Short Range Wireless P2P for Co-operative Learning

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Abstract

We present here a Mobile Peer-to-peer application for cooperative lecture notes taking. The application is based on Mobile Chedar, a mobile extension to the Chedar peer-to-peer application plateform, and Bluetooth. Mobile devices communicate with each other, but also with non-mobile computers playing the role of gateway to the fixed Chedar network. All nodes (mobile and non-mobile) taking part in the application share one multicast channel; this channel can be relayed over the fixed chedar network in order to link two distant Bluetooth piconets, or to allow non-mobile users to use the application.

1. Introduction

Peer-to-peer (P2P) systems have attracted attention lately. On one hand, this attention has been achieved by everyday news reports about file sharing systems, and on the other hand, by researchers have finding intriguing problems related to peer-to-peer environments. The reason why P2P systems have found their way into the knowledge of average people is not very flattering to the technology itself: this is because of illegal distribution of copyright-protected material, such as movies and music, over the Internet. Although the technology is widely known due to its misuse, it also has plenty of real benefits including scalability, cost-effectiveness and fault-tolerance. Providing these properties in an efficient manner causes some difficulties and that is the reason why P2P has lately been under heavy research.

The ability to harness different resources scattered in the Internet is probably the biggest appeal of the P2P technology. The resources that can be shared over the Internet are, for example, computing power, storage space and network bandwidth. Taking advantage of P2P starts from a primary approach, in which all the tasks and responsibilities are shared between the peers. This means that there is no single control entity responsible for services, hence the name peer-to-peer network. Therefore Peng et al. [15] characterize P2P-systems as a new philosophy compared to the traditional client/server framework (C/S).

The C/S-systems do have their advantages due to which they are widely used: only a small amount of resources is required on the client side, and the maintenance of the systems is easy, because of their centralized nature. On the other hand, these features previously considered as strengths are now turning into weaknesses due to the increase in the number of the devices connected to the network. The C/S-systems are also unable to benefit from increased resources on the client side [10]. The differences between the P2P and C/S-systems can be described as following: in the C/S framework the network is a required part of the system, whereas P2P concentrates on taking maximum performance out of the peers [14].

Today the computing power and storage capacity of the devices connected to the Internet are at a level where they are staying idle most of the time. And since this extra capacity already exists, but is mostly underused, taking advantage of it can be justified. The P2P-systems therefore provide an alternative to the traditional C/S-systems. The P2P-systems use the constantly growing capacity found in the Internet, instead of centralizing all the services into one control node, which would expose this node to a heavy load [1].

Compared to the C/S-system, the P2P-system offers the user an active role in producing information: the user does not only passively download the information, but also participates in propagating it [14]. Due to a growing number of providers, a greater amount and diversity of information can be attained from the Internet. This large amount of information does bring its own problems, but P2P-systems are, nevertheless, believed to be gaining a substantial role in the future. [16]

2. Mobile Peer-to-Peer

In addition to peer-to-peer networks, another technology has also lately attracted attention in the science world: mobile ad hoc networks (MANET). These were developed by a DARPA project in the early 1970's [17], and have later spread to civilian use as well. A mobile ad hoc network is a network with no predetermined structure. It consists of mobile wireless network nodes that are able to communicate with each other through intermediate nodes [7].

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Certain similarities can be found in comparing MANET and P2P. First of all, neither system has a central node controlling the services. Second, both systems have a network topology which is constantly changing, due to which delivering messages between two nodes is problematic.

Despite these similarities, it is important to note that these two systems work on different network layers: the MANET is specified on the network layer, while the P2P is considered to be on the application layer [7]. Combining these two systems is now rising to be the next interesting research challenge. This combination is referred to as MP2P (Mobile Peer-to-Peer).

There may, however, be problems in combining these two technologies working on totally different network layers. The traditional P2P-protocols functioning on the application layer are not aware of any lower layers, and are thus unable to determine whether they are, for example, situated above a fixed network infrastructure or MANET. In a case of using MANET, link breaks are common as nodes are in motion. A traditional P2P-application would try to re-establish the broken link using the same routing information, but due to possible changes in the network topology there might be other sources that could provide better quality of service [17].

