Video Streaming Systems in Mobile Social Networks

Chenguang Kong

***Abstract*—Mobile has been witnessed as one of the most important methods for communication in recent year. Hands of applications have been proposed to promote its function. We present our novel contribution on mobile application based on social network. The particular scenarios of the application is set in museums or places of interests. We discuss how to implement the social network to facilitate peoples' communication.**

I. Introduction

Mobile phones show their powerful influence on daily communication. Telephone and sms are the basic services provided by mobile for social interaction. Now the development of wireless technology, e.g. Wi-Fi and Bluetooth, promotes people's communication though mobile. Even in the scenarios that mobile phones have never shown their appearance before, we can deploy mobile in the activities to exert the effect of social interaction.

This paper explores the potential scenario in which mobile can be deployed to promote peoples' communication. When we visit museums or places of interest, traditionally a guide is arranged if we want to make a better sense about the exhibits or the scenes. However, this costs extra expense and labors. In other case, the museums or the places of interest may deploy a screen, and keep on playing a video introducing the exhibits and scenes. The negativity lies that visitors arrive at different time slots. In most case, they have to start to watch from the middle of the video. Besides, they also have to watch the whole video before they find out the part they want mostly. That problem may be more serious when there are many people crowding in a certain exhibition.

To solve the problems, we propose the approach that visitors download the streaming media from the servers provided by the museums to their mobile. Then they can watch the certain part of the video at their will. However, the servers may be too busy to serve all visitors. So the visitors are encouraged to share data they have obtained to other visitors. Then a P2P streaming system is built.

One of the challenges of the system lies at the formation of network infrastructure.Given the particular scenario, we choose Bluetooth as the wireless technology to form the network for several reasons. First, the area of the application is limited in a small range, typically about 10 meters around. Bluetooth is effective in the area with such size. Second, Bluetooth is more widely deployed in mobile compared to Wi-Fi. Third, the battery energy consuming of Bluetooth is much less than Wi-Fi. That ensures visitors able to run the application for a longer time. Sometimes, the advantage is quite significant to visitors. Next, the usage of Bluetooth requires a special infrastructure to distribute data to visitors.

Another challenge involves the social interaction between visitors. Since visitors share their data with others, the incentive of visitors should be taken into consideration. One factor influencing visitors' strategy is the capacity of the battery. Visitors whose mobiles have high degree of battery energy have higher probability to be willing to share data to strangers. On the other hand, visitors whose batteries are nearly run out of may only intent to share data to their friends. It is significant to combine users' strategies to the design of the network infrastructure.

This paper analyzes the user requirement in museum content sharing system, and propose our novel design of the network infrastructure based on Bluetooth. We pay attention to the requirement and behavior of visitors, and form a scatternet network to satisfy the requirement. Besides, we implant our design of social network and users' strategies in the system. We present our model based on users' personal preference, which ensures that the system is practical and rational. Finally, we deploy a p2p streaming system in mobile platform. We foresee the potential of mobile based p2p system.

The rest of the paper is organized as follows: Sec. 2 discusses related works on mobile social network and Bluetooth architecture. Sec. 3 describes the system Architecture. Sec. 4 discusses our protocol design on the layers of the architecture. Sec. 5 present the simulation result and analysis. The rest talks about future work and conclusion.

II. Related Works

In this section, we review related works on mobile social networks and Bluetooth related background. Many works have presented their contribution on the application of mobile social network. Generally, such application can be divided into two categories. First can be called "centralized mobile social network". In this category, there is a server to provide service and store users' personal data. Users mainly share their profiles and data though Internet. Due to the characteristic of mobile, most of the applications in this category involve the location of users. Either do users share geotagged data to others or inquire the profiles of users in physical proximity.

Micro-Blog [1] is a typical example of the former. Micro-Blog talks about the scenario that people share the information they own to others though the Internet. Users generate geotagged multimedia by their mobile phones and update such data. Then others are allowed to query or browse them though either an Internet map service or in physical space as they move through

a location.
On the other side, Social serendipity [3] contribute on the communication between users in physical proximity. Users' profiles are stored in a web server and mapped with the Bluetooth MAC address of users' mobiles. One user is able to retrieve another's profile by enquiring the Bluetooth MAC address. Applications in this category include PeopleTones [10], Just-for-Us [9], and so on.
The other category of mobile social network is distributed mobile social network. There is no central server in this case. Users' profiles are stored in mobiles of themselves. When they move into the range of each other, they exchange the profiles directly and start the interconnection. Comparing to centralized mobile social networks, distributed mobile social networks have little demand on internet connection. There is also much less cost during communication compared to centralized mobile social networks. The connection is maintained only if related devices, e.g. WiFi, Bluetooth, are deployed. E-SmallTalker [2] is a typical example of this category. It discusses a solution to deal with the problem of social gap in physical proximity communication. Users exchange personal profiles without establishing a Bluetooth connection. PeopleNet [5] is another representative application based on distributed mobile social networks. It proposes an algorithm on multicasting messages to a group of devices in a mobile ad hoc network.

