Lappeenranta University of Technology
Faculty of Information Management
Department of Information Technology

Social Networking on Mobile Environment on top of PeerHood

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Supervisors: Professor Jari Porras
M.Sc. Arto Hämäläinen
(Lappeenranta University of Technology)

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Bishal Raj Karki
Punkkerikatu 5 A 1
53850 Lappeenranta
Finland
bishal.karki@lut.fi
bishalonline@hotmail.com

ABSTRACT

Lappeenranta University of Technology
Department of Information Technology

Karki, Bishal Raj

Social Networking on Mobile Environment on top of PeerHood

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59 pages, 17 figures, 8 tables and 2 appendices

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Social networking and social networking sites have gained popularity among internet users during the past few years. Social networks fulfill the need of users to stay connected to friends and other people interested in the same issues. Combining social networks to the mobile environment is a growing interest of mobile device users as it allows the users to be in their online social community despite their mobility.

This thesis highlights the basics of mobile environment, social networking and PeerHood and introduces a new approach of social networking on mobile environment, which is a new concept in mobile social networking. This approach is based on dynamic group discovery in accordance to some common user interests and management in the PeerHood environment.

A reference implementation of a social networking application built on top of PeerHood is presented and it is tested and analyzed to understand the social networking on mobile environment and the new concept of dynamic group discovery in it.

TIIVISTELMÄ

Lappeenrannan teknillinen yliopisto
Tietotekniikan osasto

Karki, Bishal Raj

Sosiaalinen verkottuminen mobiiliympäristössä hyödyntäen PeerHood-tekniikkaa

Diplomityö

2008

59 sivua, 17 kuvaa, 8 taulukkoa ja 2 liitettä

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Hakusanat: Sosiaalinen verkosto, mobiiliympäristö, PeerHood, kiinnostus, dynaaminen ryhmän etsintä

Sosiaalinen verkosto ja sosiaaliset verkottumissivustot ovat kasvattaneet suosiotaan internetkäyttäjien keskuudessa viime vuosina. Sosiaaliset verkostot mahdollistavat käyttäjien yhteydet ystäviin ja muihin samoja kiinnostuksen kohteita omaaviin henkilöihin. Sosiaalisten verkkojen käyttö mobiiliympäristössä on tullut suositummaksi, mobiilikäyttäjät haluavat pysyä yhteydessä sosiaaliseen yhteisöönsä liikkuvuudestaan riippumatta.

Tämä diplomityö keskittyy mobiiliympäristön perusteisiin, sosiaaliseen verkottumiseen ja PeerHood-tekniikkaan, sekä esittelee uuden lähestymistavan sosiaaliselle verkottumiselle mobiiliympäristössä, joka on uusi konsepti mobiilille sosiaaliselle verkottumiselle. Tämä lähestymistapa perustuu dynaamiseen ryhmän etsintään tyypillisten käyttäjän kiinnostusten mukaan, sekä ryhmien hallintaan PeerHood-ympäristössä.

Käytännön toteutus sosiaalisesta verkottumissovelluksesta PeerHood-ympäristöön on esitelty, testattu ja analysoitu sosiaalisen verkottumisen ja uuden dynaamisen ryhmän etsinnän konseptin ymmärtämiseksi mobiiliympäristössä.

PREFACE

This thesis is a result of my master's degree studies at Lappeenranta University of Technology, Finland. The entire thesis work was conducted at the Communications Software Laboratory (ComLab).

During this thesis work, I encountered many problems. But, because of the determination and the helpful cooperation from the supervisors, ComLab colleagues and other friends, I finally accomplished it successfully.

Especially, I would like to thank M.Sc. (Tech) Petri Hiirsalmi for his high valued recommendation and my first supervisor Professor Jari Porras for inspiring me on this topic and giving me **THE GREAT CHANCE** to carry out my thesis work at the ComLab. It was really an honor for me.

I would like to express my sincere gratitude to my second supervisor M.Sc. (Tech) Arto Hämäläinen, for his unbounded help and valuable suggestions during the thesis duration and I truly mention that without Arto's kind cooperation, I would never had come closer to achieve this goal.

I thank my parents and sister for supporting me throughout my studies here in Finland. I thank Riitta Salminen for her incredible support and also thanks to Sapna from my heart for encouraging me to do my works perfectly.

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Bishal Raj Karki

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ABBREVIATIONS

3G	Third Generation
AES	Advanced Encryption Standard
AIESEC	Association Internationale des Étudiants en Sciences Économiques et Commerciales
AMD	Advanced Micro Devices
AP	Access Point
BNEP	Bluetooth Network Encapsulation Protocol
BTPlugin	Bluetooth Plugin
ComLab	Communications Software Laboratory
CPU	Central Processing Unit
DES3	Triple Data Encryption Standard
GB	Gigabytes
GHz	Gigahertz
GPRS	General Packet Radio Service
GPRSPlugin	General Packet Radio Service Plugin
GSM	Global Systems for Mobile Communications
IBM	International Business Machine
IEEE	Institute of Electrical and Electronics Engineers
IM	Instant Messaging
IP	Internet Protocol
IrDA	Infrared Data Association
L2CAP	Logical Link Control and Adaptation Protocol
LAN	Local Area Network
LMP	Link Manager Protocol
MAN	Metropolitan Access Networks
MB	Megabytes
Mbps	Megabits per second
MHz	Megahertz
MMS	Multimedia Message Service
MP2P	Mobile peer-to-peer
MSC	Message Sequence Chart

OS	Operating System
P2P	Peer-to-peer
PAN	Personal Area Network
PC	Personal Computer
PDA	Personal Digital Assistant
PHC	PeerHood Community
PHD	PeerHood Daemon
PIN	Personal Identification Number
PPP	Point-to-Point Protocol
PTD	Personal Trusted Device
RF	Radio Frequency
RFCOMM	Radio Frequency Communication
RFID	Radio Frequency Identification
SDP	Service Discovery Protocol
SMS	Short Message Service
SNS	Social Networking Site
URL	Uniform Resource Locator
WAP	Wireless Access Protocol
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WLANPlugin	Wireless Local Area Network Plugin
WPA	Wi-Fi Protected Access

1 INTRODUCTION

Social networking has been a growing trend among Internet users for the last few years and the desire to stay connected has enabled the growth of many social networking sites (SNSs) like Facebook [1], Hi5 [2], Linkedin [3], MySpace [4] etc. It has been estimated that more than 3 billion people or half the world's population, own a mobile device [5]. Today, the number of mobile device users is growing higher and is same with SNS users. The mobile devices are very much advanced in technologies; they are equipped with latest technologies like Bluetooth [6], Wireless Local Area Network (WLAN) [7], General Packet Radio Service (GPRS) [8][9], Third Generation (3G) [10] etc. Accessing traditional SNSs through mobile devices is common, but having Social Network on the mobile environment and accessing it through the assistance of technologies like Bluetooth is a new concept.

Mobile environment can be said to be an environment essential for mobile computing where portable wireless devices access data and information services regardless of their location and mobility. Mobile devices, networking technologies, protocols, and middleware are considered major aspects of a mobile environment. Peer-to-peer (P2P) [11][12] communication in mobile environment is considered as a great development in the field of mobile communication. PeerHood [13][14] also known as P2P neighborhood is a network management middleware that works as a personal area network for personal trusted devices (PTDs) [15][16] and offers an interface to the middleware modules on top of it.

Developing social networks on mobile environment or implementing ideas of social networking into a mobile environment in the form of middleware is the prime concern of this research.

Social networking reference application where a mobile peer communicates with other peers in mobile environment through Bluetooth or any other wireless technology was built. With this new type of social network, people can create own profile, view and list their interests. When a peer approaches near another peer, groups are formed

dynamically, if any interest matches between them. Like in SNSs, one member can view another members profile, interest and comments. The peers can send short messages to each other and on accepting the peer as a trusted friend, that trusted peer can view what files the accepting peer has shared and use them if needed. The reference application is built on top of PeerHood and it is tested and analyzed.

1.1 Objective of the research

The objective of this research is to understand the social networking environment in mobile devices that use some existing wireless technologies like Bluetooth, WLAN, GRPS etc for mobile communications and to realize the essence of dynamic group discovery on mobile environment.

It also deals with a practical implementation as a case study in this work. A social network test application on mobile environment on top of PeerHood was developed, implemented and analyzed.

1.2 Research Questions

Increasing interest on social network and rapid development of fast processing mobile devices leads to ones desire to implement and use social networking applications very efficiently on those mobile devices or PTDs.

The questions that drive this research are:

- What is social networking on mobile environment? Can social networking be done on mobile environment? If yes than what it is the difference between social network on mobile environment and SNSs?

- What actually is “Social Networking on top of PeerHood”?

- What is Dynamic group discovery in social networking on mobile environment?

1.3 Thesis Outline

This thesis consists of an introductory part and five other chapters. The introductory part gives a brief overview of the entire research work. Objectives of the research and research questions are clearly stated in this part. Rest of the introductory part is organized as follows.

Chapter 2 introduces the environment for mobile communication, i.e. mobile environment and defines and explains some related terms like PTD, P2P etc in context to mobile environment. This chapter will also focus on some existing hardware technologies like Bluetooth, WLAN and GPRS which could be used for wireless communication in mobile environment.

Chapter 3 mainly deals with various aspects of social networks. It starts with the definition of social network, social network on internet and SNSs with some reliable statistics, a short literature review and few popular examples of SNSs. Then finally a detailed explanation of social network on mobile environment is given.

Chapter 4 outlines the definition, history and introduction of PeerHood and describes the essence of mobile P2P (MP2P) communication in it. It explains the concept, architecture and functionality of PeerHood. This chapter also includes a short introduction about middleware communication software and applications on mobile environment on top of PeerHood.

Chapter 5 explains social networking on top of PeerHood. This chapter is divided into two parts. First part explains the conceptual part of social networking on top of PeerHood and focuses on dynamic group discovery on mobile environment. It discusses the development issues, used technologies, understandings, advantages, disadvantages and feasibility of social networking on mobile environment on top of PeerHood.

The second part of chapter 5 is totally dedicated to a test application developed in ComLab. The application is named as PeerHood Community. It is a social networking application in mobile environment, built on top of PeerHood. This application works in full cooperation with the service level of the PeerHood. In this chapter, some sequence diagrams and important code snippets are also included. A brief explanation of Client and Server, output, features, analysis, benefit, disadvantages and feasibility of the test application are also discussed here.

Chapter 6 concludes the thesis answering those research questions stated in the introductory part and states some important future works in this field.

2 Mobile Environment and its aspects: A Literature Review

This chapter outlines the environment for mobile communication and some important aspects of communication in mobile environment.

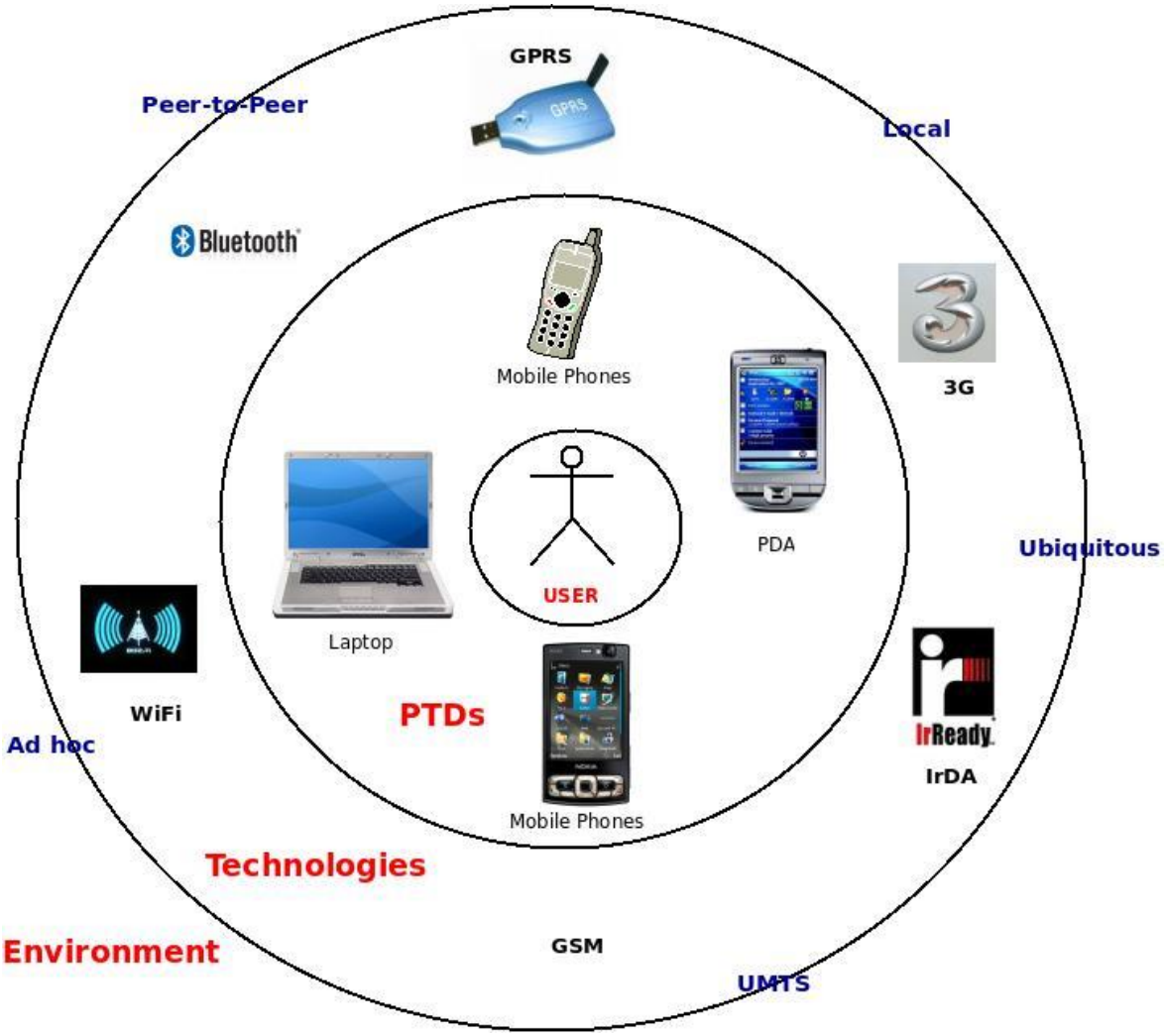

Figure 1: Mobile Environment and its aspects (source: [15])

Figure 1 demonstrates the various aspects of mobile environment. Among various essential factors of mobile environment, Peer-to-peer communication, personal trusted devices, mobile devices and the technologies used in the mobile communication are considered here to be its important aspects and explained in context to each other. From

these outlines, a clear concept of mobile environment can be visualized and its underlying working fundamentals could be understood.

2.1 Mobile Environment

According to the Merriam-Webster's online dictionary, environment is the circumstances, objects, or the conditions by which one is surrounded, also it states environment is an interface from which various tasks can be performed [17]. When a mobile device communicates with another mobile device or fixed device, then the entire surroundings, circumstances, objects, conditions, technology, protocol, interface etc all which assist the mobile device to communicate as desired is taken in whole as a mobile environment.

