the top level. Similarly, the users who barely make any contributions to the Comtella community will not feel so urged to participate more if the majority of users do not contribute. It would be more motivational if they see there are not many people at the bottom level and they are among the few. For this reason, there should not be too many people at either the top level or the bottom level. However, the top level should not appear too high to be reached. So its size cannot be too small; otherwise, it will be limited to only one or two users. Similarly, the size of the lowest level also cannot be too small; otherwise, users at this level may feel too discouraged and may give up using the system. I picked 10% of the total number of users to be the size of the highest level. The reason for not combining the two middle levels is also for the goal of maximizing the motivational effect. It will be harder to persuade people to improve if they see most of the others are just the same as them. Moreover, merging the second and the third levels will create a super-sized middle level which will make the top and the bottom levels appear too small and exclusive.

Besides the above clustering algorithm, this version of the visualization is also modified to allow users to generate a customized community view using the following options:

1. Topic selection. Users were able to view the community for a specific area of interest i.e. a specific topic. Once the user selected a topic, the visualization changed the current view by redefining the sizes of the nodes according to the contributions made by the users for this particular topic. There were two benefits from this design. The system needs less data to generate the graph and so will be faster. Users who are interested in a particular topic can focus on a specific view, and be active in the group showing interest in the topic. Thus, one can maintain his/her level of participation and be visualized with a big star in the view for this topic and get recognition and satisfaction without worrying about his/her overall participation. This design maximizes the effect of social comparison because users can compete in a specific area of interest as well as in the entire Comtella community. Thus, this design will encourage the participation from users who have limited interests in particular areas.

2. Criteria selection. Instead of one single participation value determining the size of a star in the visualization in the first version, there are four participation criteria that users can choose from to determine the sizes of the stars in his/her preferred view of the visualization. Each of these criteria is one factor that is used to compute the participation value. These criteria cover all the higher levels of participation introduced earlier in chapter 2. As shown in figure 4 (top right), the criteria are, "sort by original contribution", "by total sharing", "by status", and "by usage frequency". These criteria offer four ways to compare the cooperativeness of users independently of the selected topic. The *original contribution* of a user only includes the new articles brought by this user into the Comtella community; the *total sharing* is the sum of all the shared articles of this user including both the new articles brought by him/her and the articles s/he downloads from others and re-shares; the *usage frequency* is the number of times that a user logs into the system; and the *status* is a combined measure calculated from several factors including a weighted sum of comments and ratings of this user. Finding out a formula for computing the status and appropriate rewards associated with the status is a different research topic, carried out by Ran Cheng, another Master's student who works in the same lab with me, and my visualization provides a way to represent the status.

The participation criteria selection and the topic selection are orthogonal and can be combined. For example, if a user selects "Freedom of Speech" from the topic selection box (figure 5) the visualization will draw all the nodes including the one representing this user. The sizes of these nodes, by default, are determined by the original contribution of each user and will be sorted and arranged in descending order. If the user selects sorting "by total sharing" without changing the topic selection, the visualization will re-compute the sizes of the nodes based on the total number of files shared by each user and these nodes will be re-sorted based on their new sizes. If the user does not make any selection from either the topic list or the criteria list, the visualization shows a default view, which is the "General View" sorted by the "original contribution", i.e. the size of a node is determined by the sum of the *original contributions* made by the represented user in *all the topics* and the nodes are sorted and arranged in descending order of their sizes. The design of the criteria selection is also for the purpose of maximizing the social comparison effect since users can compete with each other in

different dimensions. Users who are more interested in competing in one dimension are able to maintain the large size of their stars in the view where nodes are sorted by that criterion.

3. Viewing the details about a peer. Users are able to double-click on a node to list the files (showing at the left side in figure 4) that were commented by the represented user; a single click on any of these files opens up a comment-window for users to see the comment (figure 6). When a user moves his/her mouse over a node in the visualization, a brief summary of the contributions made by the represented user will show up at the bottom-right bar (figure 4). The bottom-left bar in figure 4 is a button to refresh the graph by reconnecting to the database and regenerating the current graph using the latest information. This is useful when a user has had his/her system running for a long time without changing his/her selection of either topics or sorting criteria and the visualization never gets a chance to fetch new data and regenerate a more current view.

In order to verify the motivational effect of the second design, Ran Cheng (another graduate student working on a different motivational feature using Comtella) and I carried out a systematic experiment which ran over a school semester.

4.2 Experiment and Evaluations

The visualization with the second design (the second version) was evaluated by a group of 35 fourth-year computer science students taking CMPT 490, a class on Ethics in Computer Science offered by the Department of Computer Science at the University of Saskatchewan from January to April 2004.

4.2.1 Experimental Setup

In the experiment, Comtella was used to support students in CMPT 490 (a senior computer science class on social impact of information technology at the University of Saskatchewan) to share web links and do their course-work so I had to ensure the all-time availability of the shared materials. In other words, I had to make sure that the Comtella network existed independently of whether users were online or offline. Thus, I modified the original Comtella system to fit the need of the class by splitting its user interface, which includes the visualization, from the “backend”, which is the main part

of the Comtella servent and provides all the functionalities as a Gnutella-based application: forwarding messages including queries and replies, locating resources, maintaining the network of peers etc. Every student who participated in the experiment had his/her own Comtella servent, but all the servents were moved to reside on one of two dedicated server machines instead of residing on the students' own computers. Students only downloaded the Comtella interface from the class website on their own computers. The interface allowed them to log into their Comtella servents which were running on the server all the time. This modification ensured that the shared materials from each student were always available for search even when the student is logged out of his/her servent and has quit his/her interface. Consequently, the basic (lowest) level of the participation – keeping users online for as long as possible – is automatically guaranteed. Each user could be easily identified regardless of his/her location i.e. if the user was logging on from two different computers s/he was be recognized as the same user, which was not the case in the pure P2P version. This made it convenient to keep track of user behaviour in the Comtella community for the purpose of the experiment. Users still needed to install the interface. If a student was logged out of the interface his/her status was shown as offline in the visualization, and the duration of a student being online in each session was counted from the moment s/he logged into his/her Comtella servent through the interface until the moment s/he logged out of the servent by closing the Comtella interface. Only the students registered in the CMPT 490 class were able to log into the system.

To adjust to the new domain the list of categories/topics we modified. The new list contained the weekly topics (themes) discussed in the class, as shown in figure 5; the Comtella servent was also modified to share only the URLs (i.e. bookmarks) of the articles on the web instead of the actual files, because Comtella was used as a tool to help students finding and sharing up-to-date popular articles related to the class topics from web magazines, such as Wired, cNet etc. These articles are all copyright-protected and Comtella system will not duplicate them on its server.

The experiment started on January 11, 2004 and finished on April 5, 2004 (the last day of classes for that academic term). All students could decide if they wanted to use or not to use Comtella. There was an alternative way of accessing materials for each week,

selected by the instructor from those submitted by the students in Comtella and posted on the class website.

At the extrinsic motivation of the class, all students were invited to fill in a questionnaire and received for this a 3% bonus towards their total mark in the class. The students who did not consent to participating in the experiment or didn't use Comtella received the bonus mark too, if they filled in the questionnaire: it provided special branching points for these students, after the first two questions: "Did you use Comtella?" and "Did you sign consent to participate in the experiment?" If a student answered "No" to any of these two questions, they were directed to the end of the questionnaire; those who had given consent had the option to give a reason or comment on why they didn't use Comtella. The students who didn't sign consent exited the questionnaire immediately and no data was stored in the system about them apart from the fact that they have logged in to fill it. In both cases it was considered that they have completed the questionnaire and they received a 3% bonus. The goal was to ensure that the students' who didn't participate in the experiment and in Comtella were treated equally and had no disadvantage in comparison with the other students and to eliminate the influence of the extra bonus marks as a motivation for using Comtella. The bonus was considered as a reward for the effort of filling the questionnaire, not for participating in Comtella, so students who chose not to use the system or not to participate in the experiment weren't punished in any way. Students who used the system, filled up the online questionnaire, and gave consent to us will receive the bonus marks. The class instructor had no access to the students' data about the experiment, i.e. the instructor won't know who used the system and who did not, she won't know who answered the questionnaire and who did not, and she won't know who gave what specific answer to which question. Only Ran Cheng and I had access to the details of the students' data for the experiment.

The class lasted for thirteen weeks and covered ten different topics. Each topic was discussed for a week except the sixth topic, "computer security and computer crime" which was discussed for two weeks with an extra week in between (the midterm break in the academic schedule); thus this topic ran over three weeks. The last week of the

class was entirely dedicated to team-project presentations, and there was no particular topic in Comtella for this week.

The students downloaded initially a version of the interface without the community visualization. After the sixth topic (i.e. one week after the middle of the term) they could download a new version of the interface containing the motivational visualization. I collected and analyzed the usage data of all students before and after the introduction of the visualization. A final online questionnaire survey was conducted after the end of the class to find out if the students felt that motivational visualization had encouraged social comparison, feeling of belonging to a community and to what degree it motivated them to participate.

In this same experiment, there was another motivational factor being tested and evaluated besides the motivational visualization, which was a topic of research by a different graduate student, Ran Cheng. As mentioned briefly before, there was an algorithm to compute the status of each user based on the user's activities and behaviours in the Comtella community. The status of a user is a comprehensive measure of his/her reputation and contribution in the Comtella community. In the main Comtella interface, each user sees a membership card which reflects his/her status level: Gold membership card reflects the highest status, Silver reflects the medium status, Bronze – the baseline status. Since the visualization is meant to reflect the activities in the Comtella community, it also visualizes the status of the community members. As figure 4 in Chapter 3 shows, users are given different options to sort the nodes in the visualization and one of the options is to "sort by status". By selecting this option, users are able to see which users are holding what memberships. When visualizing the Comtella community with other sorting options, all nodes are yellow (either empty or filled); however, with the sorting option being "status", nodes are painted in a way reflecting their memberships: yellow nodes representing Gold memberships, white nodes representing Silver memberships, and blue nodes representing Bronze memberships.

4.2.2 Experimental Results

I evaluated the effect of the visualization on four participation metrics: (1) the total number of shared articles for each topic, (2) the number of original (new) shared articles

on each topic, (3) the number of comments given on the shared articles, and (4) the number of ratings given on the shared articles.

The term *total number of shared articles* i.e. *"total contribution"*, refers to the URLs of the articles that the students found on the web and brought to the community as well as the articles that students downloaded from each other and re-shared in the community (i.e. the duplicates of the original articles). Each article was categorized by the topic that its original contributor assigned to it, or re-categorized by the topic that a later contributor re-assigned it after s/he downloaded a copy from its original contributor, so it is possible for the same article to be shared under different topics. The *original shared articles* i.e. "*original contribution*" refers to the URLs of the articles that the users found directly from the web and brought to the community. Since the Comtella servents are designed to share all the downloaded articles by default, some of the articles shared by a peer may not be part of this peer's original contribution but rather reflect his/her downloads from other peers, which requires far less effort than finding new original contributions. So the original contribution is a subtler measure of the activeness of the participants than the total contribution. Original contributions are important to a P2P community because the new materials that users bring to the community enrich the diversity of the resources provided by the community. Increasing the original contributions is one of the primary goals of the visualization.

Figure 7 shows the distribution of the total contribution (all files shared by all students for the different topics) throughout the experiment. Roughly each topic was discussed in class for one week except for Topic 6 which ran over three weeks (as explained in the experiment set up, and this is the same for all the following graphs and tables). Topic 7 on the horizontal axis represents the contribution in the first week of applying the new interface which contains the motivational visualization and the algorithm for computing the user status. The figure shows that the number of total contributions for Topic 7 is more than 3 times higher than it is for each of the previous topics, for Topic 8, it is more than six times higher, for Topic 9 it is more than 2 times higher, and for Topic 10 it is about the same as it is before introducing the new interface. The increase in contributions shows that the new interface had a strong positive effect on the students' sharing behaviour, but in the end, the effect was weakened. It is not

possible to claim that this dramatic increase is due to the motivational effect of the visualization since the algorithm of computing the status (another research topic by Ran Cheng) may also have played a significant role. The only conclusion I can draw at this point is that the two new features added in Comtella, the community visualization (by me) and the user status (by Ran Cheng), encouraged the users to share more files. However, I am aware that other factors may also play a role such as personal interests in certain topics, the stress of the coursework, the professor's promotion of the system in the class, as well as the novelty effect, which died off as users got familiar with the visualization.

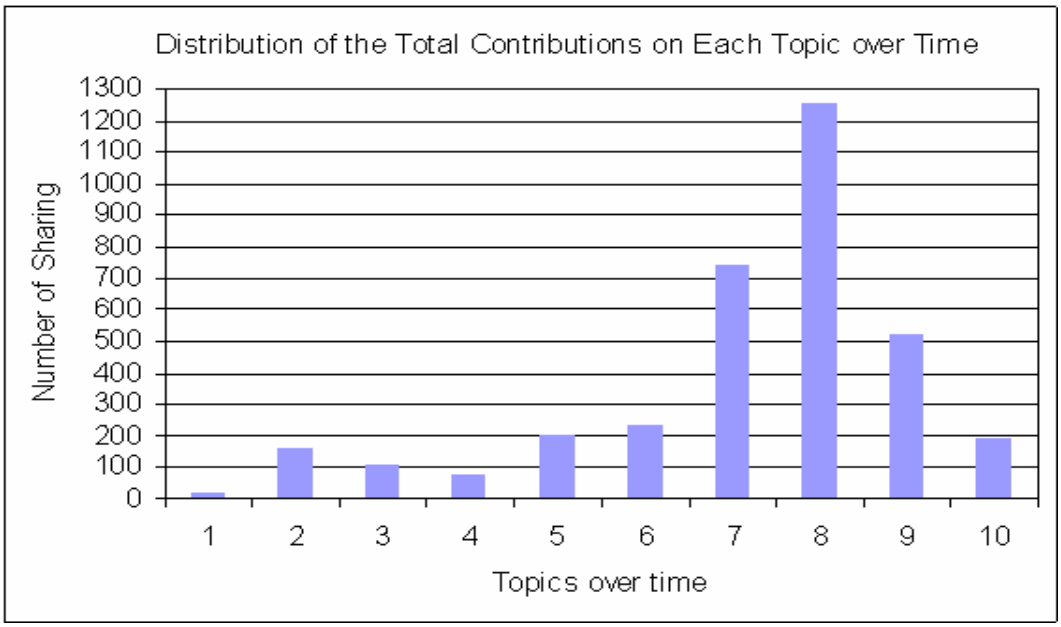

Figure 7. Distribution of the Total Contributions on Each Topic

Figure 7 shows a significant decline in contributions for Topic 9, but still twice as high as the average number of contributions made per topic up to Topic 6. The contributions continue declining at Topic 10 where it almost levels with the values for Topics 6 and 5, i.e. nearly the same total contribution as it was before the visualization was introduced. At first sight this result looks discouraging. However, one has to keep in mind that Topic 10 is the last in the year, on "Ethics and Professionalism", which is mostly dedicated to discussing different professional codes of ethics and examples of ethical decision making. The topic is thus somewhat narrower as compared to the

previous topics and there isn't much public polemic on the web that could be found and shared in Comtella. On the other hand, Topic 5 for which the students shared a comparable number of links is the most interesting for the students (dedicated to Encryption and Wiretapping, and Computer Crime and Security) and has always attracted the most contributions (in previous offerings of the class, when students had to post class-related links on their own websites).

Nevertheless, the reason for the decline needs further investigation. First, as pointed out by many HCI studies, the novelty of a particular interface feature could be a very strong motivator for a short time, but might not be sustained for a longer time. A second possible explanation is that the decline is caused by external factors related to the class and the nature of the last topic. Subjects in this experiment were students in their last year; for many of them this was the last class before graduation. The last week of class was dedicated to project presentations, which had a high weight in the final grade for the class. The students focused their efforts on their final projects that were due near the end of the term; many students also had final examinations coming up soon. These factors would naturally distract the students from competing in the Comtella community at the latter stages of the course, since there were higher stakes outside of the system.

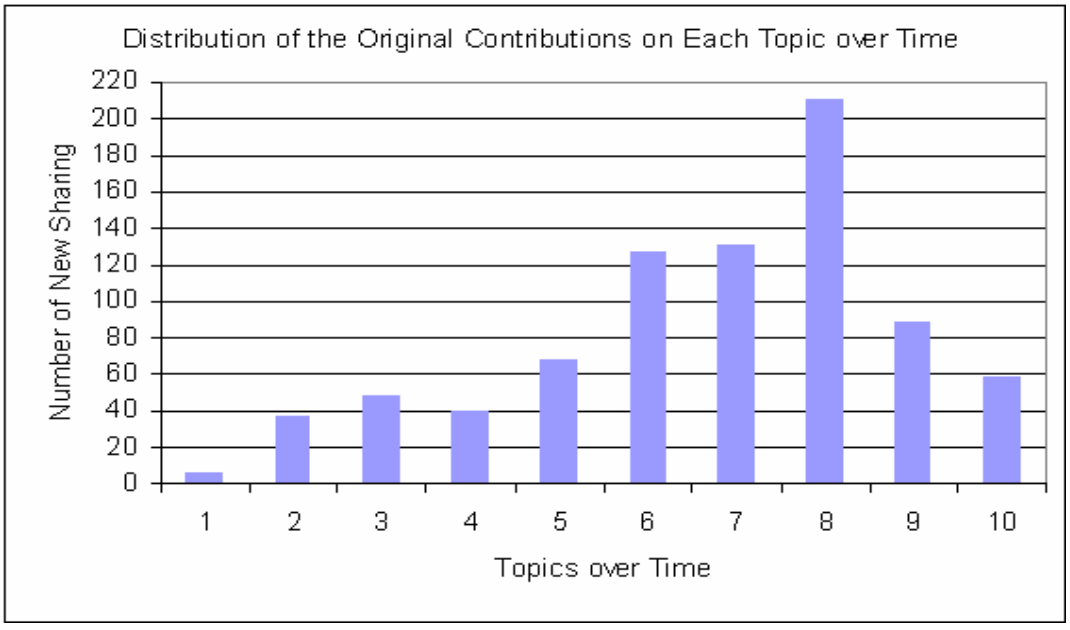

Figure 8. Distribution of the Original Contributions on Each Topic

Figure 8 shows the distribution of the original contributions (i.e. the new web links brought by students) throughout the experiment. While there is a significant increase of original contributions for topic 6, unlike figure 7, where there is no obvious increase for Topic 7 when the visualization was introduced. As explained in the experimental setup, Topic 6 was discussed for three weeks so the students had more time to find and bring in new files, while all the other topics were discussed for only one week. Also, according to the instructor, Topic 6 was of the highest interest for the students, many of whom picked projects related to this topic. There is a significant increase of original contributions for Topic 8 and then, similar to the tendency in the total contributions in figure 7, the original contributions decline significantly for Topic 9 and continue to decline for Topic 10 but at a slower rate. The general trend is similar to figure 7 and so reinforces the previous discussion about the possible reasons. Both measures indicate that the new interface including the community visualization may motivate users to share more files in the Comtella community, even if temporarily.

Table 1. Participation Data

	Total Contribution		Original Contribution		Comments		Ratings	
	number	%	number	%	number	%	number	%
All	3526	100%	821	100%	888	100%	578	100%
before 7	803	22.77%	331	40.32%	176	19.82%	73	12.63%
topic 7	745	21.13%	131	15.96%	162	18.24%	112	19.38%
after 7	2723	77.23%	490	59.68%	712	80.18%	505	87.37%

Table 1gives a clearer idea of the significance of the increase in the total and the original contributions since the new interface was applied. Here “before 7” means the sum of the data from Topic 1 through Topic 6, and “after 7” means the sum of the data in all topics after and including Topic 7. The first data row (the row starting with “Overall”) in table 1 shows the overall participation data in four categories: the total contributions, the original contributions, the total number of comments, and the total number of ratings given by users. The second row (the row starting with “before 7”) shows the data before the new interface has been introduced (i.e. Topics 1 through 6). The third row (row started with “Topic 7”) shows the corresponding numbers during the first week of applying the interface with the visualization. The fourth row (row started

with “after 7”) shows the data after introducing the new interface with the visualization, including the data for Topic 7.

None of the percentages in the four participation categories given by all the users before the introduction of the new interface is over half of their corresponding overall numbers; in other words, users did not make many contributions in any of these four categories before the new interface with the visualization was applied. However, the percentages in Week 7 show that the contributions in this week are almost the same as the sums of the contributions in the previous 6 weeks in all four categories except the original contributions where the original contributions of Week 7 are about 40% of the total original contributions throughout the previous 6 weeks. The last row shows that most of the contributions in all the four participation categories are made after the new interface with the visualization was introduced, this observation is even clearer with the data of comments and ratings.

The users could give comments on both the articles they originally contributed and the articles that they downloaded from other users. The *number of the comments* given by a user represents a fairly high amount of effort spent in the Comtella community. This is because giving comments especially when the comments are meaningful and instructive on articles takes much more time and thought than simply sharing the articles. It evolves reading the articles carefully, thinking about the ideas presented in the articles and the information given in the articles, and then writing up their thoughts. Good comments can help the community by instructing other users to find articles of interest. Therefore, motivating participants to give good comments is another important goal of the visualization.

Besides giving comments, the users could also rate the shared articles. Rating (except the careless and irresponsible ratings) may take less effort than giving comments but more effort than sharing articles. So the *number of the ratings* given by the participants on the shared articles is another measure on how effective the visualization is in motivating active participation. Table 1 shows a similar pattern of the given comments and ratings as that of the total contributions and the original contributions.

In Table 1, comparing the numbers of the comments and ratings given before and after Week 7, the majority of comments and ratings were made since the new interface was

introduced, where the motivational community visualization shows the number of ratings and comments given by each user. It seems that the new interface encouraged users to compete with each other in making comments and ratings as well as sharing more files by either brining new files or re-sharing the copies of other users' original contributions. Before the new interface was used in Comtella, users could only see comments and ratings given on the articles during their search for papers in the system since they are listed as part of the search results together with the topic and the URL of the articles. When the list of the search results becomes long, which is usually the case due to the duplicates of popular articles, no one bothers to count the number of comments and ratings given by each user. So it is hard to notice the difference in these numbers from user to user. However, the visualization does the counting automatically and displays the totals of these numbers for a user conveniently at the bottom of the visualization whenever the mouse moves over the node of that user. The visualization also shows the status which is a combined value of the numbers of comments and ratings given by a user together with the two types of the contributions. The algorithm used to calculate the status, as indicated earlier, is another research topic, but how to display it in the visualization is part of my research topic (see chapter 3).

While Table 1 summarizes the quantitative aspect of contributions, a different aspect of social comparison is the quality of contributions from users. In the Comtella community, this means the quality of the shared articles and the quality of the comments and ratings given by users for these articles. To evaluate the quality of shared articles one needs to see if these articles are related to the topic that they are claimed to be by their contributors; also, one needs to evaluate if all the comments are meaningful and instructive; and if all the ratings are fair and justifiable. While there were some anecdotal data from students' comments like "It is better to contribute few but good articles, than many uninteresting on unrelated ones", I could not find any evidence that social comparison took place in the aspect of quality. This may be because the visualization did not focus on the quality and there was no external quality control. Developing a visualization that allows for showing the quality versus the quantity of contributions was left for future work.

