Video Streaming Systems in Mobile Social Networks

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***Abstract*—With the proliferation of wireless technologies and mobile devices, more and more novel applications and functionalities are being implemented on the mobile platform. Exploring social connections among the mobile users, mobile social networks have emerged as new platforms to facilitate novel social networking applications. Preliminary applications in a mobile social network include message routing and content searching. However, how to efficiently utilize the social connections to enable more resource-demanding content-sharing applications on the mobile platform, remains a significant challenge.**

In this paper, we present our works on the design and implementation of a video streaming application in mobile social networks. As one of the motivating scenarios, we consider the streaming of introductory videos to exhibition items, in the setting of a museum or an expo. Visitors on the scene stream the video clips to their mobile phones in a P2P fashion. We study how the streaming topology can be constructed by exploiting the Bluetooth infrastructure, as well as exploring the social connections among the participants. We also seek to evaluate the system design based on prototype implementation on the Android platform.

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 novel powerful application can be deployed in mobile network. Today, most of the applications on the communications though mobiles are limited in the area of exchanging of small size data, such as messages. People send out messages to or receive massages from others or internet. The communication is operated though small size messages. However, there are few applications developed to transfer files with large size. File transfer though mobiles brings great convenience for products advertising, file diffusing, document exchanging, and so on. Such communication activities often occur in public location where people can't access to their personal computers to transfer the data though wire network. The most convenient devices to them are their mobile phones. They can enjoy a P2P data downloading system as those in wire network while they keep the character of mobility in mobile wireless network.

Besides, social network has emerged as a hot and wonderful topic and is implemented in series of mobile network applications. But most applications focus on message routing and content searching. The users in those applications often have no sense about the social relationship among them.In that case, we aim to propose a novel efficient social network model based on the social relationships and deploy it to facilitate the data transfer system.

A video streaming system is designed in our paper based on mobile social network. Video distribution is a large partition in data distribution both in wire network and mobile wireless network. We have an insight into users'requests in such a system and propose our protocol design. A typical scenario of the system is introduced in the following.

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.

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 commonly 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.

One of the challenges of the system lies the approach to model the social network and implement it in the system. Our social network is built based on the social relationship in real society. It is a core question that how to categorize the users and their social relationship. After the social relationship is categorized, how the social relationship influence the behavior of users is another significant question we must overcome.

Another challenge involves the streaming system in mobile social network. There are kinds of wire streaming system such as PPStream and UUsee. However, there are many differences in the streaming system in mobile network. One of them is the mobility. So we have to propose our protocol design on the particular demand of the network. Besides, the social network is implemented in the system. We also should combine the social network model into our streaming protocols.

To address the challenges, we novelly propose our social network model. We analyze users social attributes and personal preference to collaborate with others. Then we define users behavior according to their attributes and preferences. The social network model is combined with the streaming system protocol. We also discuss the protocols of streaming system in mobile network. We discuss the appropriate structure in the scenario and the factors to obtain a better performance.

The contributions of this paper include: First, we propose a novel social network based on the social relationship of users. Users take different operations to different people. We divide users into different categories according to their social attributes and preference. The social network will influence the connection building between users, the structure of the streaming system, and so on. Second, we present our design on streaming system in mobile network. We discuss the suitable structure in our scenario and protocols on peer selection. The protocols to promote broadcasting is also designed.

The rest of the paper is organized as follows: Sec. 2 discusses related works on mobile social network. Sec. 3 discusses our protocol design.Sec. 4 describes the system 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 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 geo-tagged 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. Protocol Design

In this section, we present our approach to implement social network and streaming system in mobile network based on the scenario in our system.

A. 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.

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 users as 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.

B. Streaming system

We propose our streaming protocol design in mobile network. There are a few factors considered in our system. First is the appropriate structure of the streaming system. Second is the approach for users to select peers. Third is the broadcast design implemented in the system.

1) The Structure of Streaming System: Today, researchers have developed different kinds of structures for wire streaming system. It is our works to find the most suitable structure based on our scenario and user demands. Basically, the structure of streaming system can be divided into two categories, tree based and mesh based.