According to J. Jing et al. "*in mobile computing, users who carry portable devices have access to data and information services regardless of physical location and movement behavior*" [18]. From this statement, mobile environment can be the environment essential for mobile computing also it can be said as an environment where the portable wireless devices access data and information service disregard of the location and mobility.

Within the scope of this thesis, the entire combination of mobile devices or PTDs, a P2P communication protocol, P2P neighborhood, technologies like Bluetooth, WLAN, GPRS etc which takes part in desired mobile communication is considered as a mobile environment. With contrast to normal communication environment, mobile environment does not care about physical locality and the mobility of the communicating devices unless within the range of the hardware technology used in the communication.

2.2 Peer-to-Peer (P2P)

In P2P network the end user nodes communicate directly with other end nodes. There is no centralized infrastructure. P2P systems are distributed systems with each peer acting as both client and server and using shared resources more efficiently between the peers. **"***The term peer-to-peer refers to the concept that in a network of equals (peers) using appropriate information and communication systems, two or more individuals are able to spontaneously collaborate without necessarily needing central co-ordination. In contrast to client/server networks, P2P networks promise improved scalability, lower cost of ownership, self organized and decentralized coordination of previously underused or limited resources, greater fault tolerance, and better support for building ad hoc networks.*" [19]

There exists several approaches for P2P communication in fixed network like Napster [11] [20], Gnutella [20], Power Server Model [11] etc but these approaches for fixed networks are not beneficial for mobile environment. P2P is suitable for mobile networks since it allows truly dynamic networking. Some approaches of P2P in mobile environment are mentioned in [20][21][22].

P2P in mobile environment can be explained as the distributed communication disregard of physical location and mobility where peers can be found on the network with dynamic discovery across firewalls. Sharing of resources with anyone across the network and secure communication with other peers on the network is possible. Mobile Peer-to-Peer (MP2P)[12] is characterized firstly as it is truly access independent i.e. any access method like wireless, cellular, LAN based can be used. Secondly, the services of MP2P are transport independent i.e. any services must be able to be transported over any type of transport and access.

2.3 Personal Trusted Device (PTD)

Mobile phones are used for communication and Personal Digital Assistant(PDAs) also known as handheld computers serves multipurpose activities like information storage,

access and modification, entertainment and web access etc and they contain multiple specific applications for specific purpose. These devices are personal devices and owned by a single person for the single use. Trust is a factor of reliance and the reliable personal devices which can be trusted are termed as PTDs [15][16]. PTDs offers strong authentication of the users for the services whenever necessary. PTDs may also allow anonymous personalization besides strong authentication of the single owner. Owner of PTD carries the device anywhere almost all the time together and the user uses it in both local and global communications. The owner of the device can trust on the information that are held inside. It is also believed that the informations in PTDs are not tampered and holds high level of trust and reliance and sometimes information can be very personal and confidential.

All the personal devices like mobile phones, PDAs, Smartphone, communicators, iPhones etc. all could be commonly considered as PTDs. Specifically in this research work, mobile phones and PDAs are referred as PTDs.

2.4 Existing wireless technologies for communication on Mobile Environment

There exist numerous wireless technologies which could be used for communication on mobile environment. Bluetooth, WLAN, GPRS are the most popular and widely used in present day MP2P communications. Some basic aspects of those common technologies are explained below.

2.4.1 Bluetooth

Bluetooth is a wireless protocol which uses short range radio links between the different nodes or connected units for data communication over short distances from fixed and/or mobile devices, creating wireless personal area networks (PANs) [6]. Even though it has not been long that Bluetooth has been introduced, it gained a wide popularity in short range mobile communication. The reason behind is Bluetooth is advantageous over other data transmission technologies like InfraRed Data Association (IrDA) since it

covers more distance and does not depend on the line of sight as in IrDA [23]. Almost all PTDs today are equipped with Bluetooth technology.

Bluetooth communication always exists in pairs and one act as a master and other acts as a slave. The simplest Bluetooth network topology is a piconet [24] with single slave operation; it is a simple point to point connection and is used by many Bluetooth applications. Bluetooth operates in the 2.4GHz radio band for industrial, scientific and medical use [25]. This radio band is limited to frequency ranging from 2400 MHz to 2483.5 MHz [25]. While connecting devices through Bluetooth, the Bluetooth device address of other device is known through device discovery procedure and connection is established between these devices.

The general Bluetooth protocols are Link Manager Protocol (LMP) [26], Logical Link Control and Adaptation Protocol (L2CAP) [27], Service Discovery Protocol (SDP) [28] and Radio Frequency Communications (RFCOMM) [29]. Bluetooth consists of security architecture suitable for personal use and uses Personal Identification Number (PIN) code as a shared secret authentication keys.

2.4.2 Wireless Local Area Network (WLAN)

WLAN [7] or wireless LAN simply is a local area network without wires. WLAN enables mobile communication between devices in a limited area or in the limited range of the WLAN hardware used. This technology is widely used in portable devices for web access. Nowadays WLAN is common in numerous personal devices for getting connected to the Internet or some network in a mobile environment. WLAN allows users or PTDs the mobility to move around within a broad coverage area and still remains connected to the network.

Wireless LAN supports Infrastructure mode implemented using Access Point (AP) and Ad-hoc mode implemented without AP [30]. Inter-networking with wired LAN is allowed in infrastructure mode based on AP and communication range is longer. Network is configured with wireless LAN equipment without AP in Ad-hoc mode and has an advantage of saving AP cost. Inter-networking with wired LAN is not allowed in

Ad-hoc mode and communication range is comparatively short [30].

There exists various wireless networking standards as listed in Table 1.

Table 1: WLAN Standards. (source: [31])

Standard	Data Rate	Security	Description
IEEE 802.11	Upto 2Mbps in the 2.4GHz band	WEP WPA	This standard was extended to 802.11b
IEEE 802.11a (Wi-Fi)	Upto 54Mbps in the 5GHz band	WEP and WPA	Eight available channels. Less potential for RF interference than 802.11b and 802.11g. Better than 802.11b at supporting multimedia voice, video and large-image applications in densely populated user environments. Relatively shorter range than 802.11b. Not interoperable with 802.11b.
IEEE 802.11b (Wi-Fi)	Up to 11Mbps in the 2.4GHz band	WEP and WPA	Not interoperable with 802.11a. Requires fewer AP than 802.11a for coverage of large areas. Offers high-speed access to data at up to 300 feet from base station. 14 channels available in the 2.4GHz band
IEEE 802.11g (Wi-Fi)	Up to 54Mbps in the 2.4GHz band	WEP and WPA	May replace 802.11b. Improved security enhancements over 802.11. Compatible with 802.11b. 14 channels available in the 2.4GHz band
IEEE 802.16/a (WiMAX)	10 to 66 GHz range	DES3 and AES	IEEE 802.16 is a specification for fixed broadband wireless metropolitan access networks (MANs)

2.4.3 GPRS

GPRS [8][9][32] is a packet oriented mobile data service for Global System for Mobile Communications (GSM) users. It is widely used by the telecom providers throughout the world for various purposes or services like Short Message Service (SMS), Multimedia Message Service (MMS), Wireless Access Protocol (WAP) access, internet communication services such as email and World Wide Web (WWW) etc. In GPRS the connections are routed through the GPRS gateway. GPRS is very common today among the mobile device users even though it is very expensive and is charged on the basis of data transfer rate.

GPRS is a data network that overlays a second-generation GSM network. This data overlay network provides packet data transport at rates from 9.6 to 171 kbps. Additionally, multiple users can share the same air-interface resources simultaneously. GPRS systems support both X.25 and IP network layer protocols. One of the main requirements in the GPRS network is the routing of data packets to and from a mobile user and this is done by either data packet routing or mobility management [33].

2.4.4 Others

The other technologies for wireless communication on mobile environment are Infrared standard by IrDA [23], Radio Frequency Identification (RFID) [34] and ZigBee [35] etc. IrDA is a short range data transfer technology that uses infrared as a physical network layer and it needs a visual communication/line of sight to transfer data. IrDA has a limited range and operates on a straight limited direction so it is considered disadvantageous in comparison to other wireless technologies like Bluetooth and WLAN [23].

RFID is a technology which is based on an antenna, a transceiver and a transponder. A transponder is a RFID tag with unique information. RFID is an automatic identification method which relies on storing and remotely retrieving data using RFID tags and it requires a cooperation of an RFID reader and an RFID tag for communication [34].

ZigBee supports low data rates, low power consumption and security. ZigBee is a wireless technology based on the IEEE 802.15.4-2006 standard for wireless PANs. It is very essential for devices which require low latency, low data rate, long battery life, secure networking and does not require very high bandwidth. ZigBee is considered simpler and cheaper than Bluetooth [35].

3 Social Networking on Mobile Environment

This chapter mainly focuses on social networking and its basic forms. Firstly, social network is explained focusing on physical social network. Secondly, social networking on Internet and various popular SNSs are discussed and lastly, social networking on mobile environment is presented.

3.1 Social Networks

Social network literally means a group of people sharing common interests, motives, background and various other personal aspects. Basically, any organization, group or any club where people work together or share a common motive, goal or interest is social network. Technically social network refers to a social structure comprising of various nodes and links representing participants and their relationship [36]. Users in social network know other users directly or indirectly and can communicate with various unknown persons that share some common interest [37]. Social networks can be formed physically as a social community or it can be a logical social network which could exist on Internet or on a mobile environment. The major factors involving in the formation of the social networks are interest and different age groups. For example, AIESEC [38] is one of the oldest social networks of students where various students of different universities and different countries interact with each other, share their valuable experiences and exchange their cultures. There exist numerous such physical social networks and have been a part of people's behavior and need throughout the passage of time since centuries.

3.2 Social Networking on Internet

Social networking on Internet is simply online network which focus on building online communities of people sharing activities and interests or interested in exploring others activities and interests. SNSs are social networks on internet and they are web based

services which provide numerous ways of interaction for the users such as profiling, commenting, uploading pictures, e-mail, instant messaging, file transfer, finding an old friend, finding a stranger with same interests etc [37][39][40][41]. SNSs are very popular among the internet users and they have been used as a way to keep in touch with friends and even strangers. Some popular SNSs are MySpace, Facebook, Hi5, LinkedIn etc. MySpace is the largest SNS with 217,000,000 registered users [39].

Table 2: Social networking sites and their registered users. (source: [39])

SNS	**URL**	**Focus**	**Registered Users**
MySpace	myspace.com	Videos, movies, IM, news, blogs, chat	217,000,000
Facebook	facebook.com	Upload photoes, post videos, get news, tag friends	58,000,000
Friendster	friendster.com	Search for and connect with friends and classmates	50,000,000
Classmates	classmates.com	School, college, work and military groups	40,000,000
Windows Live Spaces	spaces.live.com	Blogging	40,000,000
Broadcaster	broadcaster.com	Video sharing and webcam chat	26,000,000
Fotolog	fotolog.com	338 million photoes around the world	12,695,007
Flickr	flickr.com	Photo sharing	4,000,000

Table 2 shows the list of few popular SNS, their web address, motives and number of registered users. From this table we can figure out what actually social networks are and what SNS is. "*55% of online teens have created a personal profile online, and 55% have used social networking sites like MySpace or Facebook*" [41]. Mostly young users are attracted towards SNSs. The age factor and interest plays a great role in joining any online community or simply being in a social network.

The major requirements/needs of the SNS are the users, users' interest behaviors, a fast Internet connection and a computer or a smart device to access. SNS needs a centralized server and a centralized database system. Users' registration and all other essential information are stored in the centralized database and users access the centralized server through a web page. Administrator for service maintenance is another need of SNS. Dynamic group discovery [42][43] is not present in SNS, so users need to create their interest group themselves and advertise it to others to join that group. Group management is the major issues in SNS.

3.3 Social Networking on Mobile Environment

A majority of world's population own mobile device. Accessing Internet through mobile devices is common these days. As SNSs are very popular, many people access SNSs through their mobile devices. Even though social networking on mobile environment sounds very much similar to accessing SNS through mobile device, they differ a lot. The concept of mobile environment when applied to the context of social networking, accessing SNSs through mobile device and social networking on mobile environment however are two completely two different aspects of social networking. Social networking on mobile environment refers to those social networks in wireless environment where mobile nodes do not connect to any centralized servers like in SNS and they communicate with each other using some existing network technology like Bluetooth, Wi-Fi, GPRS etc.

On this form of social network, technology plays a great role in categorizing similar users or users with similar interests, activities and motives. As on mobile environment, creating some groups and searching for the members with similar interests and requesting them to join that newly created group is highly ineffective, more time consuming and cost expensive. So, considering the expense of time and cost, the concept of dynamic group discovery [44][45] according to one aspect of user behavior like interest, activity, location etc exactly fits with the context of social networking in mobile environment.

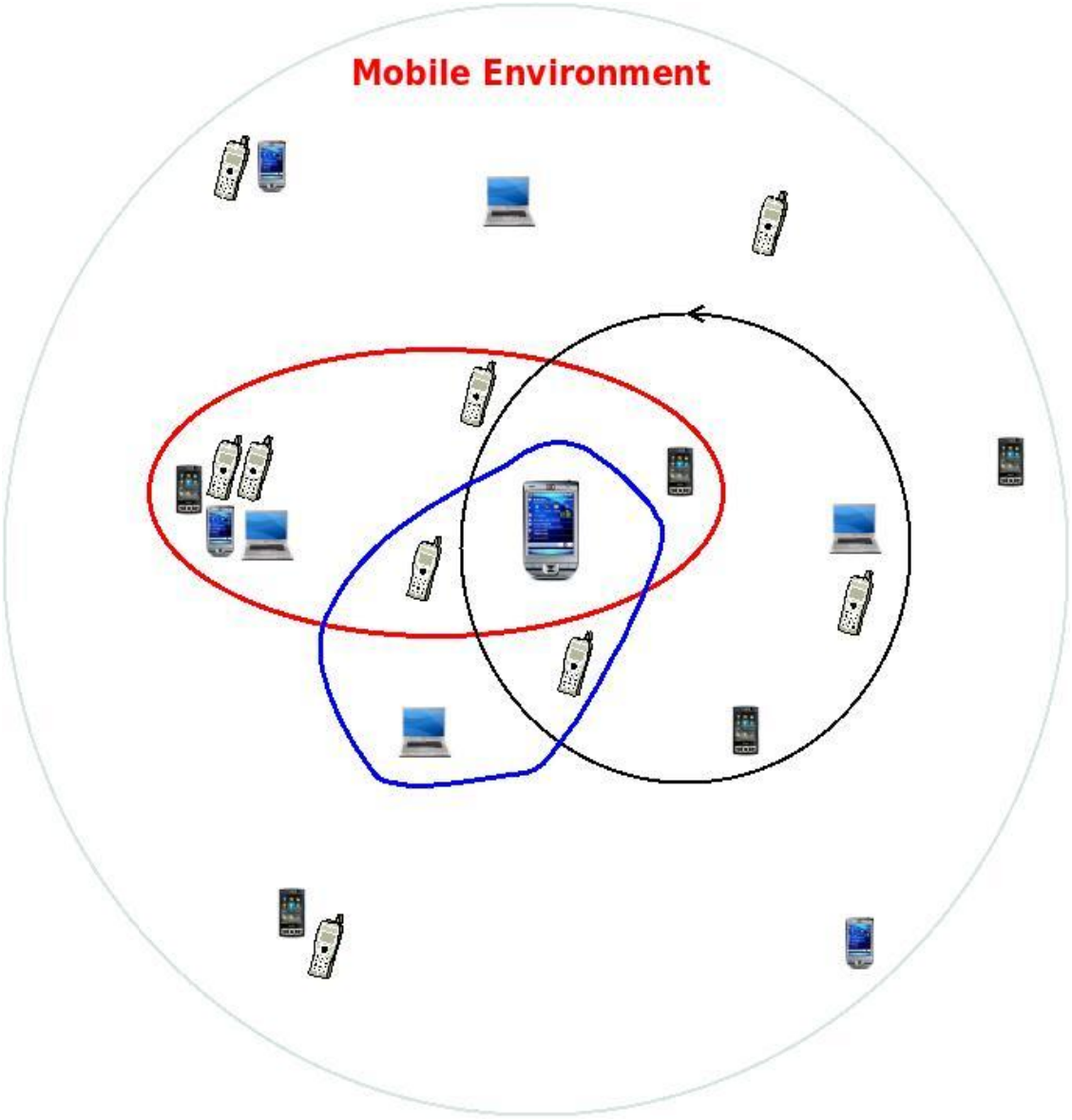

Figure 2: Dynamic Group Discovery Concept.