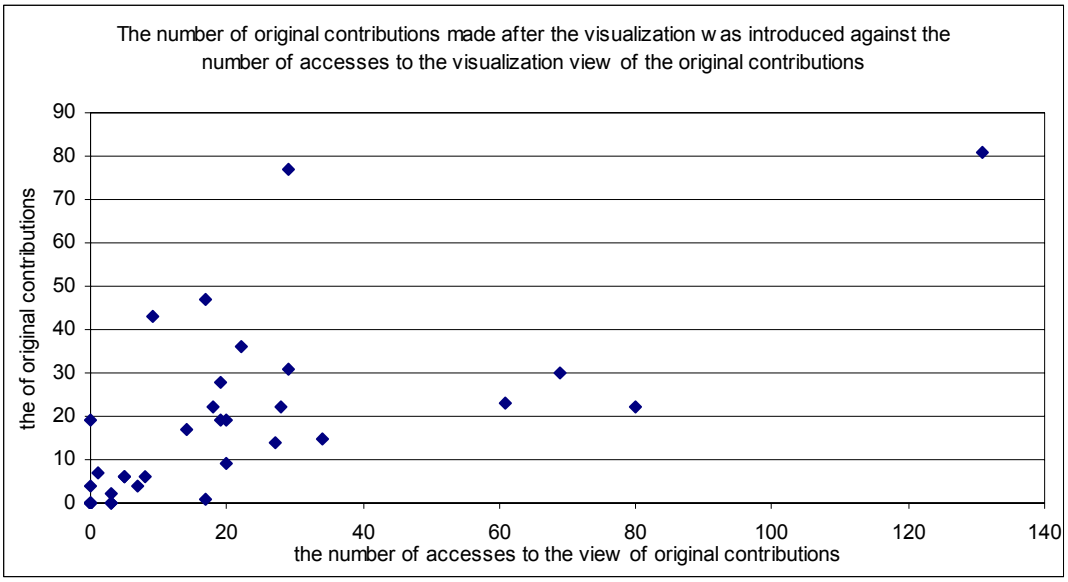

Figure 9. Original Contributions against Usage of the Visualization

To see if viewing the visualization correlates with more contributions, Table 1 in Appendix 3 was created which shows the number of accesses each user made to the visualization and the number of contributions the user made in each category. Figure 9 visualizes the data from the left half of Table 1 in Appendix 3. The Y-axis shows the number of original contributions made by a user and the X-axis represents the number of times the user accessed the visualization with a view sorted by the original contributions. If a user accessed the visualization, s/he would see a view of the community's contributions for the topic of the current week, sorted by the number of original contributions. Since the focus of this design was to motivate more original contributions, "Sort by original contributions" was made as the default view for any given topic, i.e. the view seen by the user without selecting any sorting criterion. To see other views, users have to make specific selections; either to select a different sorting criterion, or a different topic. Therefore, the number of times the user accessed the "sort by original contributions" view equals to the number of times each user accessed the visualization (represented on the X-axis). The Y-axis represents the number of original contributions that each user made after the visualization was introduced. Even though there are several exceptions, it can be seen as a general trend that the subjects who viewed the visualization more often, made more original contributions. Statistical test shows that the correlation between the number of accesses to the visualization sorted by

the original contribution and the actual original contributions made after the visualization was introduced is 0.66.

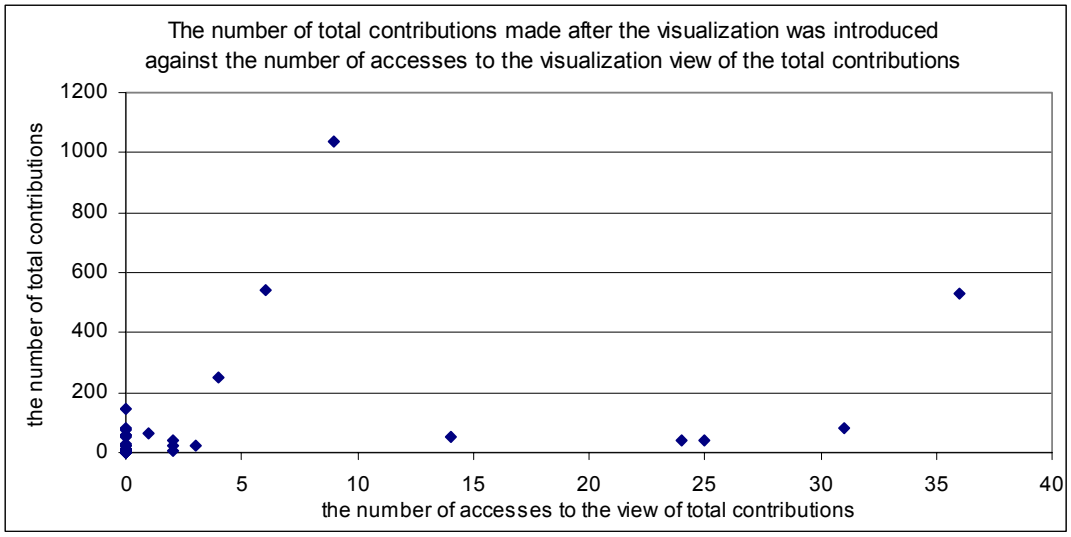

Figure 10. Total Contributions against Usage of the Visualization

Figure 10 visualizes data from the right half of Table 1 in Appendix 3. Here the X-axis represents the number of times each user accessed the visualization with a view sorted by total contributions, and the Y-axis represents the number of total contributions made by each user after the visualization was introduced. Since the "sorted by total contributions" view was not a default, the users accessed this view far less since they had to make an extra selection (effort). It is harder to see in figure 10 a correlation between the number of times the visualization sorted by the total contributions was accessed and the total number of contributions after introducing the visualization. The statistical test shows that the correlation is 0.34, which is considerable less than the correlation shown in figure 9. This weaker correlation in figure 10 indicates that the effect of the visualization on the original contributions is stronger than it is on the total contributions.

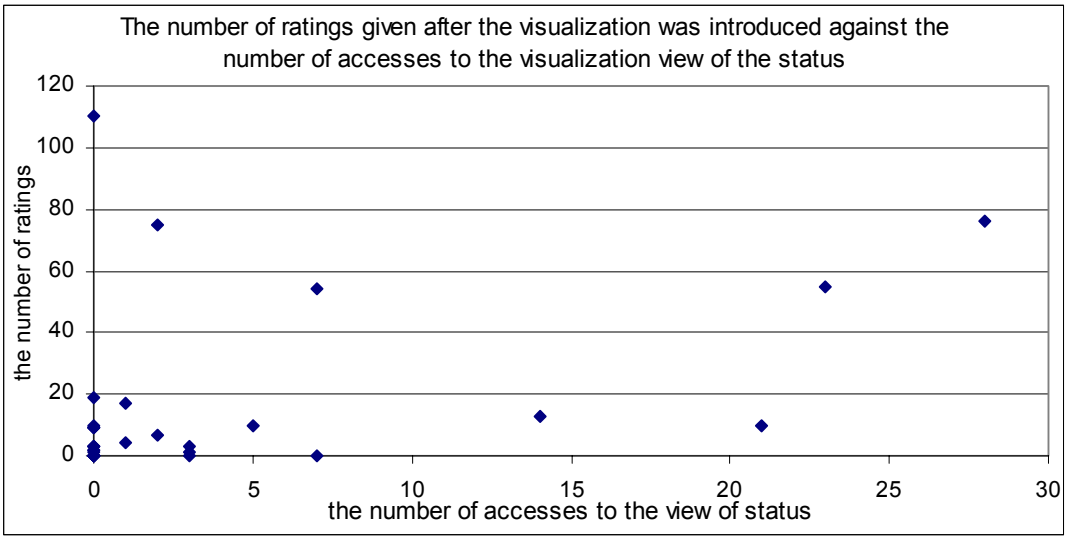

Figure 11(a). Ratings against Usage of the Visualization

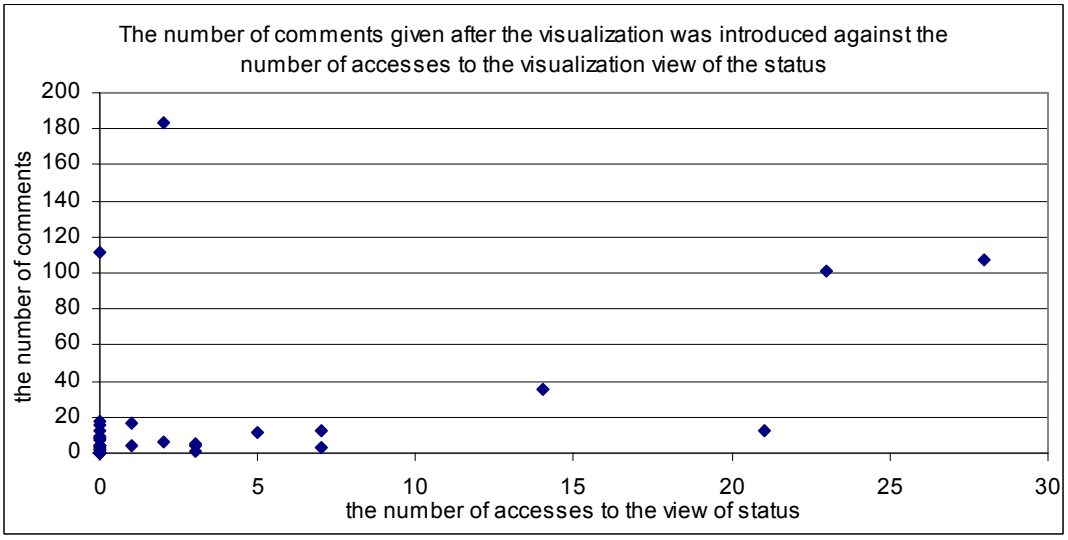

Figure 11(b). Comments against Usage of the Visualization

As explained before, although the design of the algorithm to compute the status is beyond the scope of my research, the visualization gives users a chance to see and compare their statuses with each other. Two main factors affecting a user's status are ratings and comments given by the user. In figure 11(a), the X-axis represents the number of time each user accessed the visualization and the Y-axis shows the number of ratings given by each user after the visualization was introduced, and in figure 11(b) the X-axis is the same as figure 11(a) and the Y-axis shows the number of comments given by each user after the visualization was introduced (data is extracted from Table 2 in

Appendix 3). These two figures indicate that there were not many users making the extra selection to see the view sorted by status, but those who did so normally tended to give more comments and ratings. Statistical tests show the correlations of figure 11(a) and (b) are 0.42 and 0.43 respectively, which are weaker than the correlation shown in figure 9, but stronger than the correlation shown in figure 10. This indicates that this version of the visualization has stronger effect on encouraging original contributions, weaker effect on encouraging ratings and comments, and very weak effect on encouraging total contributions.

None of the users ever selected the sorting criterion "usage frequency", which indicates that users are not interested in competing in how often they use the system. On the other hand, the Comtella system used in this experiment is centralized to guarantee the shared materials are always available independent of users being online or not, so staying online is not a contribution towards the community in this case.

The sorting criteria in this design allowed presenting to users specific types of community related information. This information is meant to encourage user competition, but an alternative way has to be found to present it since users did not use the sorting criteria, instead, they simply left it as default. Thus, in my next design I tried to find out a way to combine these sorting criteria into one community view - not customizable, but in a self-explanatory way to eliminate user effort for selection, without sacrificing the readability of the visualization.

So far, there is evidence in terms of statistics of contributions made before and after the introduction of the visualization and in terms of correlation between users' access to the visualization and level of contribution, which allows me to conclude that this version of the visualization motivates users in the Comtella community to participate more actively in making more contributions, giving more comments and ratings. There is also evidence from the questionnaires returned by the users after the experiment showing that the visualization promoted social comparison in the Comtella community.

4.2.3 User Feedback

We asked the participants to answer a long questionnaire (see Questionnaire 1 attached in Appendix 2; where questions 5-14 address the visualization) after the end of

the experiment. Thirty-two out of the thirty-five participants returned their questionnaires. The information corroborated the analysis of the data on the actual usage collected by the system and supports the conclusion that the current visualization motivated the participants to behave more actively in the Comtella community by encouraging social comparison and competition.

In the questionnaire users were asked if they remembered the username of the person who shared most articles. With some small variance but still among the top 5, most of the participants who responded correctly gave the user IDs of the top contributors.

1. What would be your reaction if you saw from the number of query results that there are already a large number of contributions in a given week?
    a. There is a lot, so I have to bring some links too to compete with others. (23%)
    b. There is enough already, no need for me to add more. (19%)
    c. The instructor will not notice my participation when there are so many links, what is the use of bringing links? (16%)
    d. Maybe I should try to find some higher quality papers to share (quality versus quantity). (16%)
    e. Other. Please specify: (26%)

    In the specifications given, students raised the concern on efficiently locating useful materials when there were too many of them. They worried about people bringing too many "garbage" links in order to compete but it would take a long time for others to find what they want.
2. What would your reaction be if you saw yourself as one of the smallest nodes in the visualization?
    a. Take immediate action: share more links to make your node larger. (35%)
    b. Think of sharing more links, but later. (19%)
    c. Feel unhappy, but do nothing. (10%)
    d. Feel that the system is unfair, so it doesn't make sense to contribute. (10%)
    e. Do not care, so will do nothing. (16%)
    f. Other, please specify: (10%)

In the optional comments given for this question, a couple of students expressed concern about the quality of the shared articles as they noticed that not all the users with bigger nodes were sharing useful resources.

3. If you saw yourself as one of the largest nodes in general, what would you do?
    a. Feel proud of your status and try to contribute even more. (42%)
    b. Feel proud, but at the same time, in some sense 'exploited'. The others are not bringing in so much, so I will stop or decrease my contributions. (6%)
    c. Feel worried, you may be raising the bar too high and others may hate you or you may be perceived as an 'overachiever' by the others. (6%)
    d. Feel nothing, since it is not important to me. (19%)
    e. Other, please specify: (26%)

In the specifications given, some students said they would only share more links when they had some time if they were already one of the biggest stars and if they decided to share more they would focus on the quality of their contributions, and one student stated that if s/he saw him/her self as one of the biggest stars s/he would feel it was too easy to reach a high contribution level and the evaluation system needed to be improved.

4. If their answers to the above two questions are affected by whether the topic is of interest to them?
    a. Yes (55%)
    b. No (32%)
    c. I don’t know. (13%)

This suggests that the users’ competitive attitude doesn’t depend much on whether a topic is of interest or not. It is important to notice that users replied in the context of a class where topics are changed based on a weekly schedule and are pre-selected by the textbook or the professor. Perhaps the answers would have been different in a real-life paper-sharing community e.g. a research group, where users would have more stable personal interests.

5. What would you like to know about other users?

	-2	-1	0	1	2
who is online	13%	16%	26%	23%	22%
how much others contributed	3%	6%	13%	35%	43%
who downloaded from me	3.23%	9.68%	12.90%	35.48%	38.71%
who I downloaded from	3.23%	19.35%	19.35%	38.71%	19.35%
who gave similar ratings as me	3.23%	9.68%	22.58%	41.94%	22.58%
am I a freeloader or an contributor?	16.13%	16.13%	12.90%	35.48%	19.35%

To sum up, about 77% of the subjects wanted to know how much others contributed and 55% were interested in knowing if others see them as freeloaders or as active contributors. This indicated there is great potential for motivating subjects to contribute more through this prototype visualization.

The two major problems found by the users were that:

1. The system was not very stable. There were problems throughout the term with some Comtella servents on the server that were crashing due to Java memory leaks and needed to be re-started manually, in the meantime the students could not log in.
2. The interface was not visually appealing.

Finally, the users were generally happy with the system and 70% of the returned questionnaires said the participants considered the system as a good support for the class and 67% would recommend it to other classes since they thought it was a good tool for finding diverse resources. Both the user feedback and the experimental data indicated that users were not interested in the usage frequency i.e. who used the system most often. Instead, they were more interested in who was currently online.

4.3 Discussion and Conclusion

The experiment using the Comtella system for sharing articles with and without community visualization showed that the visualization in combination with an expert ranking mechanism (the algorithm to calculate the status) encouraged social comparison and competition, and the users were motivated to contribute to the Comtella community. The experimental results and the user feedback discussed previously showed that the interface with the second version of the motivational visualization effectively increased the participants' awareness of their Comtella community and encouraged social

comparison as a result – both the total contributions and the original contributions went up significantly, and participants gave more comments and ratings.

It should be acknowledged that it is hard to control the "noise" in this type of experiment during a deployment of a system in class. There are many other factors that could possibly influence users' participation, such as users' inherent interests in different topics and the currency and relevancy of the topics in the real world. It can be argued that the increase in the contributions, comments, and ratings may be caused by the subjects being more interested in topics discussed in the latter half of the term when the visualization was introduced. It can also be argued that the topics discussed latter in the term were "hotter" and it was easier to find relevant articles on the web. However, after examining the topic list (figure 5) and consulting the class instructor, who was able to compare three different offerings of the class in different years, I think these reasons are not likely. According to the class instructor the topics that are most interesting for students and richest of materials on the web are "Privacy", "Freedom of Speech", "Intellectual Property", and "Computer Security and Computer Crime", all topics discussed in the earlier half of the class. The topics discussed after the visualization was introduced, "Computers and Work", "Broader Social Issues", "Can we Trust the Computer", and "Ethics and Professionalism", are normally not so appealing to students, and compared with the other topics there are fewer articles on these topics available on the web. However, in this experiment, the contributions towards these topics are significantly larger than the contributions make to the topics before the introduction of the new interface; thus, I can conclude that the increase in the contributions was caused by the new interface with the motivational visualization.

A question that can be asked is: "Is the increase only due to the visualization?" since there was another parallel experiment (by Ran Cheng) based on the same system evaluating the effect of the status on user motivation for participation. The answer is that the status probably also has effect but it has to be combined with the visualization in order to have that effect, because the main Comtella interface, without the visualization, only shows the user's own status i.e. a Gold, Silver, or Bronze membership card. There is no explicit encouragement in the Comtella interface for users to compete in upgrading their status. However, the visualization creates such an encouragement and facilitates

social comparison by enabling the user to sort the nodes in the community by their status. The users can easily see which users have Gold membership and which and how many users hold higher memberships than him/her self. Table 1 and Table 2 in Appendix 3 give stronger evidence that users most often saw the view of "original contribution" and only a few of them took the effort to make another selection and see the view of the "status". Yet this experiment did not allow clearly distinguishing the effect of the visualization from the status. This aspect was considered in the next evaluation of the visualization design where two groups, both using status, but one with visualization and one without were compared.

One clear conclusion was that user-customizable views are not needed, since users tend not to use them; most users used just the default view. This seems to support Erickson's first guideline. However, one has to be careful in generalizing from this experience. The above experimental results show only that user-controlled customization tends not to be used, which in retrospect is not surprising, considering that it violated the "minimum user effort" principle in HCI (i.e. Human-Computer Interaction) design. The results do not say anything about how automatic customization of the view would have worked. However, an adaptive customization that showed a view of the users sorted by different criterion depending on what category of participation the individual user is currently lagging behind in, it may have been motivating and acceptable for users (though special effort would have to be made to avoid confusion in the user about what s/he is currently viewing).

One general observation that was made in the experiment was that as the quantity of contributions increased, their quality somewhat deteriorated. This may be because the visualization showed only the quantity of the articles shared by each user regardless of the quality i.e. the visualization did not encourage quality competition. Several users found ways to game the system and exaggerate their nodes in order to gain higher status and visibility. For example, two users immediately downloaded a lot of articles from others and re-shared the copies, most likely without ever reading them. Another student shared new articles from the web that looked superficially related to the current topic, but without any effort into reading and rating them, or giving uninformative comments such as "this article is interesting" or "this article is relevant". So quality control became

a major problem after the new interface was introduced. Therefore, motivating social comparison regarding the quality of the contributions, comments, and ratings is an important future direction of research. Developing an intuitive representation of both quality and quantity of contribution of a peer is not easy and will become the focus of future efforts.

Motivating active users to continue their contributions or even increase them is another problem. In the questionnaire, one student indicated that if one was already the best contributor and was visualized as the largest node, there was no motivation for him/her to continue contributing.

The above problems are closely related to the motivational effect of the visualization. From the technical point of view, a major issue is about the clustering algorithm, i.e. the algorithm used to classify users into four contribution levels based on the files that they shared when the number of possible users is fixed. Ideally, the algorithm should find a significant difference between the marginal cases on both sides of a boundary between two clusters. More specifically, if the list of nodes is sorted by the original contributions, there may be the case that the last node at the top level only shares one or two files more than the first node at the second level, which may share 10 more files than the second node at this level. A better algorithm should find reasonable gaps between contributions of users to classify these users into different levels. A compromise between desired sizes and sharper boundaries would be a direction to explore in the future.

One should not forget that the ultimate purpose of the Comtella system (apart from being an experimental tool for testing motivational approaches for user participation) was to facilitate students in finding and reading fresh materials related to the topics of the Ethics in IT class. One student commented that s/he didn't like the competition of bringing resources, since people were caring more about finding resources than about reading them, which should be the main goal in the system. It seems that reading articles found by others is also an important activity, even if it is "invisible" from the viewpoint of the community. However, I want to encourage bringing good quality new resources, rating and commenting resources, it is important to remember that the resources are only valuable for the community if they are read by the community members. Otherwise, participation becomes a game with no higher, in this case educational, purpose.

Chapter 5

Final Design of the Visualization for Comtella

The final version of the visualization is a redesign combining the advantages from both of the previous versions: the first design and the second design, and considering the feedback from the user questionnaires in the evaluations of both of these two versions, and the experimental results from the second design. The new design provides user interaction but without requiring many selections. To view the visualization, users only need to select a topic (an area of interest), instead of selecting both a topic and a sorting criterion as in the second design. By default, the topic is set according to the current week, so if the user wants to see the current view of the community, he/she doesn't need to select anything. The semantics of the different sorting criteria used in the second version are represented into one picture with more complexity and dimensions, which generate visually more attractive and consistent view of the community. The visualization applies a better algorithm to smooth the classification of users into different levels of contributions.

The Comtella system itself has been redesigned from a P2P system into a web-based application, supported by Apache Tomcat web server and mySQL database server. Also a different algorithm for computing the user status is used in the new version of Comtella, which takes the quality of papers and ratings into account.

5.1 Design Rationale

The images used to represent users in this visualization design are cartoon versions of stars on a black background. The images are static, not generated dynamically as in the last version, so in this way, the new design is similar to the initial first design. From the user feedback of both previous versions, it is observed that the users of the first design generally liked the picture, while the users of the second design thought the picture

looked dull and not attractive, so I decided to use star images instead of circles (nodes) in this final design. However, I did not use the same set of pictures that I used in the first design because they were JPEG images of real stars and could not be manipulated consistently in terms of colors and brightness. The pictures I actually used in this design are pre-generated by a program written in OpenGL, the graphical package defined in C++, and saved as .PNG files after being processed by Microsoft photo editor.

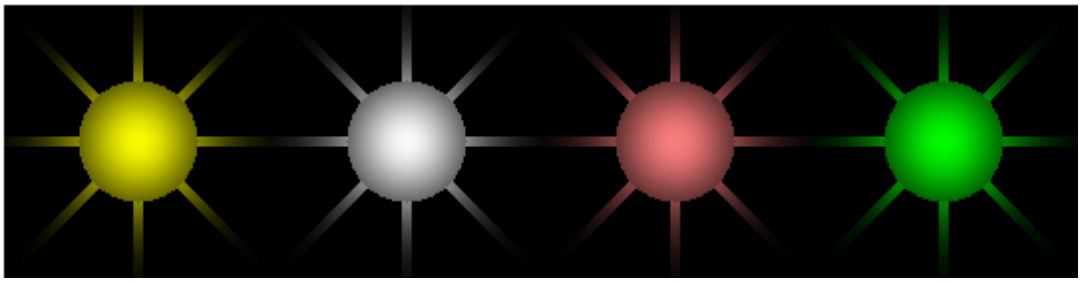

Figure 12 (a). Sample Star Pictures. Stars in this figure are of the same size (size for the first contribution level) and brightness but different in colors.