Taking into account the specific features of both systems, Charas [4] describes the MP2P using three characteristics: 1) True multi access. There cannot be any requirements for an access medium. That means the mobility is not related to any single access technology, and is not even tied to wireless ones. 2) Transport independence for services. This characteristic is the result of the first one, but also requires to be independent of the used transport protocol, and must be able to be transported over any type of access medium. 3) Identifying services and users is done without any centralized control management system. Thus it is the end user who will determine how authentication should be done.

Some technical aspects of MP2P, such as limited bandwidth, unreliable connections and constrains of mobile devices, results in limitations compared to the traditional P2P-applications [15]. Therefore the accessibility and quality of services will play an important role in the MP2P-systems [12].

Since it is not possible to solve the previously described problems with the current P2P-applications, there will be a need for middleware applications to fill in the gap between applications and actual data transmission [8].

This paper presents one implementation of a mobile peer-to-peer middleware enabling information sharing in a mobile environment. In the following sections we discuss some related work on mobile peer-to-peer middlewares, introduce Mobile Chedar mobile peer-to-peer middleware and describe a co-operative learning application using Mobile Chedar middleware.

3. Related Work

MOBY [8] is characterized as a service network that enables access to services on large computing platforms at supercomputing centers as well as access data repositories around the world. In addition to be able to use remote services, MOBY also provides means for a mobile terminal to act as data source. Thus MOBY enables each mobile device to be both service user and service provider. This framework is build with Jini and Jini Technology Surrogate Architecture Specification.

Another software called Proem [9] is a mobile middleware platform that provides a solution for developing and deploying applications for mobile ad hoc networks. In Proem there is a middleware application that is responsible for presence and discovery services as well as being an identity, data space and community manager.

4. Mobile Chedar – A MP2P Middleware

4.1. Chedar

Chedar (CHEap Distributed ARchitecture) is peer-to-peer middleware designed for peer-to-peer applications. The goal of the Chedar software is to experiment with network topology optimization algorithms and resource discovery algorithms in a fully distributed peer-to-peer network. The original goal of Chedar was to locate unused resources in a computer network that could be used for a given purpose; one could thus locate idle computers with a given characteristics in order to run computationally intensive calculations. It has then been extended to handle any type of resource: data (files), software (e.g. operating systems or specific applications) and hardware (e.g. computers, printers and displays). Chedar thus allows users to easily build peer-to-peer applications. It also provides platform independence and quick adaptation to new hardware. Chedar has been programmed with Java 2 Standard Edition and is currently being used for speeding up the computations of NeuroSearch resource discovery algorithm [18] and for studying distributed data fusion in peer-to-peer environment [13].

Each Chedar node is identified with a pseudo-unique identifier (Chedar ID). It also maintains a database of locally available resources shared by the owner of the device. These resources can include for example files and databases, software running on the device that can be accessed or used by remote users, and hardware characteristics of the device. Also, remote resources discovered on the network can be added to the database combined with information about their owner identified by Chedar ID and meta-information about themselves. Meta-information can contain e.g. type and path for the files, name and version for applications or any useful description for the hardware depending on the application, which is using the information. The resource database is stored as an XML document using a specific DTD. This organization of data allows making rich and complex queries to the database in the form of XPath expressions.

4.2. Mobile Chedar

With the advent of mobile computing and the inherent peer-to-peer properties of mobile ad hoc networks, Chedar is being extended to the mobile platform under the name of Mobile Chedar. It thus provides functionalities for registering resources on the mobile device and to query resources from other peers. Mobile Chedar is implemented using Java 2 Micro Edition (J2ME), which is suitable for mobile wireless devices and in the future is expected to gain wide acceptance in new mobile phone models. Mobile Chedar uses Bluetooth [2] as a transmission technology for connecting to other peers, as it is the most common available short-range radio frequency wireless protocol stack on today's mobile devices.