In this research, Dynamic group discovery refers to automatic formation of a group of users with some similar interests or motives. When PTDs are in mobility state, which means when users are in motion with their mobile devices, the users have very less time to find some group of their interest and join those groups and start activities. So, in this case, technology and application has a vital role to keep the social network updated. The technology involved discovers the nearby users and the intelligence of the application quickly scans the newly found neighbors' interests and matches with the primary user's personal interests and dynamically forms the group on the move. In Figure 2, three closed boundaries inside the mobile environment represent three dynamically formed groups with accordance to three distinct interest of the central device user. After the

formation of these dynamic groups the users can interact with each other easily and know who is near them and has the same interests as theirs. This is dynamic group discovery and is a major aspect of social networking on mobile environment.

Social networking on mobile environment is a new issue in mobile communications. The major intent of social networking on mobile environment is to be on a preferred group always and never to be alone despite of physical location and the mobility issues. Also the ability to access those social networks and perform activities through PTDs is another intent of social networking on mobile environment.

Social networking on mobile environment and its dynamic group discovery is the major objective of this research work. In the further coming chapters, it is explained how social network on mobile environment is made possible, how groups are discovered dynamically in social networking on mobile environment and a self developed and implemented reference application is studied, which tells more about the features, feasibility, advantages and disadvantages of social network on mobile environment.

4 PeerHood

PeerHood was developed in 2004 at ComLab at Lappeenranta University of Technology in Lappeenranta, Finland [14]. It was developed in order to carry out personal communication in PTDs despite of any network technologies on mobile environment. Still some advancement works are being done on PeerHood at ComLab.

4.1 Introduction and Concept of PeerHood

PeerHood is a network management middleware that works as a personal area network for PTDs and offers an interface to the middleware modules on top of it. PeerHood is also known as peer-to-peer neighborhood [22]. PeerHood provides a communication environment for mobile devices to act as peers and communicate with each other directly without any centralized servers. In order to enable fast creation of required ad-hoc type networks, Peerhood monitors the immediate neighbors of a PTD, collects information and stores it for possible future usage [46]. PeerHood contains a library which enables the usage of Bluetooth, WLAN and GPRS networking technology through a unified interface and hides the underlying networking structure from the application point of view [22].

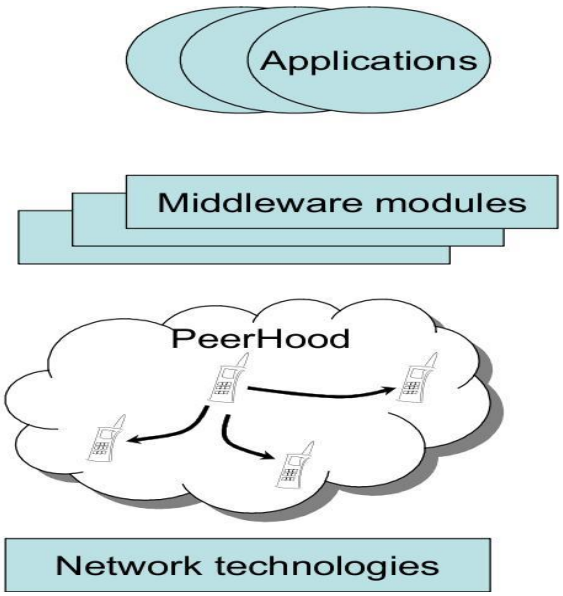

Figure 3: Concept of the PeerHood (source: [22])

Figure 3 shows that PeerHood resides on top of networking technologies and itself is the base for the remaining system, which means it offers an environment for different, higher level middleware modules and other modules and applications use these modules to provide additional functionality or services.

4.2 PeerHood Architecture

PeerHood architecture is divided into 3 separate entities, PeerHood Daemon (PHD), PeerHood library and PeerHood plugins. PHD is an independent process which continuously keeps track of other wireless devices. PeerHood library provides PeerHood functionality to the applications and it is used in local communication between appliction and daemon as well as between applications and various devices. PeerHood plugins are used by the PeerHood library and PHD. Figure 4 demonstrates the PeerHood architecture and it is explained below.

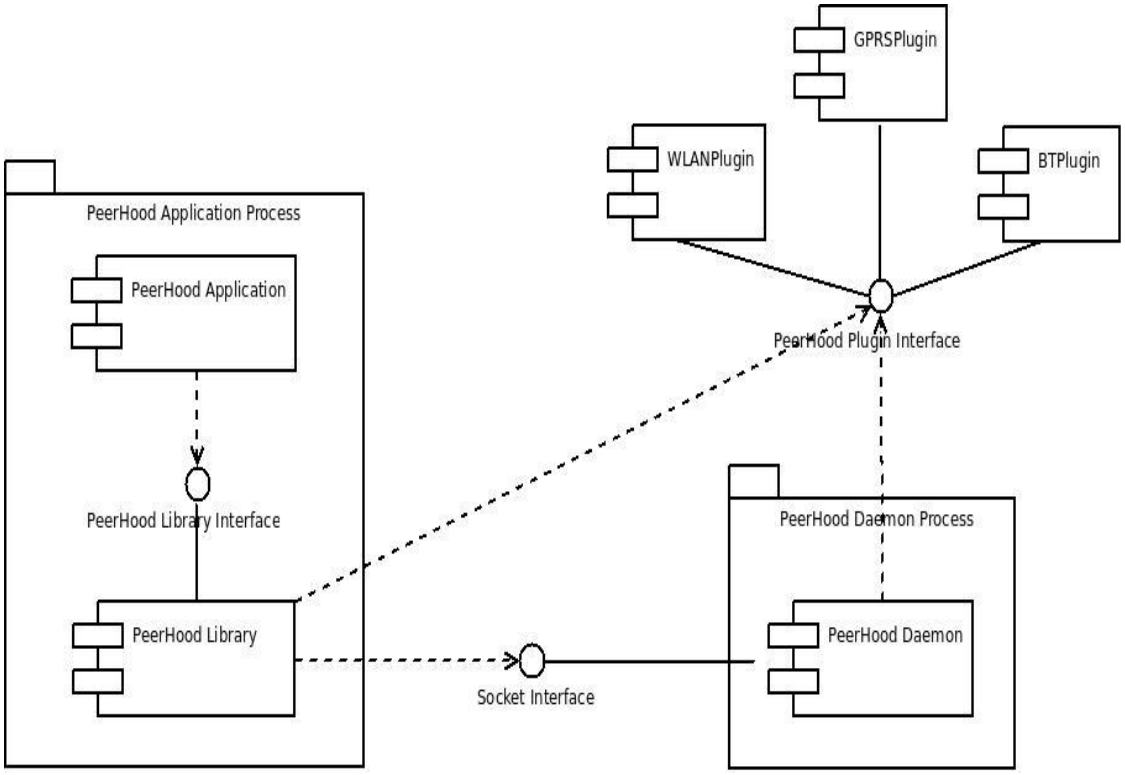

Figure 4: PeerHood Architecture (source: [14])

4.2.1 PeerHood Daemon (PHD)

PHD performs the major operations of PeerHood. It is an independent application which always runs on background and keeps tracks of other wireless device discovery and service discovery in those devices. It maintains a list of neighbor devices as well as list of local and remote services. Services through PeerHood-enabled applications are registered in PHD and PHD handles the service requests.

4.2.2 PeerHood Library

PeerHood library provides a local socket interface which could be used in handling communication between PHD and PeerHood-enabled applications. This library is used by the applications to request information from PHD and to request for connecting to remote services. PeerHood library is dynamically loaded into PeerHood-enabled applications and it provides the functionality interface to those applications for necessary operations. It is also used to register services into PHD and transmit data between devices.

4.2.3 PeerHood Plugins

Unique plugins for different network technologies have been implemented and they are loaded dynamically by PHD and/or PeerHood Library. Currently, PeerHood has implementation of Bluetooth, WLAN and GPRS plugins.

BTPlugin provide L2CAP [27] operation for Bluetooth connectivity in PeerHood, avoids the overhead caused by the BNEP [47] or RFCOMM [29] and PPP [47] and it offers ordered and reliable data delivery.

WLANPlugin operates over IP connections and uses broadcast-based service discovery. It offers direct connection between communicating devices without any intermediate devices or bridges.

GPRSPlugin also operates over IP connections and uses proxy device as a bridge or an intermediate device.

4.3 PeerHood Functionality

Table 3: Functionality of PeerHood

Functionality	**Description**
Device Discovery	PeerHood detects other PeerHood-capable devices which are within the range and belongs to the same neighborhood.
Service Discovery	PeerHood detects all the services and its attributes available in any PeerHood-capable remote device.
Service Sharing	PeerHood allows applications or middleware components to use and register services. The list of all local and remote services can be obtained on request.
Connection Establishment	Peerhood allows two or more devices to connect in same PeerHood neighborhood.
Data Transmission between Devices	PeerHood allows data transmission between connected devices through the objects implementing the connection interface.
Active monitoring of a device	PeerHood supports active monitoring of devices, i.e. when the monitored device goes out of range than application is notified of its disappearance. Also, the application is notified when the monitored device approaches the range.
Seamless Connectivity	PeerHood supports seamless connectivity. When PeerHood senses the breaking or weakening of the established connection, it tries to find the best possible alternative for that breaking connection, maintaining the connectivity.

PeerHood offers a variety of functionality and it can be summarized as device and service discovery, service sharing, connection establishment, data transmission between devices, active monitoring of a device and seamless connectivity [14][46][48]. Table 3 below describes the various functionality of PeerHood.

4.4 Applications on Mobile Environment on top of PeerHood

Applications on mobile environment refers to those applications dedicated to operate on PTDs. Emergence of high technology PTDs has encouraged development of numerous user centric software application for PTDs. Such applications are very much aware of mobile environment and consider its applicability with close understanding with mobility and range of different short range wireless technologies used in the application. Applications like Access control system [49] and Guidance system [50] are applications on mobile environment which operates on PTDs. Access control system is used for some physical security purposes, where PTDs with wireless access control system can be used as keys for locking or unlocking and provides access to locked resources and places. The guidance system offers guidance to travelers in some strange environment into some selected destinations. Both the applications are mobile applications and Bluetooth technology is used for the short range wireless communications. The applications controls the necessary synchronization between the PTDs and Bluetooth-controlled doors and between PTDs and guidance points, while remaining within the proximity of the Bluetooth technology used in both the applications and devices. From these examples of access control system and guidance system, applications on mobile environment are understood.

Applications on mobile environment on top of PeerHood are those mobile applications which are built on top of PeerHood network management middleware. Applications built on top of PeerHood differs from other mobile applications as PeerHood provides the easy interface for the applications to play with different network technologies (Bluetooth, WLAN and GPRS) and hides the underlying technology dependent functionality. PeerHood acts as a middleware for the application and application utilizes the services offered by the PeerHood Library. Fitness System [51] is an application built on top of PeerHood. This application promotes physical exercise through

encouragement and motivates the users by providing instant analyzed feedback of the exercise. As Fitness System is built on top of PeerHood, this application can be offered as a service in Bluetooth, WLAN and GPRS network when using PTDs.

Neighborhood devices and the services offered on those devices are discovered by the PeerHood library and the applications built on top of PeerHood simply utilize those discovered list. Establishing connection and service sharing with discovered devices is also maintained by the PeerHood library for the application. Application can transfer data to paired device through the interface provided by the PeerHood library and additionally PeerHood monitors moving devices and supports seamless connectivity and as its result, it is very easy for the application to retain existing connection and communicate with all the moving devices.

5 Social Networking on top of PeerHood

The concept of social networking on top of PeerHood and its practical realization is explained in the subchapters below.

5.1 Social Networking on top of PeerHood: A concept

Social networking on top of PeerHood is a concept of implementing a social networking middleware for mobile environment on top of Peerhood. The subject involves managing a social network on mobile environment, where the middleware is implemented on PTDs and users creates their profile on their PTD. As this middleware system is built on top of PeerHood, it uses the component of the PeerHood and functionality to discover other user nodes and find social networking service on them and connect to that service. The middleware system uses PeerHood library for the connection establishment, data transmission and monitoring a remote device. The neighborhood devices are monitored continuously. Remote devices approaching inside the proximity of active device and vanishing away from it are recorded. On the arrival of a new remote device inside the range, the middleware checks for the PeerHood capability and the registered services on that remote device. When the remote device is found positive of PeerHood capability and necessary social networking service is registered, the middleware checks for the detailed profile of user created on that remote device. The interests of the remote user on the social network are mapped with the personal interest of the active user and interest groups are formed dynamically. The devices inside same interest groups acts as connected members and the various functionality of the middleware like file viewing and sharing, sending messages, viewing profiles, sending profile comments, add/remove trusts and join/leave other interests groups manually etc are accessible to all the members. As PeerHood is monitoring all the remote devices, and if any remote device is unreachable, than that remote device is considered as disconnected and removed from all associated interest groups. Besides, the social networking middleware allows the users to create a new group and add others interests as own interest.

For the privacy among users of the social network, the social networking middleware impose a concept of trust levels and determine the authority for accessing different available features depending upon the trust levels. For example, non trusted users can view or see only the interest groups and members of different groups. Trusted users are allowed to see /transfer the shared files, comment profiles etc.

