Sharing Information Resources in Mobile Ad-hoc Networks

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Abstract. Many people are sharing digital resources through networks in order to facilitate, enhance or improve collaborative work. Information sharing is not only important to support collaborative work but it also represents the basis for design and implementation of solutions for typical design aspects of groupware applications, such as: floor control, group memory, shared objects replication and sessions and users management. Advances in mobile technology have extended the sharing information scenarios to Mobile Ad-hoc Networks (MANETs), which has brought new challenges. This paper presents a simple service platform to share information resources among members of a MANET-supported groupware session. People interact using notebooks and PDAs. In addition, a shared presentation tool which has been developed using the services of the platform is described. This presentation tool can be used to assist other collaborative activities, such as: technical presentations, casual interactions, meetings for decision making and software technical reviews.

1 Introduction

Gartner's report estimated that PDA revenues in 2004 reached a record $4.3 billion for a 16.7 percent increase, compared to 2003 figures [2]. IDC estimate that 13 million handheld devices are sold each year and the estimation for 2005 is 71 million units to be sold [8]. Advances in mobile technology and the price reduction of computing mobile devices have prompted the spread of this technology to many scenarios, such as: schools, hospitals, police, government and business. However, handheld machines are not massively used to assist group work yet; their main use still is to support personal activities.

These devices incorporate communication capabilities - usually based on Wi-Fi - which allow them to interact with each other using wireless (one hop) and mobile (multihop) networks [17]. Therefore, any physical scenario providing these communication services to people on the move becomes a potential collaboration arena. Examples of these scenarios are: shopping malls, offices, universities, hotels and airports. Software reviews, brainstorming sessions, shared presentations and synchronous learning activities are some of the collaboration activities that could be supported using these devices. However, supporting these collaboration activities in

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mobile networks, also named MANETs (Mobile Ad-hoc NETworks) [17], involves finding MANET-based data sharing solutions.

This paper presents a service platform that allows collaborators be grouped in ad-hoc sessions and share information resources on MANETs, by using notebooks and PDAs. That platform can also be considered as a basis to develop solutions to support groupware design aspects, such as floor control, group memory, shared objects replication and sessions and users management. Solutions found to support these design aspects will depend on the MANETs information sharing strategy.

Next section describes the challenges to share information on MANETs. Section 3 presents related research work. Section 4 describes the service Platform for Ad-hoc Sharing Information Resources (PASIR), a presentation tool which has been developed using the services of the platform, and a discussion on PASIR strengths and weaknesses. Finally, Section 5 presents the conclusions and future work.

2 Sharing Information in MANETs

For many years the CSCW and CSCL communities have used shared information as a way to support or enhance collaboration among people [14, 15]. Shared information has also being used to develop software solutions supporting design aspects of groupware applications [4, 13]. The most common strategy to share information among collaborators involves centralizing data and services. Many groupware platforms were designed following this strategy [12], and they show good results in distributed systems supported by stable wired and wireless networks. However, this strategy is useless when collaborators are communicated through an unstable network like a MANET [1, 5]. The network structure becomes highly dynamic since collaborators move continuously, and each centralized resource represents a failure point for collaborative solutions in term of ensuring the communication availability. Hence, low availability of the shared data space jeopardizes the collaboration process. Although sharing information on mobile systems is not a new challenge, most of the proposals do not consider the use of handheld devices, such as PDAs, and unstable communication services, which is a particular feature of MANETs. These particularities bring new challenges for sharing information for collaboration.

PDAs typically constrain groupware applications mainly in terms of screen size, processing power, memory capacity and networking services provided by the operating systems. These services allow notebooks and PDAs be integrated in the same workgroup scenario [5]. On the other hand, the signal instability and the tight bandwidth in MANETs represent the main restrictions for the groupware communication services design. Collaborative systems using such communication services should exhibit high shared data availability to avoid jeopardizing the collaborative process. These restraints also show the need for new solutions able to keep high availability of shared information even in that unstable scenario.