III. Architecture

The system architecture is discussed in this section.
During to the challenges, we propose a hierarchy architecture. Four hierarchy layer is defined in the architecture, named Bluetooth Network, Social Network, P2P Streaming and User Interface. In the architecture, different layers focus on different challenges, and design protocols to solve them. Figure 1 shows the hierarchy of the system architecture. The lowest layer is Bluetooth network. It mainly deals with the Bluetooth connection and file transfer protocols. It includes Bluetooth device discovery, service discovery, connection build up, streaming data transfer, etc. The second layer is social network . In this layer, we implement the strategies on the selection of users to connect based on social relationship. The upper layer is P2P streaming protocol. It involves the protocols of blocks transfer, blocks request, streaming player,etc. The highest layer is user interface, including users' actions and user profile.
The figure of the architecture is shown as follow:

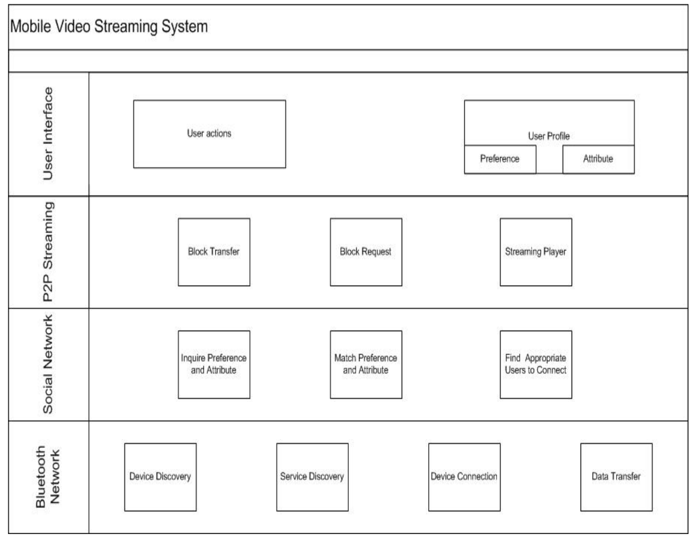

Fig. 1. Architecture

The details of every layers are presented in next section.

IV. System Design

In this section, we present our design for every layer of the system architecture. We first overview the basic concept of Bluetooth scatternet. Then we propose our protocol design on scatternet building up to implement the social relationship. We talk about the dynamic scenario in the system.

A. Bluetooth Network

When two Bluetooth devices come across, they will set up a *piconet* if they want to communicate with each other. In a piconet, the device initiating the connection takes the role of *master* while the other one becomes its *slave*. The max number of active slave devices in a piconet is limited to 7. Besides, the communication is performed only between master device and slave devices. Time-Division Duplex (TDD) is used for bi-directional communication.
A Bluetooth device can take part in different piconets concurrently. The BT devices timesharing among different piconets are called "*bridging node*". Several piconets connecting though some bridge nodes form a *scatternet*. Bridging devices can act as different roles in different piconets. In particular, a device can be a master of one piconet while a slave in another piconet. Although Bluetooth Specification has described the concept of scatternet, the methods for the foramtion and optimization of scatternet are not indicated. Furthermore, based on the particular request of our application on the performance of scatternet and the behavior of the bluetooth nodes, we propose an original approach to form our scatternet.

In this layer, the Bluetooth network provides the protocol for Bluetooth device to execute the series of operations. The procedure to download the data wanted is listed: First, users discovery other devices to get the names and the MAC addresses of the devices when they join the system. The names of the devices are used to identify the friendship between them. Then users inquiry other users' attributes and preferences though service discovery. The attributes and preferences obtained are used to select the most suitable users to connect to. The strategies to select users are introduced in social network part. Next, users establish connections to appropriate users, and send out the request for the data they want until they have download all data or the connections are broken.
When users have received data from others, they start to provide downloading service. They first published their service records. As described above, the service records store the

information of their attributes and preferences. Then they listen to the coming connection socket and output the data to receivers after the connection is established.
In this system, the network is a tree-based network. There are several reasons for the design. First, the RFCOMM protocol is the protocol used for Bluetooth streaming transfer. It requires that one device can only receive data from one device at one time. In that case, a mesh-based network is unavailable.