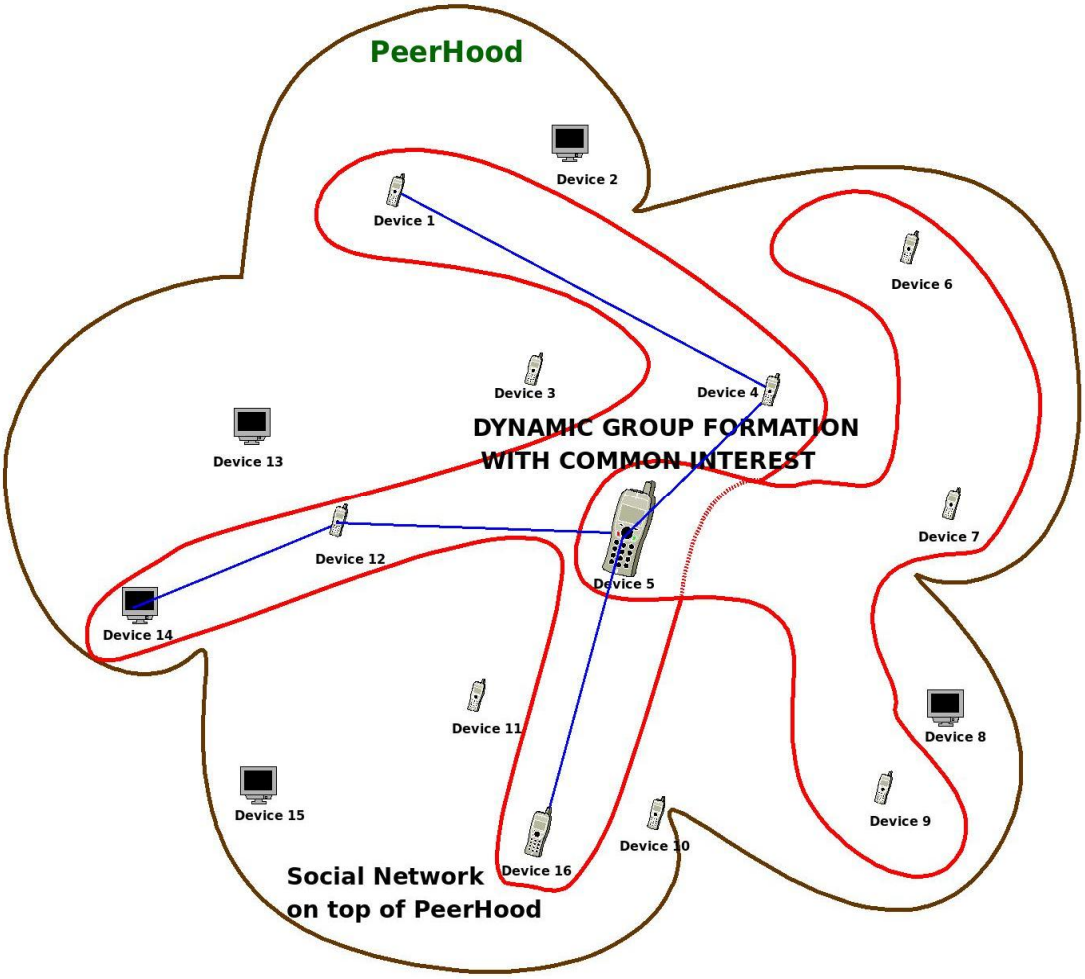

Figure 5: Social Network on top of PeerHood: A Concept.

Figure 5 explains a social network build on top of PeerHood. This social network is based on interest profiles of each user/device in the close proximity of the device. Groups are formed dynamically according to the interests. When PeerHood detects new device in the close vicinity, interests are compared and devices added to appropriate social networks. While defining interests users may teach the semantics to the

environment by combining terms meaning the same issue. If the remote device travels beyond the proximity, monitoring function of PeerHood detects this and automatically the remote device gets excluded from the social network. When in the network, the device may use all the functionality offered by the social networking middleware. In figure 5, the mobile nodes inside the two inner boundaries are in two different dynamic groups which are formed automatically due to some common interests.

```
Algorithm: Dynamic Group Discovery
begin
    1.    Get_My_Personal_Interest_List(MyInterestList)
    2.    Get_Nearby_Device_List(RemoteDeviceList)
    3.    For each myInterest in MyInterestList
    4.          myInterest.memberList=NULL
    5.          For each device in RemoteDeviceList
    6.                Get_Remote_Member_Name(remoteMemberName)
    7.                Get_Remote_Members_Interest_List(remoteMembersInterestList)
    8.                result=compare myInterest with remoteMembersInterestList
    9.                If result==true then
    10.                     Insert remoteMemberName into myInterest.memberList
    11.               End If
    12.         End For
    13.   End For
    14.   If View_Interest(myInterest1) then
    15.               Display(myInterest1.memberList)
    16.   End If
end
```

Figure 6: Dynamic Group Discovery Algorithm.

The algorithm for dynamic group discovery is shown in figure 6. Initially when the user starts the social networking application, the application collects the list of active user's personal interests and gets the list of all the nearby devices. A personal interest of the active user is compared to personal interests of other nearby users. If the interest

between active user and remote user matches than both the active user and the interest matching remote user are listed in same interest group. Similarly, each interest is compared with the personal interests of all the found nearby members and this process is carried for all the personal interests of that active user in social networking on top of PeerHood.

Social networking on top of PeerHood, can communicate through three different networking technologies. They are Bluetooth, WLAN and GPRS. All these wireless technology sets a predefined range for the social network area. Underlying communication structure between the three different network technologies and the social networking middleware is handled by the PeerHood.

Social networking on top of Peerhood is very much feasible in instant local communities like in university or pub and in mobile community like in bus or airplane while travelling. The dynamic group discovery feature benefits the users to find the members with same interest in very small time and communicate with them very easily. Other benefits of social networking on top of PeerHood are users will never feel alone or socially disabled. The cost of data service is low as Bluetooth and WLAN can be primely used.

The social networking middleware on top of PeerHood applies to small sized social networks and it is an instantaneous social network. Instantaneous social network here is referred as a network created on the move and as it is not operated from any centralized servers, some long distance traveling members could never be together again. This is a major disadvantage of social networking on top of PeerHood.

On the next subchapter, the reference implementation of this social networking middleware is studied and explained. It tells more about the features, requirement specification, analysis, working structure and some sample outputs with screenshots.

5.2 Social Networking on top of PeerHood: A case study

Social networking on top of Peerhood was understood and realized practically through a reference implementation. Various aspects of social networking, mobile environment and PeerHood were considered carefully in this reference implementation. An application is built, tested and analyzed as the partial work of this research. The environment and outcome of the research work is clearly presented below in the sub chapters.

5.2.1 PeerHood Community

PeerHood community is a client server application developed in ComLab, Lappeenranta University of Technology for testing and analyzing social network on top of PeerHood. It is developed using C++ programming language in Linux environment. It is a practical realization of social networking on top of PeeHood. This application manages a social network on mobile environment, considering the PTDs are PeerHood capable. It allows the user to create a profile and user can log in to this application with the valid username and password through their PeerHood capable PTD. Logged in user can access all features listed on Table 6 and they can log out successfully. The dynamic group discovery was also realized through this implementation. Even though the application supports all three network technologies (Bluetooth, WLAN and GPRS), the application was tested using Bluetooth only. PCs and laptops were used as PTDs for experimentation.

5.2.2 Test Specification

The detailed software and hardware specification used in this implementation are listed as below.

5.2.2.1 Software Specification

Table 4 lists the software specification used for the reference implementation.

Table 4: Software specification for reference implementation.

Software Used	**Specification**
PeerHood	Version 0.2
GNU C++ Compiler	Version 4.2.3-2ubuntu7

5.2.2.2 Hardware Specification

Table 5 lists the hardware specification used for the reference implementation.

Table 5: Hardware specification for reference implementation.

Hardware Used	**Specification**
Desktop PC1	Processor: AMD Athlon(tm) 64 Processor 3000+ MHZ Memory: 1005.0 MB OS: Ubuntu (Release 8.04(hardy))
Desktop PC2	Processor: Intel(R) Pentium(R) III CPU 1200 MHZ Memory: 757.5 MB OS: Ubuntu (Release 8.04(hardy)
Laptop (IBM ThinkPad Model No: T40)	Processor: Intel(R) Pentium(R) M Processor 1600 MHZ Memory: 1.5 GB Inbuilt Bluetooth(TM) OS: Ubuntu (Release 7.04(feisty)
Bluetooth	Bluetooth(TM) 3COM(R) (2Pcs)

5.2.3 Working Principle

The test application is a client server application and every device must have both the client and server. The client of one device communicates with other remote servers to receive and transfer data. Figure 7 below demonstrates the working principle of the reference implementation. It shows the application server registers the service and gets the neighborhood information. After remote application client is connected to the server, information exchange between the two devices is allowed and connection is terminated successfully on request.

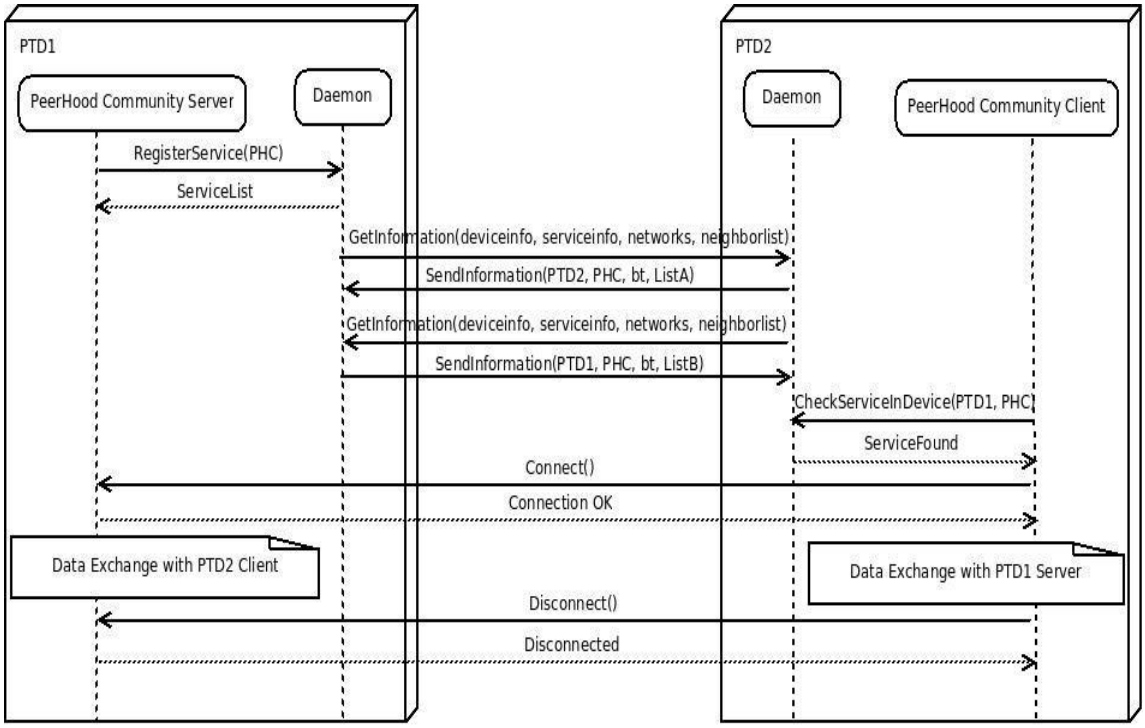

Figure 7: Working Principle of Reference Implementation.

5.2.3.1 The Server

Every PTD must contain the application server and server must run continuously. As the server is started, it registers the service named “PeerHoodCommunity” into the Peerhood Daemon. The server always stays in the listening state for any request from the remote clients. The remote clients can connect to the server through the registered service. On the request received from the remote client, the server analyses the request and packages the desired information into buffers and transmits to the connected client. When server receives some informations to be updated or written from any client, it instantly updates or writes it and make the changes available to the local active client.

```
callback = new ServerCallback;
peerHood = MPeerHood::GetInstance(callback);

//PeerHood Initialization
if (!peerHood->Init(argc, argv))
{
        cerr << "PeerHood initialization failed!" << endl;
        exit(EXIT_FAILURE);
}
//Registering Service into PeerHood Daemon
if ((peerHood->RegisterService(string("PeerHoodCommunity"), string("1"))) == 0)
{
        cerr << "Registering the PeerHoodCommunity service failed, aborting..." << endl;
        return EXIT_FAILURE;
}
```

Figure 8: Code Snippet of Server registering PeerHoodCommunity service

Figure 8 shows a part of server code, which registers “PeerHoodCommunity” service into the Peerhood Daemon. The requested operations and corresponding server functions are listed as below in Table 6.

Table 6: Client Requests and corresponding Server function.

Operations Requested by The Client	Server Function
PS_GETONLINEMEMBERLIST	Identifies list of online member and transmits the list to the requesting client.
PS_GETINTERESTLIST	Identifies list of local interests and transmits the list to the requesting client.
PS_GETINTERESTEDMEMBERLIST	Identifies the list of online member in accordance to a common interest and transmits the list to the requesting client.
PS_GETPROFILE	Transmits the local user profile to the requesting client.
PS_ADDPROFILECOMMENT	Writes or appends the Profile comments send by remote client into the local user's profile.
PS_CHECKMEMBERID	Compares the received MemberID with local user's member ID and returns the success or failure.
PS_MSG	Receives the message from the remote client and writes into the local user's message inbox.
PS_SHAREDCONTENT	Identifies the content shared by local user and transmits the contents list to the requesting client.

5.2.3.2 The Client

The Client contains the user interface and provides the user with various possibilities to access the features of reference application after logging successfully into the client. The main functionality of the client is to connect to remote application servers on

remote PTDs and send requests and receive the desired information from servers. The received information is analyzed, properly formatted and displayed on the user terminal.

```
MAbstractConnection* connection;
list = aPeerHood->GetDeviceListL(&std::string ("PeerHoodCommunity"));
id = 1;
if (list->Size() > 0)
{
        for (TDeviceIterator i = list->Begin();i != list->End();++i, ++id)
        {
                connection = aPeerHood->Connect(i, "PeerHoodCommunity");
                if (!connection)
                {
                        cout << "Failed to create a connection" << endl;
                }
                else
                {
                        cout << "  Getting the Avialable Members list from Device No: " << id ;
                        cout << " " << (*i)->GetAddress() << " "<<(*i)->GetPrototype() << endl;

                        stringstream strs;
                        strs << "PS_GETONLINEMEMBERLIST";
                        buffer = strs.str();
                        length = buffer.length();
                        length = htonl(length);

                        connection->Write(&length, sizeof(length));
                        connection->Write(buffer.c_str(), buffer.length());

                        int actualRead = 0;
                        int ilength;
                        char* ibuffer;
                        actualRead = connection->Read(&ilength, sizeof(ilength));
                        //Analyse the received buffer
                        //If "ONLINE_MEMBER_OK" received add member to the AvialableMembersList
                }
                connection->Disconnect();
                delete connection;
        }
}
```

Figure 9: Code Snippet of Client requesting an operation.

Figure 9 is a part of client code. In Figure 9 the client gets the list of all nearby PeerHood Capable devices. It connects to the server of all those nearby devices through the service “PeerHoodCommunity”. It sends a request (PS_GETONLINEMEMBERLIST) to the connected server to know the online status of that remote device. The client listens for response from the remote server. It receives some response from server, analyses the response and performs the task as per the state of the response.