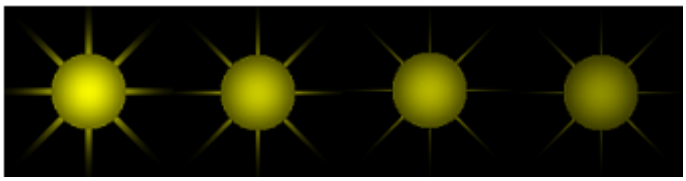

Figure 12 (b). Sample Star Pictures. Stars in this figure are of the same size (size for the third contribution level) but different in brightness (from left to right, brightness decreases).

The size of a star indicates the contribution level in terms of shared links of the represented user. There are four possible levels of contribution: the users who contribute the most links are at Level 1, and the users who contribute no links – at Level 4. If the center of a star is covered a by a black "cloud", this indicates the represented user is currently offline, otherwise, s/he is online. In this design, "a user is offline" means that the user has not been active in the past ten minutes in the Comtella community. Each star also has a particular color (figure 12a) and a certain level of brightness of that color (figure 12b), taking advantage of the 3D effect created by the OpenGL helper application. The color of a star indicates the membership level of the represented user: a yellow star represents a user who holds a Gold membership, a white star represents a user who has a Silver membership, a red star, a Bronze membership, and a Green star,

the lowest “plastic” level of the membership (the initial membership level for everyone when s/he first starts to use the system).

Each star has a certain level of color density, which visually appears as the brightness of the star. The brightness of a star is designed to represent the reputation level of a user. There are also four levels of reputation. Brighter stars represent users with higher levels of reputation. Although the algorithms of calculating the membership and the reputation for each user is the research topic of another student (Ran Cheng), my visualization has to find a way to visually represent the result of the membership computation (to show which membership a user holds) and the result of the reputation computation (what level of reputation a user holds). A user may have a combination of any contribution level, membership level, reputation level, and be either online or offline, so there has to be one star image for each possible combination of these four variables. Thus, there have to be 128 (i.e. 4*4*4*2) pre-generated pictures. The OpenGL program was used to generate 4*4 = 16 pictures of the same size, with different colors and brightness, and the rest are modified based on these 16 pictures by a photo editing tool, in turns of sizes and whether or not being covered by a piece of black cloud. This mechanism of representing users solves the problem of “how to continuously motivate a user when s/he is already a good contributor”. It is almost impossible for a user to have a combination of the highest levels in all criteria, e.g. having the first contribution level, gold membership, highest reputation, and see him/her self always as being online. So there is always some factor that motivates a user to continuously contribute.

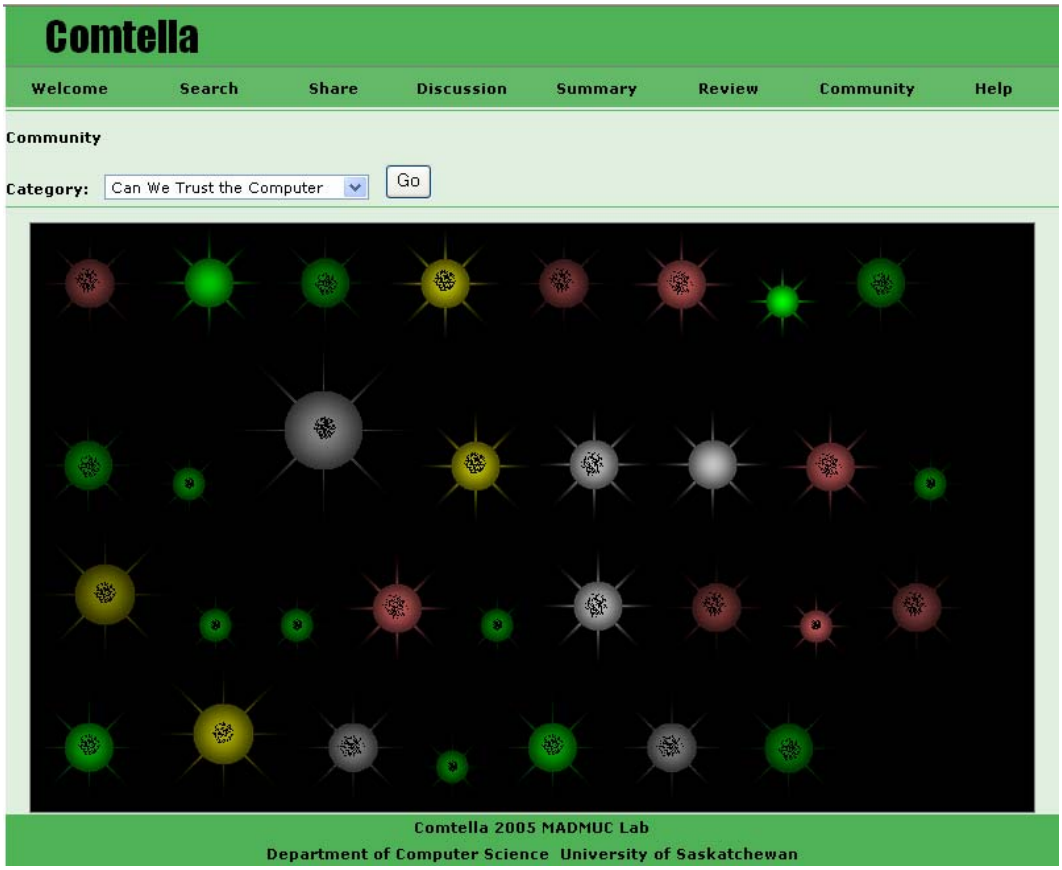

Figure 13. Motivational Visualization – final Design. A sample screen shot.

As Figure 13 shows that the largest star does not necessarily have to be a gold member or the brightest star. This is because the size of a star is solely determined by the number of contributions (new links) made by the represented user, while the membership is calculated based on other criteria. The arrangement of the stars in this version of the visualization is fixed and doesn't change when users log in and out of the system. The system randomly assigns every user a unique id at his/her first log-in, which is only visible to the system and not visible to users. The location of a user in the visualization is determined by this unique id. In addition, each user can create his/her alias, which is the name under which he/she will be known in the community. The users can see their own alias and the aliases of their peers by moving the mouse over each star in the visualization (the alias is displayed as an "alt" text for the star-image). Since the star representing each user has a fixed location, the users are able to quickly and easily find their own stars after using the system for a couple of times, and it is also convenient for them to identify and monitor their competitors.

To determine the size of a star, I classify the users into four levels according to the number of contributions they made to the community. Users at the same contribution level have stars of the same size. In the entire community visualization, it is not necessarily to have all four levels. Depending on the particular situation, there may be three, two, or even only one level showing up in the visualization. The main idea behind the classification algorithm is that I try to spread out the users as much as possible into four contribution levels in such way that the first level contains the users who contribute more than most of the others in the community, and at the same time this level should not appear to be too exclusive (having too few people) to reach. The second and the third levels contain most of the users, while the second level has a size that is slightly smaller than the third level so that people at the second level may still feel that they are better-off than the majority, and the people at the third level may not feel that they are too far away to catch up. The details of the classification algorithm of contribution levels are as follows:

case 1: List (**L**) all the users in descending order of their contributions.

case 2: Set everyone who shares nothing with a contribution level = 4.

case 3: If everyone shares something but they all share the number of files i.e. make the same contribution, set their contribution level = 3.

case 4: If it is not case 3: find the biggest gap in contributions among the top 20% of the users in **L** and mark it *gap_1*, e.g. if the biggest gap in this range falls between user **A** and user **B**, where **A** is in front of **B** in L (i.e. A shares more than B), then *gap_1* = the index of **A** in L. Set users before *gap_1* with a contribution level = 1. Find *gap_2* which is the biggest gap after *gap_1* among the top 50% of the users in **L**, and set contribution level = 2 to all the users after *gap_1* but before *gap_2*. Find *gap_3*, the biggest gap among the rest of the users, and set everyone between *gap_2* and *gap_3* with a contribution level = 3, and those after *gap_3* with a contribution level = 4; however, if there are some users who have not contributed anything, then *gap_3* will be the index in **L** of the last non-zero contributor.

However, it is not necessary to have all the four contribution levels in the visualization in this design. Depending on the specific situation, there may be one or two less levels.

For example, if everyone in the range of *gap_1* happens to share the same number of URLs, then there will not be the first contribution level and everyone before *gap_2* will have a contribution level = 2, if everyone after *gap_2* happens to share the same number of URLs then there will not be the fourth contribution level and everyone after *gap_2* will have a contribution level = 3. In this situation, there will only be two contribution levels: level 2 and level 3.

Table 2. Example on the Classification Algorithm

topic 1	topic 2	topic 3	topic 4	topic 5	topic 6	topic 7	topic 8	topic 9	topic 10	overall
3	5	14	14	24	28	23	15	20	20	124
0	5	8	10	19	28	15	15	13	10	111
0	4	7	10	16	21	11	10	11	8	102
0	2	6	9	12	15	10	10	8	6	77
0	1	5	9	10	12	8	10	7	6	69
0	1	5	7	8	11	7	6	7	6	58
0	1	5	7	6	11	6	6	6	6	49
0	1	5	7	6	11	6	6	6	6	48
0	0	5	6	6	11	6	6	6	5	47
0	0	5	6	6	9	5	5	5	5	45
0	0	5	6	6	9	5	5	5	5	43
0	0	4	6	5	7	5	5	5	4	40
0	0	4	5	5	6	5	5	5	4	39
0	0	4	5	5	6	5	4	4	3	38
0	0	4	4	5	6	4	4	4	3	35
0	0	4	4	4	5	4	4	4	3	34
0	0	4	4	4	5	4	3	4	3	34
0	0	3	4	4	5	4	3	4	2	33
0	0	3	4	4	4	3	3	3	2	32
0	0	3	4	3	4	3	3	3	2	29
0	0	3	3	3	4	2	2	2	0	28
0	0	3	3	3	3	2	2	2	0	25
0	0	2	2	3	3	1	0	2	0	18
0	0	1	2	3	3	0	0	0	0	15
0	0	1	2	2	2	0	0	0	0	13
0	0	0	1	2	2	0	0	0	0	11
0	0	0	0	0	0	0	0	0	0	4
0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0

* Yellow – contribution level 1, White – contribution level 2, Light pink – contribution level 3, Light blue – contribution level 4.

This algorithm is designed to solve the problem of insignificant boundaries between two consecutive clusters of users when classifying these users into different contribution levels. This problem was obvious with the old classification algorithm used in the second design and created feelings of unfairness in the students who were close to the margins of different contribution classes. For example, see Table 2, which shows the contributions of each of the users for each topic. According to the old classification algorithm, the first contribution level should always contain the top three users, and

according to the contributions for topic 1 (i.e. the first column in table 2) some of the zero-contributors will be classified into the first contribution level, while the rest will be classified into the other contribution levels, which is obviously not fair. However, the new classification algorithm avoids this unfairness by defining the boundaries of contributions between two consecutive clusters on natural gaps (see table 2) instead of straight percentage cutting. Therefore, the size difference of stars seems to be more reasonable in the visualization.

The way to determine the brightness level is simpler since the algorithm of computing the average reputation of a user's shared URLs (referred to as "paper-reputation" in the following context) is out of the scope of this research (it is the research topic of another student, Ran Cheng, mentioned before). The visualization determines the brightness level according to the computed paper-reputation of a user. If the highest paper-reputation of all the users, either online or offline, is **H** then everyone whose paper-reputation = **H** will have the brightest star (i.e. the highest reputation level). If a user's paper-reputation is less than **H**, for example *r*, then another value **R** is computed as **R** = *r*/**H**: if **R** > 0.9 with an allowable margin of 0.05 (i.e. **R** > 0.85) then this user will also have the brightest star; otherwise, if **R** > 0.55 then this user will have a second brightest star (i.e. reputation level 2); otherwise, if **R** > 0.35 then this user will have a dark star (i.e. reputation level 3); and if **R** <= 0.35 then this user will have the darkest star (i.e. lowest reputation level) which almost fade into the background.

The above algorithm underlies the final version of the motivation community visualization. The next section explains how I tested and evaluated this final version.

5.2 Experiment and Evaluations

This final version of the community motivational visualization was evaluated by a group of 32 forth-year computer science students taking CMPT 408, the same class on Ethics in Computer Science, but this year offered by the Department of Computer Science under a new number from January 17 to April 8, 2005.

The hypothesis is that visualizing the community and the user contributions motivates users to contribute more along the outlined participation categories: contribute more papers, rate more papers, read more papers, and login more often in the system. While in

the previous experiment a big increase is observed after introducing the motivational interface with the visualization and the status, I could not attribute this clearly to the visualization, since there were many other factors at play; for example, the status that the users could have been pursuing, the novelty of the interface, coincidental general interest in the topics that happened to be discussed after introducing the new interface. This time I designed the experiment carefully to mitigate the effect of these factors.

5.2.1 Experimental Setup

In the experiment, the Comtella system was used to support students to share web articles (URLs) related to the class topics and do their course-work (e.g. summarizing selected articles and reviewing the summaries of their classmates). Therefore it was critical to ensure the all-time availability of the shared materials, and the stability of the system. The user feedback of the second design generally indicates that the system was not stable enough to satisfy the users and the system was not easy enough to use. Thus, instead of asking each user to install a Comtella servent on his/her own computer, I redesigned the system into a web application, using Apache Tomcat 4.0 web server and mySQL database server. By doing so, the Comtella system technically is not a P2P application any more; however, from the user point of view, it is still a peer resources-sharing system, since all the links are provided and consumed by the users.

Similarly to the previous experiment, the list of categories of interest consists of the main topics discussed in the class. Each topic was discussed in one week following the class curriculum, except for the one topic (Computer Crime and Security) in the middle of the term which was discussed for two weeks with an extra week in between (the midterm break in the academic schedule), so this topic ran over three weeks, weeks 4, 5, and 6. Week 5 was the midterm break. Records from last year's experiment show that not many activities in the Comtella community occurred during the break, so not many activities were expected in Week 5. But this would not affect much of the results because Week 5 was the last week in the first half of this experiment, and there would not be many activities in the last week (Week 10) of the second half of this experiment. Week 10 is the week before the class project's due date, and according to the experience of last year's experiment, students were busy with catching up their work and there were

not many activities in the Comtella community. Therefore, weeks 5 and 10 are still comparable, if comparison is needed for these two weeks. The next two weeks of the class after these 10 weeks' experiment were dedicated to the team-project presentations, and there was no particular topic discussed in the Comtella system for these two weeks. Students were asked to fill up the online questionnaire survey in these two weeks.

Students who participated in the experiment had unique ids (usernames) and passwords of their choices stored in the database so that they can log in the Comtella system from any computer with internet connection. If they wanted to hide their real identities, they could use aliases as their screen names instead of their real usernames, which were their default screen names, and they could change their aliases at any time to anything they wanted. Among 32 users, 30 signed and returned their consent forms to us and 29 filled out the online questionnaire survey. The following experimental results are based on the data from the subjects who submitted their signed consent.

The experiment started on January 17, 2005 and finished on April 8, 2005 (the last day of the class for this semester), a total of 12 weeks. I accumulated the data of the subjects for the first 10 weeks. In this experiment, Monday is considered as the first day of a week and Sunday, the last day of a week. The experimental subjects were divided into two groups of equal size, Group A and Group B, and the time duration of the experiment was also divided in to two equal parts: the first five weeks (from January 17 to February 20, 2005) and the latter five weeks (from February 21 to March 28, 2005). The midnight on Sunday February 20 is the "**switching point**" — at this point the two groups were switched in such a way that Group A, who had access to the visualization in the first five weeks, was not able to use the visualization any more, and Group B, who was not able to use the visualization in the first five weeks, gained access to the visualization. The reason of switching the two groups in this way is to reduce as much as possible the ordering effect and the effect of novelty. However, the novelty effect cannot be entirely eliminated. In the case of this experiment, it was stronger on Group A than it was on Group B because Group A was the first group who had access to the visualization, so for them both the system and the visualization were new. The subjects in Group A had no knowledge about the visualization when they were exposed to it in the beginning of the experiment, but the subjects in Group B had at least heard about the

visualization and might have seen it occasionally, since they were sharing classes and project teams with subjects from Group A. So the visualization was not as new to Group B as it was to Group A.

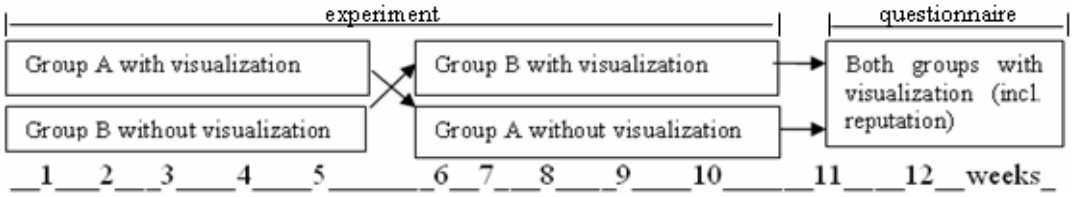

Figure 14. Experiment Time Schedule

The visualization used during these 10 weeks classified users into four different contribution levels and four different membership levels as discussed earlier in the design of this version. After these 10 weeks, the two groups were united by setting both Group A and Group B to be able to access the visualization, and the visualization was modified to show the members of both groups, i.e. all users.

The classification of the stars into four different brightness levels was added into the visualization only in the last two weeks, when the two groups were united. As mentioned before, the brightness of a star represents the user's reputation which is based on the ratings of the materials shared by a user. The reputation is one of the components of the user status which is represented with the colour of the star. The brightness of the star would provide an additional cue as to why the status of a user is higher or lower, e.g. a large star may stay at silver status level and never be upgraded to gold, if it is dull. On the other side, a smaller but brighter silver star may be upgraded to gold in the next week.

However, in this experiment, my goal was to test the effect of the community view on the user's participation in general. The difference in star brightness and the reputation as a concept is more subtle. The variation in size and colour provided already quite a rich semantics for the users to interpret. I decided to leave the investigation of the impact of the additional information for future work and in this study just test if the users would notice a difference in the brightness of stars so that in further research on this topic it is known whether or not the brightness is an effective representation of the reputation level of a user in the Comtella community. Therefore I didn't study the effect of visualization

of the users' reputation as star brightness on their contributions, but just asked the subjects in the questionnaire if they noticed any difference in the presentation of their stars.

5.2.2 Experimental Hypothesis

The general hypothesis of this experiment is that the visualization motivated the subjects to contribute more and participate more actively in the Comtella online community. I define the users' participation as four types of measurable activities:

- how often they use the Comtella system measured by the number of times they login into the system,
- the number of contributions (shared papers) the users create,
- the number of ratings the user have given to papers shared by others, and
- how often the users read contributions shared in Comtella measurable by the number of times they open shared URLs in the Comtella community.

The research hypothesis can be formulated in two ways: for each individual subject, when s/he had access to the visualization s/he participated more actively and contributed more than when s/he did not have access to the visualization; or for each group of subjects, the group with the visualization performed better than the group without the visualization. If either one of these two hypotheses could be proven, it could be concluded that the visualization had a motivational effect on user performance.

I adopted the second approach: compare on a group basis, instead of doing the comparison for each individual. An individual's behaviour is too much influenced by his/her personality and cannot be generalized to an overall case, and secondly, a straight comparison between the two situations, with and without the visualization, cannot account for collective influence of external factors that are common for all users (e.g. coursework load, deadlines etc.). So I chose to sum up the individual performance at each type of activity (as listed above) in a group and compare the performance between the two groups (Group A and Group B) over time. Since I decided to do group comparison the hypothesis can be restated as follows:

H1: Group A performed better than Group B in all of the four activities in the first five weeks when Group A had access to the visualization and Group B did not, and Group B

performed better than Group A at all of the four aspects when Group B had access to the visualization and Group A did not in the next five weeks.

However, a direct comparison between the collective participation of each group can still be influenced by external or uncontrollable factors, due to the random selection of individuals and the fairly small group size (15). Such factors are:

- variation in the individual participation motivation
- variation in the individual personal interest on particular topics
- variation in the course workload due to different classes, assignments etc.

Due to these factors one of the groups may show more active participation independently of the treatment. So I need a different metric that could capture relative rather than absolute performance differences.

Therefore, I decided to compare the *difference in the performances* of the two groups instead of comparing the absolute performance differences. Performance is measured by the number of actions that a group of subjects made in each type of activity. If the assumption is that there is an inherent difference in the performance of the two groups due to other factors, the hypothesis can be restated to correspond to this metric: the motivational community visualization reduces the difference between the performances of the two groups when the more active group does not have access to the visualization and the less active group has access to the visualization; and reversely, the visualization amplifies the difference when the more active group has access to the visualization and the less active group does not have access to it (figure 16).

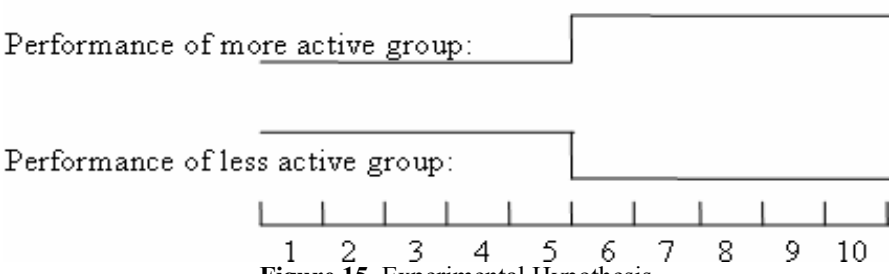

Figure 15. Experimental Hypothesis.

To rephrase this hypothesis more precisely in the context of my experiment:

H2: If the less active group is Group A (the group with the treatment in the first half of the experiment), and the active group, Group B (the group without the treatment in

the first half of the experiment), then the difference, **D1**, between the performances of Group A and Group B before the switching point (in weeks 1 to 5) is **significantly** smaller than the difference, **D2**, between the performances of these two groups after the switching point (in weeks 6 to 10). By "significantly", I mean that D1 being smaller than D2 is not due to chance or randomness.

5.2.3 Experimental Results

Figure 16 shows the difference in the performances of the two groups regarding the login activity, measured by the number of times subjects logged in to the Comtella system each week. The number of logins is an indirect measure of the performance of subjects compared with the number of ratings (figure 17) and the number of shared URLs (figure 18). However, the number of logins can reflect the subjects' interest in using the Comtella system i.e. if subjects log in more frequently when they can access the visualization than when they cannot; it indicates that subjects are more interested in the system with the visualization.

