A Survey on Mobile Peer-to-Peer Technology

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Abstract. Centralized client-server networks are being transformed to distributed peer-to-peer networks. Lessons learned from fixed networks have been applied in cellular network. But the special requirements of mobile devices and networks necessitate the elaboration and the adoption of different solutions in order to fulfill the expectations which arise with the use of mobile peer-to-peer technology. Many researchers are currently proposing and developing new P2P schemes for mobile environments. In this paper we present a survey of alternative network architectures, protocols and implementations proposed for mobile peer-to-peer networking.

1 Introduction

Recent advances in mobile devices and wireless communications have enabled the development of mobile P2P applications for mobile phones. These new mobile P2P systems seem promising in a new domain of applications based on physical location and context, together with the possibility of using a wide variety of wireless radio access technologies (figure 1).

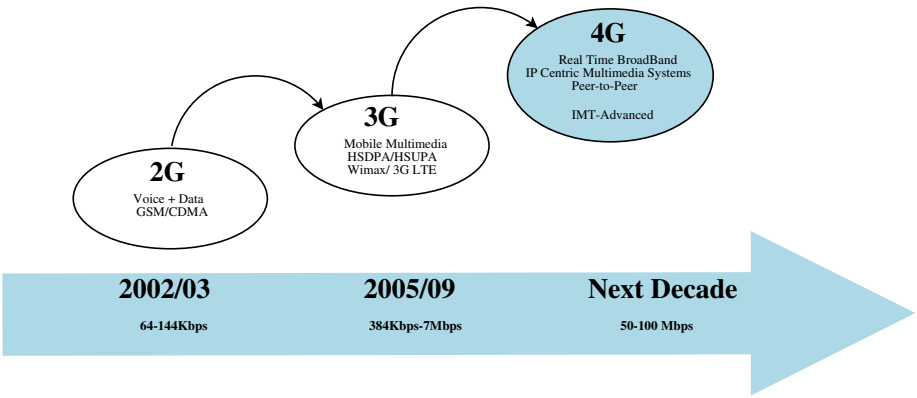

Fig. 1. Wireless radio access technologies evolution

In this context, new applications, different from traditional file sharing applications, are expected to appear. For example, in all cell environments radio resources are very limited and multicast architectures are not recommendable. In this sense peer-to-peer video streaming applications appear as a real alternative to services based on multicast. Peer-to-peer systems allow users to distribute their own content by means of the Internet or between their friends, without using costly and centralized servers with high bandwidth requirements. Peer-to-peer content distribution is a very interesting paradigm in cellular environments because the bandwidth available to the content server according to the with demand. This feature ensures a wide range of applications for peer-to-peer systems in mobile environments. For the development of these applications new techniques need to be adopted in order to deal with the limitations present in mobile devices and in cellular networks.

Current P2P applications and architectures are mainly designed to work in fixed and wired networks. Now recently developed wireless communication technologies and the new available capacities presented in mobile devices have allowed a novel peer to peer paradigm to emerge which focusses mainly on mobile devices such as PDA and mobile phones.

This paradigm involves new challenges due to constraints present in mobile devices and wireless networks such as:

- Memory
- Processing power
- Network accessibility such as the problems related with low bit rates, high latency, packet losses, temporal disconnections, etc.
- Battery consumption

and mobility issues

- Roaming between different radio access technologies. There are some standards that are trying to resolve this problem, such as GAN (Generic Access Network), known before as UMA (unlicensed mobile access) [1] or MIH (Multiple independent handover) IEEE 802.21 [2].
- Operator Control. Operators want to control traffic and services offered in their networks. In the available literature it has been proposed to use a hybrid architecture where super-peers are located in the core network (which is the logical location for sharing resources in a mobile network) under the control of the operator.
- Other existing issues are related with firewall and NATs existing in cellular networks.

A lot of research is centered on the development of new architectures and protocols to fulfill these new requirements.