5.2.4 Features

The features of the reference application are divided into three parts. Firstly, features regarding user profile are considered under ***Profile.*** Secondly, the dynamic group discovery and group related features under ***Dynamic Groups*** and lastly, features

considering trusts and trusted transfer under ***Trusted Friends***. Table 7 lists features of the reference application.

Table 7: Features of the reference implementation.

Features
Profiles:
Add/Edit Profile
Add/Edit Personal Interest
View All Members
View/Comment Other Members Profile
View Own Viewers and Comments
Support for Multiple Profiles
Send/Receive Messages
View all Registered Services
Dynamic Groups:
Dynamic Discovery with Common Interest
View All Groups
View Members of Group
Join/Leave Manually
Trusted Friends:
Add/View/Remove Trusted
File Sharing

After logging into their local account, users are presented their personal *profile*, if available. After creating a profile, user can edit it or view or comment profiles of other users found in the PeerHood social neighborhood. Messaging between users is also implemented as part of common operations in this reference implementation. User's personal interests are also modified within profile management. These interests are used to create social networking *groups dynamically*. Matching interests are automatically grouped, and this feature also allows users to combine similar interests or join groups manually. To get a comprehensive view of the social network, users can list all the groups and see the members of those groups. As a more personal approach than a

dynamic group management [52] [53], reference application allows users to add *trusted friends* to their account or remove accounts from the list of trusted friends. To create personal links throughout the network, users can see the trusted friends of other members and add them as their own trusted friends. As an example of trusted-only applications, file sharing and discovering shared lists of others has been implemented.

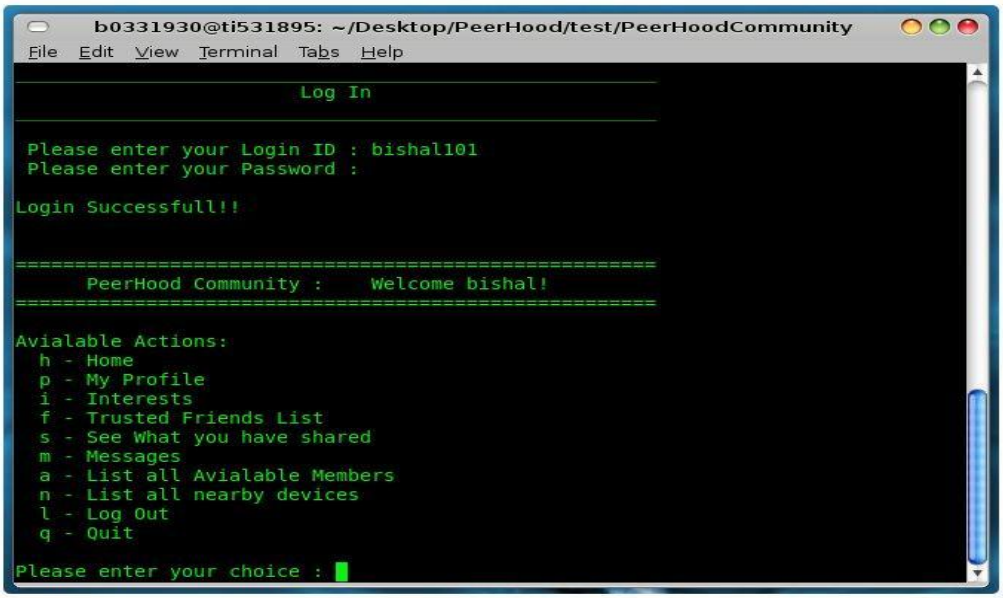

Figure 10: Main user screen.

Figure 10 shows the main user screen of the reference application. The user is provided with various features as choices and can select any of the functionality when desired. Other screenshots of the reference application are listed at Appendix 2.

5.2.5 MSC representations of client-server operations of reference implementation

The various operations of the reference implementation are represented by message sequence diagrams and explained in this sub section.

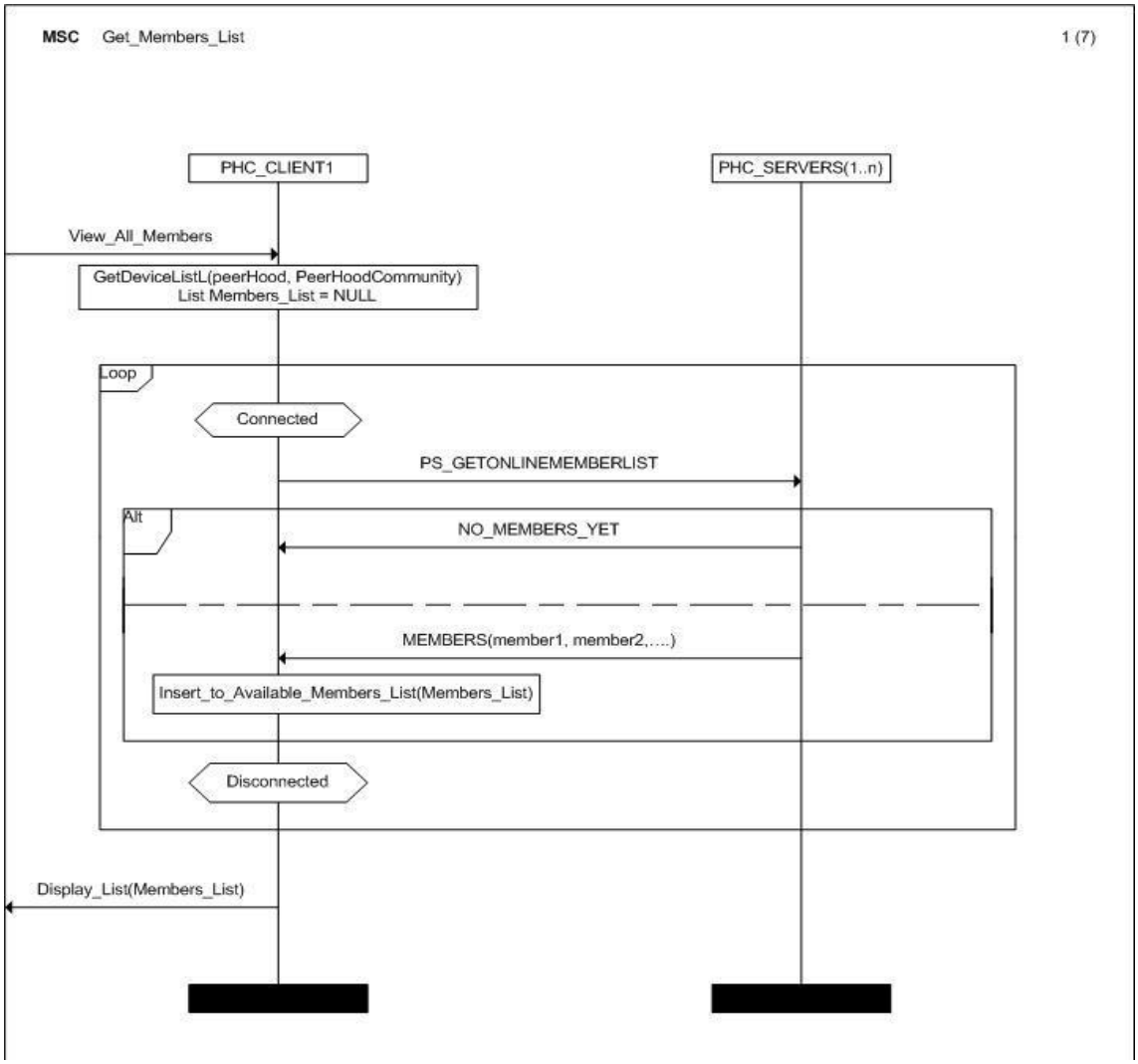

Figure 11: MSC Get Member List.

Figure 11 shows the message sequence for displaying the list of online members in the application. Client sends PS_GETONLINEMEMBERLIST message to all the connected servers simultaneously and in return receives the name of online members and stores it to a list and finally displays the list.

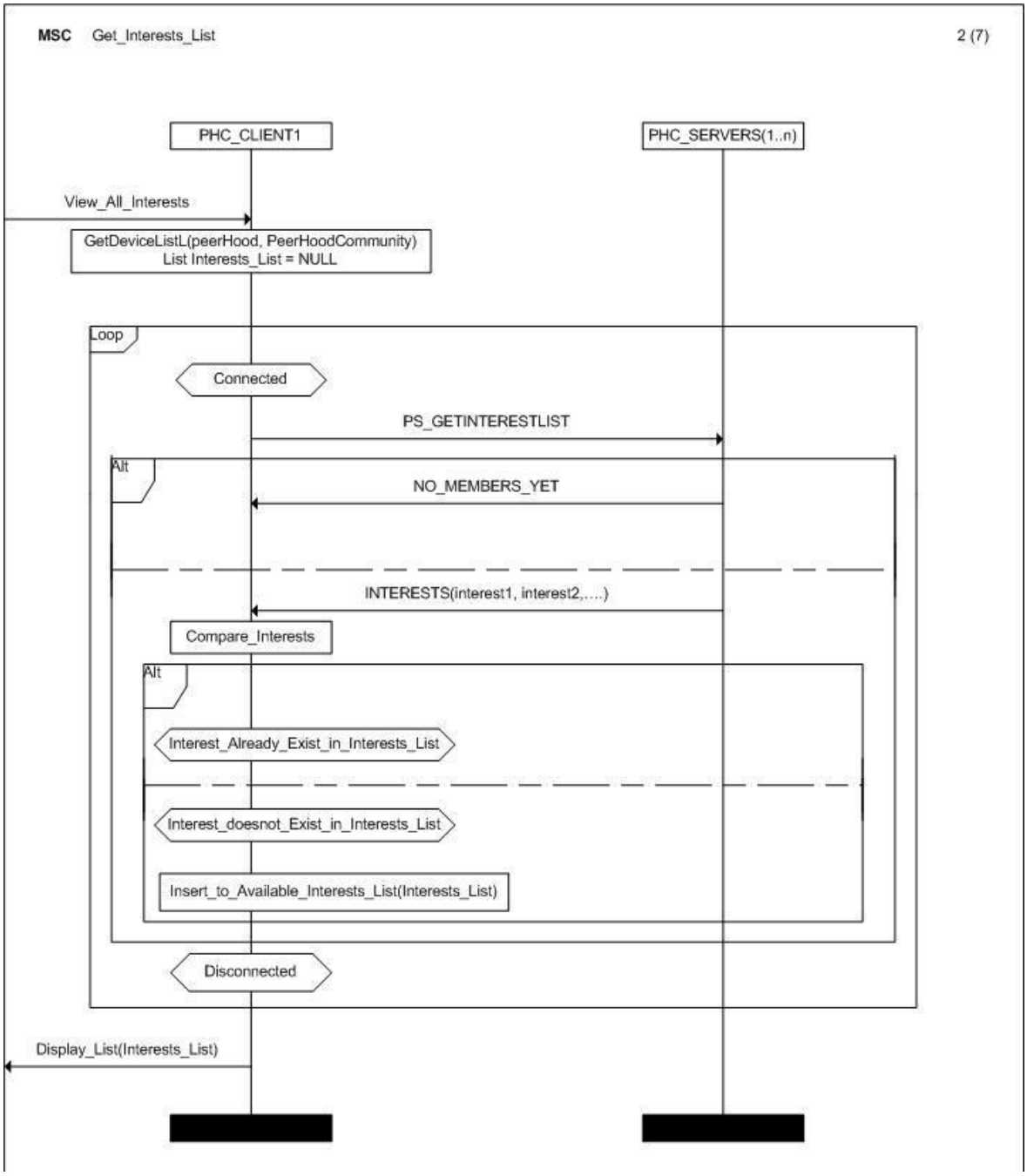

Figure 12: MSC Get Interests List.

Figure 12 shows the message sequence for displaying the list of available interests in the application. Client sends PS_GETINTERESTLIST message to all the connected servers simultaneously and in return receives the interest names. It then compares the newly received interests with the interests stored in a list and stores it to that list if it doesn't exist already. Finally the list is displayed.

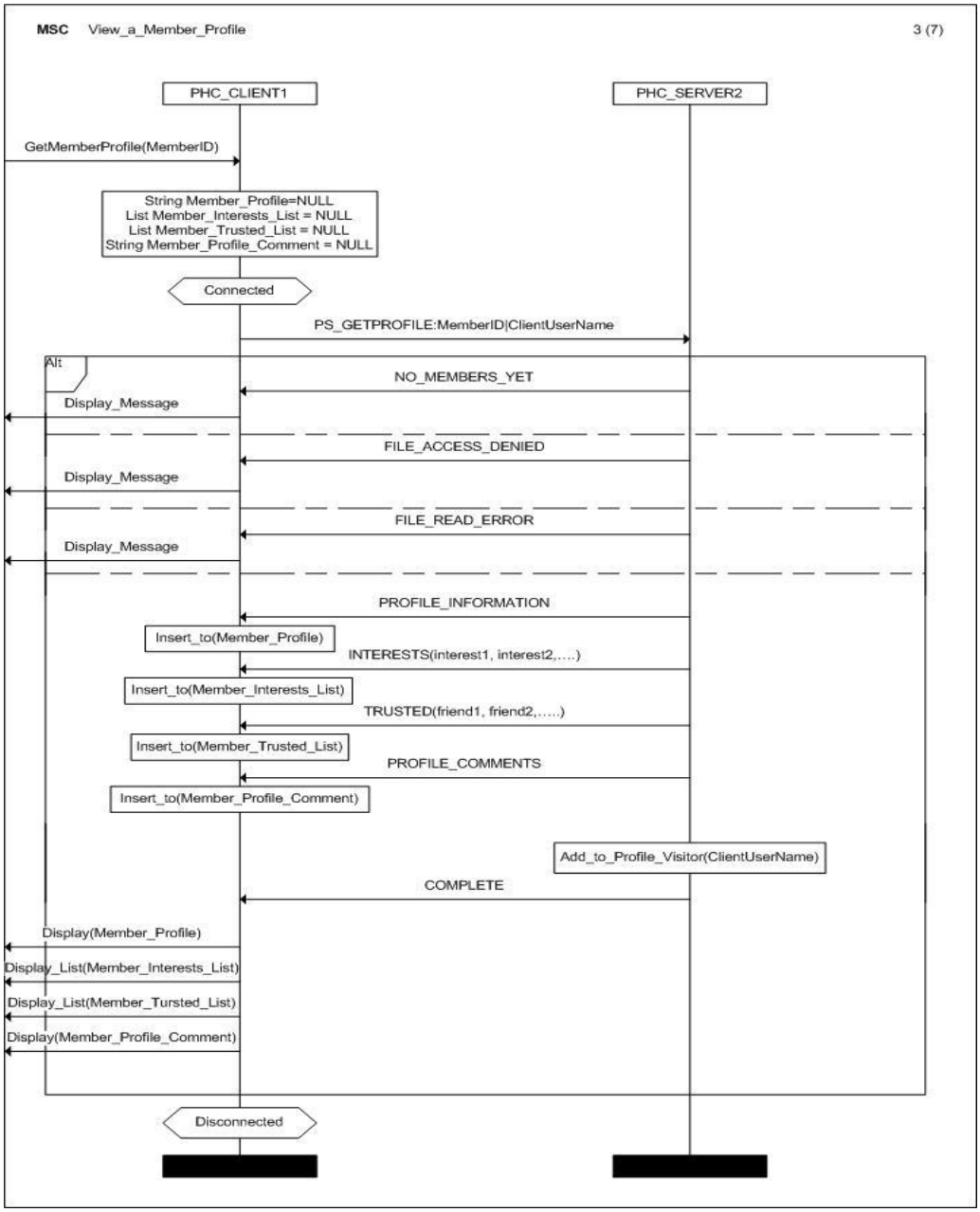

Figure 13: MSC View Member Profile.