First of all, our system is built as a VOD streaming system.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.

Our system is built as a tree based streaming system. Such design is mainly decided by the requests of our scenario. In our system, we use Bluetooth to communicate and transfer the data. In Bluetooth network, one peer can only receive data from one other peer at the same time according to the RFFCOM protocol. In that case the relationship between data supplier and data receiver is similar with parent node and child node in tree based structure. Besides, the limitation of social network indicates that each user can only access to certain kinds of users. Among those users, some ones are more appropriate to connect than others because they own more data wanted by him. There is the most appropriate user to connect. We choose the most appropriate user as the parent peer to get an effective performance.

In the system, a server is provided to provide the initial streaming data. So it is the first layer of the tree. Every parent peer has different children peers. And every parent is the most appropriate user of his children. The approach to select the most appropriate is discussed in the following content.

2) Approach to Select Peers: The system 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. However, much extra works are cost if users want to change topology structure. So it is important to reduce the times needed to reduce the cost for connection changing.

An efficient approach to select most suitable users as the parent peer is necessary. If We can choose the most appropriate user as the parent peer each time when we need to build a new connection, we can achieve the least times to change the connection. It is a significant point of the approach 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:

$$Y = (y_1, y_2, \cdots, y_i, \cdots, y_n) = \quad (2)$$

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

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.

3) Broadcast Mechanism: Broadcasting is another challenge we make effort to solve. Broadcast is a fundamental character of wireless network. 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 approach 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 requests 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.

IV. System Architecture

The system architecture is discussed in this section.

According to the protocol design, 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:

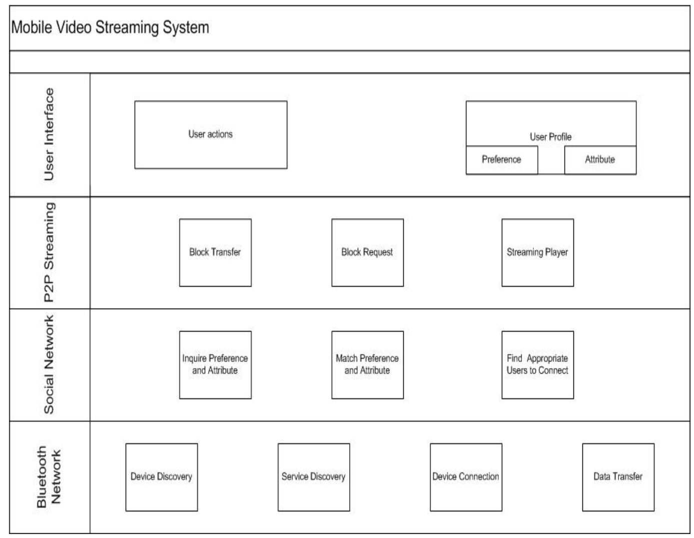

Fig. 1. Architecture

A. Work Flow

Based on the system we have built, the behaviors of users to download the video streaming is defined. Next we will describe the work flow of users to download the data from other users

Step 1. New users join in the system. When a user join in the system, he should first custom his own user profile, including name, preference and attribute. Besides, the information on the data he supplies and requires is also initialed.

Step 2. Obtain the information of other users in the system and broadcast his own information. The information obtained includes three parts. First part is the user profiles. Second part is the information on connection, such as the device address, service record UUID. The last part is the information on data users providing. This part is used to match with the request of user.

Step 3. User finds out the most appropriate user based on both social network and data matching.

Step 4. User connects to the user chosen as a child user and sends the data request list to parent user.

Step 5. The parent user updates the request information he gathers. The data request will be added to the request list of the parent user if there isn't such data in parent user.

Step 6. Parent user chooses the most wanted data block and broadcast it. Before broadcasting, the parent nodes notice their children peers which block is broadcast so that users can sense whether it is the data they want.

Step 7. Then update the request information. Initial the weight of the data block just transferred. If there are any users disconnect the connection with parent user, the request information from them is cleared.

Step 8. Turn to step 3 to start the next round of data transfer.

V. Simulation Result

VI. Conclusion

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