Investigating Sharing in Memory for Life Systems

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Abstract: **Memory for Life (M4L) systems store and organize life events captured by people in digital form using their cameras, mobile phones and so on. This paper describes M4L systems and the challenges for sharing digital events. Based on the challenges, an investigation is carried out in order to find a suitable technology that allows sharing of digital events according to the social network of a user. For this purpose, Web-based online social networks and peer-to-peer networks are particularly studied. The requirements for a social P2P model for sharing human digital events (HDEs) are suggested as future work.**

I. INTRODUCTION

Human life is filled with many events which people try to capture or store in different ways. In the era before reading and writing was widespread, the only way to keep these events was though "learning by heart" either in simple story form or in the form of verse. These events were then told to people by a poet who captured them in the form of verse or as story tellers in large gatherings. In some ages, symbolic or pictorial forms were also used to record different events which we see in the form of ancient remains in different regions of the world. After the introduction of pen and paper, monarchs of different kingdoms used to keep annalists/historians in their court to record the events that happened in the period of their ruling. With the start of the modern age, other forms of recording these events were introduced such as through pictures, audio, video etc. and nowadays the development of technology has produced high quality data capturing and huge data storage devices at a low cost.

In fact, it's not unusual for people in all ages to create memoirs, recalling different events in their lives with different people and at different places and times. Many people want to keep their memories in some form or other: either in written paper form or in the form of pictures, videos etc. Human lives are filled with so many events, but after some time or reaching a specific age, many people find they have forgotten many of them. Now, thanks to technological developments, it's possible to have a record of the most beautiful events in our lives in the form of pictures, audio, video and so on, all recorded in digital form. However the need remains to allow them to be organized in such a way that reminds us not only of the place and time but also the feelings we were having at those times. M4L [1] is such an effort to enable collecting, organizing and sharing of such events, bringing the computer world and the physical world closer to each other. We refer to an event captured as a memory in digital form as a human digital event (HDE).

M4L is a new research area with the aim to help in storing and managing data properly and extracting different information like lifestyle, stories, medical history, interest etc. about the life of a person. Data will be annotated at the time of capture or storage, automatically via the device that is capturing or storing the data. The parameters for annotating data could include GPS location, time, object names, events, temperature, and so on. This data could be used for a variety of interesting and useful reasons, often allowing extensions beyond the purposes for which it was originally intended [2]. For example, pictures could be used to understand a person's social life by counting the number of people in a picture, while the same data could be used to establish the state of a person's health using face detection software to compare different photos. The information stored could also be used to generate daily schedule for the person and stories about their life by collecting connected information. It can help with a child's education by collecting information about their behavior, different approaches for solving problems across the world and so on. Also, the schedule of elderly people, who have weak memories, might also be predicted by analyzing their previous routines. These digital events which capture the most memorable minutes of life are not only to be stored, but also to be shared with other people.

Consider a scenario of a wedding ceremony in which both wedding bride or bridegroom and guests capture the event using their cameras, mobile phones etc. Each party capture the same event as their memories in digital form, but the point of view of each of them is different while capturing it. For example, a bridegroom might capture it to see who came to their wedding, how many guests there were, how the arrangements went and so on. The guests, on the other hand, might keep the memories to see the expressions and outfits of the bride and groom, and to keep a record of the speeches that were made. This attracts people, even those who have captured the events and also those that have missed the event, to see the point of view of each person through their memories. This behavior results in sharing and/or collecting the memories of other people. This process is also described by Olsson *et al.* [3].

The aim of this paper is to identify the issues and challenges in the sharing of HDEs. The challenges are illustrated by considering the social priorities and the requirements of M4L systems for sharing data. Currently used technologies for carrying online social activities are investigated. The purpose is to find an appropriate option that has the potential to carry out social activities and allow M4L systems to perform their functions as required.

This paper is organized as follows. In Section 2 we explain the research so far for collecting and organizing HDEs. Section 3

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gives an overview of the challenges that need to be overcome for sharing these events. Each issue is explained with examples in the scenario of a M4L system. The following section investigates Web-based online social networks and peer-to-peer networks (P2P) for sharing HDEs, in terms of the challenges. The last section, Section 5, concludes the discussion and describes the requirements for a social P2P model for our future work.