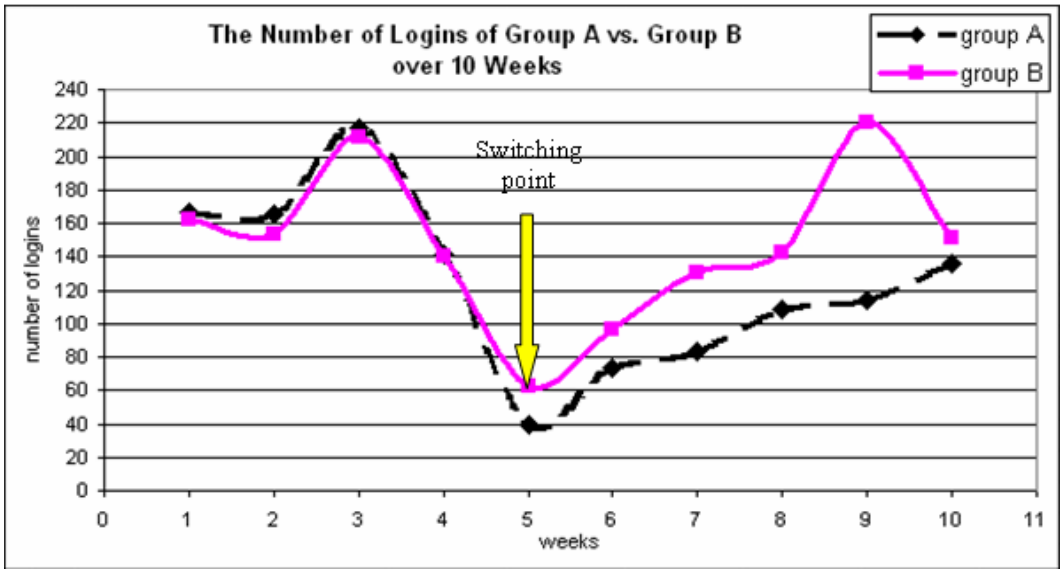

Figure 16. The Number of Logins from Group A vs. Group B

In figure 16, the dark dashed line represents the performance of the Group A and the lighter solid line represents the performance of Group B. The X-axis shows the time duration of the experiment in terms of weeks, starting at Week 1 and ending at Week 10.

The Y-axis shows the number of times subjects logged in to the Comtella system. Each point is the sum of the number of activities in the corresponding week. The groups were switched at midnight on the last day of Week 5 i.e. the beginning of Week 6. Thus, points from one to five along the X-axis represent the numbers of the activity ,which is login in this figure, in each week of both groups when Group A was able to access the visualization and Group B was not; and points from six to ten represent the numbers of the activity in each week of both groups after the groups were switched in such a way that Group A was not able to access the visualization while Group B was able to. The X-axis and the location of the switching point are the same in figures 17, 18, and 19. Weeks 4, 5 and 6 were on the same topic and students, from my observation through the data collection, shared most of their files on this topic in Week 4 and almost nothing in weeks 5 and 6. Moreover, Week 5 was the midterm break of the university. This explains the big drop in Week 5 in figures 17, 18, and 19.

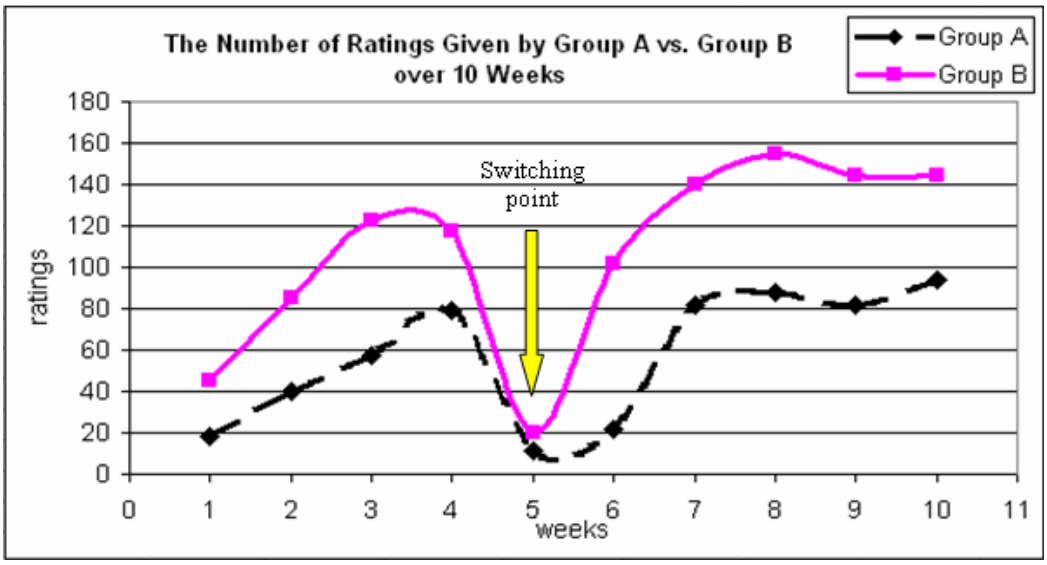

Figure 17. The Number of Ratings Given by Group A vs. Group B

In the Comtella system, subjects can rate each other's shared materials (the mechanism of regulating the ratings is another research topic). Figure 17 compares the number of ratings by the subjects in Group A with the number of ratings given by Group B on a weekly basis. The Y-axis shows the number of ratings. Giving ratings is a major type of activity in the Comtella community. It takes effort to read and evaluate the

material, and is considered to be valuable contribution to the community since reasonable ratings will guide users to find good articles.

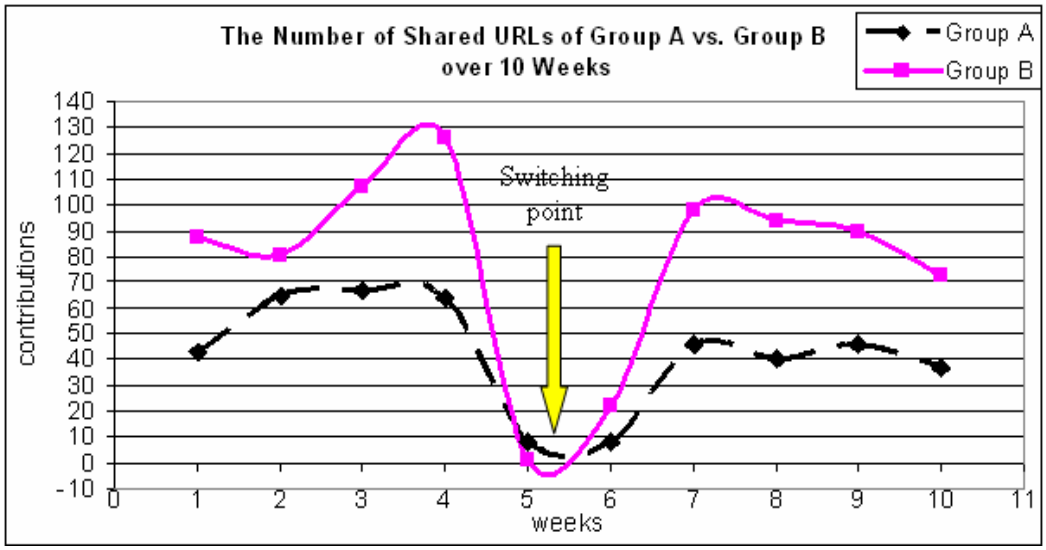

Figure 18. The Number of Shared URLs Given by Group A vs. Group B

A major type of contribution that each user brings into an online community is the number of shared papers. In the context of this experiment, this is the number of shared URLs. Figure 18 compares the number of URLs shared by Group A subjects with the number of URLs shared by Group B subjects on a weekly basis. Y-axis shows the number of shared URLs.

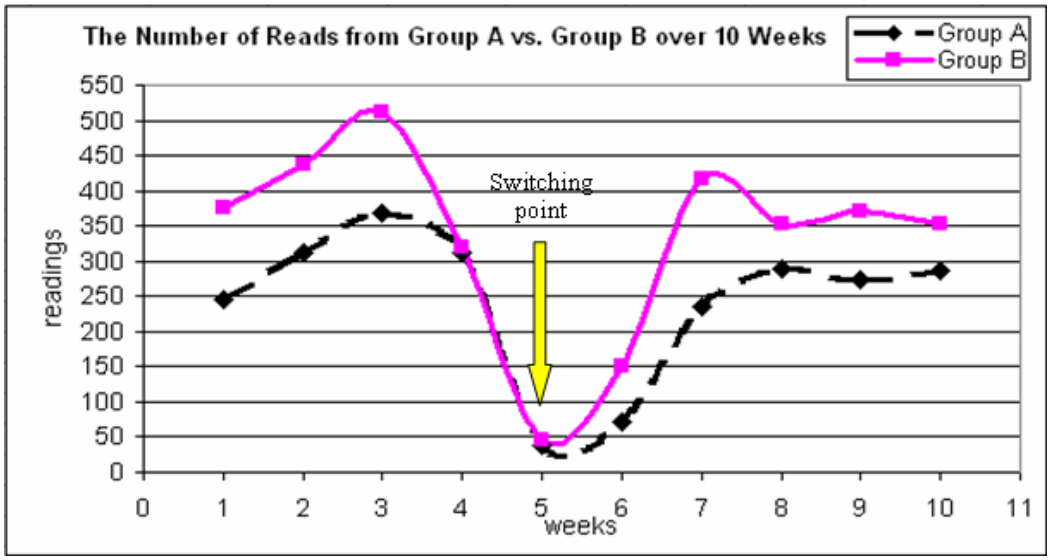

Figure 19. The Number of Reads from Group A vs. from Group B

Figure 19 compares the number of times Group A subjects opened to read a URL with the number of times Group B subjects opened any shared URLs to read. Similar to logins, the number of reading times is also a minor measure of the performance of subjects, but it reflects how much subjects are interested in using the materials shared in the Comtella system: if subjects read significantly more URLs when they have access to the visualization, it indicates when there is a community visualization, users are more interested in using the Comtella system to check up and read the shared materials.

It has been observed in all these four figures (figure 16 to 19):

1. Both groups A and B (the light and the dark lines) show some decline in participation in the second half of the experiment (weeks 6 to 10) in comparison with the first half of the experiment. This observation is similar to the trend shown in last year's experiment with the second version of the visualization as discussed in section 3.4 of this chapter. The most likely reason is that external factors (e.g. the fact that in the latter half of the semester, subjects were getting busier with their course workload: meeting the deadlines of their term projects and preparing for the up-coming final exams, etc.). These external factors distracted subjects from using as actively the Comtella system and even distracted them from participating in the class, which is supported by some anecdotal evidence: the instructor observed noticeably lower class attendance in the latter half of the semester. It is important to take into account the effect of these external factors on the general trend of contributions and participation in the analysis of results. If I compare the performance of each individual with and without visualization, I cannot take into account these external factors. Therefore, it is important to take into account the time in the term (first half or second half of the period).
2. The light line is almost always higher than the dark line through the 10 weeks (especially in figures 17, 18, 19). This indicates Group B generally performed better than Group A no matter which group had access to the visualization. Based on this observation, it can be concluded that Group B consisted of more active users than Group A. Thus, it is not proper to only look at the extract number of occurrences of a type of activity in either group to conclude that the visualization

had an effect on that group in that type of activity, since the activeness of the two groups is different. A higher occurrence of a certain type of activity in a group may not be necessarily due to the motivational effect of the visualization; it may be due to the coincidence of active individuals in the group; and a lower occurrence of a type of activity in a group may not be due to the de-motivational effect of the visualization, if there is any, it may be due to the inactive nature of the group. Therefore, it is necessary to consider the differences in the performance of the two groups, rather than their absolute values and try to confirm the hypothesis H2. If we assume that Group B is generally more active than Group A and that the visualization has a motivational effect, then the performance of Group A which has the visualization in the first half of the period will be pushed up and therefore the difference between the performance of the two groups will be smaller than if both groups had no access to visualization. During the second half of the experiment Group B (the more active group) had access to visualization therefore its performance will be even higher. In contrast, Group A, who is anyway less active and now has no access to visualization, will perform even less actively, so that the difference between the two groups will increase. So, if the experimental hypothesis is correct, a smaller difference between the performances of Group B and Group A is expected to be observed in the first half of the experiment and a bigger difference is expected in the second half of the experiment.

3. There is a big valley around weeks 4, 5, and 6 in figures 16 to 19. This is because Week 5 was the midterm break during which students were supposed to take a rest, so the performance of all activities dropped to almost zero for both groups. Weeks 4 to 6 were dedicated on the same topic, as explained in the experimental setup. In this case, subjects habitually shared most of their URLs in the first week (Week 4) of this topic because they were supposed to take a break in the following week. Some students had mid-term exams in Week 6, which additionally suppressed their activities in the Comtella system. This is the explanation for the big drop at Week 5 in these four figures.

From figure 16 to 19, it is clear that there is difference between the performances of Group A and Group B. Group B performed better than Group A in general. However, it is hard to tell from these four figures whether or not the difference in the first five weeks is significantly smaller than the difference in the latter five weeks. In order to compare the differences, I did statistical analysis. To verify the significance, two statistical tests were performed: a *t*-Distribution test, and a "Wilcoxon's Matched-Pairs Signed-Rank Test" (Mendenhall & Reinmuth, 1974), on the difference in performances of the two groups before and after the switching point.

The rationale is: when each group first got access to the visualization the novelty effect played a role, and also it took a while for users to get accustomed to the system. In the design of the experiment, the reason of switching the groups, as mentioned previously in the experimental setup, was to reduce the novelty effect. So the comparison is done as follows: the difference in the performances of the two groups in Week 1 is used to compare against the difference in the performances of the two groups in Week 6, the difference in Week 2 is used to compare against the difference in Week7, and so on. This is because Week 1 was the first week Group A had access to the visualization and Week 6 was the first week Group B had the access to the visualization, so the novelty effect of the visualization on Group A in Week 1 is comparable to it is on Group B in Week 6, and so on (i.e. Week 2 compared with Week 7, Week 3 compared with Week 8, Week 4 compared with Week 9, and Week 5 compared with Week 10, see figure 14). Therefore, a comparison on a paired-weekly basis is fair.

The calculation details are: list the total number of actions for each activity that Group A made on a weekly basis in one column (*groupA*), list the same type of data of Group B in another column (*groupB*), and then subtract *groupA* from *groupB*, for each week and each activity and list the results in another column (*diff = B-A*). This procedure and the data are shown in Table 3, Appendix 3. To compare the differences, the data in column *diff=B-A* is rearranged into two columns in Table 4, Appendix 3 so that the difference in performances in weeks 1 to 5 is in column *w1*, and the difference in weeks 6 to 10 is in column *w2*, and then subtract the data in *w1* from its counterpart in *w2* and list the result in column *w2-w1*.

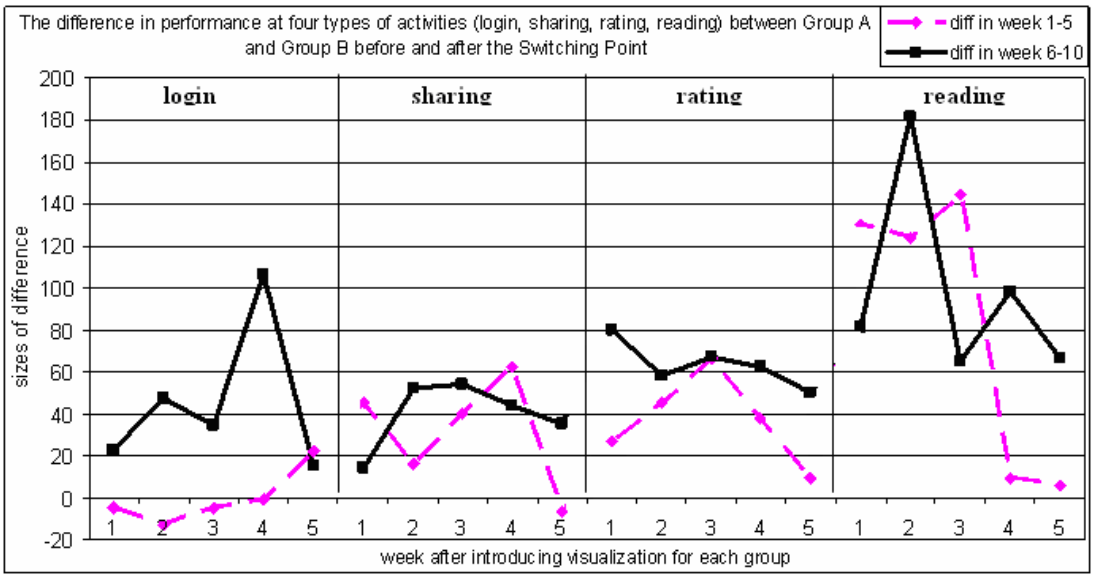

Figure 20. The Difference in the Performances of the Two Groups (i.e. the difference in the performances between the first half of the experiment vs. it is in the second half of the experiment.)

In figure 20 the lighter dashed line represents the difference in the performances of the two groups in the first five weeks of the experiment, and the darker solid line represents the difference in the performances in the latter five weeks of the experiment. The X-axis is divided into four sections, each representing the difference in the performances in a particular type of activity (login, sharing URLs, rating URLs, or reading). Each section along the X-axis contains five segments, from 1 to 5, each segment representing a pair of weeks (Week 1 paired with Week 6 as marked by 1, Week 2 paired with Week 7 as marked by 2, Week 3 paired with Week 8 as marked by 3, Week 4 paired with Week 9 as marked by 4, and Week 5 paired with Week 10 as marked by 5). Thus, each point on the darker solid line is comparable to the point on the lighter dashed line. For example, the first point on the solid line represents the first week when Group B had access to the visualization and Group A did not, and the first point on the dashed line represents the first week when Group A had access to the visualization and Group B did not, and so on for the rest of the points. The solid line is mostly above the dashed line which indicates that most of the times the difference in the performances of the two groups after the switching point is bigger than it is before the switching point. This seems to confirm the hypothesis H2.

Table 5 in Appendix 3 shows the result of the *t*-test on each activity and Table 7 in Appendix 3 gives the result of the Wilcoxon's Matched-Pairs Signed-Rank Test on each

activity. There is significant difference in the performances of the two groups regarding the login and the rating activities. According to the *t*-test, the significance for logins is greater than 95% and the Wilcoxon's test gives the same result on this activity. The significance for rating is 97.5% according to the *t*-test, and 95% according to the Wilcoxon's test. However, the results for sharing and reading activities are not strong. The *t*-test shows the probability of the difference in sharing activity being random is 29%, and the probability of the difference in reading activity being random is 33%.

Since this version of the visualization mainly targeted on encouraging users to share and rate more files, I did further statistical tests on these two types of activities, i.e. sharing and rating. Figure 21(a) shows the comparison of Group A's contributions with and without the visualization. Figure 21(b) shows the comparison of Group B's contributions with and without the visualization.

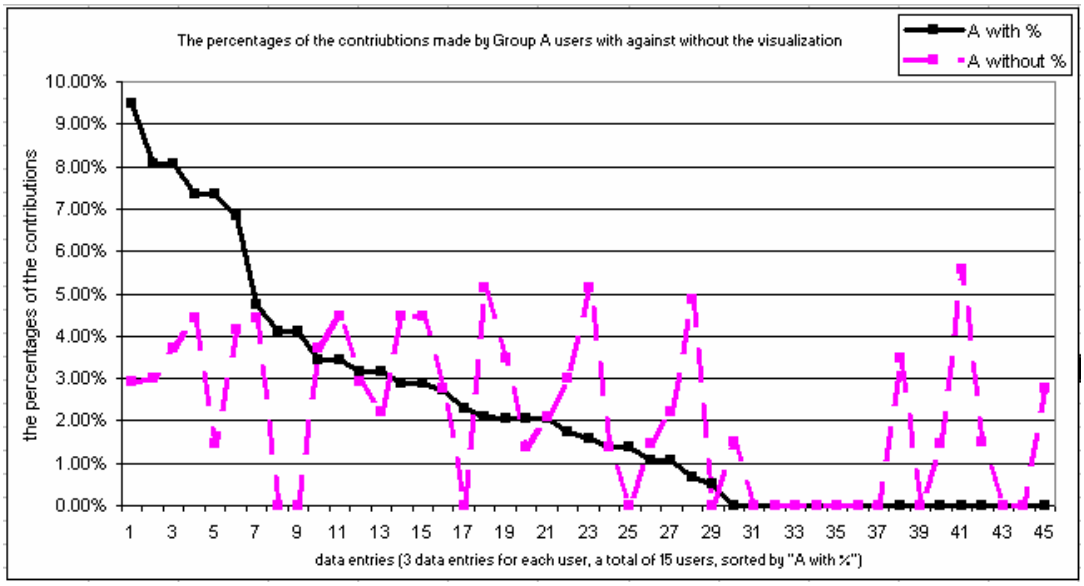

Figure 21(a). Group A Percentages of Contributions. (i.e. the percentages of the contributions made by Group A while they had access to the visualization compared with the percentage of contributions made while they had no access to the visualization. Data was extracted from Table 8, Appendix 3. There were 15 users in this group, with three data entries for each user, representing the contribution made by this user in a week, and sorted by the descending order of the data in series "A with %".)

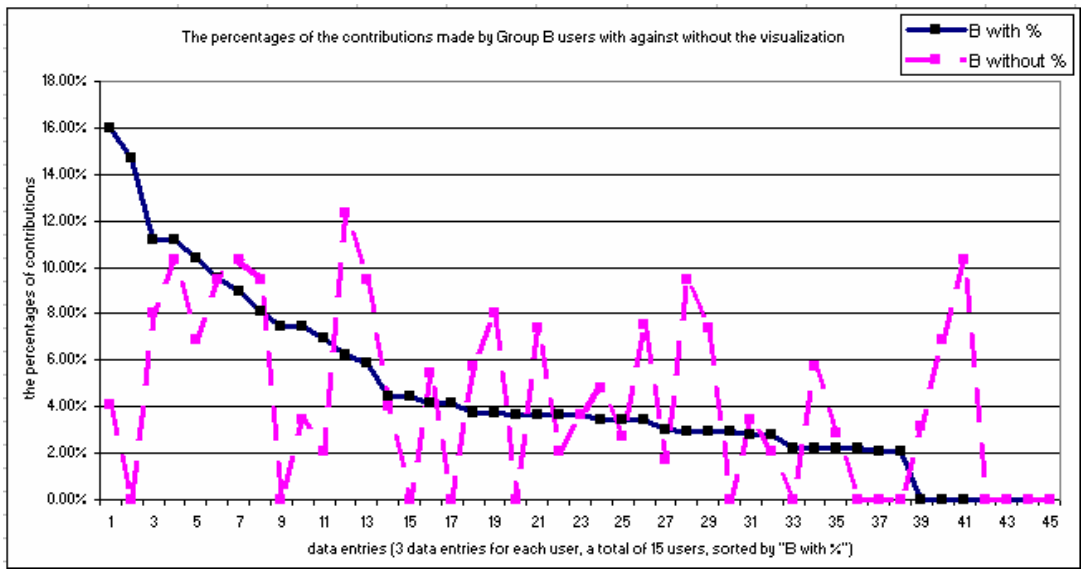

Figure 21(b). Group B Percentages of Contributions. (i.e. the percentages of the contributions made by Group B with the visualization compared with it without the visualization. Data was extracted from Table 8, Appendix 3. There were 15 users in this group with three data entries for each user, representing the contribution made by this user in three selected consecutive weeks, sorted according to the descending order of the data in series "B with %".)

The data graphed in figures 21(a) and 21(b) are about the percentages of contributions from Group A and Group B in weeks 2 to 4 and weeks 7 to 9. The reason of cutting off Week 1, 5, 6, and 10 is that there were not many activities in these weeks, especially weeks 5 and 6. Contributions in weeks 5 and 6 were almost zero and the reason is discussed before. Week 1 was at the beginning of the semester, so was affected by the noise caused by the novelty of the system and the unfamiliarity of using the system. Therefore, there were not many activities in Week 1. Week 10 was the last week of the experiment and also was the week before the class project's due date so students were busy with their projects in this week. Also, the topic discussed in Week 10 was apparently not interesting and not rich of related online materials. So students did not have many activities in Week 10. Moreover, these four weeks were the beginnings and endings of the two halves of the experiment. Cutting off one of them leads to cut off its paired week, e.g. week 6 was the first week of the second half of the experiment and its paired week was week 1, which was the first week of the first half of the experiment, so cutting off Week 6 leads to cut off Week 1, similarly with weeks 5 and 10.