3 Related Work

There are several research initiatives that are trying to provide good solutions to support sharing information in peer-to-peer networks. Some of these related works are

tuple-based distributed systems derived from LINDA [3], such as: FT-LINDA, JINI, PLinda, T-spaces, Lime and JavaSpaces [6, 11]. Although these implementations allow sharing information in peer-to-peer networks, they use centralized components to provide binding among components of the distributed system. Such centralized components become critical failure points in unstable networks.

Another related project is the iClouds framework which offers spontaneous mobile user interaction and file exchange in mobile ad-hoc networks [7]. This framework does not require centralized components because it does a full replication of any shared file, which is appropriate in MANET scenarios. However, it does not provide support to exchange shared objects, just files. In addition, iClouds does not distinguish among copies of a same shared file (e.g. master and slave copies) and does not support distributed operations on those files either. Similarly, the Proem platform provides support for shared files, but on Personal Area Networks [9].

Another interesting platform is XMIDDLE. It allows mobile hosts to share XML documents across heterogeneous mobile hosts, permitting on-line and off-line access to data [10]. However, these capabilities do not allow manipulating compound documents (like MS-Office documents or Adobe Acrobat documents), which are used by many people to support the collaboration activities.

Next section presents a software platform named PASIR (Platform for Ad-hoc Sharing Information Resources), which was designed to share files and compound documents using the functionality provided by the .NET framework. It allows users to share information resources through a distributed data space.

4 PASIR

The proposed platform is implemented using C# programming language and reuses the services provided by the .Net framework for object and file manipulation, and also for networking. There are no centralized services or data in the platform. Every component of PASIR is fully replicated in order to keep high availability of resources even when a session member gets isolated. Although a groupware system supported by PASIR is composed of three layers (Fig. 1), the proposed platform involves the two lower layers.

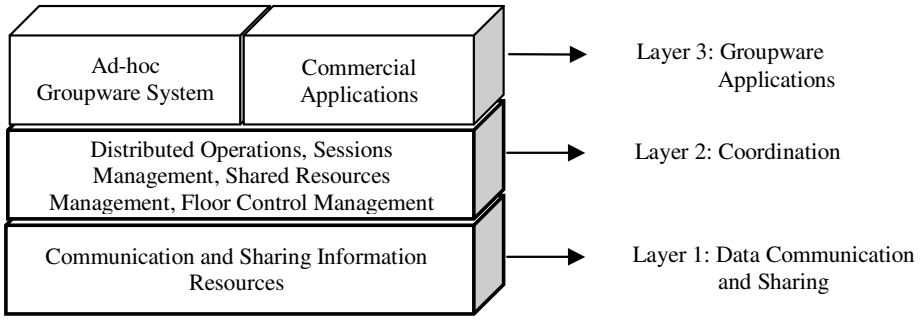

Fig. 1. Architecture of a PASIR-supported Groupware System

Each layer carries out a specific function and it communicates with the adjacent layers through a well-defined interface. The lower layer is in charge of providing all the networking and data sharing services among the groupware applications. The coordination layer uses the services of the lower layer to implement the typical groupware services for collaborative applications. It coordinates distributed operations and it generates a consistent vision of the group activities. The services currently implemented in this layer correspond to the services required by the prototype application used to test the platform. They include session and user management, floor control and shared objects synchronization. Nevertheless, many other services for groupware applications can be included in this layer.

Finally, services for data sharing provided by PASIR can be embedded in ad-hoc collaborative applications and also in some commercial software products, such as Microsoft Office, Adobe Acrobat and Photoshop. This particular functionality allows some monolithic applications support collaborative activities. Thus, it is possible to reuse all data-manipulation applications functionality if the data is based on COM (Component Object Model) objects [16]. These applications represent the upper level of the architecture. The current implementation of PASIR supports just on-demand shared objects synchronization through services provided by the coordination layer.

4.1 Data Communication and Sharing Layer

The PASIR communication services are asynchronous and based on UDP over IP. UDP does not guarantee packet delivery as TCP; however, it is suitable for mobile environments because it is connectionless. In addition, it allows using IP multicast to detect the presence of reachable hosts. Communication services provided by PASIR can be used on any network platform able to use UDP over IP, such as Bluetooth, IrDA and IEEE 802.11x. Consequently, PASIR can be used in stable and unstable communication environments. These communication services are the same provided by the .Net framework for both notebooks and PDAs. Yet, the semantics of the messages was specifically designed to allow information sharing on MANETs.