Currently Bluetooth has a restriction that nodes can only be connected to one piconet at a time [11]. Therefore the only topology that is available for constructing Bluetooth network is star-shaped. One device functions as a master and others as slaves. In Mobile Chedar the master device can be e.g. a workstation with a Bluetooth adapter and an Internet connection, working as a Mobile Chedar/Chedar gateway node. Through the Internet connection it keeps contact with other Chedar nodes and through Bluetooth it can communicate with other Mobile Chedar peers.

A common use case for Mobile Chedar is the querying a resource located on Chedar nodes or on other Mobile Chedar nodes through the gateway peer and using of the found resource. Chedar nodes can provide text, audio and video stream resources to Mobile Chedar peers and depending on the capabilities of the Mobile Chedar node's device they can subscribe to these streams. Multiple peers can simultaneously subscribe to the same stream and after subscribing they also start to publish the stream as a resource. Therefore it is enough for a peer to locate one peer that provides the needed stream. This kind of a streaming is called end system multicasting [5]. Also, because streams are duplex, the data written to the streams by peers will be delivered to all other peers currently subscribed. However, the order of the data is not preserved and it is handled in a First-In-First-Out manner. Totally ordered delivery of data would require more complex implementation in this kind of environment [6]. Figure 1 illustrates a stream delivery between Chedar and Mobile Chedar peers.

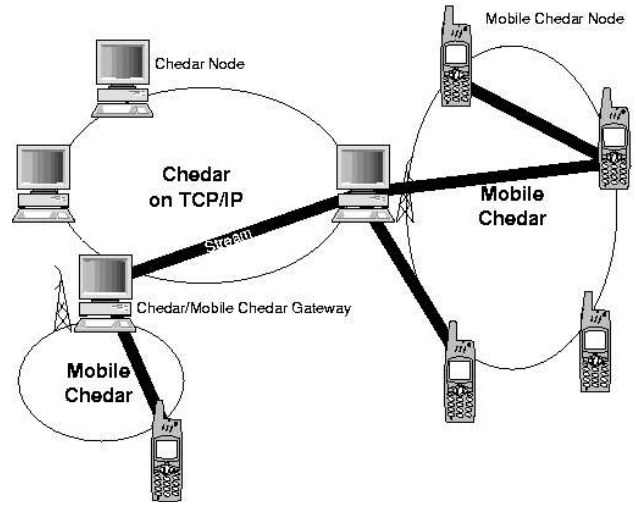

Figure 1. Stream delivery between Chedar and Mobile Chedar nodes.

Neighbor discovery is a prerequisite for resource queries. Since the nodes are able to communicate with each other using a wireless channel, it is easy to discover all nodes which are within range of the radio frequency transciever, using Bluetooth's Service Discovery Protocol (SDP) [3]. Mobile Chedar thus advertises itself to other nodes using SDP and, when searching for neighbors, the received advertisements are added to the resource database, if they are not yet present there. The information stored in the database about one node must at least contain its Chedar ID and its Bluetooth MAC address.

The discovery of resources is then performed as one-hop query, tagged with a unique Message-ID, to all the nodes within Bluetooth range. In the case when the query arrives to a Chedar/Mobile Chedar gateway node, it checks if the query has already been received: if not, it is forwarded to all of its Chedar neighbors with default time-to-live; otherwise, the query is discarded. If the query message matches one of the resources owned by the node, the node replies to the neighbor from which it received the query (the reply message must be tagged with the same Message-ID as the one of the query message). The reply message then travels back to the originator of the query on the same path as the query travelled on. Once the location of the resource (or locations, if the resource exists in multiple instances in the network) is known, Mobile Chedar informs the application, which decides how to acquire or use the resource.