Figure 13 shows the message sequence for viewing a member profile through the application client. Here, the client sends PS_GETPROFILE message with the MemberID and the client's username to all the connected servers simultaneously. From the desired server, the requested profile information, interest list, trusted friends list and profile comments are received and displayed. The remote server writes the name of the requesting client as the profile visitor. From all other servers a NO_MEMBERS_YET message is received.

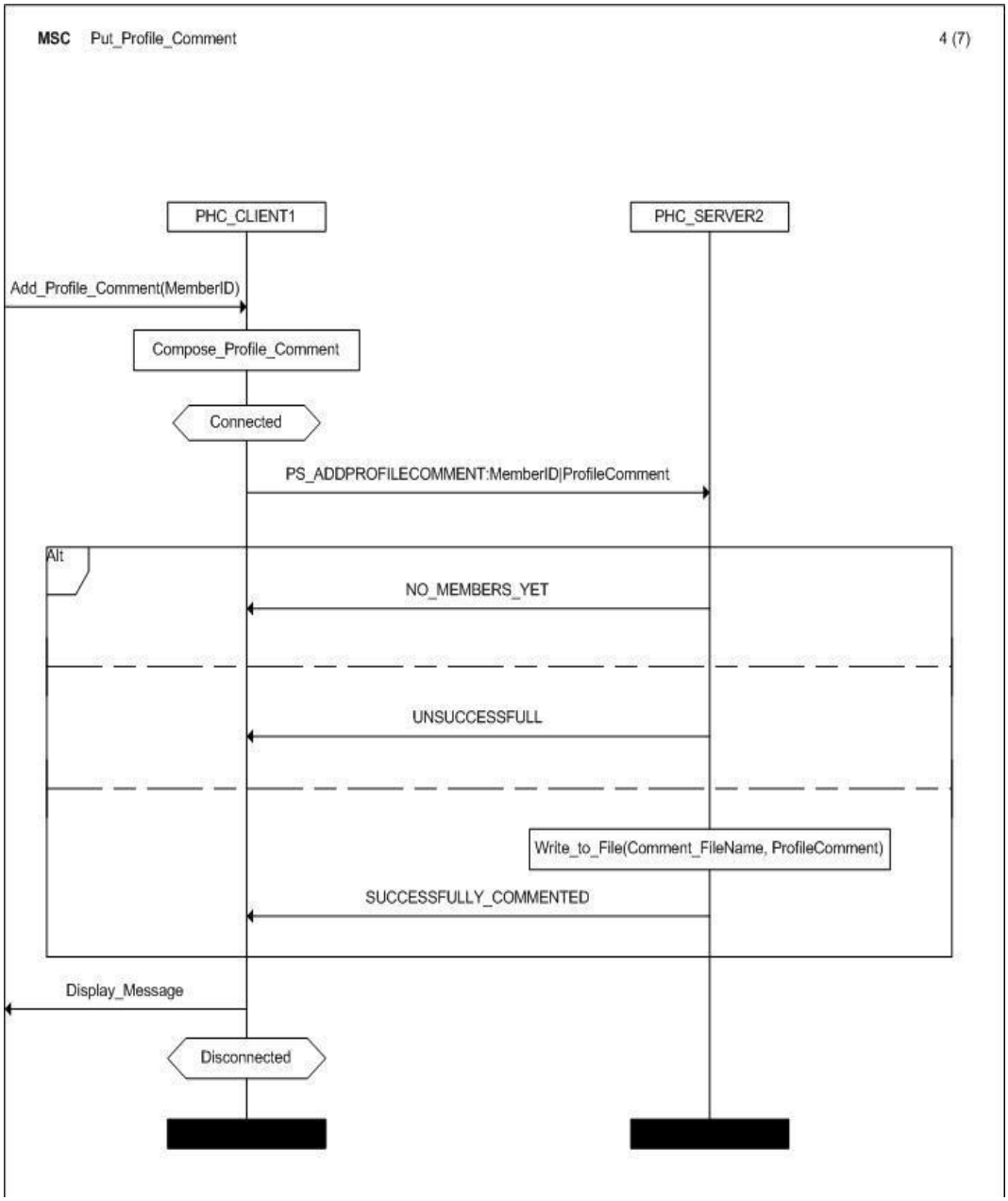

Figure 14: MSC Put Profile Comment.

Figure 14 shows the message sequence for commenting a member's profile through the application client. Here, the client composes the comment and sends PS_ADDPROFILECOMMENT message with the MemberID and comment to all the connected servers simultaneously. Only the desired server reads the sent profile comment and writes to a profile information file and from all other servers a NO_MEMBERS_YET message is received.

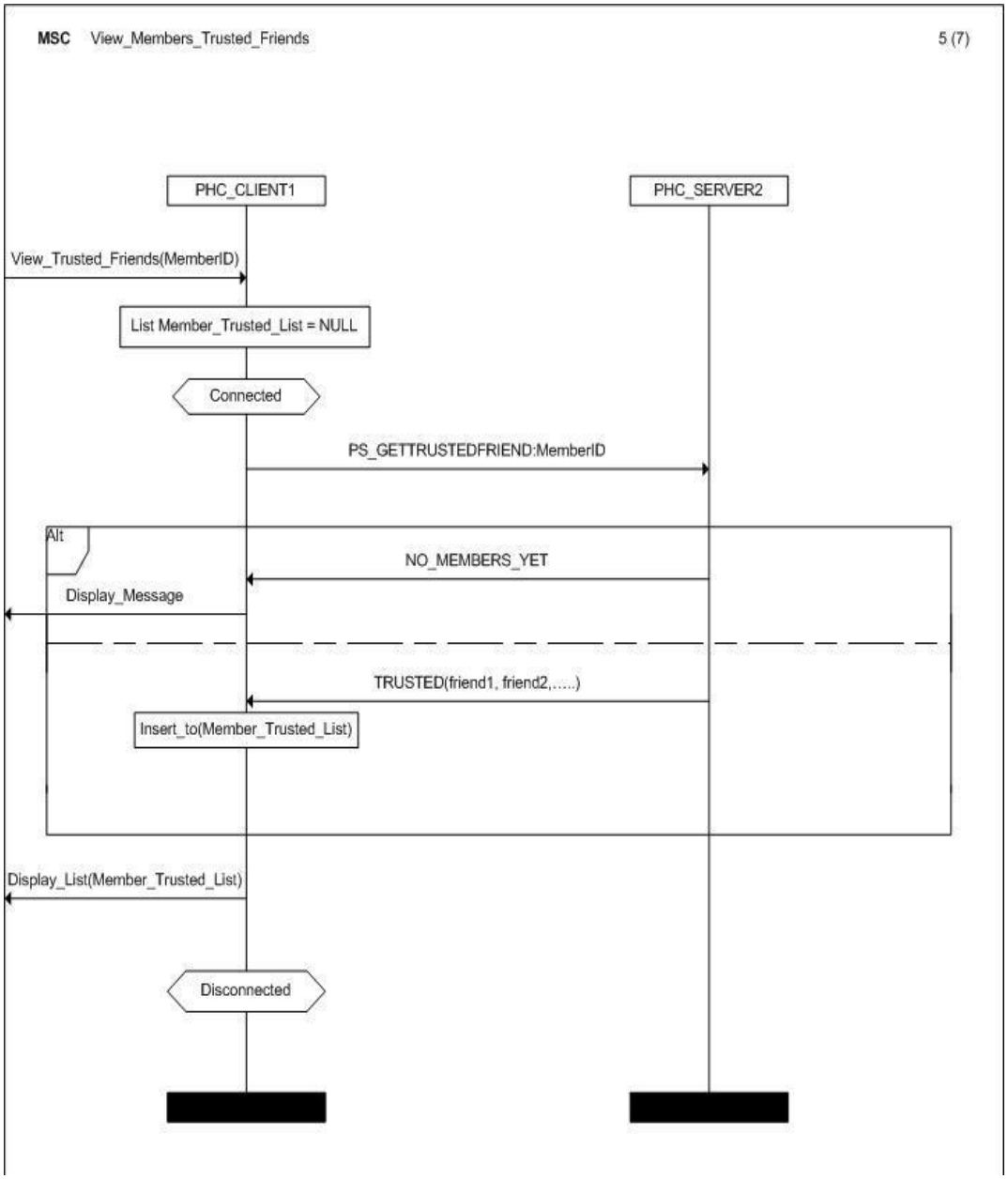

Figure 15: MSC View Members Trusted Friends.

Figure 15 shows the message sequence for viewing the list of trusted friends of a member. Here, the client sends PS_GETTRUSTEDFRIEND message with the MemberID to all the connected servers simultaneously. Only the desired server recognizes the message and sends the list of trusted friend to the requesting client and it is displayed. Other servers send a NO_MEMBERS_YET message to the client.

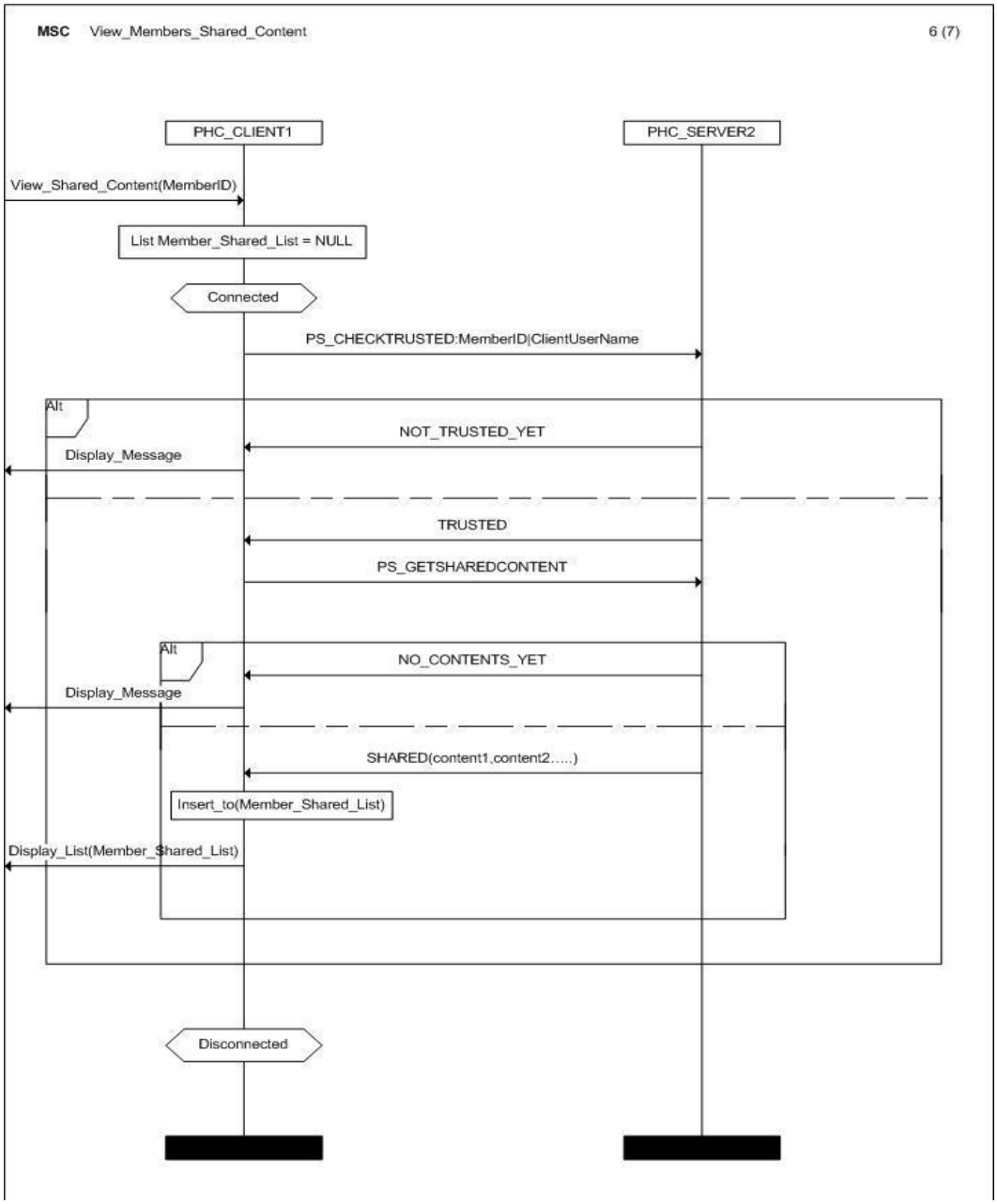

Figure 16: MSC View Members Shared Content.

Figure 16 shows the message sequence for viewing shared content of a member. Here, the client first checks whether it can view the shared content or not by sending PS_CHECKTRUSTED message with the MemberID and clients username. The client receives NOT_TRUSTED_YET if the remote user has not accepted the client as trusted. If the client is trusted, it again sends PS_GETSHAREDCONTENT message and in return it receives the list of shared content of that remote user and displays it.