In this article we carry out a survey of mobile peer-to-peer solutions proposed for mobile phones. This paper has been prepared using the research from the European SMEPP project (Secure Middleware for Embedded Peer-to-Peer Systems). This project has as its main objective to develop a new secure and generic middleware, based on a new network centric abstract model, for embedded peer-to-peer systems (EP2P). The paper is centered on mobile peer-to-peer systems for mobile phones. Our objective is

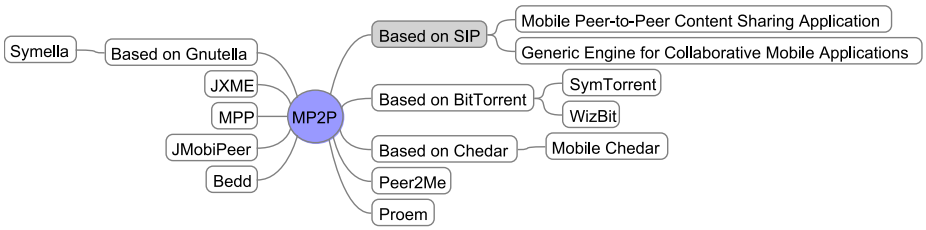

Fig. 2. Mobile Peer-to-Peer Technology Overview

to provide a complete overview on the mobile peer-to-peer technology available on the market and to extract design requirements for the development of a generic middleware for EP2P (Embedded Peer-to-Peer) systems.

2 Networking

Recent advances in hardware available in embedded mobile devices such as mobile phones and the fast integration of the new wireless technologies in these kind of terminals have enable us to envision new applications and services based on the context and the collaboration between the mobile terminals and fixed infrastructures available around us.

2.1 Network Technologies

Technologies for P2P networking include fixed and wireless network technologies e.g. Bluetooth, WLAN, WiMax, GPRS (General Packet Radio Service) and UMTS (Universal Mobile Telecommunications System), allowing devices both to be ”mobile” and to ”interconnect” with mobile or fixed P2P infrastructures.

Analysis of the usability of the different wireless technologies and the possibility of handover between them, in order to maintain connection permanently even when users are in movement, is an important task to be carried out in order to ensure the success of mobile P2P technology. Another important field of study is centered on determining which is the most suitable technology in each scenario, and for each application or service.

2.2 Overlay networks in cellular environments

Some of the proposed solutions to bridge wired and wireless P2P networks center around the idea of using proxies as gateways between both domains. This model can be extended to let mobile devices act as peers to other mobiles in the same network, firstly allowing direct connections, and then enabling indirect connections through several mobile nodes.

Following in this line, another work investigates using the already existing eDonkey architecture to let mobile users directly participate in the network. The index server

would be hosted by the mobile operator. Also, the protocol would be extended with enhanced signalling information about the mobile network domain, and some infrastructure could be added to deal with the needs of the mobile users. These new elements are caching peers, servers that act as regular peers but are under the control of the mobile operator. They would provide popular content, eliminating the need to connect to nodes outside the mobile network; crawlers, nodes that bring information of the wired network to the index server; and proxies, that act as bridges between mobile and regular peers.

However, the main focus of research in overlay networks is in the adaptation of already existing structured P2P architectures to the peculiarities of a mobile environment, namely frequent disconnections, node mobility issues and scarce bandwith and resources. For example, DynaMO [3] is a modified Pastry [4] system that exploits physical proximity between nodes, trying to make the overlay network similar to the underlying ad-hoc network. To this end, DynaMO adds two new mechanisms to form clusters of related nodes, in which neighbours in the overlay network are, probably, physically near nodes. Another example of this kind of architecture is MobiGrid [5]. This system, like the previous one, is based on an already existing structured P2P network targeted at fixed networks. Specifically, P-Grid [6] is used as a base, adding mechanisms to provide replication, security and self-organization in ad-hoc networks.

2.3 New Protocols

The JXTA [7] project defines a set of open protocols that should allow devices connected to the network, ranking from from cell phone and wireless PDAs to PCs and servers, to communicate and collaborate in a P2P manner.