In figures 21(a) and 21(b), the X-axis represents the number of data points with 3 data points for each user and there are a total of 15 users. The Y-axis in figure 21(a) shows

the contribution made by each user of Group A, and the Y-axis in figure 21(b) show the contribution made by each user of Group B. In both figures, each point on the black solid line represents the contribution made by a user in a week, which can be Week 2, 3, or 4, and the entire series of data are sorted in the descending order; and on the lighter dashed line, each data point represents the contribution made by the same user in a week, which can be Week 7, 8, or 9. The data on the black solid line is comparable to the data on the lighter dashed line. Take figure 21(a) (of Group A) for example, if a point on the solid line represents the contribution of user U1 in Week 2, the second week when this user had access to the visualization, then its corresponding point on the dashed line represents the contribution of the same user in Week 7, the second week when this user lost access to the visualization. The data points in figure 21(b) on both lines are comparable for the same reason.

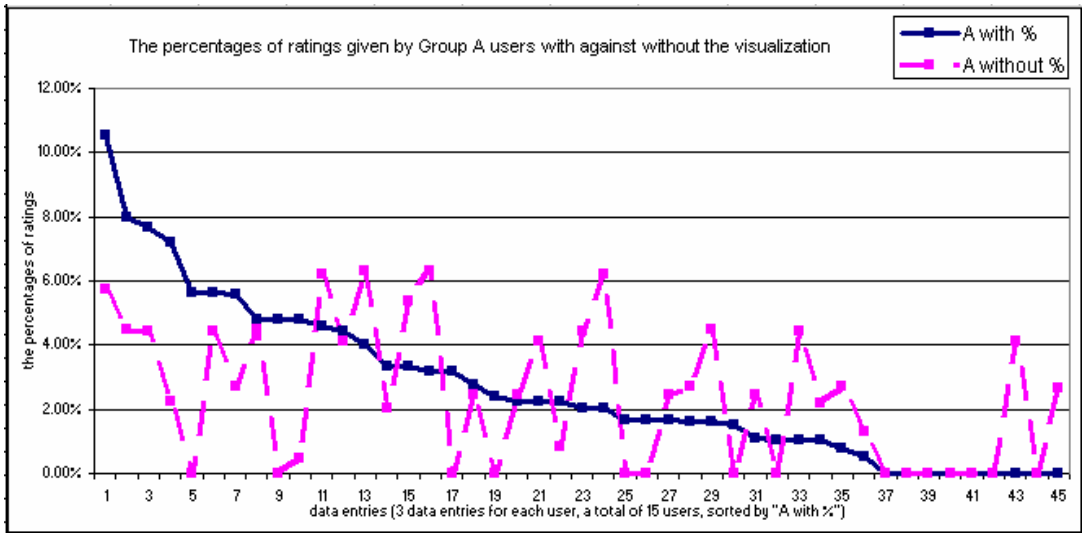

Figure 22(a). Group A Percentages of Ratings. (i.e. the percentages of the number of ratings given by Group A with the visualization compared with it without the visualization. Data was extracted from Table9, Appendix 3. There were 15 users in this group with three data entries for each user, representing the number of ratings given by the user in three selected consecutive weeks, sorted by the descending order of the data in series "A with%".)

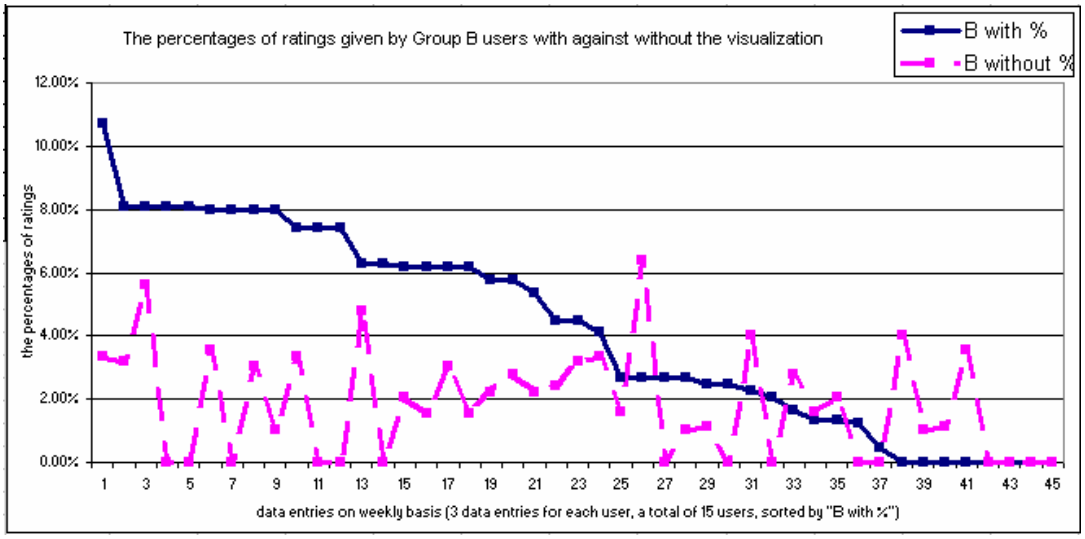

Figure 22(b). Group B Percentages of Ratings. (i.e. the percentages of the number of ratings given by Group B with the visualization compared with it without the visualization. Data was extracted from Table9, Appendix 3. There were 15 users in this group, three data entries for each user, representing the number of ratings given by the user in three selected consecutive weeks, sorted by the descending order of the data in series "B with%".)

In figures 22(a) and 22(b), the X-axis represents the number of data points with 3 data points for each user and there are a total of 15 users. The Y-axis in figure 22(a) shows the number of ratings given by Group A, and the Y-axis in figure 22(b) shows the number of ratings given by Group B. The data on the black solid line and the data on the lighter dashed line in both figures 22(a) and 22(b) are comparable for the same reason as discussion above in figure 21.

T-tests (Table 10, Appendix 3) were performed at a 95% significance level on the data presented in figures 21(a), 21(b), 22(a), and 22(b) (i.e. Table 8 and 9, Appendix 3). The probabilities of these results being due to the treatment, which is the motivation visualization in this case, and not due to randomness are different. There is 36.9% chance that the difference in the contributions from Group A with and without the visualization (figure 21a) is random, 35.15% chance that the difference in Group B's contributions (figure 21b) is random, and 28.96% chance that the difference in Group A's ratings (figure 22a) is random. Since the chance for the above results being random, is high (higher than the 5% margin), they are not significant. The only difference that is significant is in Group B's ratings (figure 22b) because the probability of this result being random is almost zero.

According to the t-tests that I carried out on the users' sharing and rating activities, the final version of the visualization had more significant effect on encouraging ratings than it was on encouraging contributions, and it seems that the visualization had stronger motivational effect on Group B, the active group, than it had on Group A, the less active group. The reason why the active group was motivated more effectively was unknown. However, if a group is generally more active than the other in making contributions then this group probably care more about their contribution levels in the community and care about if other users see them as good users or freeloaders. So the active group may be more willing to compete since they care. Thus, the visualization motivated Group B more effectively than it did on Group A.

5.2.4 User Feedback

Among the 30 subjects who signed and returned their consent forms, 27 filled out an online questionnaire survey (questionnaire 2 in Appendix 2). The following provides a summary and brief discussion of the user answers to each of the questions in the questionnaire.

1: Have you ever used the community visualization?

a. Yes (74% of the subjects selected this option)

b. No (26%)

Among those who answered no, the major reason chosen was that "they did not care to see others" and one of them answered that s/he "did not like the view". However, records in the database show that among the 30 subjects who signed and returned their consent forms, 25 (83%) of them actually clicked on the "community" tab, the tab to access the visualization. The three subjects who did not participate in the survey also accessed the visualization. Two of the subjects who claimed that they did not use the visualization actually accessed it with lower frequency compared to others who claimed that they used the visualization; one of these two subjects gave as a reason that s/he "did not care to see others" and the other subject did not give a reason.

2. Did you notice the decreasing participation after the spring break?

a. Yes (67% of the subjects selected this option)

b. No (33%)

This indicates that subjects realized that there was less participation and contributions after the reading break.

3. Did you check the community visualization for the topics of the previous weeks?

a. Yes, very often (15% selected this option)

b. Occasionally (40% selected this option)

c. No, I was only interested in the current topic (45% selected this option)

This means the majority of the subjects were mostly interested in the state of the ranking by community contributions for the current topic. Since the subjects in this experiment are students taking this class, this phenomenon is normal; however, if we generalize the Comtella system into any public online community, we do not have the issue of weekly topics, people will most likely choose their topics based on their interests.

4. If the same information is provided in a different form such as a table or a chart, do you think you would have used the visualization as often as you did?

a. Yes (35% selected this option)

b. No (20% selected this option)

c. I don't know (45% selected this option)

Since my research focuses on the impact of visualizing community information for user motivation to participate in general rather than on the specific impact of one particular type of metaphor, we did not explore the differences in the motivational effect of different types of visualization metaphors. The mixed answers to this question indicate that it would be another interesting project to investigate the difference of the motivational effects of different types of visualizations.

5. Please rank the following reasons for which you used the visualization (1: most important; 5: least important):

	1	2	3	4	5
appears interesting	15%	20%	30%	20%	15%
find articles	10%	0%	20%	20%	50%
compare contributions	30%	35%	15%	5%	15%
check who contributed what	5%	20%	5%	35%	35%
find top contributors	15%	25%	30%	10%	20%

To summarize, 35% of the subjects ranked the visual appearance as important (rank 1 and rank 2), 30% of them ranked it as neutral (rank 3); 65% of the subjects ranked

“comparing contributions” as important (rank 1 and 2); 40% of the subjects ranked “find top contributors” as important (rank 1 and 2).

6. Please rank the following (from -2: "very poor" to +2: very good):

	-2	-1	0	1	2
overall	9%	0%	23%	59%	9%
support tool to cmpt408	9%	4%	13%	35%	39%
usability	11%	21%	21%	42%	5%
reliability (crashes etc.)	10%	19%	14%	43%	14%
visualization attractive	10%	5%	35%	30%	20%
visualization useful	10%	5%	35%	40%	10%
visualization intuitive	10%	15%	35%	25%	15%
visualization effective	25%	15%	40%	20%	0%
quality of shared links	20%	0%	25%	45%	10%
fairness	10%	0%	10%	65%	15%

Overall, 68% of the subject ranked positively the overall quality of the Comtella system, 74% of the subjects ranked positively the System as “a support tool for the class”. 47% of the subjects ranked positively the usability, and 57% considered the system as very reliable which is a much better result compared with the second design, where 70% of users complained about the reliability. 50% of the subjects ranked “visualization attractiveness” as positive compared with the second design where only 34% of the subjects ranked this criterion positively and only 18% thought the second design “appeared interesting”. 40% of the subjects thought the visualization was intuitive and 20% thought it was effective; however, the second design gave a slightly better result on the intuitiveness (48% positive ranking) than the final design. 80% of the subjects accepted the system as being fair, which is also a much better result than the second design where only 50% of the subjects accepted the system as fair. These numbers indicate that the final version of the Comtella system is more successful in general compared with the second version.

7. What would you like to know about the other users? (please rank)

	-2	-1	0	1	2
who is currently online	35%	5%	25%	20%	15%
how much others contribute	5%	0%	15%	40%	40%
membership	10%	5%	43%	28%	14%
am I a freeloader	20%	5%	35%	25%	15%
don't want to know anything	48%	9%	33%	5%	5%

From this question it is clear that most of users - 80% - were interested in “what materials that others contributed” which is a slightly higher result than the second design

(76% positive ranking on this aspect). This tells that users are generally interested in knowing about other users' numbers of contributions. The above result also show 40% of the subjects were concerned if others saw them as freeloaders, while in the survey in the second design the questionnaire asked a slightly different question "if other users perceive me as a freeloader or an active contributor" (i.e. the wording contains both positive side and the negative side) and the positive ranking on this criterion is 54%, which indicates the second version might have a better motivational effect but this is not certain since the wording is different.

8. What would you like other users to know about you? (please rank)

	-2	-1	0	1	2
am I online	25%	10%	40%	5%	20%
how many links I share	5%	5%	35%	35%	20%
quality of my shared links	5%	5%	20%	20%	50%
ratings I give to others	33%	9%	29%	19%	10%

It seems that the users didn't really care much if others know if they are currently on line. However, only a few users (10%) didn't care if others knew about how many links they share, so it seems that users were proud of the links they shared, since 55% wanted others to see their contributions. 70% agreed to reveal the quality of their shared materials to other users. Compared with the last year's experiment on the second version, in which only 29% of the subjects were willing to reveal the number of their contributions, people are much more willing to be visible and involved in the Comtella community with the final design.

9. What would be your reaction if you saw from the search results that there were already a large number of contributions in a given week?

a. you decide to find some links to compete with the others (45% selected this option)

b. there is enough already, no need to add more (10%)

c. the Prof will not notice your participation, why bother? (5%)

d. try to find some better quality papers to share (10%)

e. Other: please specify (30%)

The comments included: subjects would share more if they did not have much workload at the moment; subjects wanted to focus on bringing quality materials and compete in the quality instead of quantity. Compared with the feedback on the second

design, in which only 20% of the subjects stated that they would continue to share more and their complaints about “too much junk shared by others”, the final design of the visualization is well improved.

10. What would be your reaction if you saw yourself as one of the smallest stars (regardless of its color and brightness) in the visualization?

a. Take immediate action: share more links to make your star larger (20%)

b. Think that you should probably share more links, but later (45%)

c. Feel unhappy but do nothing (0%)

d. Feel that the system is unfair, so it doesn't make sense to contribute (0%)

e. Do not care, so will do nothing (20%)

f. Other - please specify: (15%)

Overall, 65% of the subjects were willing to share more to upgrade their stars, and no one complained about the fairness of the system. Some subjects indicated in their comments that they did not care much about the quantity (i.e. size) of their stars; instead they would pay attention to the quality and the relevancy of both their shared materials and the other users’ shared materials. For the same question in the survey on the second design, 54% of the subjects said they would take immediate action or at least think of sharing more to upgrade their stars, and 9% thought the system was unfair.

11. If you saw yourself as one of the largest stars (regardless of its color and brightness), would you:

a. Feel proud of your status and try to contribute even more. (40%)

b. Feel proud, but also in some sense "exploited", stop bringing more links. (10%)

c. Feel worried, you may be raising the bar too high and the others may hate you or you may be perceived as "overachiever" by the others. (10%)

d. Feel nothing, since it is not important for me. (35%)

f. Other - please specify: (5%)

5% of the subject did not choose any options provided for this question but gave other comments. One student commented that s/he worried about if s/he “raised the bar too high and others may hate them or see them as overachiever”. For the same question in the survey of the second design, 41% indicated they would continue to share at the same level or more – almost the same result as it is in the final design (40%).

12. Please rank the following factors according to how strongly they motivated you to contribute (1: strongest; 6: weakest):

	1	2	3	4	5	6
community visualization	8%	19%	19%	11%	8%	35%
earn higher membership	22%	19%	18%	15%	15%	11%
earn higher marks	43%	21%	4%	14%	11%	7%
bringing good papers	23%	12%	35%	11%	11%	8%
being best user	11%	28%	14%	18%	11%	18%
having best papers	11%	25%	18%	18%	18%	10%

To summarize, 46% of the subjects ranked the community visualization as strong (1 to 3), and 69% ranked "bring good papers" as strong.

13. Did you find any difference in the visualization presented in the final 2 weeks of the class, after March 28, 2005?

a. I did not see the visualization in the last two weeks. (35%)

b. No (25%)

c. Yes (20%)

d. If Yes, what was the difference? (20% selected this answer, among whom 31% pointed out the difference in brightness)

Among the subjects who used the visualization during the last 2 weeks, 44.44% noticed that the visualization appeared different and 31% of the users who gave justifications (selected d) to this question pointed out that there was a brightness level associated with each star. However, a significant proportion did not notice the difference in the brightness or could not point it out correctly. A possible reason for this is that stars representing offline users are covered by black cloud in the center (figure 13) so brighter stars do not appear much brighter than others and it is hard for users to easily recognize the difference in the brightness. Most of the stars were offline during the last two weeks, when there were no new class topics for which papers were shared. Maybe due to the insufficient exposure to the actual not-shaded brightness of stars, only 45% of the subjects agreed that the way of associating the quality of their shared materials with the brightness of their stars was intuitive (q17 in the questionnaire of the final design), while the rest (55%) thought it was not intuitive enough. However, the reason may also be the increasing complexity of the picture and the semantics represented by the graphical "language".

14. Did you find the final visualization represents fairly your overall level of contribution in the class?

a. Yes (60% selected this option)

b. No (25%)

c. If No, why?

The justification given by the students who selected "b" above was mainly on the quantity vs. quality. They thought there should be more emphasis given on the quality of the shared materials. 15% of the subjects were not sure about the overall fairness, and from the given justifications, we found this uncertainty was caused by unfamiliarity with using the system.

15. Did you use your real name in Comtella, or did you create an alias?

a. Used my real name throughout the term (65%)

b. Used my alias throughout the term (10%)

c. First used my real name, then changed to alias (25%)

d. First used an alias, then changed to my real name (10%)

Recall in No.11 above there was some concern about "raising the bar too high and others may hate them and see them as overachievers" when subjects saw themselves as one of the biggest stars in the visualization. This may explain why some users always used aliases in the experiment or used their real user ids at the beginning but switched to aliases latter to hide their real identities.

5.3 Discussion and Conclusion

Comparing with the feedback from the previous experiment on the second design of the motivational community visualization, this experiment on the new design of the visualization shows that users generally preferred the new version of the visualization (from the fact that there is noticeable complaint on the visual appearance, fairness, and stability of the second design, while the same type of complaint on the final design is much less or none, see results of both questionnaire in Appendix 2), which appeared more attractive and stimulated more effective competition among users in their contributions. The feedback from this experiment also shows that compared with the second design, there is a higher percentage of users using the visualization to check who

contributes how much and who the top contributors are (No.7 to 9 in 3.6.3), and the willingness to reveal information about one's own contribution is also much higher (No.10 in 3.6.3) in this years' experiment. The final version of the visualization effectively motivates users' contributions in each of the two groups under the tested condition. The experimental results confirm the hypothesis that the visualization helps shrinking the difference in the performances of the two groups when the naturally inactive group had access to the visualization and the naturally active group did not, and the visualization amplifies the difference in the performances of the two groups when the active group had access to the visualization and the inactive group did not. The *t*-test and the Wilcoxon's Matched-Pairs Single Rank Sum test show that the difference in the performances of the two groups before and after the switching point is significant for login and rating activities but not for sharing and reading activities. Therefore, I can conclude that the final version of the community visualization motivates users to contribute more at some aspects e.g. active participation in giving ratings to other users' shared files in Comtella online community.

However, to conclude on each specific type of activity that may possibly happen in the Comtella online community such as reading and sharing, the experiment needs to be run for a longer period of time, or double the size of the experimental subjects so that we could run the experiment with two groups, one group with the visualization and the other group without, parallel. Due to the limited class duration (12-13 weeks) this is not feasible, but it could be a possible future direction of research.

Chapter 6

Summary and Conclusion

Most visualizations discussed in the literature have been created with the purpose of informing the users about activities in the online community, since they allow a quick grasp of complex information. To my knowledge, there are no other visualizations specifically targeted at influencing the users' behaviours in the online community, even though some, like the Task Proxy Space (Erickson et al., 2004) may influence users' behaviours as a side effect.

I carried out research on motivating user participation using a community visualization in an online file-sharing system, Comtella, a P2P decentralized paper-sharing application, which latter transformed into a web-based application to meet the requirements of supporting students in a class to share course-related materials. The main idea of my research is to develop a prototype of motivational community visualization for the Comtella system, to test the motivational effect of this prototype visualization on users' participation in an online sharing community such as Comtella. This research took two years from May 2003 to May 2005. The development of the visualization went through three major designs: first design, second design, and final design, as well as a usability study on the first design and an experiment and an online questionnaire survey on the second and the final design. The whole experience of developing this prototype visualization tells that it is not straightforward to create a motivational visualization. Apart from the great amount of information that needs to be represented, it has to be easy to operate, intuitive, attractive, and powerful enough to represent different semantics.

From its first design as a static webpage to its second design adapting a dynamic approach as a Java application embedded into the distributed version of the Comtella system, and to its final design as a web application supported by Apache Tomcat web server and mySQL database server, each later version is improved based on the user

feedback from the previous version. There was positive feedback from all three versions and the users generally found the community visualization useful and interesting. The motivational effect of this prototype visualization has been first systematically tested within the second design of the visualization. The way the experiment was set up was that all the subjects were given a Comtella system without the visualization interface to use in the first half of the experiment, and we collected the data on subjects' activities especially on their sharing behaviours. Then in the latter half of the experiment, the subjects were given a Comtella system with the visualization interface embedded in. I collected the same types of data and compared it with the data we collected before. The experimental results on the second design were encouraging: users shared more files once they had the new interface (even though there was a decline latter) and they reported the system as "a good support tool for the class". However, users also complained about the system being not visually attractive, not easy to use, and not stable. I was not able to pinpoint the reason for the surge of participation and the consequent decline, since there were several different factors at play during the experiment.

So I resigned the visualization into its final version with improved stability, usability, and visual appearance, and carried out another experiment on the final design. In addition, I wanted to isolate the effect of the visualization from other factors that influence participation as much as possible. In the experiment on the final design, there was no obvious increase in the contributions brought by users, unlike in the experiment on the second design. This is due to the way the experiment was set up: one group (Group A) had access to the visualization and the other group (Group B) did not have access in the first half of the experiment, and in the latter half of the experiment the groups were switched so that Group B gained the access to the visualization and Group A lost this access. It is normal and actually happens very often that in this type of experiment one group is naturally more active than the other. In the case of my experiment on the final design, Group B was generally more active and almost always performed better than Group A no matter which group had access to the visualization. To avoid this ordering effect as much as possible I used a traditional approach: switching the groups in the middle of the experiment and applying statistic tests on the

difference in the performances of the two groups to find out if the difference is significant to claim that it is not due to chance or randomness. The tests results show that the differences in login and rating activities are significant enough to be due to the treatment, which in this case is the visualization, rather than to chance. However, the differences in sharing and reading activities are not significant enough to make the same claim. Further tests on the contributions and ratings given by Group A and Group B with the visualization compared with it without the visualization show that the visualization had stronger effect on motivating both groups to give more ratings than it was on motivating them to contribute more files, and the motivational effect was more obvious on Group B, the active group, than it was on Group A, the inactive group. The reason why the active group is motivated more effectively is uncertain, however, it may because that the active group put more effort (so that they are active) and so they cared more about their performance in the community and how other users saw them (i.e. as good users, or freeloader).

My hypothesis of the final design is confirmed partially, for rating and login activities: the visualization helps significantly shrink the difference in these activities of the two groups when the inactive group had access to it and the active group did not, and amplify this difference when the active group had access to it and the inactive group did not. However, the effect of the visualization is not certain for the other two types of activities, sharing and reading papers. Although the experimental results from these two types of activities show some confirmation to the hypothesis, the statistical tests show that these results are not significant enough to make the claim that they are due to the treatment, i.e. the visualization, and not due to chance or randomness. Thus, to make the same claim for each sharing and reading activities, a longer experiment is necessary, and this could be a possible direction for a further research.