II. M4L Systems

The idea behind the Memory for Life was originally conceived by Vannevar Bush in 1945 in the article "As We May Think" where it took the form of a machine called *Memex*: "A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory" [4]. It was posited that only one button push could retrieve all the data you need in a small amount of time. Gorden Bell's *MyLifeBits* [5], inspired by the idea of Vannevar Bush, was developed with the intention that with the tools and technology and the relatively-speaking large storage devices available at the time, it would be possible to collect and organize all of our data easily. The MyLifeBits software is able to store text, images, links, videos etc. in a database and annotate. The annotation is currently manual, but in future some hardware or software solutions are expected to annotate the data automatically. Jim Gemmell *et al.* [6] described the four principles for designing MyLifeBits. First, there should be no strict hierarchy for organizing data. Second, many visualizations of their *life bits* were desirable to help understand what they would be looking at. Third, the value of non-text media is dependent on annotations. Fourth, authoring tools create two-way links to media that they included with new media.

Another project with similar aims to those of MyLifeBits is *Haystack* [7], which facilitates users in organizing and managing their emails, documents, appointments, tasks etc. *Total Recall* [8, 9] collects data through personal sensors such as cameras, microphones etc. and organizes and annotates them for future use under security and privacy constraints so that the collected data cannot be used by the wrong people. *Eyetap* [10], similar to Total Recall, gathers data using a small camera that is attached near an eye and stores all the things which a human eye sees as part of its normal routine. Memory for Life [11] not only collects and manages data but also analyses in a way that shows different aspects of a person's life and helps him in his normal routine if he does something unusual or forgets to do it. Azizan *et al.* [12] describe a Human Life Memory system for collecting, storing and organizing different life events which they call "Serendipitous Moments", as well as discussing sharing via P2P networks. JXTA is used as the peer-to-peer networking technology for this system.

As an example, an interesting feature of Memory for Life is to generate stories about the life of a person. These stories are generated from the stored data of a user and possibly from the data of his friends and family members, since other people may also be an integral part of the scene or story. Therefore the stored events of other members may also be required to complete the story that a particular user is interested in. Incorporating the stored events of others into a story in this way is possible by allowing the sharing of events between users.

III. Challenges for sharing Human digital events

The Memory for Life systems will store every aspect of a human's life, which in theory should make it easy to know their interests, lifestyle, social activities, schedule, stories and so on. However there are several challenges which must be overcome when using these systems over a computer network. These are given below.

Data privacy: The first challenge is to ensure data privacy; the system must ensure that the personal data stored is accessible only by those people that are allowed to access it, and that it should never be stored on any unwanted system. The user of the system should be able to adjust the level of privacy of his data to allow some people to access, yet limit access to others. The interesting aspect about data privacy of M4L systems is that it requires the information to be kept hidden not only from unknown people but also from different groups of known people. In the latter case, the differences in privacy could be because of age, culture and so on. For example, husband-wife and child-parent relationships are two different trusted relationships. The difference is in part due to age, because usually at an early age the child-parent relationship is a trusted relationship, but after getting married a husband-wife could become more trusted then a child-parent.

User's control over data: We believe that users' control over data is an important feature of any social P2P system. Data sharing should be based on a user's choice, which means that a number of accredited people can be authorized to access some portion of a user's human digital events, whereas the user can deny access to others. Furthermore, data access is based on a user's trust level, which implies that a user will only be allowed to access the data when their trust level is equivalent to or above a predefined trust threshold value. The two important elements are that data should be under a sharer's control: *a) while sharing data* and *b) when data is shared.* In the first case, data should be accessible only to those people that are authorized by the user. For this purpose each relationship/connection should be defined in terms of the trust of the user. In the second case, it's important that data should also be under the control of the user even once it has been shared. In other words, a user should not lose control over access to their data just because it's been passed on to someone else. This provides a number of technical challenges, and can arise when the trust level of a user is changed to a non-trusted level. In such a situation there should be some procedure to prevent them from further using the data, *i.e.* accessing the user's new or already shared data.