Java version of these protocols are the most widely known, but there are projects in other languages and areas such as C++ [8] or Symbian OS [9][10].

The Java version of these protocols for embedded devices (JXME [11]) such as mobile phones is not completely functional due to limitations in the MIDP profile present in these kind of terminals.

Another example of protocol is the Mobile Peer-to-Peer Procol (MPP) [12]. MPP has been developed for P2P networking in mobile ad hoc environments. MPP implements an efficient signaling messages mechanism and cross layer communication between the network layer and application layer. Current results are based on NS2 simulations and show that the MPP-protocol stack copes with node failures and link breaks, typical issues associated with wireless networks.

3 Current Implementations

With the prior constraints in mind there are many available projects and solutions focused on offering and developing mobile P2P applications in a straightforward manner. JXME (a limited version of JXTA) and Microsoft P2P framework are the best known solutions for the development of mobile P2P applications. In this survey we focus on other existing implementations.

3.1 Mobile Peer-to-Peer Content Sharing Application

Mobile Peer to Peer Content Sharing Application [13] is an innovative proposal of an architecture of mobile peer to peer content sharing services in cellular networks developed by the Nokia Research Center and Helsinki University of Technology. This approach uses the SIP protocol as a basis for the deployment of mobile P2P services (figure 3). The implementation consists of a peer to peer client application in the mobile phone and an application server in the network. The mobile peer to peer client was implemented on the Nokia Series 60 (Symbian platform). This solution presents a hybrid architecture with peers and super-peers.

3.2 Generic Engine for Collaborative Mobile Applications

This Generic Engine [14] uses mechanisms introduced in SIP in order to make a terminal globally discoverable. Collaborative networks created with this engine have a ring topology. Entering a network relies on the invite mechanism provided by SIP, in which the communication initiator must provide a remote node SIP identifier. Symbian has been choose as the engine platform. This engine facilitates quick and robust data modeling by providing a metamodel-based generative mechanism.

3.3 JMobipeer

JMobipeer [15] is a framework designed to work on J2ME enabled mobile devices on mobile ad hoc networks (figure 4). This framework uses a reactive routing algorithm although due to the modularity of its architecture the routing algorithm can be replaced with any other.

Interpretability with JXTA is supported, and the the increased network load is the main cost to be accepted if this interpretability is to be maintained.

3.4 Proem

Proem [16] is a platform for the development of P2P collaborative applications in mobile ad- hoc networking environments. Proem provides a complete SDK which includes

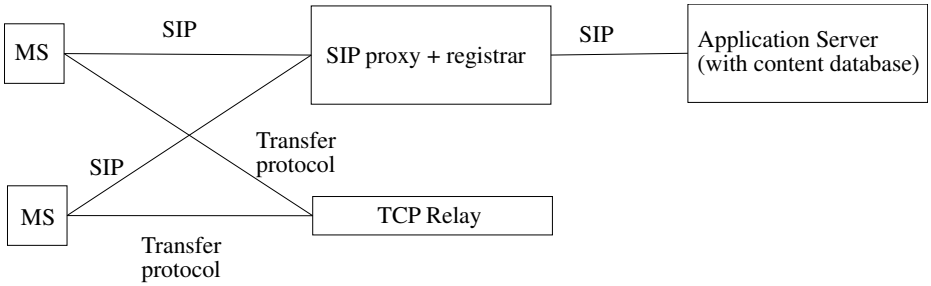

Fig. 3. Mobile Peer-to-Peer Content Sharing Prototype

a collection of Java interfaces and classes for rapid development of mobile peer-to-peer applications called peerlets. Proem also provides a runtime environment for the execution peerlets.

The Proem middleware consists of three main components: an application runtime environment, a set of middleware services, and a protocol stack. Proem defines four protocols, one low level transport protocol and three higher-level protocols.

Proem differs from previous platforms by focusing on the requirements of face-to-face applications.