To summarize the results over the three designs, I could conclude that my prototype of the online community visualization has effect on motivating contributions and more active participation from users but the significance of the effect is different depending on what is visualized, how it is visualized (i.e. what graphical representation is used), if it is easy enough for users to read and understand the visual representation (i.e. how intuitive the pictures are), and so on. The experiment on the final design of the

visualization indicates that visualizations like this type tend to be more effective on people who are naturally active in social activities and care about others' opinions and views on themselves. For people who are not sociable, or do not care about others' opinions on themselves, my prototype of visualization would not be effective on motivating for their contributions and participations.

One important conclusion is that the simpler the visualization is, the more predictable the effect is. As it was observed in the experiment with the second design, users usually do not select any sorting criterion and rely on the default view, i.e. sorted by original contributions, so the visual representation, a node, of each user was only different in size. The nodes remained the same in color and there was no difference in brightness; even if users selected another sorting criterion, the visualization still visualized only the selected criterion at a time. Therefore, the second design was one-dimensional visualization with the dimension determined by user's selection of the sorting criteria, which most of the times was "by original contribution". The users related the size of their star with the number of their original contributions and this representation provided a clear direction for social comparison and improvement. That is why the second design was more effective in motivating contributions, as the experimental results on this design showed.

In comparison, the first and the final designs appear to be less effective than the second design in motivating user contributions. However, it would be too big a jump to say that the final design was not good in motivating contributions. In fact the community had enough diverse contributions, which is probably more desirable than one-dimensional contributions (just in one activity, sharing new papers). A complex visualization showing several dimensions at a time (e.g. size representing contribution level, color representing membership level, and brightness representing reputation level) is interpreted differently by users. Users can focus on different dimensions to compete, rather than one particular area of competition such as the number of contributions, so the motivational effect is dispersed to a variety of activities. If the longer time was available for the experiment and more data for analysis, perhaps I would have been able to show significant effect of the visualization on the other user activities, i.e. sharing papers, and reading papers.

One clear conclusion for the system designer is that when there is a clear goal about what type of participation or contributions are needed for the community, the visualization should represent just one aspect, the one in which participation should be encouraged to focus the social comparison in this aspect. During the lifetime of an online community, different needs arise and different activities should be encouraged at different times and so the default community view should be changed to represent the activity that has to be encouraged at the moment.

There are many other interesting directions for further research, including the following:

1. Investigating the effects of different graphical representations of an online community. My prototype of the visualization chose a specific metaphor, a staring sky, but there are alternatives, from simple representations such as dots, circles, beehives, tables with numbers, charts, graphs, to complex metaphors such as cities, gardens, or combinations of any of the above. Which particular representation works best depends on the purpose of the visualization and the online community that it serves (e.g. the age of the members, their attitudes to computers, etc.) Investigating the effect of different metaphors for presenting community information is worthwhile.
2. Exploring the impact on user participation of incorporating more semantics through new dimensions of the star metaphor that haven't been used so far: such as the distance between stars based on, for example, the similarity in taste or ratings given by users;
3. Representing likeness between users, e.g. who reads whose contributions most often, who rates whose contributions most often, who normally rates whose contributions high and rates whose contributions low etc.
4. Creating a more advanced graphical representation, e.g. allowing the navigation in the cosmos, like in a 3-D game. For example, in my metaphor of representing the Comtella online community, it might be possible to group users with similar interests into subgroups and visualize it by a galaxy, clicking on which will cause the expansion of this galaxy and displaying the inside view of this galaxy; or clicking on a star will navigate users to the group of friends of this star (based on

what criterion to define a user is a friend of another user could be an interesting research topic), etc.

5. Dynamic adaptation of particular dimensions (e.g. different sorting criteria) that are visualized depending on what is needed mostly in the community (e.g. need more shared files, need better quality shared files, or need more people to rate or comment on the shared files).
6. If decided to present more than one dimension (e.g. size, color, brightness) in the design, it would be better to experiment on one dimension at a time, instead of testing all the dimensions at the same time. The experience from the two major experiments described in this thesis indicates that one-dimensional visualization is easier to be predicted and controlled because of less noise.

References

Adar, E., & Huberman, B. A. (2002). *Free Riding on Gnutella*.

Ahn, L., & Dabbish, L. (2004). *Labelling Images with a Computer Game.* ACM CHI April 24 -29, 2004 Vienna, Austria.

Asch, S.E. (1951). *Effects of Group Pressure upon the Modification and Distortion of Judgments*. In *Groups, Leadership, and Men*, pages 177-190.

Bretzke, H. & Vassileva, J. (2003). *Motivating Cooperation on Peer to Peer Networks.* Proceedings User Modeling UM '03, LNAI 2702, pp.218-227.

Chawathe, Y., Ratnasamy, S., Breslau, L., Lanham, N., & Shenker, S. (2003). *Making Gnutella-like P2P Systems Scalable*. SIGCOMM'03, August 25-29, 2003, Karlsruhe, Germany.

Cosley, D., Lam, S.K., Albert, I., Konstan, J.A., & Riedl, J. (2003). *Is Seeing Believing? How Recommender Interfaces Affect Users' Opinions*. CHI 2003, April 5 – 10, 2003, Ft. Lauderdale, Florida, USA.

Eick, S.G., & Wills, G.J. (1993). *Navigating Large Networks with Hierarchies*. IEEE Visualization '93 Conference, pages 204-210.

Erickson, T. (2003). *Designing Visualizations of Social Activity: Six Claims.* ACM CHI April 5 – 10, 2003 Ft. Lauderdale Florida, USA.

Erickson, T., Halverson, C., Kellogg, W.A., Laff, M., & Wolf, T. (2002). *Social Translucence: Designing Social Infrastructures that Make Collective Activity Visible*. Communications of the ACM, Vol. 45, No. 4, April 2002.

Erickson, T., Huang, W., Danis, C., & Kellogg, W.A. (2004). *A Social Proxy for Distributed Tasks: Design and Evaluation of a Working Prototype.* ACM CHI 2004, April 24-29, 2004, Vienna, Austria.

Erickson, T. & Kellogg W.A. (2003). *Social Translucence: Using Minimalist Visualizations of Social Activity to Support Collective Interaction*. In *Designing Information Spaces: The Social Navigation Approach* (eds. K. Hook, D. Benyon, A. Munroe), Springer-Verlag: London, 2003, pp. 17-41.

Festinger, L. (1954). *A Theory of Social Comparison Processes*. (1954). Human Relations, 7, 117-140.

Free Peers, Inc. (http://www.freepeers.com/), BearShare (http://www.bearshare.com/).

Ginsburg, M., & Weisband, S. (2002). *Social Capital and Volunteerism in Virtual Communities: The Case of the Internet Chess Club*. HICSS-35, Virtual Communities Minitrack, Hawaii, January 2002. IEEE.

Golle, P., & Mironov, I. (2001). *Uncheatable Distributed Computations*. In proc. of RSA Conference 2001. In the press: New York Times, New Scientist.

Hardy, N., & Tribble, E.D. (1995). *The Digital Silk Road*. Agorics, Inc. September 1995.

Hornstein, H., Fisch, E., & Holmes, M. (1968). *Influence of a Model's Feelings about his Behavior and his Relevance as a Comparison Other on Observers' Helping Behavior*. Journal of Personality and Social Psychology, 10: 220-6.

Humphrey, M.C. (2000). *Creating Reusable Visualizations with the Relational Visualization Notation*. 11th IEEE Visualization 2000 Conference (VIS 2000). October 08 – 13, 2000. Salt Lake City, UT.

Jameson, A., Baldes, S., & Kleinbauer, T. (2001). *Generative Models of Group Members as Support for Group Collaboration*. 8th International Conference on User Modeling, Sonthofen, Germany, July 13-17 2001.

Kleinberg, J. (2001). *Small-World Phenomena and the Dynamics of Information*. Advances in Neural Information Processing Systems (NIPS) 14. 2001.

Klingberg, T., & Manfredi, R. (2002). *The Gnutella Protocol Specification v0.6 Draft*. June, 2002. http://rfc-gnutella.sourceforge.net/draft.txt

Kogan, N., & Tagiuri, R. (1958). *Interpersonal Preference and Cognitive Organization*. Journal of Abnormal and Social Psychology, Vol. 56, pp. 113-116.

Lamme, A.F.Victor (2003). *Why Visual Attention and Awareness are Different*. TRENDS in Cognitive Sciences Vol. 7 No. 1 January 2003.

LimeWire. *The Gnutella Protocol Specification v0.4 – Document Revision 1.2*.

Ma, Richard T.B., Lee, C.M., Lui, John C.S., & Yau, David K.Y. (2003). *Incentive P2P Networks: A Protocol to Encourage Information Sharing and Contribution*. ACM SIGMETRICS Performance Evaluation Review. Vol.31, Issue 2, September 2003.

Mendenhall, W., & Reinmuth, J.E. (1974). Statistics for Management and Economics (second edition). Duxbury Press, North Scituate, Massachusetts, 1974.

MetaMachine. *eDonkey2000 and Overnet* (http://www.edonkey2000.com/).

MicroSoft MSN Messenger (http://messenger.msn.com/) and .Net Windows® Messenger (http://www.microsoft.com/windows/messenger/).

Milgram, S. (1967). *The Small World Problem.* Psychology Today 1, 16 (1967).

Milojicic, D.S., Kalogeraki, V., Lukose, R., Nagaraja, K., Pruyne, J., Richard, B., Rollins, S., & Xu, Z. (2002). *Peer-to-Peer Computing,* HPL-2002-57, March 8, 2002.

Nakanishi, H., Nakazawa, S., Ishida, T., & Takanashi, K. (2002). *Using Balance Theory to Understand Social Agent*. Workshop of "Embodied Conversational Agents – Let's Specify and Evaluate them!" in conjunction with the First International Joint Conference on Autonomous Agents & Multi-Agent Systems. July 16 2002 Bologna, Italy.

Ng, W.S., Ooi, B.C., & Tan, K. (2002). *BestPeer: A Self-Configurable Peer-to-Peer System*. 18th International Conference on Data Engineering (ICDE'02), p.272, February 26 – March 01, 2002.

Orkut Society. http://www.orkut.com/index.html.

Pattison, T., Vernik, R., & Phillips, M. (2001). *Information Visualization Using Composable Layouts and Visual Sets*. Conferences in Research and Practice in Information Technology, Vol. 9. Commonwealth of Australia, 2001.

Pareto, V. (1896-97). Cours d'economie politique.

Rowstron, A., & Druschel, P. (2001). *Pastry: Scalable, decentralized object location and routing for large-scale peer-to-peer systems*. Proc. Of the 18th IFIP/ACM International Conference on Distributed Systems Platforms (Middleware 2001). Heidelberg, Germany, November 2001.

Savage, R. VisitorVille (http://www.visitorville.com)

Slashdot.org Community. http://slashdot.org/.

Sharman Networks Ltd. KaZaA (http://www.kazaa.com/) Media Desktop, 2001.

Shirky, C. (2003). *Fame vs Fortune: Micropayments and Free Content*. "Economics & Culture, Media & Community, Open Source". First published on September 5, 2003 on the "Networks, Economics, and Culture" mailing list.

Shirky, C. (2000). *In Praise of Freeloaders.* A speech at O'Reilly openp2p.com.

Stoica, I., Morris, R., Karger, D., Kaashoek, M.F., & Balakrishnan, H. (2001). *Chord: A Scalable Peer-to-peer Lookup Service for Internet Applications*. Proceedings of the 2001 ACM SIGCOMM, August 27-31, 2001, San Diego, California, USA.

Sprenger, T.C., Brunella, R., & Gross, M.H. (2000). *H-BLOB: A Hierarchical Visual Clustering Method Using Implicit Surfaces*. 11th IEEE Visualization 2000 Conference, October 08-13, 2000. Salt Lake City, UT.

Szabo N. (1999). *Micropayments and Mental Transaction Costs*. Presented at 2nd Berlin internet Economics Workshop, May 1999.

Uther, J., & Kay, J. (2003). VlUM, a Web-Based Visualization of Large User Models. Proceedings User Modeling, UM'03, LNAI 2702, pp. 198-202.

Vassileva, J. (2002). Motivating Participation in Peer to Peer Communities. Proceedings of the Workshop on Emerging Societies in the Agent World. ESAW'02, Madrid, 16-17 September, 2002.

Viegas, F.B., & Donath, J.S. (1999). Chat Circles. Proceedings of the SIG CHI conference on Human factors in computing systems: the CHI is the limit, 1999.

Yang, B., & Garcia-Molina, H. (2003). Designing a Super-peer Network. In IEEE International Conference on Data Engineering, 2003, Bangalore, India.

Zhang, H., Goel, A., & Govindan, R. (2002). Using the Small-World Model to Improve Freenet Performance. IEEE INFOCOM 2002.

Appendix 1: Figures of Other Visualization Approaches

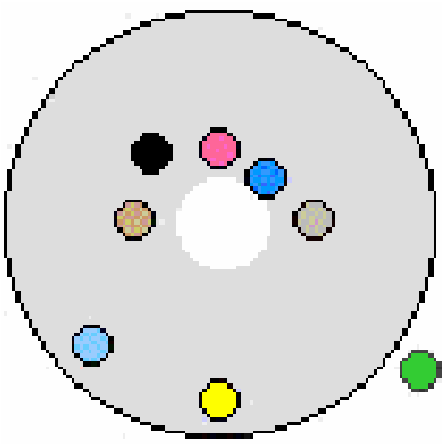

Figure 1. The Babble "Cookie". Erickson, T., & Kellogg, W.A. (2003). Social Translucence: Using Minimalist Visualizations of Social Activity to Support Collective Interaction. In Designing Information Spaces: The Social Navigation Approach (eds. K. Hook, D. Benyon, A. Munroe), Springer-Verlag: London, 2003, pp. 17-41.

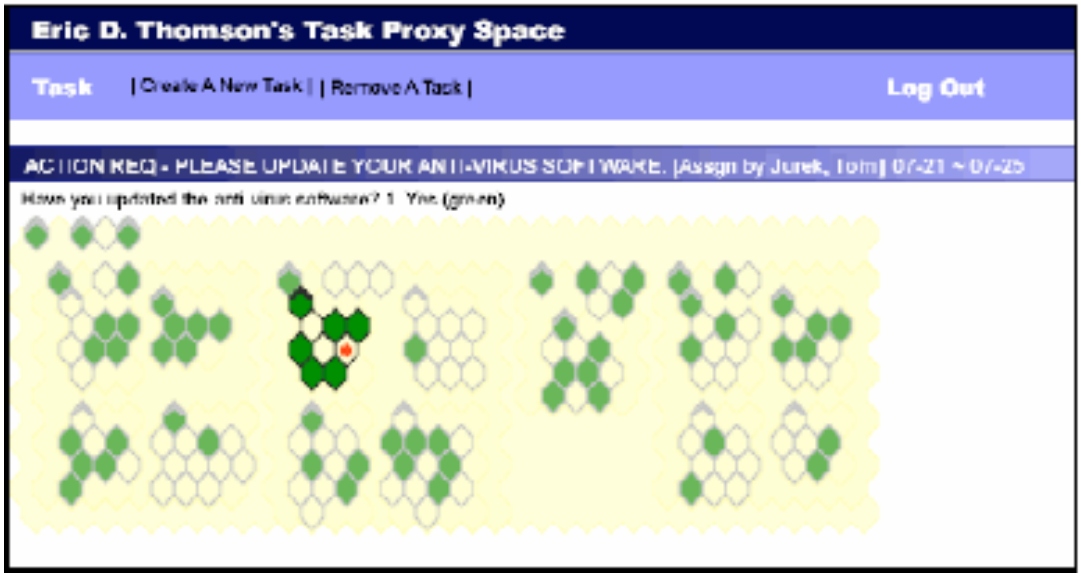

Figure 2. **Task Proxy Space.** Erickson, T., Huang, W., Danis, C., & Kellogg, W.A. (2004). A Social Proxy for Distributed Tasks: Design and Evaluation of a Working Prototype. ACM CHI 2004, April 24-29, 2004, Vienna, Austria.

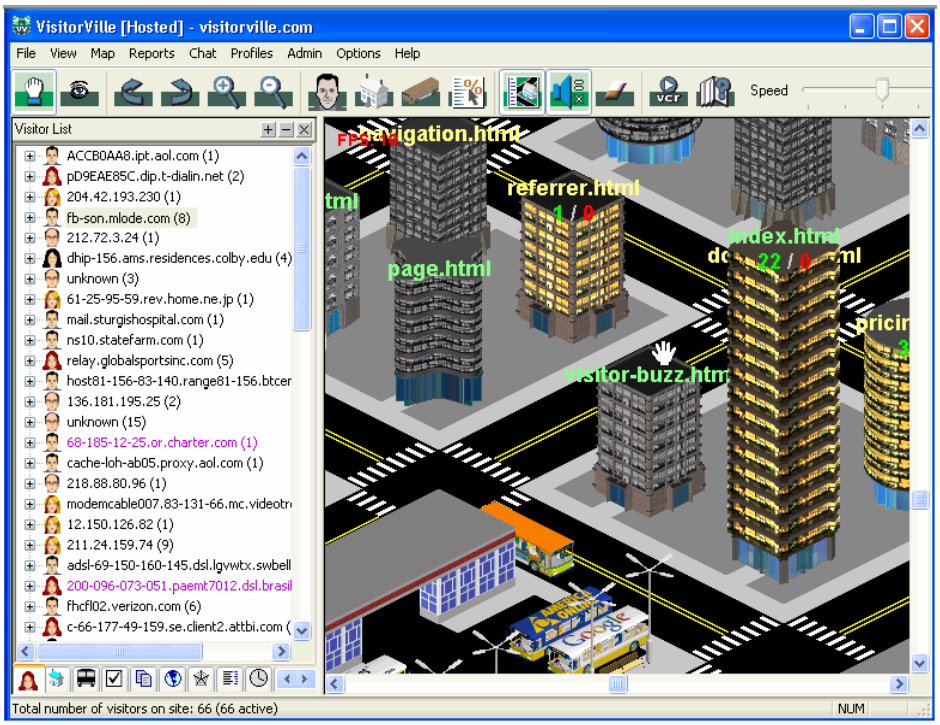

Figure 3. **VisitorVille.** Savage, R. http://www.visitorville.com/meet-the-mayor.html, and his VisitorVille http://www.visitorville.com

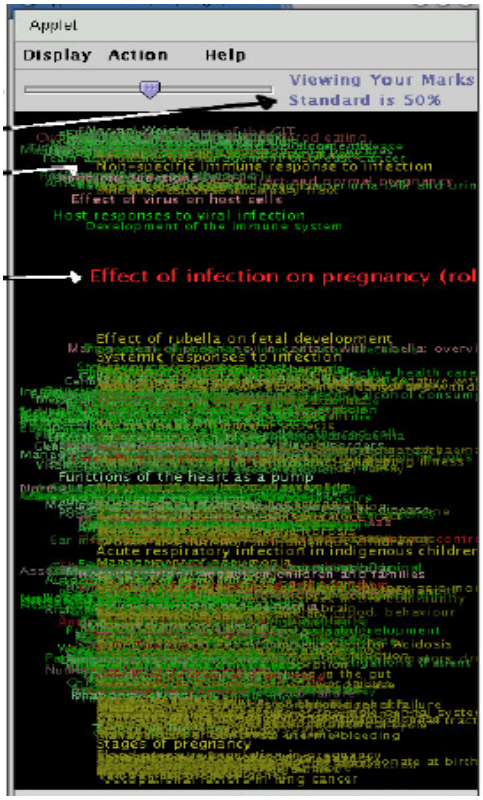

Figure 4. VIUM. Uther, J., & Kay, J. (2003). *VlUM, a Web-Based Visualization of Large User Models*. Proceedings User Modeling, UM'03, LNAI 2702, pp. 198-202.

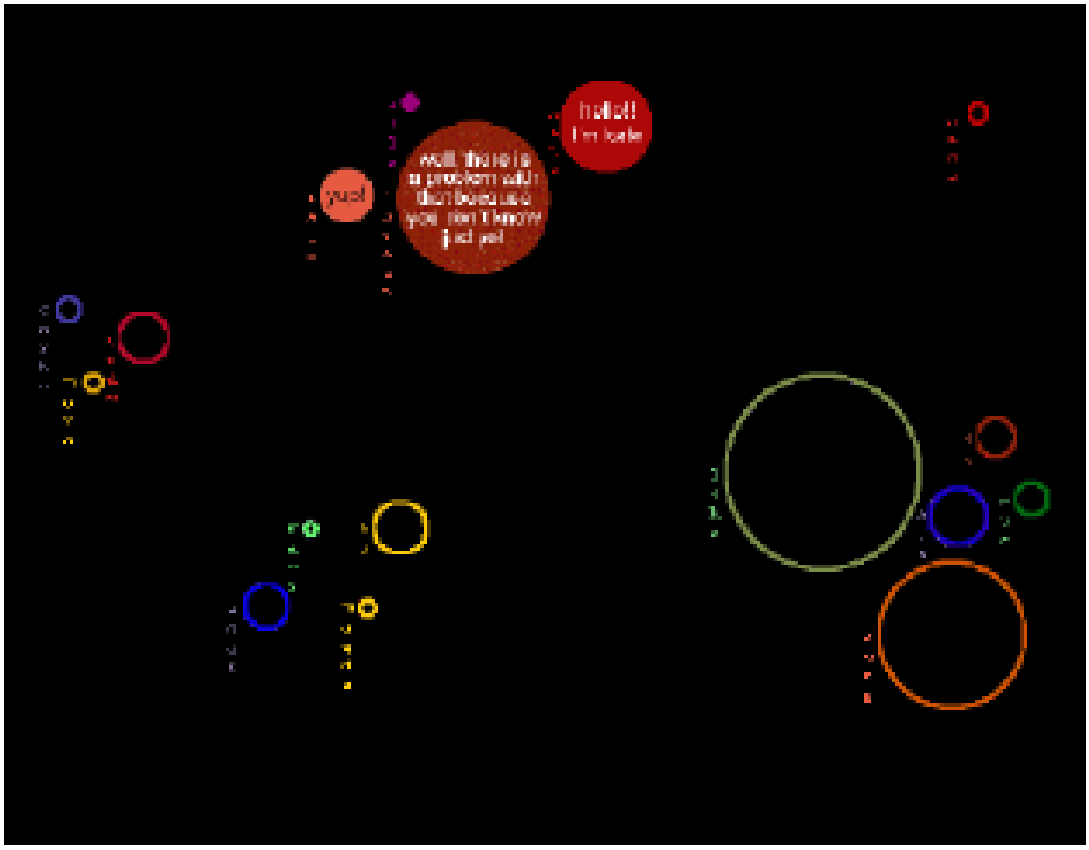

Figure 5. Chat Circle. Viegas, F.B., & Donath, J.S. (1999). *Chat Circles*. Proceedings of the SIG CHI conference on Human factors in computing systems: the CHI is the limit, 1999.

Appendix 2: Questionnaires

2-1 Consent Forms:

Consent Form used in CMPT 490 (2003/2004) for the experiment on the second version of the visualization

Title of the Study:
Impact of Persuasion Techniques and Community Visualization on User Motivation to Contribute in the Peer-to-Peer Resource Sharing Environment COMTELLA

Researchers:
Julita Vassileva, Associate Professor, Computer Science Department; 966-2073
Lingling Sun, M.Sc. Student, Computer Science Department
Ran Cheng, M.Sc. Student, Computer Science Department

The aim of this study is to investigate the usability and the motivational effects of different persuasion techniques and community visualization on participation rates in a peer-to-peer resource-sharing environment. This is accomplished through experimenting with a peer-to-peer file-sharing program (Comtella) in a 4th year undergraduate students. Comtella allows a limited number of users to share links to papers that they have found with other users of the network. Depending on the level of contribution and participation different persuasion techniques will be used, including user status (level of membership) and a community visualization, which is both informative and motivational. The visualization will allow seeing the other peers currently on-line, their level of contribution, areas of interest, the number of papers they are contributing and summarizing.