Topology: A M4L stores memories that are collected from the social activities of a person, therefore connecting people or collecting information using an M4L in a network will be

influenced by social relationships. This gives rise to the requirement of network organization (or the topology of the network). The network should be organized in a way that allows users to retain their real life relationships. The network should allow a person to connect to people they like and should differentiate people that are closer to them than those that are not. The structure of a network should not impose rules and regulations that restrict a user from carrying out his social activities or result in bad performance of network. Moreover, when sharing data, the priorities of relationships should be considered by the network or system in order to allow a person to share data according to the priority of those relationships. Therefore, it becomes necessary to consider the relationship information first and then the network information, such as speed, bandwidth and so on.

Searching: Another challenge is to provide a means to find the correct data from the appropriate people. Searching in a network by an M4L depends on the operation carried out by it. For example, in a more specific scenario to complete an action such as generating a story about a person's life, M4L systems will not need to collect every piece of data in the network. Instead, only the required data will be collected from people that are part of the story and are needed in order to complete it. As another example, to know about the social gatherings a person has had with other people, the intention of the system will not be to find all data named or recognized as "social gatherings" in a network. Instead only those that are related to the person will be searched. However, in some other cases the scenario may be more general and the system may need to find all data related to some event, location etc. such as all cultural events in Liverpool in 2008. To get the required data, M4L systems require searching data not only on file name but also on its metadata or even the contents of the file. This scenario makes searching data and the search query structure considerably more complex.

The complication of the above scenario of searching data in an M4L system can also be explained by considering the example of a person who wants to generate a story about their happy moments. For this purpose the happy moments from the life memory events of the person and friends and family members of this person will be considered. The required data will not contain all the happy moments of the lives of his friends and family but the happy moments they had with this person at a specific time, age, location, and so on.

IV. SHARING HUMAN DIGITAL MEMORIES

In this section we will consider different technologies and their suitability for sharing human digital events. The technologies will be judged based on the above described requirements for sharing HDEs.

A. Web-based social networks

Hundreds of Web-based social networks have been introduced each one grabbing some portion of people's interest. The purpose of each of these sites ranges from child care [13] to aged people care [14] and from social activities [15] to research oriented activities [16]. We will delve into this further by looking at a number of social networking sites in more detail.

YouTube [17] is a Web-based social network site through which people share their videos; usually these videos are only of a short length. If a video exceeds a given length, it is then cut to the maximum length of a video clip provided by YouTube [18]. The site displays a list of videos related to the currently running video and also the videos uploaded by the same user. Orkut [19], launched by some Google employees in the United States in 2004 [20], was initially designed as a photo sharing online community where people could upload their pictures, join communities related to their interests and make friends. In its early days, getting membership was possible only through an invitation from an existing user, but since 2006 everyone has been entitled to sign up and upload their pictures, videos etc. ResearchGATE [16] is a Web-based social network for researchers and scientists, where they share their research material and other members comment on papers and give suggestions to authors.

The positive aspect of these websites is that they facilitate the exchange of ideas or data between people for a specific interest for which the website was developed. These Web-based social networks show the diverse interests of people that exist in the real world. But their existence in such large numbers disperses the interests of their users, which can result in a misinterpretation of the personality of the user and also creates a headache for the user in keeping track of the rules and regulations of each service provider. If the interests of a user change, then the new rules of a new service provider must be accepted, and potentially large amounts of data moved between sites. Other important issues with these websites are data privacy [21] and a single point of failure, which make them an unsuitable choice for M4L systems.

For individual users, it may often be most appropriate to store their M4L data in a single place, such as a desktop computer. This has a number of advantages; for example more coherent and meaningful information can be easily extracted from the data, allowing a user's personality to be properly represented. However, one of the most appealing aspects of Web-based systems is their ability to facilitate the easy sharing of data between users. Data or extracted information should be shared in a way that maintains the privacy of the user and allows them to find people with shared interests, as and when required without worrying about new rules. We believe that Web-based social networks do not provide the important facilities either to organize a life's worth of data or to share it in a way that is appropriate for memory for life systems.

Therefore, the limited facilities and uncertain conditions of Web-based social networks cannot guarantee to present every perspective of a member's life. To overcome these problems a good alternative is to use the personal resources of a user, *e.g.* their mobile phone, desktop computer or laptop, which are under their control and bring no extra cost to the user. This opportunity can be supported using P2P networking technologies so that people can share their data, as much as they can afford, with friends, family and across the world.