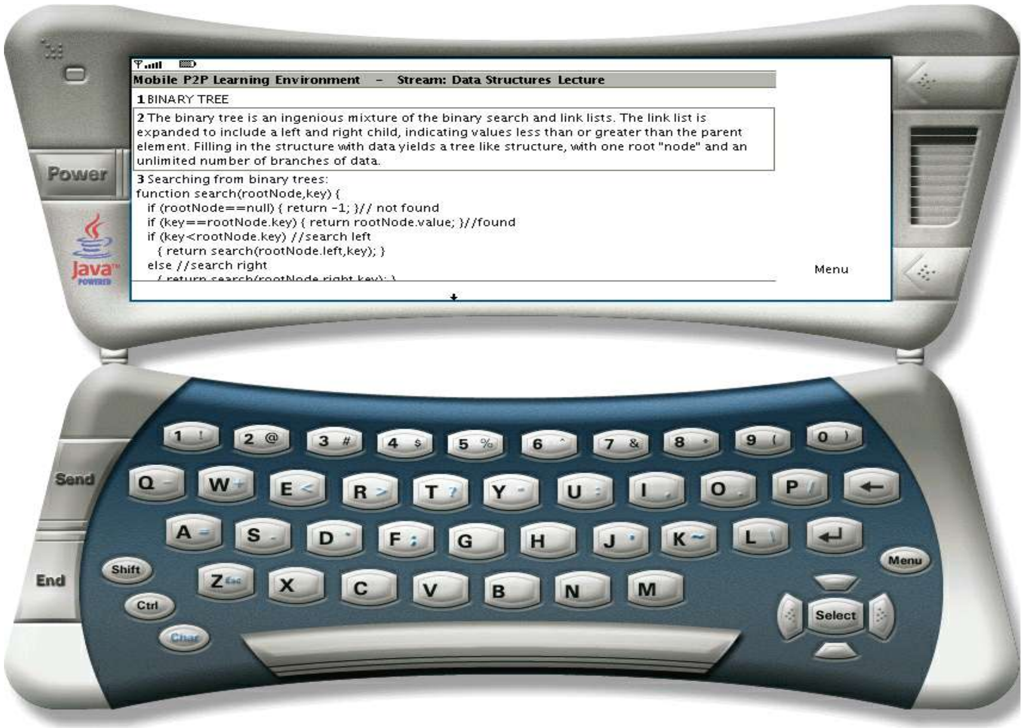

Figure 2. Mobile Peer-to-Peer Learning Environment user interface.

5. Mobile Peer-to-Peer Learning Environment

Mobile Peer-to-Peer Learning Environment (MP2PLE) is designed for collaborative note taking during lectures as a test application for the Chedar peer-to-peer network and the Mobile Chedar middleware. The MP2PLE user interface contains a text area displaying the current state of notes and provides means for users to edit them. With MP2PLE, the mobile device user may create a new stream for other participants to join or subscribe to an already existing one by executing a query. After subscription the user is allowed to modify any part of the notes by selecting a paragraph and submitting the changes. Whenever the data is being changed it is streamed to other participants subscribed to the same stream. Because of the limited screen space each user can be only subscribed to one stream at a time. In case of multiple streams there might be too much information for the user to handle. The user interface of MP2PLE is shown in figure 2.

There are two common use cases for such kind of an application. Firstly, it serves as a personal note taking tool to store lecture notes. Secondly, people who do not take notes can benefit from other user's notes, either during the lectures, or later, e.g. from home, using a fixed Chedar node. Also, in order to to disallow some malicious users to insert garbage text into the current notes, the user can block the changes received from specific peers.

5.1 Limitations of MP2PLE

The tiny user interface is problematic and provides only primitive means to take notes e.g., pictures cannot be drawn and course presentation material cannot be integrated with MP2PLE. Also, taking lecture notes is difficult because of the small keypads in mobile phones. These limitations can only be overcome if larger screen sizes and more convenient input devices are being used.

Bluetooth does not allow multihop with current mobile phones because only one piconet can be constructed. To support multiple devices in a classroom one solution would be to use the approach presented in [11] and to equip Bluetooth base stations with two radio chips. They could, for example, be plugged into power supplies inside the classroom and equipped with Mobile Chedar middleware to function as relaying devices for queries. Another solution would be to use different transmission technology e.g., Wireless Local Area Network (WLAN), but because there is a lack of mobile devices with WLAN capabilities this solution is not good at the moment.