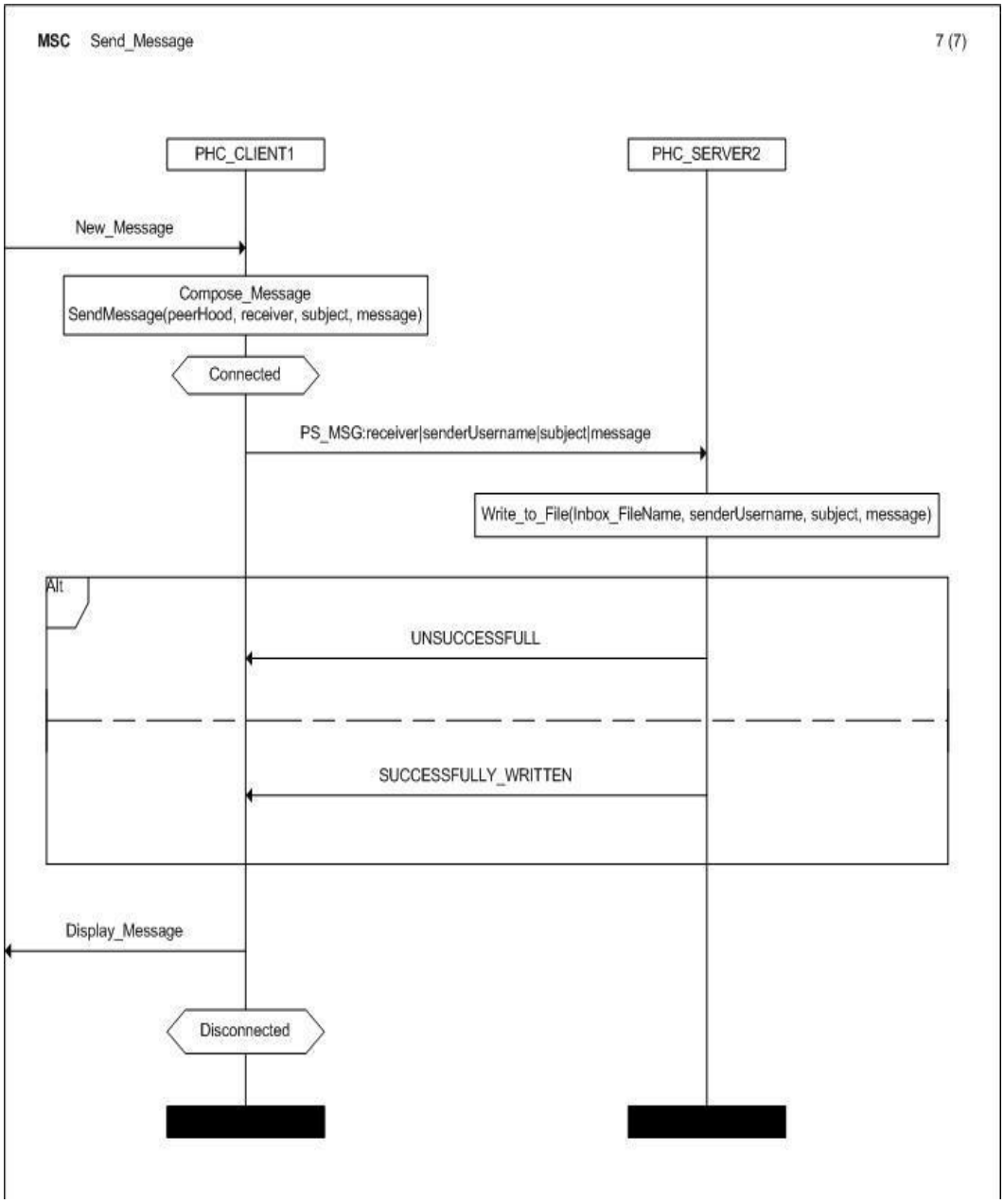

Figure 17: MSC Send Message.

Figure 17 shows the message sequence for sending mail message to a remote client. Here, the client composes the mail message and sends PS_MSG message with receiver name, sender name, subject and mail message to the remote client. The remote client receives and writes the mail message in the inbox mail file and sends back SUCCESSFULLY_WRITTEN message if the mail is written successfully else UNSUCCESSFULL is send.

5.2.6 Analysis

The reference application was successfully implemented and tested. It was analyzed to find out the feasibility of the social networking on mobile environment along with its merits and demerits. Even though, graphical user interface is not yet implemented on the application, the application is user friendly and easy to be familiar with. Bluetooth was used as a network technology and the application worked perfectly fine in short range wireless environment, without any tolerance. So, it is very much feasible for social networking purpose in mobile environment.

Comparatively, it is beneficial to use social networking application on mobile environment rather than using SNS in mobile devices. The cost of data transfer and time required to carry out desired operation is very less than using SNS in mobile devices, as our approach uses Bluetooth, which enables cost free and reliably faster data transmission. The major benefit also includes the dynamic group discovery feature of the application which eases the user to find friends with similar interests and in short time. Messages in this application is another benefit as the user can send and receive messages from friends, and posses a friendly interface to read incoming messages, compose new message and view sent messages. The Trust levels and feature to share contents to trusted friends only is another benefit of the reference application.

Various tests were performed for searching an interest group through SNS and reference application and joining the searched group and viewing a members profile from the joined members list. The time for all the tasks was recorded and average time was calculated as shown in Table 8. Total time taken to accomplish the entire tasks was calculated and analyzed.

Table 8: Time records for searching an interest group, joining and viewing any member's profile from different SNS and Reference Application.

Social Network Type	SNS (Facebook)	SNS (Facebook)	SNS (HI5)	SNS (HI5)	Social Networking on top of PeerHood
Accessed Through	Nokia N810	Nokia N95	Nokia N810	Nokia N95	IBM Thinkpad and Desktop PC1
Interest Group	England Football	England Football	England Football	England Football	Football
Average Group search Time	58 Seconds	75 Seconds	50 Seconds	69 Seconds	11 Seconds
Average Group Join Time	17 Seconds	24 Seconds	25 Seconds	40 Seconds	0 Seconds (Already in the Group)
Viewing Member List Average Time	8 Seconds	31 Seconds	18 Seconds	32 Seconds	15 Seconds
Viewing one Member profile Average Time	11 Seconds	27 Seconds	27 Seconds	40 Seconds	19 Seconds
Total Time Taken	94 Seconds	157 Seconds	120 Seconds	181 Seconds	45 Seconds

From Table 8, it can be said that accessing social networking application built on top of PeerHood is far more time efficient then accessing SNS on mobile environment. Due to

dynamic group discovery, the members with common interest are already grouped together so the joining time is always zero and thus the reference application takes less amount of time for performing all the mentioned tasks.

The major disadvantage of the application could be limited users and a small social network area as compared to SNS. As the dynamic group discovery is based on interests and many users have same interest in meaning but different in name and they are grouped differently. Teaching the semantics to the environment is missing. For example, users interested in riding bicycle can put biking or cycling as their interest. Even though both have same meaning, the application is not that much intelligent to know both interest are same and it creates two different dynamic groups rather than one single group.

6 CONCLUSION

The main objective of this thesis was to develop, implement and analyze a social network test application on mobile environment on top of PeerHood. Bluetooth was selected as the wireless technology for the implementation testing, due to its popularity and easy availability in all personal trusted devices. Preliminary studies on mobile environment, social networks and PeerHood were performed and as a result, a reference application named as “PeerHood Community” was developed as social networking on top of PeerHood, which helped a lot to understand the underlying concepts of mobile environment, PeerHood and social networking.

A concept of social network on mobile environment is studied and analyzed in this thesis and it provides adequate basis to differentiate social networking on mobile environment from social networking sites. Dynamic group discovery is a new concept and it was realized through the practical implementation of the test application.

Besides these understandings, there are many more things that could be studied more and implemented. One important thing that I would consider as a future work in this field is the semantics teaching to the environment while defining interests for combining interest terms meaning the same issue. This feature would make social networking on mobile environment more efficient and intelligent in discovering groups dynamically. Also, performance testing during the dynamic group discovery in the social network on mobile environment can be done in order to analyze the efficiency of such dynamic group discovery in any overlay networks.

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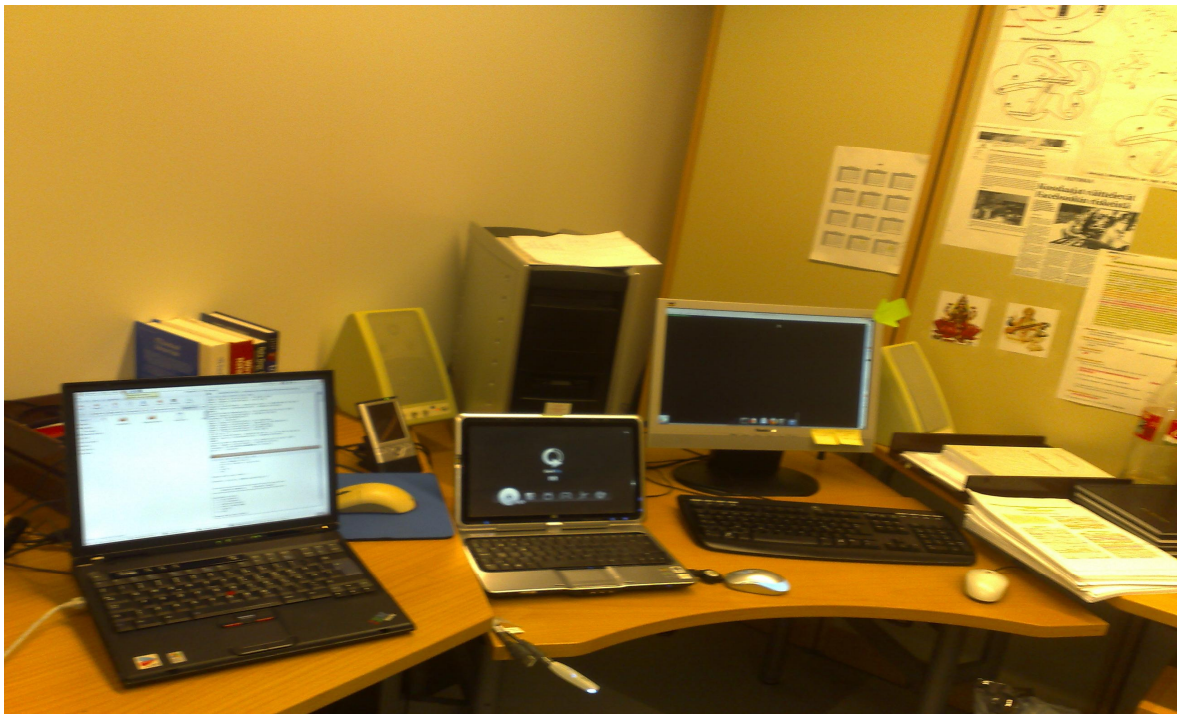
Appendix 1 – Test Environment

Reference application was tested in the environment shown in the pictures below. Two desktop PCs and two Laptops were used for testing. The pictures below are of Room 6604 at ComLab, Lappeenranta University of Technology, Lappeenranta, Finland.



Appendix 2 – Output Screenshots

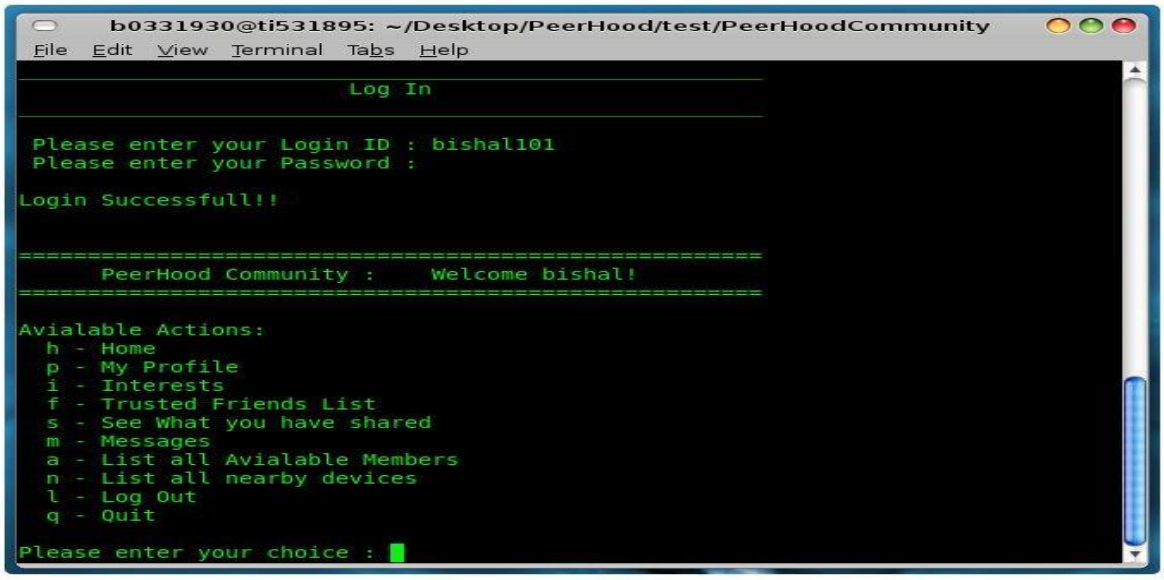


Figure: Main user screen.

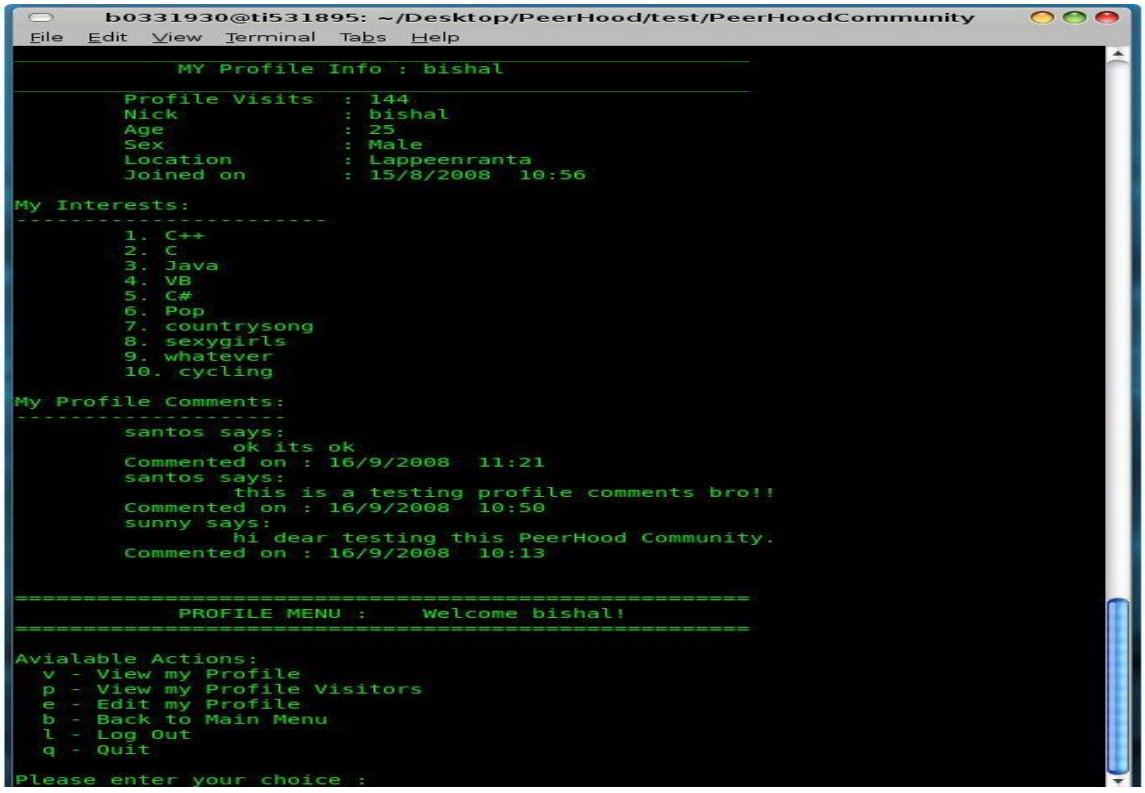


Figure: Local user profile screen.