B. Peer-to-peer networks

Data sharing plays an important role for an M4L because the intention of most people is not only to save their serendipitous moments for their own purposes, but also to share these events with others. P2P networks are suitable for sharing data of all kinds, sizes and any interest. Also, a pure P2P network has no single point of failure or a single authority to collect personal information, and this contrasts with Web-based social networks which create a potential threat to the privacy of a user.

P2P networks operate in the form of an overlay that sits above the network stack and avoids consideration of the underlying physical network details. Androutsellis-Theotokis *et al.* [22] classify peer-to-peer system into three categories: *communication and collaboration systems* that provide the infrastructure for communication and cooperation between peers; *distributed computing systems* taking advantage of available and free peer computer processors and *content distribution* infrastructure for sharing data among users. Furthermore, the content distribution technologies are grouped on the basis of services they provide as follows. *Peer-to-Peer Applications* provide for searching and transferring files without any fear for security etc. In this case publishing, storing and distributing data must be undertaken in a controlled and secure way. *Peer-to-Peer Infrastructure* provides a base and framework for carrying out the activities of peer-to-peer applications *e.g.* routing the information, anonymity and reputation management.

Many structures have been proposed by different authors, each having their own approach with differing merits and demerits. These approaches can broadly be categorized as being either *centralized* or *decentralized*. The centralized (*e.g.* Napster [23]) approach creates a single point of failure, consequently the trend has shifted towards decentralized networks. Decentralized networks are further divided into *structured*, *unstructured* and *hybrid*. The structured [24] approach uses a keying mechanism to allocate positions to nodes and data to these nodes based on their position or key value *e.g.* Chord [25]. These types of networks create a strict scenario in which file names or a specific attribute via which a file can be recognized plays an important role for storing or searching of files. But M4L systems require far broader the possibilities *e.g.* file name, metadata, contents of files etc. to allow searching and storage of files. In contrast to structured P2P networks, unstructured [26] approaches have no predefined structure or rules for the topology of the network and peers search for data within the network based on the information given by neighbours or a neighbour's neighbours, and so on (*e.g.* Gnutella v4). In unstructured schemes searching generally takes longer and the chances of accessing a desired person, which is a requirement of M4L systems, are low because of the totally unorganized structure. Consequently hybrid approaches such as KaZaA [27] and Gnutella v6 [28], where some peers with high performance resources – called super peers – take the responsibility of controlling the network locally for a group of peers. This approach is considered to be more appropriate in terms of fast searching and low network maintenance. The problem with such networks is that each super peer becomes a single point of access locally for the network and whenever such a peer leaves the network it disconnects its cluster for some time until another super peer replaces it.

It is clear from the above discussion that peer-to-peer networks offer a suitable environment to share data with each other, but they lack the social aspects required to share data with or access the data of other people. Each person, in a social network, connects through some relationship to every other person such as by friendship, family member, job colleague or similar. The establishment of a connection has a social reason behind it which a conventional P2P network doesn't consider. Alternatively they can be strangers but become friends by having common interests. Also, due to lack of knowledge about connections, a user in a P2P network usually has no control on sharing their data and anyone can access it without limitation. These relationships and the hierarchy of closeness that peers have with one another have a deep effect on most of the activities that occur within a network, such as data sharing. Therefore, we believe this problem must be overcome by application of social concepts in the P2P network.

C. Social P2P networks

Social P2P networks consider the social priorities in order to connect peers. The open nature of conventional P2P networks is controlled by the social network and activities, which make it suitable for M4L systems.

- *Social concepts to improve P2P networks*

The concept of peer-to-peer social networks first started through the deployment of various social concepts in P2P networks to improve their performance [29, 30]. Social concepts, in terms of online social networks, such as the keeping of a friends list, forwarding queries to known peers, making communities of peers with similar interests etc. improve the performance of the peer-to-peer network and help to find content in a network more easily. An important characteristic of social networks is used by Upadrashta *et al.* [31] in their work. They utilise the experience of a peer in a network. Peers analyse the queries that they receive from other peers and find and store their interests. In this way each peer stores information about other peers, resulting in the formation of virtual communities. Whenever a search query is received, it is analysed and then forwarded to those peers that have similar interests to those reflected in the search query. Anwar *et al.* [32] analyzed Orkut and, based on the social relations found among users, an information routing algorithm was implemented in a decentralized environment. Short paths were easily discovered by routing information only to peers with similar interests. This resulted in low network delay and reduced network traffic. Pouwelse *et al.* [33] designed a P2P system named Tribler and assumed social concepts in their model to improve the usability and performance of BitTorrent. The social concepts considered are friendship, trust and communities of similar interest. Instead of direct content discovery, the search is based on approaching the communities having similar interests. The five challenges: decentralization,

availability, integrity, providing proper incentive and network transparency, are addressed in their model.