Potential Benefits:
The possible benefit to the participants will be a more convenient access to class resources (papers, found on the Web). It will allow the users to make use of the search results of their peers, which can lead to a synergy in the class efforts to stay current in their knowledge of the literature.

Potential Risks:
It is hard to envisage any risks or side effects of the usage of the system. The papers that are shared are publicly available on the web, and we don't envisage copyright issues. If we become aware of any negative effects during the study, we will inform immediately the participants or interrupt the study. We may discontinue a participant's involvement in the study, if they use the environment to communicate links offensive, copyrighted or inappropriate materials. In the event of a participant withdrawing from the study, his / her data will be deleted and destroyed insofar as possible.

Collection and Storage of Data:
During the study, data will be collected about the users' actions related to accessing the different views of the community visualization, for example the view of who is currently on-line, or the view of who shares papers in a particular area, or the view of who has contributed most new articles so far. This data will be correlated in anonymized form with user-participation data, in terms of number of new links found, links downloaded from other peers, number of rated and summarized papers.
All data will be stored anonymously and will be available only to the investigators involved in the study. All data about the users will be stored securely for a minimum of five years, electronic data on a password-protected computer system, and any additional on-paper data by Dr. Vassileva.

Confidentiality:
The anonymity of the collected data and the privacy of the subjects will be completely protected, and the information obtained from this data would be used only in theses, journal articles or conference publications

written by the researchers. Only aggregate data will be reported in publications; the names and identities of the participants will not be published in any form.

Right to Withdraw:

Each participant is free to withdraw from the study at any time; this will not affect the participant's academic status or success in the class. In the event of a participant withdrawing from the study, his / her data will be deleted. An alternative way of participating in the class and doing the coursework through the Department E-Handin system exists and the students are free to choose this way, if they prefer so, at any point of the study. The participants will be advised of any new information that may have a bearing on the participants' decision to continue in the study.

Questions:

If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers at the numbers provided above if you have questions at a latter time. Any questions regarding your rights as a participant may be addressed to the Behavioural Research Ethics Board through the Office of Research Services (966-2084), or through Julita Vassileva (966-2073). If you wish to acquire information on the results of the research once the study is completed, send a request to Julita Vassileva at jiv@cs.usask.ca.

Consent to Participate:

I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily. I consent to participate in the study described above, understanding that I may withdraw this consent at any time. A copy of this consent form has been given to me for my records.

(Signature of Participant)

(Signature of Researcher)

Content Form Used in CMPT 408 (2004/2005) for the experiment on the final version of the visualization

Title of the Study:

Evaluation of the Effect of a Ratings-system and Community Visualization on ensuring a sustainable level of contributions in the Resource Sharing Environment COMTELLA

Researchers:

Julita Vassileva, Associate Professor, Computer Science Department; 966-2073
Ran Cheng, M.Sc. Student, Computer Science Department
Lingling Sun, M.Sc. Student, Computer Science Department

The aim of this study is to investigate the effect of a new ratings-system and a community visualization on ensuring a sustainable level of contributions and participation rates in a resource-sharing environment. Comtella is a web-based system developed at the MADMUC lab of the Computer Science Department, which allows a limited number of users to share links to articles that they have found with other users of the network. This particular experimental version of the system has, in addition to the main functionality, a virtual economy of ratings which results in different user status and an informative community visualization which is hoped to help motivate sustained user contributions.

Potential Benefits:

The possible benefit to the participants will be a more convenient access to class resources (papers, found on the Web). It will allow the users to make use of the search results of their peers, which can lead to a synergy in the class efforts to stay current in their knowledge of the literature related to the class topics.

Potential Risks:

It is hard to envisage any risks or side effects of the usage of the system. The papers that are shared are publicly available on the web, and we don't envisage copyright issues. If we become aware of any negative effects during the study, we will inform immediately the participants or interrupt the study. We may discontinue a participant's involvement in the study, if they use the environment to communicate links offensive, copyrighted or inappropriate materials. In the event of a participant withdrawing from the study, his / her data will be deleted and destroyed insofar as possible.

Collection and Storage of Data:

During the study, data will be collected about the users' actions related to sharing, rating, and commenting links, as well as accessing the community visualization, for example the view of who is currently on-line, or the view of who shares papers in a particular area, or the view of who has contributed most new articles so far. This data will be correlated in anonymized form with user-participation data, in terms of number of new links found, links downloaded from other peers, number of rated and summarized papers.
All data will be stored anonymously and will be available only to the investigators involved in the study. All data about the users will be stored securely for a minimum of five years, on a password-protected computer system, and any additional on-paper data will be kept securely locked in Dr. Vassileva's office.

Confidentiality:

The anonymity of the collected data and the identity the subjects will be completely protected. Only aggregate data will be reported in publications; the names and identities of the participants will not be published in any form.

Right to Withdraw:

Each participant is free to withdraw from the study at any time; this will not affect the participant's academic status or success in the class. In the event of a participant withdrawing from the study, his / her data related to the experiment will be deleted. The participants will be advised of any new information that may have a bearing on the participants' decision to continue in the study.

Questions:

If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers at the numbers provided above if you have questions at a latter time. Any questions regarding your rights as a participant may be addressed to the Behavioural Research Ethics Board through the Office of Research Services (966-2084), or through Julita Vassileva (966-2073). If you wish to acquire information on the results of the research once the study is completed, send a request to Julita Vassileva at jiv@cs.usask.ca.

Consent to Participate:

I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily. I consent to participate in the study described above, understanding that I may withdraw this consent at any time. A copy of this consent form has been given to me for my records.

Signature:
(Name of Participant) (Date)

2-2 Questionnaire 1:

COMTELLA – 490 USER SURVEY

The goal of this survey is to help us evaluate your experience of the Comtella system. This survey contains 35 questions and will take you about 60 to 90 minutes to complete.
It contains two parts: the first one is brief, and after you have completed it, you will be able to proceed with the next one.

There are several types of questions. For some you can select the answer directly from those listed below. For some questions you need to rank the answers by putting numbers 1, 2, 3, etc. in the box provided for each answer. 1 is the strongest rank. For other questions you need to select a number between -2 and +2. Negative numbers are used for a poor evaluation, and Positive numbers are used for a good evaluation. Zero means neutral, "don't know" or "don't care".

Thank you for your participation!

PART I (for everyone)

Please, try to quickly answer the questions below to the best of your knowledge (it is not a test ☺).

1. What happens if you click on a link from the search results?
2. Is Comtella centralized or decentralized system?
3. Please, list the bronze search features.
4. Please, list the extra functions a silver member gets.
5. Please, list the extra functions a gold member gets.
6. Who was the user who shared most links in Comtella?
7. What happens if you pass with your mouse over a node in the visualization?
8. What happens if you click a node in the visualization?
9. How many ways are there to view the community?
10. What do you think one needs to do to gain higher membership class in Comtella?
11. What would you rather do now: would you rather go to a party or stay home and watch a movie / TV?

If you have managed to answer at least one of the previous questions, GOTO part II.
If not, click << here – GOTO part III>>.

PART II (for people who have used Comtella)

1. Please, indicate your general reaction to the Comtella system: (select one number from -2 – very poor to +2 – very good):

-2 -1 0 +1 +2

2. Are you going to use the system again, after the class is over (if it is available)? (pick one answer only)

a) Yes
b) No
c) Maybe

3. Would you recommend the system to be used in another class?

a) Yes
b) No
c) If you answered "Yes", could you specify in which class:

4. Why did you use Comtella? (please, rank at least 3 of the answers below, most important is 1, less important - 2, etc.)

a) It appears interesting.
b) To check what my fellow students contribute and compare with them.
c) To find useful links from other students
d) To find a good article to write my weekly summary.

e) Because the professor asked us to use it for the weekly coursework
f) I am not using Comtella

5. Please rank the following aspects of Comtella in 5-point scale (-2 – very poor, +2 – very good):

	-2	-1	0	+1	+2
As a support tool for the 490 class					
Usability (Interface)					
Reliability (crashes etc.)					
Visualization attractiveness					
Visualization usefulness					
Visualization intuitiveness					
Visualization effect on your contribution level					
Fairness in ranking your level of contribution			0		

6. What would you like to know about the other users? (Please, answer each question by choosing one number from –2 – strongly disagree to +2 – strongly agree)

	-2	-1	0	+1	+2
who is currently on line.					
how much the other users contribute.					
who downloads from me the links that I have contributed.					
who I download most links from.					
who gives similar ratings like me.					
if other users perceive me as a freeloader or as an active contributor					

7. Did you prefer to use Comtella in the beginning of the term when there were fewer links available, or later, when there were more (pick one answer)?
   a) When there were fewer links, since it later it became very hard to find good links, the number of results was overwhelming
   b) When there were more links, since there was a better choice
   c) The number of links didn't really matter.

8. What would you like the other users to know about you? (Please, answer each question by choosing one number from –2 – strongly disagree to +2 – strongly agree)

	-2	-1	0	+1	+2
if you are currently on line.					
how many links you contribute.					
the ratings you give to links downloaded from other users					
your comments on the links you share					

9. How often did you use the following visualization options: (pick one answer for each feature/row)

	Often	Seldom	Never
Who is currently logged on			
General view			
View for a given week			
View by original contributions			
View by total number of shared links			
View by frequency of usage			
View by status (gold, silver, bronze)			
View comments of other users			

10. What would be your reaction if you saw from the number of query results that there are already a large number of contributions in a given week (rank those of the answers that you think apply to you):
   a) you decide to find some links too to compete with the others
   b) there is enough already, no need to add more
   c) the instructor will not notice your participation, why bother?

d) try to find some better quality papers to share.
e) Other: Please, specify:

11. What would be your reaction if you saw yourself as one of the **smallest** nodes in the visualization? (pick one answer only):
    a) Take immediate action: share more links to make your node larger.
    b) Think that you should probably share more links, but latter.
    c) Feel unhappy but do nothing.
    d) Feel that the system is unfair, so it doesn't make sense to contribute.
    e) Do not care, so will do nothing.
    f) Feel offended - will quit using the system, at least for a while.
    g) Other – please, specify:

12. If you saw yourself as one of the **largest** nodes, would you (pick one answer only):
    a) Feel proud of your status and try to contribute even more.
    b) Feel proud, but also in some sense "exploited", stop bringing more links
    c) Feel worried, you may be raising the bar too high and the others may hate you or you may be perceived as "overachiever" by the others.
    d) Feel nothing, since it is not important for me
    g) Other – please, specify:

13. Would your response to the previous question be different depending on whether the current week is on a topic you are more interested in?
    a) Yes
    b) No
    c) I don't know.

14. Would you prefer to have your servent running on your local machine (as other P2P systems, like KaZaA) rather than having to log in a server?
    a) Yes
    b) No

    If you answered "Yes", please answer also the following two questions:
    Do you keep at home a machine that is running constantly?
    a) Yes
    b) No
    c) Does not apply

    Would you keep your servent running constantly so that others can download the links that you share?
    a) Yes
    b) No

15. On average, how often did you use Comtella? (choose one answer only)
    a) Never, or maybe just once or twice.
    b) Once per week
    c) Twice per week
    d) More then twice and less then 7
    e) Every day of the week.

16. When you are logged on, you are actively using Comtella
    a) less then 20% of the time
    b) 20-40%% of the time
    c) 40-60% of the time
    d) 60-80% of the time
    e) more than 80% of the time

17. What features would you like to see in the next version of Comtella?
18. Would you like to give any comment or suggestion about the Visualization or about the Membership Level?
19. Would you like to give any comment, criticism or suggestion about Comtella in general?
20. Do you remember the screen name (alias, or user id) of the top users in Comtella?

PART III (for users who couldn't reply to any of the questions on the pre-test)

1. Can you explain briefly the reasons why you didn't use actively Comtella?
2. Would you like to give any comment or suggestion about what kind of system you would have preferred to use, if any system at all?
3. What features would you like to see in the next version of Comtella?

This is the end of the questionnaire. Thank you very much for taking the time to answer all the questions!!!

Julita Vassileva, Lingling Sun, Ran Cheng, Weidong Han

2-3 Survey Result of Questionnaire 1:

q#	options in abbreviation	ranks	%
q1	**general reaction to Comtella**	rank: -2 worst	0.00%
		rank: -1	12.90%
		rank: 0	16.13%
		rank: 1	61.29%
		rank: 2 best	9.68%
q2	**yes**		9.68%
	no		32.26%
	maybe		58.06%
q3	**yes**		67.74%
	no		32.26%
q4	**appears interesting**	rank: 1 best	9.68%
		rank: 2	9.68%
		rank: 3	12.90%
		rank: 4	19.35%
		rank: 5 worst	41.94%
		unranked	6.45%
	check others' contribution	rank: 1	9.68%
	and compare with them	rank: 2	6.45%
		rank: 3	19.35%
		rank: 4	35.48%
		rank: 5	16.13%
		unranked	12.90%
	find useful links	rank: 1	3.23%
		rank: 2	12.90%
		rank: 3	41.94%
		rank: 4	16.13%
		rank: 5	19.35%
		unranked	6.45%
	find good articles	rank: 1	25.81%
	to summarize	rank: 2	41.94%
		rank: 3	16.13%
		rank: 4	9.68%
		rank: 5	3.23%
		unranked	3.23%
	Prof asked use to do so	rank: 1	48.39%
		rank: 2	25.81%
		rank: 3	6.45%
		rank: 4	6.45%
		rank: 5	6.45%
		unranked	6.45%
q5	**overall**	rank: -2 worst	0.00%
		rank: -1	6.45%
		rank: 0	22.58%
		rank: 1	64.52%
		rank: 2 best	6.45%
	as a support for class	rank: -2	0.00%
		rank: -1	3.23%
		rank: 0	9.68%
		rank: 1	41.94%
		rank: 2	45.16%
	usability (interface)	rank: -2	6.45%
		rank: -1	19.35%

q5	usability (interface)	rank: 0	38.71%
		rank: 1	32.26%
		rank: 2	3.23%
	reliability (crashes or not)	rank: -2	25.81%
		rank: -1	45.16%
		rank: 0	19.35%
		rank: 1	6.45%
		rank: 2	3.23%
	visualization attractiveness	rank: -2	3.23%
		rank: -1	29.03%
		rank: 0	32.26%
		rank: 1	25.81%
		rank: 2	9.68%
	visualization intuitiveness	rank: -2	6.45%
		rank: -1	12.90%
		rank: 0	35.48%
		rank: 1	38.71%
		rank: 2	6.45%
	visualization effectiveness	rank: -2	6.45%
		rank: -1	16.13%
		rank: 0	22.58%
		rank: 1	29.03%
		rank: 2	25.81%
	fairness	rank: -2	6.45%
		rank: -1	16.13%
		rank: 0	25.81%
		rank: 1	25.81%
		rank: 2	25.81%
q6	**who is online**	rank: -2	12.90%
		rank: -1	16.13%
		rank: 0	25.81%
		rank: 1	22.58%
		rank: 2	22.58%
	how much others contributed	rank: -2	3.23%
		rank: -1	6.45%
		rank: 0	12.90%
		rank: 1	35.48%
		rank: 2	41.94%
	who download my shared links	rank: -2	3.23%
		rank: -1	9.68%
		rank: 0	12.90%
		rank: 1	35.48%
		rank: 2	38.71%
	who I download from mostly	rank: -2	3.23%
		rank: -1	19.35%
		rank: 0	19.35%
		rank: 1	38.71%
		rank: 2	19.35%
	who gave similar ratings	rank: -2	3.23%
		rank: -1	9.68%
		rank: 0	22.58%
		rank: 1	41.94%
		rank: 2	22.58%
	am I a freeloader or an active	rank: -2	16.13%
	contributor	rank: -1	16.13%
		rank: 0	12.90%

q6	am I a freeloader or an active	rank: 1	35.48%
	contributor	rank: 2	19.35%
q7	**fewer links**		35.48%
	more links		25.81%
	don't care		38.71%
q8	**am I online**	no	6.67%
		neutral	66.67%
		yes	26.67%
	how many links I contributed	no	6.45%
		neutral	64.52%
		yes	29.03%
	ratings I gave	no	9.52%
		neutral	71.43%
		yes	19.05%
	comments I gave	no	3.23%
		neutral	35.48%
		yes	61.29%
q9	**who is online**	often	29.03%
		seldom	32.26%
		never	38.71%
	general view	often	58.06%
		seldom	29.03%
		never	12.90%
	view for a given week	often	45.16%
		seldom	45.16%
		never	9.68%
	by original contributions	often	45.16%
		seldom	29.03%
		never	25.81%
	by total contributions	often	51.61%
		seldom	16.13%
		never	32.26%
	by usage frequency	often	22.58%
		seldom	29.03%
		never	48.39%
	by status (membership)	often	45.16%
		seldom	16.13%
		never	38.71%
	view comments of others	often	22.58%
		seldom	41.94%
		never	35.48%
q10	**bring more to compete**		22.58%
	no need to add more		19.35%
	Prof. won't notice, why bother		16.13%
	find better-quality links		16.13%
	other, specify	quality concerns	25.81%
q11	**immediate action: share more**		35.48%
	thinking of sharing more		19.35%
	unhappy, but do nothing		9.68%
	system unfair		9.68%
	don't care, do nothing		16.13%
	other, specify	quality concerns	9.68%
q12	**proud and share more**		41.94%
	proud but stop sharing more		6.45%
	worried, raise the bar too high		6.45%
	feel nothing		19.35%

q12	other, specify	quality concerns	25.81%
		pressure	
		keep current status/level	
		may share more if have time	
q13	**yes**		54.84%
	no		32.26%
	I don't know		12.90%
q14-1	**keep home computer running**	yes	58.06%
		no	41.94%
q14-2	**if yes:**	yes	61.11%
		no	38.89%
		does not apply	0.00%
q14-3	**keep servent running so that**	yes	72.22%
	other can download from you	no	27.78%
q15	**never**		6.45%
	once a week		19.35%
	twice a week		22.58%
	more than twice less than 7		45.16%
	every day		6.45%
q16	**less than 2% of the time**		22.58%
	20-40% of the time		12.90%
	40-60% of the time		12.90%
	60-80% of the time		19.35%
	more than 80% of the time		32.26%

2-4 Questionnaire 2:

COMTELLA – 408 USER SURVEY

The goal of this survey is to help us evaluate your experience of the Comtella system. This survey contains 40 questions and will take about 60 to 75 minutes to complete.

1. Have you used the community visualization?
    a. Yes
    b. No

2. If you answered "No", please tell us why you were not interested in the community visualization.
    a. Didn't care to see the others
    b. Didn't like the view (aesthetics)
    c. Didn't like the metaphor (star-sky)
    d. Other (please, specify):

Then please skip questions 3-20 (IF IT CAN BE DONE AUTOMATICALLY, BETTER). .

3. Did you notice the decreasing participation after the spring break?
    a. Yes.
    b. No

4. How often did you use the community visualization?
    a. Several times a day
    b. Once or twice a day
    c. Several times a week
    d. Once or twice a week
    e. A few times in the whole semester

5. Did you check the community visualization for the topics of the previous weeks?
    a. Yes, very often
    b. Occasionally
    c. No, I was only interested in the current topic

6. Please rank the following reasons for which you used the visualization (use 1 to 5, where 1 represent most important reason, 5, the least important)?
    a. It appears interesting _____
    b. To find links, e.g. a good article to summarize _____
    c. To find out **how** my contributions compare with other students' contributions _____
    d. To see who is contributing certain papers _____
    e. To see who are the top contributors _____

7. If the same information is provided in a different form such as a table or a chart, do you think you would have used the community visualization as often as you did?
    a. Yes
    b. No
    c. I don't know

8. **Did you feel more compelled** to share more links during the weeks when you were able to see the community visualization, compared with the weeks when you were not able to do so?
    a. Yes
    b. No
    c. I don't feel any difference

9. Please rank the following aspects of Comtella on a 5-point scale (-2: very poor; +2 very good):

	-2	-1	0	+1	+2
Overall					
As a support tool for the 408 class					
Usability					
Reliability (crashes etc.)					
Community Visualization attractiveness					
Community Visualization usefulness					
Community Visualization intuitiveness					
Community Visualization effect on your contribution level					
Quality of shared links					
Fairness in representing your level of contribution					

10. What would you like to know about the other users? (Please, answer each question by choosing one number from –2 – strongly disagree to +2 – strongly agree)

	-2	-1	0	+1	+2
Who is currently online					
How much the other users contribute					
The membership of you and/or others					
If other users perceive me as a freeloader or as an active contributor					
You don't want to know anything					

11. What would you like the other users to know about you? (Please, answer each question by choosing one number from –2 – strongly disagree to +2 – strongly agree)

	-2	-1	0	+1	+2
If you are currently online					
How many links you contribute					
The quality of the links you contributed					
Ratings you gave to others' shared links					

12. What would be your reaction if you saw from the search results that **there were already a large number of contributions** in a given week (rank those of the answers that you think apply to you):
    a) you decide to find some links to compete with the others
    b) there is enough already, no need to add more
    c) the instructor will not notice your participation, why bother?
    d) try to find some better quality papers to share.
    e) Other: Please, specify:

13. What would be your reaction if you saw yourself as one of the **smallest** stars (regardless of its color and brightness) in the visualization? (pick one answer only):
    a. Take immediate action: share more links to make your node larger.
    b. Think that you should probably share more links, but latter.
    c. Feel unhappy but do nothing.
    d. Feel that the system is unfair, so it doesn't make sense to contribute.
    e. Do not care, so will do nothing.
    f. Other – please, specify:

14. If you saw yourself as one of the **largest** stars (regardless of its color and brightness), would you (pick one answer only):
    a. Feel proud of your status and try to contribute even more.
    b. Feel proud, but also in some sense "exploited", stop bringing more links
    c. Feel worried, you may be raising the bar too high and the others may hate you or you may be perceived as "overachiever" by the others.
    d. Feel nothing, since it is not important for me
    e. Other – please, specify:

15. Did you find any difference in the visualization presented in the final 2 weeks of the class, after March 28, 2005?
    a. I didn't see the visualization in the last two weeks.
    b. No
    c. Yes
    d. If Yes, what was the difference?

16. Did you find the final visualization represents fairly your overall level of contribution in the class?
    a. Yes
    b. No.
    c. If No, why?

17. Did you find the representation of the average quality of your shared papers with the brightness of your star in the final visualization intuitive?
    a. Yes
    b. No

18. Did you use your real name in Comtella, or did you create an alias?
    a. Used my real name throughout the term
    b. Used an alias throughout the term
    c. First used my real name, then changed it to alias
    d. First used an alias, then changed it to my real name.

    Please, explain why:

19. When you are logged on, you are actively using Comtella
    f) less then 25% of the time
    g) 25% to 50% of the time
    h) More then 50% and less then 75% of the time
    i) 75% or more of the time.

20. Which one in the following do you think is most important to the thriving of the Comtella system:
    a. Quality of the articles shared.
    b. Quantity of the articles shared.
    c. Quality and quantity are equally important to the system.

21. How many articles did you read per week in average in Comtella? About _____

22. Do you think it is hard to find the interesting articles in the system?
    a. There were many links in the system and I had to spend much time filtering out the ones I was not interested in.
    b. It is okay.
    c. Easy to find good articles.