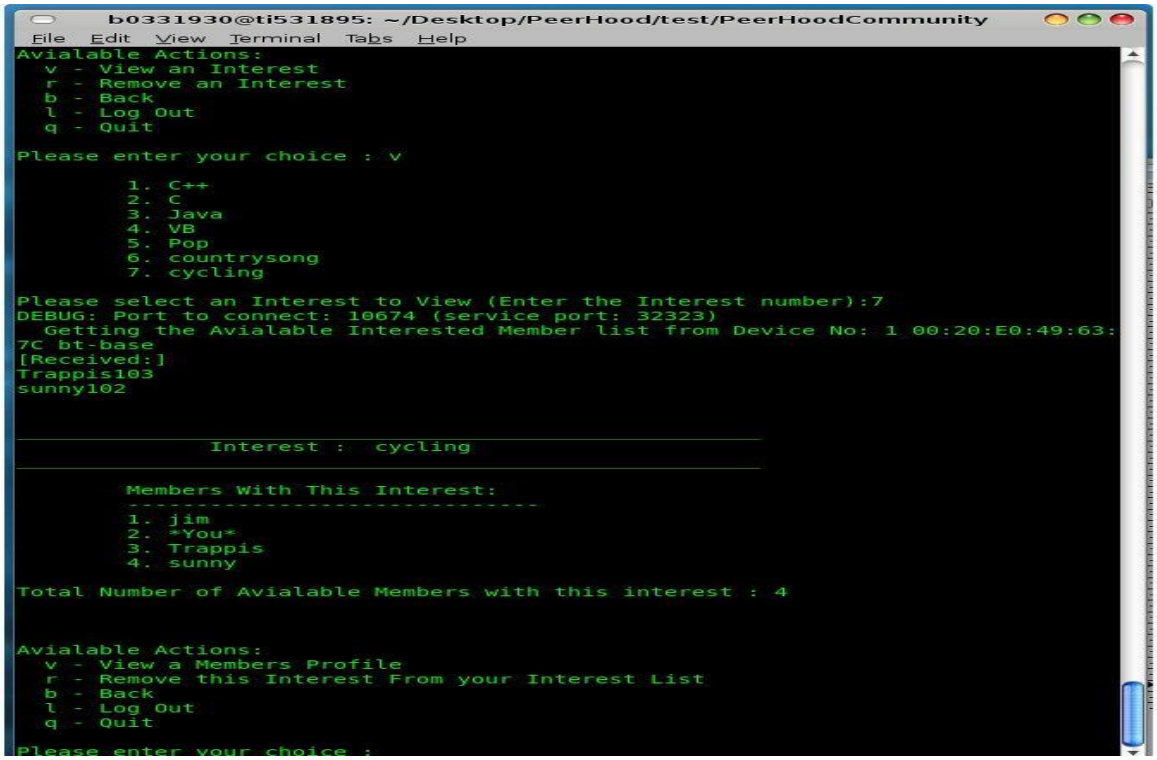


Figure: Interest List and view screen.

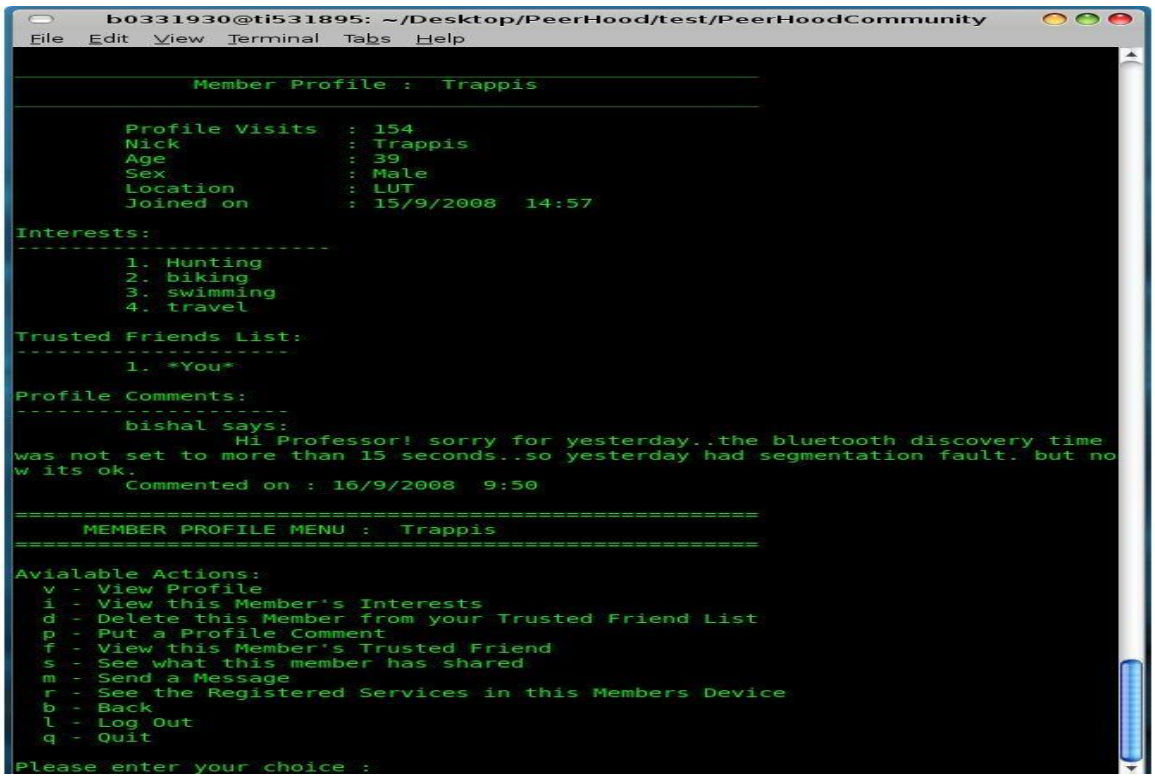


Figure: Group Members profile screen.

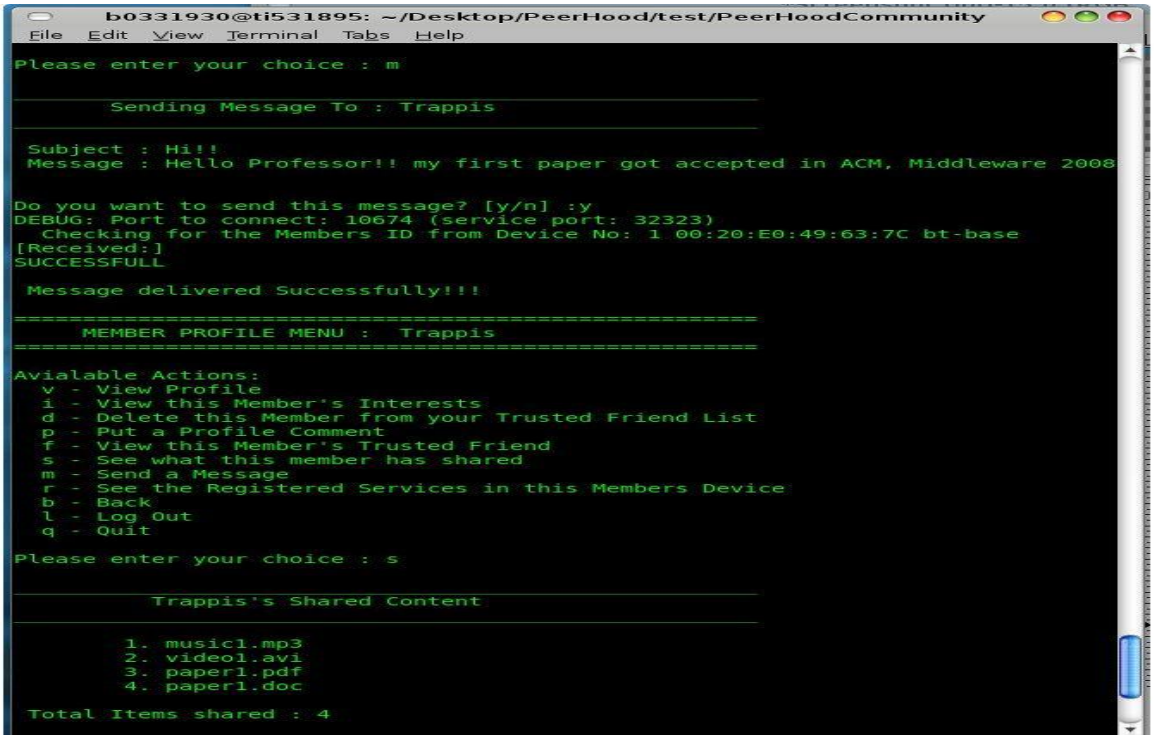


Figure: Sending Message and viewing friends shared content screen.

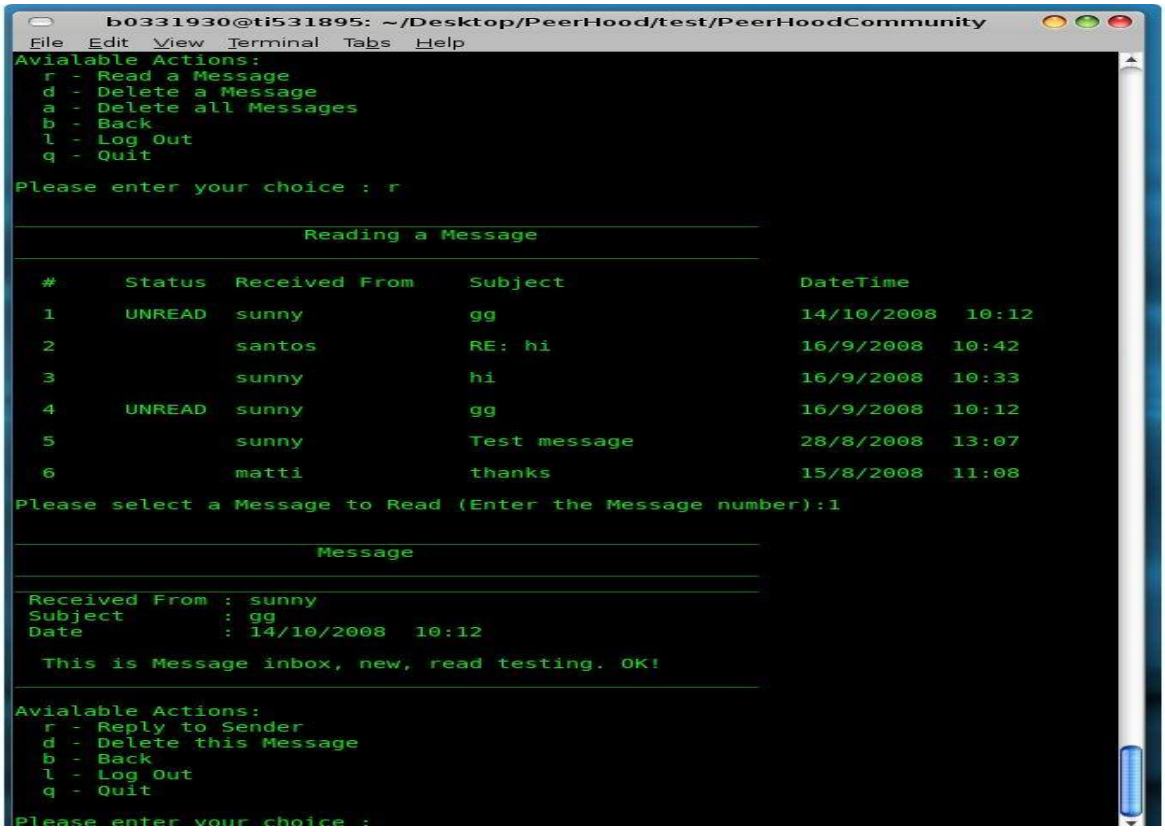


Figure: Listing and Reading Message screen.

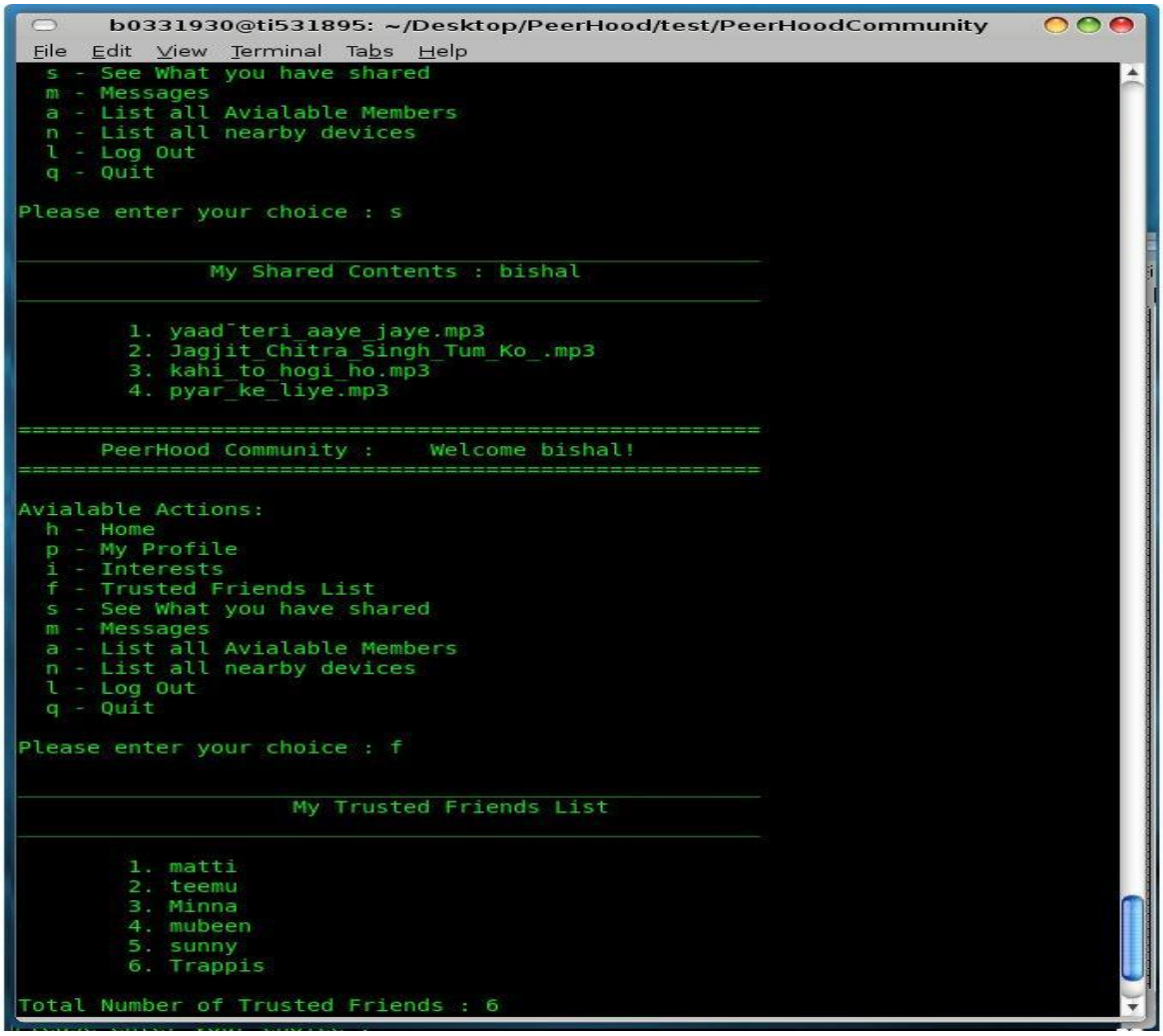


Figure: Viewing locally shared content and trusted friend list screen.