In another approach proposed by Modarresi *et al.* [34], which is developed for social P2P networks and influenced by social communities, peers with similar interests are grouped together to form a community. This approach is similar to semantic overlay networks [35], the difference being that in semantic overlay networks peers having similar data connected to the same super peer. Data lookup is performed by sending queries only to those members that have similar interests. Interest-based communities bring peers with similar data or interests together and avoid peers that do not have the required data.

Soon after using social concepts for improving network performance, social P2P networks were introduced. Social models are not only influenced by the social ideas reflected in them but also the social activities of people that make them more secure, by interacting with people that they know and being cautious with those they don't. This provides a social layer of security, which improves network security and makes the network more secure.

- *Social P2P models*

The social P2P models developed so far are limited in number and have not yet achieved the desired results because it remains at an early stage of research. Those that have been proposed are described below.

Chen *et al.* [36] describe the Maze system which is a centralized social P2P network introduced in China. Initially it was designed to improve the Tianwang search engine which has been famous in China since 1997. The system is designed around the idea of social relationships among peers. Social relationships are used to find peers in the network and then direct transfer of files can occur between peers. Peers share their friends lists and also the status of their friends. These friends lists automatically bring people with similar interests to a group where they can enjoy the resources of each other. For security purposes, a server issues tickets to each peer whenever it needs to request resources from other peers. The network can work for some time without the central server. However, this still represents a bottleneck for the network because of the great responsibility of the central server in the network in terms of facilitating peers finding information, issuing security tickets and so on.

PeerSoN [21] is an online social P2P network which emphasises data privacy and security. These properties are achieved through a decentralized architecture and direct exchange of encrypted data between users. Social links are used to interconnect peers to achieve better performance. PeerSoN has been implemented using a structured P2P approach similar to Chord [25]. Structured approaches contain complications for M4L systems as stated in section B. Also, decentralizing network doesn't achieve the required privacy according to which private information is intended for the eyes of specific audiences only.

MyNet [37] proposes a middleware solution for personal and social networking which organizes the personal resources of a user and shares them in their social network; this can be called a personal social P2P network (PSN).

D. Requirements for a social P2P model for sharing HDEs

From the above discussion, we believe that social P2P networks have significant potential for use in sharing human digital events. However, the process of designing a social P2P network is not straightforward and the following are the important challenges we need to overcome in order to develop such a system.

- The network should be decentralized to avoid any single point of failure.
- Personal information should not be accessible to anyone except those that are allowed access as assigned by the data sharer.
- The network should be organized in a way that provides real world social relationships to the user.
- A user should be able to search data using a broad selection of parameters as chosen by the user *e.g.* using metadata or the content of files. This kind of searching is not only helpful for users in a social P2P network but is also particularly important to implement the M4L systems for carrying out its own automated fine-grained searching in order to fulfil various tasks, such as suggesting interest groups, building up profiles, summarising memory threads and so on.
- Data sharing should be allowed only according to the choice of the user and there should be defined boundaries for each user or life memory system in terms of access to data by other users.
- Users should be provided with security measures to ensure that no one can use their data other than those that have been granted access.
- Each user should have an identity that is socially acceptable and recognizable by other peers.

V. CONCLUSION

The dramatic increase in the size of personal data, in the form of digital events, has made it difficult for people to properly organize their data. M4L systems facilitate this, taking the responsibilities of storage and annotation, and try to present a personality from the user's data. Sharing data for M4L systems has become important due to the fact that people are increasingly capturing data to share within their social network. We described the challenges involved in sharing these digital events. These include: data privacy, users' control of data, the topology of the network and the use of appropriate searching techniques. We also discussed Web-based online social networks and P2P networks for carrying out social activities. Web-based social networks are not a suitable choice for sharing human digital events due to the various issues discussed. P2P

networks have an open nature and peers have less control over their data. To control it, the communication of peers should be restricted using careful criteria. In the case of M4L systems, this communication is the social network of the user. We described the requirements for a social P2P model which are necessary for sharing HDEs, and which we intend to develop into a testable design in our future work.