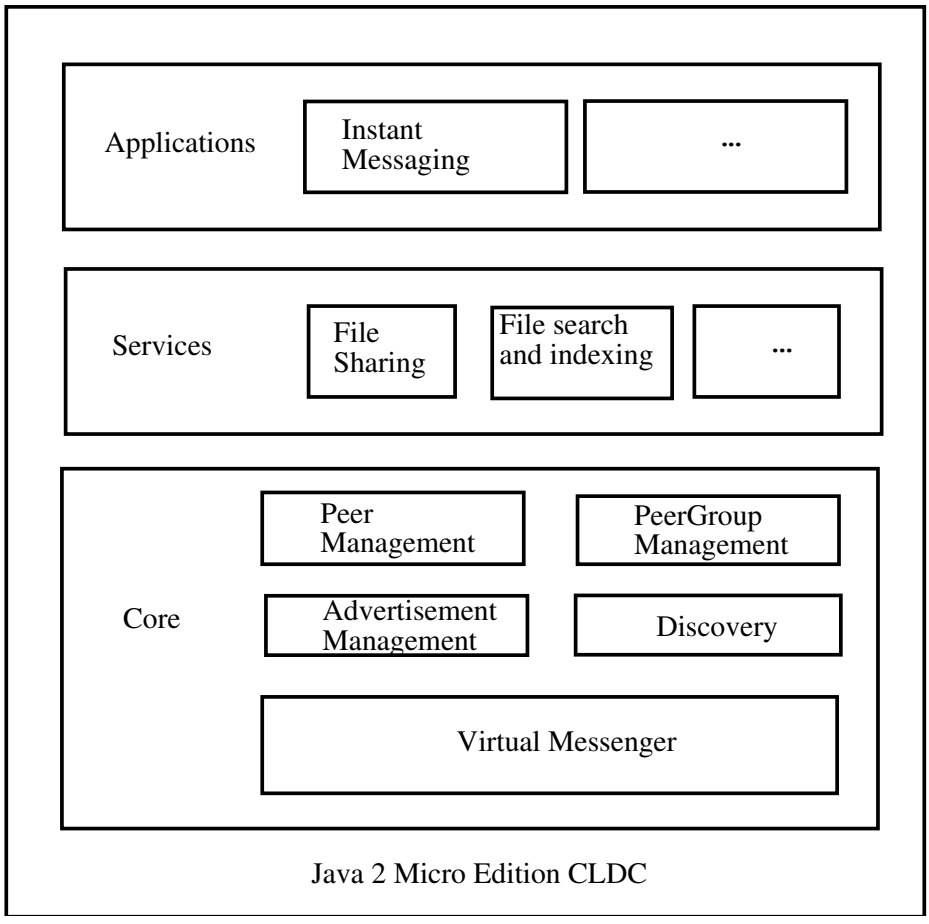

Fig. 4. JMobiPeer Architecture

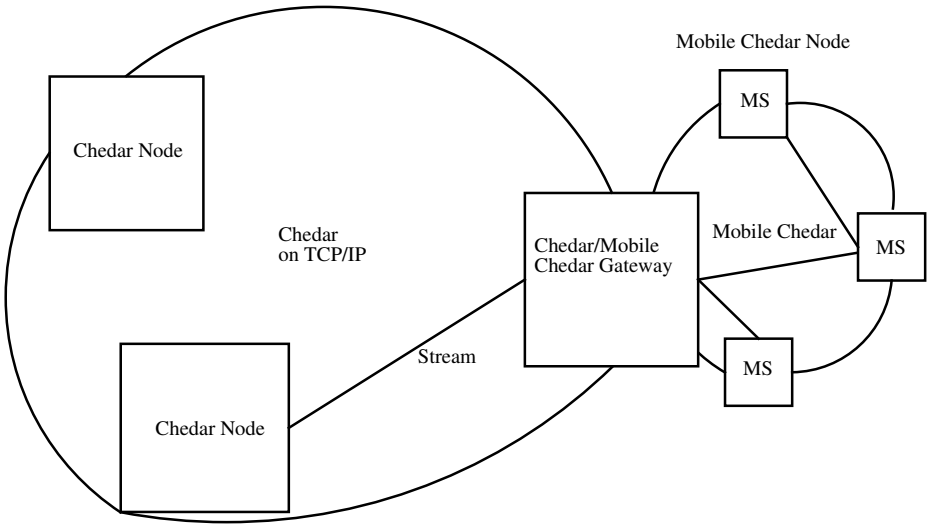

Fig. 5. Mobile Chedar Topology

3.5 Peer2Me

Peer2Me [17] is an open source project developing a framework for mobile collaborative applications on mobile phones.

Peer2Me enables developers to create collaborative applications for mobile phones using a network technology such as Bluetooth. The architecture and concepts of our framework are independent of the kind of PAN technology supported in the mobile device. The Peer2Me project was initiated to enable rapid development of proximity-based peer-to-peer applications for mobile devices on the Java 2 Micro Edition (J2ME) platform. Peer2Me is based on a hybrid peer-to-peer model.

3.6 Mobile Chedar

Mobile Chedar [18] is an extension to the Chedar peer-to-peer network allowing mobile devices to access the Chedar network and also to communicate with other Mobile Chedar peers. Chedar (CHEap Distributed ARchitecture) is a peer-to-peer middleware designed for peer-to-peer applications.

In this project Chedar has been extended to the mobile platform as Mobile Chedar. Mobile Chedar is implemented using Java 2 Micro Edition (J2ME), and uses Bluetooth as a transmission technology for connecting to other peers. Current Bluetooth implementations have a restriction that nodes can be connected to only one piconet at a time. Therefore the only topology available for constructing Bluetooth network is star-shaped. One device functions as a master and others as slaves (hybrid architecture)5.

3.7 Symella

Symella [19] is a Gnutella [20] file-sharing client for Symbian smartphones. It is capable of searching and downloading, but does not upload any data in its current release. It supports multi-threaded downloads which means that if multiple users have a particular file then Symella can download the file from several locations simultaneously. Gnutella is a flooded request model. Each request from a peer is flooded to directly connected peers. This solution consumes a lot of bandwidth, and consequently this this mobile client does not support data uploading.

3.8 SymTorrent