B. Social Network

One significant issues met in our system is visitors' concern about the social network. In this section, we propose our design on the efficient model of social network. The motivation of the design lies the consideration of users'selfishness and awareness of social relationship.

During the interactions with others, users will take into consideration their social relationship when they are inspired to share their data to others. It is naturally that someone is willing to share his data source to strangers while others will select their friends in real society as the only ones having the right to get their data. In this system, we divide the users to three categories:
(1)users distribute their data only to their friends.
(2)users are willing to provide their data to the users sharing the same attribute with them.
(3)users distribute their data to all other users including strangers.
User preference is influenced by different factors. The main factor is users' will. Besides, other factors also play an important role. For instance, the museum is probable to propose a incentive strategy to encourage users to share data to more users. Besides, the battery energy of mobiles may limit users'choice greatly. Users with limited battery energy will constraint the energy cost, and are more likely to choose a more selfish preference. On the contrary, users with full battery energy are more willing to distribute their data to others.
Besides user preference, each user should also indicate his attribute to the system. A necessary component of user attribute is the friend list, which indicates the friendship between him and other users. Besides, there are other information needed to show users social relationship. A typical example used in our system is the institutes or organizations users are.
Different users allow different users to download data from their devices. The method to judge wether a user has the privilege to download data from another user is based on user'preference and user attribute. We define three scenarios in which user attribute matches user preference:
(1)one node is a friend of the other node;
(2)one node share the same attribute with the other node while the other node is willing to distribute his data to others with the same attribute;
(3)one node is a stranger of the other node, but the other node is willing to share his data to strangers.
The privilege is authorized if and only if the social relationship between the two node satisfies one of the conditions.
We specific the steps for user A to get the list of users to whom he has the privilege to connect to as follows.
Step 1:User A inquires the information of users preference . We make user of service record in Bluetooth network to broadcast users' preferences.
Step 2:User A matches the preferences with his own attribute.Then he can get a list of users to whom he has the privilege to connect.
Step 3: User A set corresponding weight to the users in the list.We set a priority sequence to user with different style. Friends are the users we always want to connect to, so they have the highest priority.Next are the users sharing the same attributes with them. The strangers have the lowest priority. Such priority is built based on peoples'tendency to communicate with peoples more closely to them. According to the priority of users, we set different weight to different kinds of usersas follows.
Suppose user Y has privilege to connect to user X. Set $W(X,Y)$ means the weight of user X to user Y when Y consider to connect to X. Then

$$W(X,Y) = \begin{cases} a & : \text{user X is a friend of user Y} \\ b & : \text{user X share the same attribute with user Y} \\ c & : \text{user X is a stranger of user Y} \end{cases}$$

a, b, c are the parameter set by the system. They should satisfy:

$$a + b + c = 1; a, b, c > 0; a > b > c$$

Particularly, the weight of user X to user Y is set to 0 if user Y doesn't have the privilege to user X.

C. Streaming system

We propose our streaming protocol design in mobile network. In our system, users have different requests when they watch a streaming video. Some users watch the video from the start while some other users watch the video part attracting them. So we establish a VOD streaming system based on Bluetooth network.
Compared to Internet VOD streaming system, our system holds some special characteristic. First, the video to be distributed in our system is small. The time length of the video is typically about 5 min. Second, it is a highly dynamic system. Users join in or leave the system frequently. Besides, users may frequently change their connection to achieve better downloading performance. Third, the connection between users are limited. Users keep connecting to only a few number of users concurrently. Much extra works are cost if users want to change topology structure.
To have a better performance, an efficient strategy is necessary to select most suitable users as the data suppliers. It is a significant point that how much data the data suppliers can provide to satisfy the demand of users connecting to them. The more data a user can download from one user, the less time is needed to transform the connection. So a efficient user selection strategy can reduce the network load.
Another reason for an efficient strategy lies the demand

of broadcast.The nodes in Bluetooth network can only communicate with the nodes within the same piconet. The broadcast in Bluetooth network is only executed in piconet. To have a better broadcast performance, we had to arrange the users with similar playback procedure into same a piconet. So a parent node can broadcast the data to several children nodes if they have the same request.