References

[1] K. O'Hara, R. Morris, N. Shadbolt, G. J. Hitch, W. Hall, and N. Beagrie, "Memories for Life: A Review of the Science and Technology," *Journal of the Royal Society Interface, 3(8)*, pp. 351-365, 13 April 2006.

[2] P. J. Brown, "GC3: Memory for Life: Getting Things Back," in *Grand Challenges in Computing Research conference*, Newcastle, UK, 2004.

[3] Thomas Olsson, Hannu Soronen, and K. Vaananen-Vainio-Mattila, "User needs and design guidelines for mobile services for sharing digital life memories," in *Proceedings of the 10th international conference on Human computer interaction with mobile devices and services*, Amsterdam, The Netherlands, 2008, pp. 273-282.

[4] V. Bush, "As We May Think," in *The Atlantic Monthly*. vol. 176, 1945, pp. 101-108.

[5] J. Gemmell, G. Bell, R. Lueder, S. Drucker, and C. Wong, "MyLifeBits: fulfilling the Memex vision," in *Proceedings of the tenth ACM international conference on Multimedia, MULTIMEDIA '02*, Juan-les Pins, France, 2002, pp. 235-238.

[6] J. Gemmell, G. Bell, and R. Lueder, "MyLifeBits: a personal database for everything," *Commun. ACM*, vol. 49, pp. 88-95, January 2006.

[7] D. Huynh, D. Karger, and D. Quan, "Haystack: A Platform for Creating, Organizing and Visualizing Information Using RDF," in *Semantic Web Workshop, The Eleventh World Wide Web Conference (WWW2002)*. Hawaii, USA, 2002.

[8] W. Cheng, L. Golubchik, and D. Kay, "Total recall: are privacy changes inevitable?," in *CARPE'04: Proceedings of the the 1st ACM workshop on Continuous archival and retrieval of personal experiences*, New York, USA, 2004, pp. 86-92.

[9] S. Cherry, "Total recall [life recording software]," *Spectrum, IEEE*, vol. 42, pp. 24-30, Nov. 2005.

[10] L. Chaisorn and C. Manders, "An exposure invariant video retrieval method for eyetap devices," in *Proceedings of The 7th ACM SIGGRAPH International Conference on Virtual-Reality Continuum and Its Applications in Industry* Singapore: ACM, 2008.

[11] A. Fitzgibbon and E. Reiter, "Memories for life: Managing information over a human lifetime," in *Grand Challenges in Computing Research, and Grand Challenges in Computing Education*, Newcastle, UK, 2003.

[12] A. Ismail, M. Merabti, D. Llewellyn-Jones, and S. Sudirman, "A framework for sharing and storing serendipity moments in human life memory," in *First IEEE International Conference on Ubi-Media Computing*, China, 2008, pp. 132-137.

[13] CafeMom home page, http://www.cafemom.com/, 5 June 2009.

[14] HelptheAged home page, http://www.helptheaged.org.uk/en-gb, 20 June 2009.

[15] Facebook home page, http://www.facebook.com/, Sep. 2008.

[16] ResearchGate home page, https://www.researchgate.net/, 20 Dec. 2008.

[17] J. E. Burgess and J. B. Green, *YouTube : online video and participatory culture*, 1st ed.: Polity, 2009.

[18] C. Xu, C. Dale, and L. Jiangchuan, "Statistics and Social Network of YouTube Videos," in *16th International Workshop on Quality of Service. IWQoS '08*, Enschede, The Netherlands, 2008, pp. 229-238.

[19] Orkut home page, http://www.orkut.com, 14 Aug 2008.

[20] d. m. boyd and N. B. Ellison, "Social Network Sites: Definition, History, and Scholarship," *Journal of Computer-Mediated Communication*, vol. 13, pp. 210-230, 17 Dec 2007.

[21] S. Buchegger, D. Schioberg, L.-H. Vu, and A. Datta, "PeerSoN: P2P Social Networking - Early Experiences and Insights," in *Proceedings of Second ACM Workshop on Social Network Systems (Co-located with EuroSys 2009)*, Nuremberg, Germany, 2009.