23. How would you classify the typical weekly shared papers in quality categories?
    High-quality ____%
    Medium-quality____%
    Low-quality ____%
24. Please rank the following factors according to how strong they motivated you to contribute (1 to 6, 1: strongest, 6: weakest):
    a. The community visualization
    b. Earning a higher membership level
    c. Earning a higher participation mark in the class
    d. Bringing good papers for others to read
    e. The satisfaction to see myself as best user of the week on the front page

f. The satisfaction to see some of my papers as best papers of the week on the front page

25. Would you like to give any comments, criticism, or suggestions
    a. About the community visualization?
    b. About the membership mechanism?
    c. About Comtella in general?

This is the end of the questionnaire. Thank you very much for taking the time to answer all the questions!!!
Julita Vassileva, Lingling Sun, Ran Cheng

2-5 Survey Result of Questionnaire 2:

questions #	options (abbreviated)		percent
q1	**yes**		83%
	no		17%
q3	**yes**		67%
	no		33%
q4	**a. several times/day**		5%
	b. once/twice a day		0%
	c. several time/week		15%
	d. once/twice a week		40%
	e. a few time/semester		40%
q5	**yes, very often**		15%
	occasionally		40%
	no		45%
q6	**a. appears interesting**	1: most important	15%
		rank 2	20%
		rank 3	30%
		rank 4	20%
		5: least important	15%
	b. find articles	rank 1	10%
		rank 2	0%
		rank 3	20%
		rank 4	20%
		rank 5	50%
	c. compare contributions	rank 1	30%
		rank 2	35%
		rank 3	15%
		rank 4	5%
		rank 5	15%
	d. check who contributed what	rank 1	5%
		rank 2	20%
		rank 3	5%
		rank 4	35%
		rank 5	35%
	e. find top contributors	rank 1	15%
		rank 2	25%
		rank 3	30%
		rank 4	10%
		rank 5	20%
q7	**yes**		35%
	no		20%
	I don’t know		45%
q8	**yes**		25%
	no		30%
	can't tell the difference		45%
q9	**1. overall**	-2: very poor	9%
		rank -1	0%
		rank 0	23%
		rank 1	59%
		2: very good	9%
	2. support tool to cmpt408	rank -2	9%
		rank -1	4%
		rank 0	13%
		rank 1	35%

q9	**2. support tool to cmpt408**	rank 2	39%
	3. usability	rank -2	11%
		rank -1	21%
		rank 0	21%
		rank 1	42%
		rank 2	5%
	4. Reliability (crashes etc.)	rank -2	10%
		rank -1	19%
		rank 0	14%
		rank 1	43%
		rank 2	14%
	5. visualization attractive	rank -2	10%
		rank -1	5%
		rank 0	35%
		rank 1	30%
		rank 2	20%
	6. visualization useful	rank -2	10%
		rank -1	5%
		rank 0	35%
		rank 1	40%
		rank 2	10%
	7. visualization intuitive	rank -2	10%
		rank -1	15%
		rank 0	35%
		rank 1	25%
		rank 2	15%
	8. visualization effective	rank -2	25%
		rank -1	15%
		rank 0	40%
		rank 1	20%
		rank 2	0%
	9. quality of shared links	rank -2	20%
		rank -1	0%
		rank 0	25%
		rank 1	45%
		rank 2	10%
	10. fairness	rank -2	10%
		rank -1	0%
		rank 0	10%
		rank 1	65%
		rank 2	15%
q10	**1. who currently online**	rank -2	35%
		rank -1	5%
		rank 0	25%
		rank 1	20%
		rank 2	15%
	2. how much other contrb.	rank -2	5%
		rank -1	0%
		rank 0	15%
		rank 1	40%
		rank 2	40%
	3. (your or others) membership	rank -2	10%
		rank -1	5%
		rank 0	43%
		rank 1	29%
		rank 2	14%

q10	**4. am I a freeloader**	rank -2	20%
		rank -1	5%
		rank 0	35%
		rank 1	25%
		rank 2	15%
	5. don't want to know anything	rank -2	48%
		rank -1	10%
		rank 0	33%
		rank 1	5%
		rank 2	5%
q11	**1. am I online**	rank -2	25%
		rank -1	10%
		rank 0	40%
		rank 1	5%
		rank 2	20%
	2. how many links I share	rank -2	5%
		rank -1	5%
		rank 0	35%
		rank 1	35%
		rank 2	20%
	3. quality of my shared	rank -2	5%
		rank -1	5%
		rank 0	20%
		rank 1	20%
		rank 2	50%
	4. ratings I give to others	rank -2	33%
		rank -1	10%
		rank 0	29%
		rank 1	19%
		rank 2	10%
q12	**find more, compete**		45%
	no need to add more		10%
	don't bother		5%
	share better quality links		10%
	other, specify		30%
q13	**take immediate action**		20%
	think of sharing more later		45%
	unhappy but do nothing		0%
	system unfair		0%
	don't care, do nothing		20%
	other:		15%
q14	**proud, contribution even more**		40%
	proud, but stop sharing		10%
	worried		10%
	feel nothing, not important		35%
	other, specify		5%
q15	**did not use it**		35%
	no		25%
	yes		20%
	what's the difference?		20%
q16	**yes**		60%
	no		25%
	other, specify		15%
q17	**yes**		45%
	no		55%
q18	**use real name**		65%

q18	use an alias		10%
	real name to alias		25%
	alias to real name		0%
	why?		0%
q19	**active < 25%**		22%
	active 25-50%		7%
	active 50-75%	total over 50%: 70%	33%
	active >75%		37%
q20	**quality of articles**		44%
	quantity		7%
	both quality and quantity		48%
q21	**read urls / week**	on average	930%
q22	**spend much time-hard**		50%
	okay		42%
	easy		8%
q23	**high-quality (D31h)**	on average	24%
	medium (D31m)	on average	40%
	low (D31l)	on average	26%
q24	**a. community visualization**	1: strongest	8%
		rank 2	19%
		rank 3	19%
		rank 4	12%
		rank 5	8%
		6: weakest	35%
	b. earn higher membership	1: strongest	22%
		rank 2	19%
		rank 3	19%
		rank 4	15%
		rank 5	15%
		6: weakest	11%
	c. earn higher participation marks	1: strongest	43%
		rank 2	21%
		rank 3	4%
		rank 4	14%
		rank 5	11%
		6: weakest	7%
	d. bringing good papers	1: strongest	23%
		rank 2	12%
		rank 3	35%
		rank 4	12%
		rank 5	12%
		rank 6	8%
	e. the satisfaction to see myself as	1: strongest	11%
	best user of the week at front page	rank 2	29%
		rank 3	14%
		rank 4	18%
		rank 5	11%
		rank 6	18%
	f. the satisfaction to see some of	1: strongest	11%
	my papers as best papers at the	rank 2	25%
	front page	rank 3	18%
		rank 4	18%
		rank 5	18%
		rank 6	11%

Appendix 3: Tables of Experimental Results

Table 1. Contributions vs. Accesses to the Visualization (in the Second Design)

ID	access original	original contrib.	Original after		ID	access total	total contrib.	Total after	
26	131	131	81	61.8%	**32**	36	559	531	95.0%
42	80	22	22	100.0%	**13**	31	111	83	74.8%
13	69	41	30	73.2%	**25**	25	59	41	69.5%
32	61	41	23	56.1%	**19**	24	51	42	82.4%
7	34	27	15	55.6%	**24**	14	89	55	61.8%
3	29	82	77	93.9%	**42**	9	1095	1035	94.5%
25	29	49	31	63.3%	**15**	6	570	542	95.1%
9	28	40	22	55.0%	**3**	4	291	252	86.6%
19	27	21	14	66.7%	**21**	3	52	25	48.1%
34	22	50	36	72.0%	**34**	2	65	43	66.2%
31	20	20	9	45.0%	**29**	2	58	26	44.8%
12	20	33	19	57.6%	**18**	2	10	3	30.0%
1	19	44	28	63.6%	**1**	1	85	63	74.1%
6	19	26	19	73.1%	**26**	0	231	145	62.8%
29	18	43	22	51.2%	**7**	0	125	74	59.2%
24	17	75	47	62.7%	**30**	0	110	84	76.4%
43	17	2	1	50.0%	**31**	0	88	59	67.0%
21	14	39	17	43.6%	**41**	0	79	53	67.1%
30	9	52	43	82.7%	**12**	0	73	58	79.5%
15	8	16	6	37.5%	**9**	0	56	26	46.4%
14	7	11	4	36.4%	**28**	0	49	13	26.5%
41	5	12	6	50.0%	**6**	0	29	21	72.4%
2	5	17	6	35.3%	**2**	0	28	12	42.9%
33	3	0	0	0.0%	**14**	0	21	8	38.1%
18	3	7	2	28.6%	**33**	0	13	6	46.2%
16	3	0	0	0.0%	**16**	0	7	2	28.6%
28	1	21	7	33.3%	**43**	0	2	1	50.0%
5	0	0	0	0.0%	**5**	0	6	0	0.0%
8	0	0	0	0.0%	**8**	0	7	0	0.0%
11	0	2	0	0.0%	**11**	0	10	3	30.0%
17	0	0	0	0.0%	**17**	0	20	0	0.0%
20	0	48	19	39.6%	**20**	0	148	27	18.2%
22	0	7	0	0.0%	**22**	0	17	4	23.5%
23	0	4	4	100.0%	**23**	0	16	8	50.0%
27	0	9	0	0.0%	**27**	0	54	11	20.4%

- access original: the number of times that a user clicks to view the community visualization with all nodes sorted by the original contributions.
- original/total after: the original/total contributions made by a user after the visualization interface was introduced.
- access total: the number of times that a user clicks to view the community visualization with all nodes sorted by the total contributions.

Table 2. Comments & Ratings vs. Accesses to the Visualization (in the Second Design)

ID	Access status	comments	comments after		ratings	Ratings after		original contrib.	Original after	
15	28	114	107	93.9%	81	76	93.8%	16	6	37.5%
32	23	107	101	94.4%	55	55	100.0%	41	23	56.1%
13	21	18	12	66.7%	11	10	90.9%	41	30	73.2%
3	14	38	35	92.1%	13	13	100.0%	82	77	93.9%
21	7	23	13	56.5%	0	0	0.0%	39	17	43.6%
24	7	8	3	37.5%	84	54	64.3%	75	47	62.7%
19	5	17	11	64.7%	10	10	100.0%	21	14	66.7%
34	3	11	5	45.5%	1	1	100.0%	50	36	72.0%
25	3	4	4	100.0%	3	3	100.0%	49	31	63.3%
18	3	4	1	25.0%	1	0	0.0%	7	2	28.6%
42	2	186	183	98.4%	76	75	98.7%	22	22	100.0%
7	2	11	6	54.5%	7	7	100.0%	27	15	55.6%
1	1	28	17	60.7%	20	17	85.0%	44	28	63.6%
29	1	10	4	40.0%	7	4	57.1%	43	22	51.2%
2	0	13	7	53.8%	0	0	0.0%	17	6	35.3%
6	0	9	9	100.0%	9	9	100.0%	26	19	73.1%
9	0	2	1	50.0%	2	1	50.0%	40	22	55.0%
12	0	14	8	57.1%	3	3	100.0%	33	19	57.6%
14	0	11	4	36.4%	10	3	30.0%	11	4	36.4%
16	0	5	2	40.0%	5	2	40.0%	0	0	0.0%
26	0	117	111	94.9%	110	110	100.0%	131	81	61.8%
28	0	20	3	15.0%	1	0	0.0%	21	7	33.3%
30	0	17	16	94.1%	20	19	95.0%	52	43	82.7%
31	0	27	18	66.7%	17	10	58.8%	20	9	0.0%
33	0	0	0	0.0%	0	0	0.0%	0	0	0.0%
41	0	21	13	61.9%	10	9	90.0%	12	6	0.0%
43	0	0	0	0.0%	0	0	0.0%	2	1	50.0%
5	0	0	0	0.0%	0	0	0.0%	0	0	0.0%
8	0	0	0	0.0%	0	0	0.0%	0	0	0.0%
11	0	0	0	0.0%	0	0	0.0%	2	0	0.0%
17	0	0	0	0.0%	0	0	0.0%	0	0	0.0%
20	0	22	8	36.4%	13	9	69.2%	48	19	39.6%
22	0	10	4	40.0%	0	0	0.0%	7	0	0.0%
23	0	10	4	40.0%	2	2	100.0%	4	4	100.0%
27	0	11	2	18.2%	7	3	42.9%	9	0	0.0%

- access status: the number of times that a user clicks to view the community visualization with all nodes sorted by the status.
- comments/ratings after: the number of comments/ratings that a user gave after the visualization interface was introduced.
- original after: same as in Table 1 in this Appendix.

Table 3. Performances of Group A and Group B (in the Final Design)

		group A	group B	diff = B-A
logins	w1	167	162	-5
	w2	166	153	-13
	w3	217	212	-5
	w4	141	140	-1
	w5	40	62	22
	w6	73	96	23
	w7	83	130	47
	w8	109	143	34
	w9	114	220	106
	w10	136	151	15
sharing	w1	43	88	45
	w2	65	81	16
	w3	67	107	40
	w4	64	126	62
	w5	8	1	-7
	w6	8	22	14
	w7	46	98	52
	w8	40	94	54
	w9	46	90	44
	w10	37	72	35
rating	w1	18	45	27
	w2	40	85	45
	w3	57	123	66
	w4	79	117	38
	w5	11	20	9
	w6	22	102	80
	w7	82	140	58
	w8	88	155	67
	w9	82	144	62
	w10	94	144	50
reading	w1	245	375	130
	w2	313	437	124
	w3	368	512	144
	w4	312	321	9
	w5	39	45	6
	w6	71	152	81
	w7	236	418	182
	w8	288	353	65
	w9	274	372	98
	w10	287	353	66

Table 4. The Difference in the Performances of Group A and Group B (in the Final Design)

Activity	difference in week 1-5 (w1)		difference in week 6-10 (w2)		diff(diff) = w2 - w1
logins	week 1	-5	week 6	23	28
	week 2	-13	week 7	47	60
	week 3	-5	week 8	34	39
	week 4	-1	week 9	106	107
	week 5	22	week 10	15	-7
sharing	week 1	45	week 6	14	-31
	week 2	16	week 7	52	36
	week 3	40	week 8	54	14
	week 4	62	week 9	44	-18
	week 5	-7	week 10	35	42
rating	week 1	27	week 6	80	53
	week 2	45	week 7	58	13
	week 3	66	week 8	67	1
	week 4	38	week 9	62	24
	week 5	9	week 10	50	41
reading	week 1	130	week 6	81	-49
	week 2	124	week 7	182	58
	week 3	144	week 8	65	-79
	week 4	9	week 9	98	89
	week 5	6	week 10	66	60

Table 5. T-test Results on the Difference in the Performances (in the Final Design)

	week 1-5 (w1)	week 6-10 (w2)	diff (w2 - w1)
logins	-5	23	28
	-13	47	60
	-5	34	39
	-1	106	107
	22	15	-7
mean	-0.4	45	**45.4**
variance	175.8	1307.5	1774.3
std	13.25895924	36.15936946	**42.12244058**
T-value	-0.067458326	2.782765863	**2.410057081**
TDIST			**0.031986307**
sharing	45	14	-31
	16	52	36
	40	54	14
	62	44	-18
	-7	35	42
mean	31.2	39.8	**8.6**
variance	726.7	264.2	1042.8
std	26.95737376	16.25423022	**32.29241397**
T-value	2.587986557	5.475221177	**0.595501613**
TDIST			**0.288718373**
rating	27	80	53
	45	58	13
	66	67	1
	38	62	24
	9	50	41
mean	37	63.4	**26.4**
variance	447.5	124.8	437.8
std	21.1541958	11.17139204	**20.92367081**
T-value	3.911021527	12.69015619	**2.821311574**
TDIST			**0.018525697**
reading	130	81	-49
	124	182	58
	144	65	-79
	9	98	89
	6	66	60
mean	82.6	98.4	**15.8**
variance	4753.8	2364.3	5569.7
std	68.94780635	48.62406811	**74.63042275**
T-value	2.678826561	4.525106547	**0.473397748**
TDIST			**0.327938368**

- Yellow indicates the data is significant i.e. not due to chance or randomness, light green indicates the data is not significant enough to be concluded that it is not due to chance or randomness.

Table 6. Wilcoxon's Test on the Difference in the Performances (in the Final Design)

activities	differences	rank
logins	28	2
	60	4
	39	3
	107	5
	-7	**1**
negative rank sum		**1**
sharing	**-31**	**3**
	36	4
	14	1
	-18	**2**
	42	5
negative rank sum		**5**
ratings	53	5
	13	2
	1	1
	24	3
	41	4
negative rank sum		**0**
readings	**-49**	**1**
	58	2
	-79	**4**
	89	5
	60	3
negative rank sum		**5**

- This table shows the Wilcoxon's Matched-Pairs Signed-Rank Test" (Mendenhall & Reinmuth, 1974) on the differences of the performances of Group A and Group B in the final design for each of the four types of activities: login, sharing, rating, and reading.
- Yellow indicates the data is significant i.e. not due to chance or randomness, light green indicates the data is not significant enough to be concluded that it is not due to chance or randomness.

Table 7. The Percentages of Contributions of Group A and Group B

A with %	A without %		B with %	B without %
9.47%	2.94%		15.97%	4.11%
8.05%	2.99%		14.71%	0.00%
8.05%	3.73%		11.19%	8.05%
7.37%	4.41%		11.19%	10.34%
7.37%	1.47%		10.42%	6.85%
6.85%	4.17%		9.56%	9.47%
4.74%	4.41%		8.96%	10.34%
4.11%	0.00%		8.09%	9.47%
4.11%	0.00%		7.46%	0.00%
3.45%	3.73%		7.46%	3.45%
3.45%	4.48%		6.94%	2.05%
3.16%	2.94%		6.25%	12.33%
3.16%	2.21%		5.88%	9.47%
2.87%	4.48%		4.48%	4.02%
2.87%	4.48%		4.41%	0.00%
2.74%	2.78%		4.17%	5.48%
2.30%	0.00%		4.17%	0.00%
2.11%	5.15%		3.73%	5.75%
2.05%	3.47%		3.73%	8.05%
2.05%	1.39%		3.68%	0.00%
2.05%	2.08%		3.68%	7.37%
1.72%	2.99%		3.68%	2.11%
1.58%	5.15%		3.68%	3.68%
1.37%	1.39%		3.47%	4.79%
1.37%	0.00%		3.47%	2.74%
1.05%	1.47%		3.47%	7.53%
1.05%	2.21%		2.99%	1.72%
0.68%	4.86%		2.94%	9.47%
0.53%	0.00%		2.94%	7.37%
0.00%	1.49%		2.94%	0.00%
0.00%	0.00%		2.78%	3.42%
0.00%	0.00%		2.78%	2.05%
0.00%	0.00%		2.24%	0.00%
0.00%	0.00%		2.24%	5.75%
0.00%	0.00%		2.24%	2.87%
0.00%	0.00%		2.24%	0.00%
0.00%	0.00%		2.08%	0.00%
0.00%	3.47%		2.08%	0.00%
0.00%	0.00%		0.00%	3.16%
0.00%	1.47%		0.00%	6.85%
0.00%	5.56%		0.00%	10.34%
0.00%	1.49%		0.00%	0.00%
0.00%	0.00%		0.00%	0.00%
0.00%	0.00%		0.00%	0.00%
0.00%	2.78%		0.00%	0.00%

- This table compares the percentages of the contributions made by Group A and Group B with and without the visualization.
- Three data entries for each user for a total of 15 users. The first two columns of data are sorted by the descending order of column “A with %”, and the last two columns of data are sorted by the descending order of column “B with %”.

Table 8. The Percentages of Ratings from Group A and Group B

A with %	A without %		B with %	B without %
10.56%	5.76%		10.70%	3.33%
8.00%	4.50%		8.11%	3.20%
7.65%	4.42%		8.11%	5.60%
7.20%	2.25%		8.11%	0.00%
5.61%	0.00%		8.11%	0.00%
5.61%	4.42%		7.96%	3.57%
5.60%	2.70%		7.96%	0.00%
4.80%	4.50%		7.96%	3.06%
4.80%	0.00%		7.96%	1.02%
4.80%	0.45%		7.41%	3.33%
4.59%	6.19%		7.41%	0.00%
4.44%	4.12%		7.41%	0.00%
4.00%	6.31%		6.31%	4.80%
3.33%	2.06%		6.31%	0.00%
3.33%	5.35%		6.19%	2.04%
3.20%	6.31%		6.19%	1.53%
3.20%	0.00%		6.19%	3.06%
2.78%	2.47%		6.19%	1.53%
2.40%	0.00%		5.76%	2.22%
2.22%	2.47%		5.76%	2.78%
2.22%	4.12%		5.35%	2.22%
2.22%	0.82%		4.50%	2.40%
2.04%	4.42%		4.50%	3.20%
2.04%	6.19%		4.12%	3.33%
1.67%	0.00%		2.70%	1.60%
1.67%	0.00%		2.70%	6.40%
1.67%	2.47%		2.65%	0.00%
1.60%	2.70%		2.65%	1.02%
1.60%	4.50%		2.47%	1.11%
1.53%	0.00%		2.47%	0.00%
1.11%	2.47%		2.25%	4.00%
1.02%	0.00%		2.06%	0.00%
1.02%	4.42%		1.65%	2.78%
1.02%	2.21%		1.35%	1.60%
0.80%	2.70%		1.33%	2.04%
0.51%	1.33%		1.23%	0.00%
0.00%	0.00%		0.44%	0.00%
0.00%	0.00%		0.00%	4.00%
0.00%	0.00%		0.00%	1.02%
0.00%	0.00%		0.00%	1.11%
0.00%	0.00%		0.00%	3.57%
0.00%	0.00%		0.00%	0.00%
0.00%	4.12%		0.00%	0.00%
0.00%	0.00%		0.00%	0.00%
0.00%	2.65%		0.00%	0.00%

- This table compares the percentages of the ratings given by Group A and Group B with and without the visualization.
- Three data entries for each user for a total of 15 users. The first two columns of data are sorted by the descending order of column “A with %”, and the last two columns of data are sorted by the descending order of column “B with %”.

Table 9. T-Test on the Data Presented in Table 8 and Table 9 in this Appendix.

t-Test: Two-Sample Assuming Unequal Variances		
Sharing - Group A		
	Variable	Variable
Mean	0.022608	0.024319
Variance	0.000689	0.000482
Observations	45	45
Hypothesized Mean Difference	0	
df	85	
t Stat	-0.33535	
P(T<=t) one-tail	0.369095	
t Critical one-tail	1.662979	
t-Test: Two-Sample Assuming Unequal Variances		
Sharing - Group B		
	Variable	Variable
Mean	0.045418	0.042331
Variance	0.001463	0.001467
Observations	45	45
Hypothesized Mean Difference	0	
df	88	
t Stat	0.382637	
P(T<=t) one-tail	0.351456	
t Critical one-tail	1.662354	
t-Test: Two-Sample Assuming Unequal Variances		
Rating - Group A		
	Variable	Variable
Mean	0.027083	0.024319
Variance	0.000628	0.000482
Observations	45	45
Hypothesized Mean Difference	0	
df	87	
t Stat	0.556554	
P(T<=t) one-tail	0.289631	
t Critical one-tail	1.662556	
t-Test: Two-Sample Assuming Unequal Variances		
Rating - Group B		
	Variable	Variable
Mean	0.042348	0.018331
Variance	0.000983	0.000293
Observations	45	45
Hypothesized Mean Difference	0	
df	68	
t Stat	4.509617	
P(T<=t) one-tail	1.32E-05	
t Critical one-tail	1.667572	