We first calculate the fitness between data demander and supplier before we establish a connection between them. Each data supplier maintains a list showing the data blocks he holds as:

$$X = (x_1, x_2, \cdots, x_i, \cdots, x_n) = \tag{1}$$

$$\begin{cases} 1 & : \text{ user X holds data block i} \\ 0 & : \text{ user X doesn't hold data block i} \end{cases}$$

Besides, users also have a request list showing their request on data blocks:

$$Y = (y_1, y_2, \cdots, y_i, \cdots, y_n) = \tag{2}$$

$$\begin{cases} 1 & : \text{ user Y has request on data block i} \\ 0 & : \text{ user Y doesn't has request on data block i} \end{cases}$$

Then we can calculate the fitness between user X and user Y:

$$F(X,Y) = \sum_{i=1}^{n} x_i * y_i$$

The fitness is combined with Social network analysis to provide an efficient user selection strategy. Then we can get a measurement of the priority when we consider to connect to a user:

$$M(X,Y) = W(X,Y) \cdot F(X,Y)$$

Based on the model we build for user selection, users can obtain a sequence of users with different priorities. Such priority is calculated according to both social network and the matching of data demand and supply. User will choose the user with the highest priority to connect.

Broadcasting is another challenge we make effort to solve. We propose our protocols to maximize the degree of broadcast during the streaming distribution. First,we execute a user selection to select the most appropriate user when we initial a new connection. The design is described above. Second, we optimize the data distribution scheduling when parents nodes distribute data to their children nodes. At the beginning of each round, the parents nodes gather the data demand from children nodes. As the children nodes with same parents nodes have similar data demand, it is quite probable that they require same data blocks. Then the parents nodes will find out the data block required by most children nodes currently. So there are as many as possible children nodes able to download data blocks from parents nodes in each round. In this way, the performance of broadcast in Bluetooth network is optimized.

V. Simulation Result

VI. Conclusion

References

[1] Shravan Gapnkar , Jack Li , Romit Roy Choudhury and Landon Cox , Al Schmidt." Micro-Blog: Sharing and Querying Content Through Mobile Phones and Social Participation", In *Proc. 6th Int'l. Cong. on Mobile Systems*, Breckenridge, Co, Jun. 2008.

[2] Zhimin Yang, Boying Zhang, Jiangpeng Dai, Adam C. Champion, Dong Xuan, Du Li, "E-SmallTalker: A Distributed Mobile System for Social Networking in Physical Proximity", In Proc. 30th ICDCS, Genoa, June 2010

[3] N. Eagle and A. Pentland. "Social Serendipity: Mobilizing Social Software." In *IEEE Pervasive Computing, Special Issue: The Smartphone*, pp. 28-34, April 2005.

[4] M. Terry, E. D. Mynatt, K. Ryall and D. Leigh. "Social Net: Using Patterns of Physical Proximity over Time to Infer Shared Interests." In *Proc. Human Factors in Computing Systems (CHI)*, ACM Press, pp. 816C817, 2002.

[5] M. Motani, V. Srinivasan, and P. S. Nuggehalli. "PeopleNet: Engineering A Wireless Virtual Social Network." In Proc. of the 11th Annual Int'l. Conf. on Mobile Computing and Networking (MobiCom), pp. 243C257, 2005.

[6] Anupriya Ankolekar, Gabor Szabo, Yarun Luon, Bernardo A. Huberman, Dennis Wilkinson, Fang Wu, "Friendlee: a mobile application for your social life", In Proc. 11th MobileHCI, September, Bonn, 2009

[7] Bluetooth.com. The Official bluetooth website. http://www.Bluetooth.com/.

[8] Bluetooth.org. The Official bluetooth membership site. http://www.Bluetooth.org/.

[9] J. Kjeldskov and J. Paay. "Just-for-Us: A Context-Aware Mobile Information System Facilitating Sociality." In Proc. 7th Intl. Conf. on Human Computer Interaction with Mobile Devices & Services, Salzburg, Austria, Sep. 2005.

[10] K. Li, T. Sohn, S. Huang, W. Griswold. "PeopleTones: A System for the Detection and Notification of Buddy Proximity on Mobile Phones." In Proc. 6th Intl. Conf. on Mobile Systems (MobiSys),Breckenridge, CO,Jun. 2008.

[11] Bluetooth Specification Version 2.0 + EDR [Online]. Available: http://bluetooth.com/Bluetooth/Technology/Building/Specifications/

[12] Anna-Kaisa Pietilainen, Earl Oliver, Jason LeBurnMobiClique, "MobieClique: Middleware for Mobile Networking", in WOSN 2009.

[13] M. Musolesi and C. Mascolo. "Designing Mobility Models based on Social Network Analysis." ACM SIGMOBILE Mobile Computing and Communication Review. 11(3). July 2007.

[14] Brendan J. donegan, Daniel C. doolan, Sabin Tabirca, "Mobile Message Passing Using a Scatternet Framework". In Internation al Journal of Computers, Communications & Control Vol. III(2008), No. 1, pp. 51-59.