[22] S. Androutsellis-Theotokis and D. Spinellis, "A survey of peer-to-peer content distribution technologies," *ACM Comput. Surv.*, vol. 36, pp. 335-371, Dec. 2004.

[23] Napster Peer-to-Peer Networks, http://www.napster.co.uk/, Sep. 2008.

[24] K. Lua, J. Crowcroft, M. Pias, R. Sharma, and S. Lim, "A survey and comparison of peer-to-peer overlay network schemes," *IEEE Communications Surveys & Tutorials*, vol. 7, pp. 72-93, Second Quarter 2005.

[25] I. Stoica, R. Morris, D. Liben-Nowell, D. R. Karger, M. F. Kaashoek, F. Dabek, and H. Balakrishnan, "Chord: a scalable peer-to-peer lookup protocol for Internet applications," *IEEE/ACM Transactions on Networking*, vol. 11, pp. 17-32, Feb. 2003.

[26] H. Park, J. Yang, J. Park, S. G. Kang, and J. K. Choi, "A Survey on Peer-to-Peer Overlay Network Schemes," in *10th International Conference on Advanced Communication Technology, ICACT*, Gangwon-Do, S. Korea, 2008, pp. 986-988.

[27] KaZaA home page, http://www.kazaa.com/, September 2008.

[28] L. Fuhong, C. Changjia, and Z. Hongke, "Characterizing Churn in Gnutella Network in a New Aspect," in *The 9th International Conference for Young Computer Scientists, ICYCS 2008*, Hunan, China, 2008, pp. 305-309.

[29] S. Marti, P. Ganesan, and H. Garcia-Molina, "SPROUT: P2P Routing with Social Networks," in *First International Workshop on Peer-to-Peer Computing and Databases (P2P&DB 2004)* Heraklion, Crete, Greece, 2004.

[30] S. Marti, P. Ganesan, and H. Garcia-Molina, "DHT Routing Using Social Links," in *In 3rd International Workshop on Peer-to-Peer Systems (IPTPS 2004)*, San Diego, CA, USA, 2004.

[31] Y. Upadrashta, J. Vassileva, and W. Grassmann, "Social Networks in Peer-to-Peer Systems," in *Proceedings of the 38th Annual Hawaii International Conference on System Sciences, HICSS '05*, Big Island, Hawaii, 2005, pp. 200c-200c.

[32] Z. Anwar, W. Yurcik, V. Pandey, A. Shankar, I. Gupta, and R. Campbell, "Leveraging Social-Network Infrastructure to Improve Peer-to-Peer Overlay Performance: Results from Orkut," in *In Networking and Internet Architecture*, 2005.

[33] J. A. Pouwelse, P. Garbacki, Wangand, J. Yang, A. Iosup, D. Epema, M. Reinders, M. R. van Steen, and H. J. Sips, "Tribler: A social-based based peer to peer system," in *5th Int'l Workshop on Peer-to-Peer Systems (IPTPS)*, Santa Barbara, CA, USA, 2006.

[34] A. Modarresi, A. Mamat, H. Ibrahim, and N. Mustapha, "A Community-Based Peer-to-Peer Model Based on Social Networks," *IJCSNS International Journal of Computer Science and Network Security*, vol. 8 no.4, pp. 272-277, 30 April 2008.

[35] A. Crespo and H. Garcia-Molina, "Semantic Overlay Networks for P2P Systems," in *Agents and Peer-to-Peer Computing*. vol. 3601/2005: SpringerLink, 2005, pp. 1-13.

[36] L. Qiao, Z. Zheng, Y. Mao, B. Y. Zhao, D. Yafei, and L. Xiaoming, "An Empirical Study of Collusion Behavior in the Maze P2P File-Sharing System," in *27th International Conference on Distributed Computing Systems, ICDCS '07.* , Toronto, Canada, 2007, pp. 56-56.

[37] D. N. Kalofonos, Z. Antoniou, F. D. Reynolds, M. Van-Kleek, J. Strauss, and P. Wisner, "MyNet: A Platform for Secure P2P Personal and Social Networking Services," in *Sixth Annual IEEE International Conference on Pervasive Computing and Communications, PerCom '08*, Hong Kong, 2008, pp. 135-146.