6. Future Work

Future developments include the support of audio/video data as well as a distributed whiteboard in the application in order to enable mobile interactive conferencing, as well as support for other wireless communication technologies, such as WLAN, and multihop routing.

7. References

[1] K. Aberer, M. Punceva, M. Hauswirth, and R. Schmidt, "Improving data access in P2P systems", Internet Computing, IEEE, Volume: 6, Issue: 1, Jan.-Feb. 2002, pp. 58-67.

[2] Bluetooth Core Specification v1.2

[3] Bluetooth's Service Discovery Protocol (SDP)

[4] P. Charas, "Peer-to-peer mobile network architecture", The First International Conference on Peer-to-Peer Computing, 2001, Proceedings, 27-29 Aug. 2001, pp. 55-61.

[5] Y. Chu, S. G. Rao, and H. Zhang, "A Case for End System Multicast", International conference on Measurement and modeling of computer systems, SIGMETRICS, Proceedings, 2000, pp. 1-12.

[6] G. Coulouris, J. Dollimore, and T. Kindberg, "Distributed Systems – Concepts and Design", 3rd Edition, Addison-Wesley, 2001.

[7] G, Ding, and B. Bhargava, "Peer-to-peer file-sharing over mobile ad hoc networks", The Second IEEE Annual Conference on Pervasive Computing and Communications Workshops, 2004, Proceedings, pp. 104-108.

[8] T. Horozov, A. Grama, V. Vasudevan, and S. Landis, "MOBY-a mobile peer-to-peer service and data network", International Conference on Parallel Processing, 2002, Proceedings, 18-21 Aug. 2002, pp. 437-444.

[9] G. Kortuem, "Proem: a middleware platform for mobile peer-to-peer computing", Mobile Computing and Communications Review, ACM, Volume: 6, Issue: 4, October 2002, pp. 62-64.

[10] G. Kwon, and K.D. Ryu, "An efficient peer-to-peer file sharing exploiting hierarchy and asymmetry", Symposium on Applications and the Internet, 2003, Proceedings, 27-31 Jan. 2003, pp. 226 – 233.

[11] M. Leopold, M. B. Dydensborg, and P. Bonnet, "Bluetooth and Sensor Networks: A Reality Check", The first international conference on Embedded networked sensor systems, Proceedings, November 2003, pp. 103-113.

[12] N. Maibaum, and T. Mundt, "JXTA: a technology facilitating mobile peer-to-peer networks", International Mobility and Wireless Access Workshop, 2002, MobiWac 2002, 12 Oct. 2002, pp. 7-13.

[13] S. Nazarko, "Evaluation of the data fusion methods using Kalman filtering and Transferable Belief model", Master's Thesis, University of Jyväskylä, 2002.

[14] M. Parmeswaran, A. Susarla, and A.B. Whinston, "P2P networking: an information sharing alternative", Computer, IEEE, Volume: 34, Issue: 7, July 2001, pp. 31-38.

[15] G. Peng, S. Li, H. Jin, and T. Ma, "M-CAN: a lookup protocol for mobile peer-to-peer environment", 7th International Symposium on Parallel Architectures, Algorithms and Networks, 2004, Proceedings, 10-12 May 2004, pp. 544-549.

[16] Y. Ren, C. Sha, W. Qian, A. Zhou, B. C. Ooi, and K.-L. Tan, "Explore the "small world phenomena" in pure P2P information sharing systems", 3rd IEEE/ACM International Symposium on Cluster Computing and the Grid, 2003, Proceedings, 12-15 May 2003, pp. 232-239.

[17] R. Schollmeier, I, Gruber, and F. Niethammer, "Protocol for peer-to-peer networking in mobile environments", The 12th International Conference on Computer Communications and Networks, 2003, ICCCN 2003, Proceedings, 20-22 Oct. 2003, pp. 121-127.

[18] M. Vapa, N. Kotilainen, A. Auvinen, J. Töyrylä, H. Hyytiälä, and J. Vuori, "NeuroSearch: evolutionary neural network resource discovery algorithm for peer-to-peer networks", University of Jyväskylä, 2004.