SymTorrent [21] is a complete BitTorrent [22] client for Symbian OS. It supports downloading multiple torrent files at the same time, is capable of both downloading and uploading and can save the status of unfinished torrents, so that downloading can be resumed after restarting the application. BitTorrent organizes peers sharing the same file into a P2P network and focuses on fast and efficient replication to distribute the file.

WizBit [23] is another BitTorrent client for mobile phones. It does not fully work yet and is only suitable for alpha release.

3.9 Bedd

Bedd [24] is a commercial application which runs on Symbian Series 60 smartphones. Bedd, currently, uses GPRS and Bluetooth wireless technology. Bedd is an end user application which enables ad hoc mobile communication between mobile phones.

4 Conclusions

After the analysis carried out we can conclude that there is a huge fragmentation in the mobile peer-to-peer field. Interoperability between the analyzed solutions has only been considered within the JMobiPeer project, where only interoperability with JXTA is taken into account. In this sense we propose a middleware which allows the integration of existing fixed and mobile solutions in order to ensure the interoperability between the different available applications.

On the other hand although many solutions have been proposed none of them approach the problem related with the heterogeneity of wireless and fixed networks, and the majority of them center on only one communication technology. In these sense all the presented solutions are limited as they fail to exploit the main advantage of mobile phones, the mobility.

In the same way security issues are not taken into account in the previous implementations. One of the most important challenges of SMEPP project is adapting security techniques to P2P systems.

Many of the solutions proposed are based on existing protocols, such as Gnutella or BitTorrent, others are based on specific protocols designed taking into account constraint present on mobiles devices such a MPP. Finally the most extended solution in mobile environments are based on SIP protocol [25].

Acknowledgment

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