People are able to share two types of resources using the communication services: flat files and COM objects. Every shared resource has an XML descriptor specifying its features and indicating whether the resource is a master or slave copy. These shared resources are located in a folder that every user has for each opened session. Some shared resources could be a collection of shared interrelated objects (e.g, a MSWord document or a PowerPoint presentation can be considered a collection of shared linked COM objects). Besides, the comments a user can include in that collection are also shared objects that are part of the collection. These shared objects can travel together or they can be filtered to decouple them for synchronization purposes. The synchronization services are provided by the coordination layer.

4.2 Coordination Layer

The coordination layer is based on a fully replicated session manager. It locally records information about users, sessions and shared resources (Fig. 2), and allows users to interact with the shared objects through a visual interface (Fig. 3a and 3b). Shared objects are grouped in sessions. Every session also groups users sharing

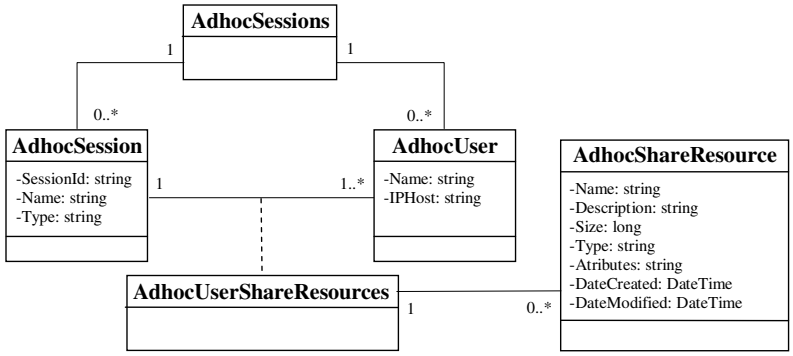

Fig. 2. Structure of the PASIR Session Manager

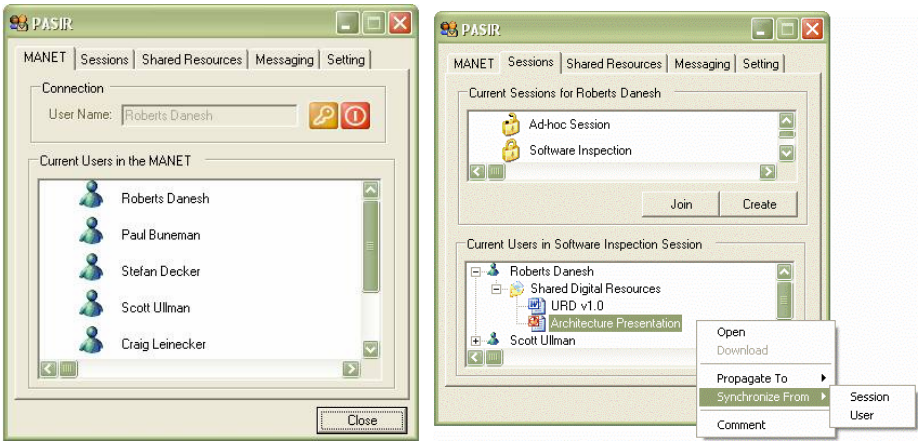

Fig. 3. User Interface of the PASIR Session Manager

information resources with the remaining session members. Every user in the MANET can be part of more than one session. Users showing interest to connect to the MANET are registered by the AdhocSessions class (Fig. 2) and they become available in the shared environment (Fig. 3a).

Once inside the environment, a user (AdhocUser class) can access a session in two ways (Fig. 3b): (a) creating a session, in that case she is automatically inside; or (b) requesting access to an existing session (AdhocSession class). When a user creates a session the platform gives her a SessionId which is not visible to the rest of the MANET members. The SessionId should be sent to the users that are invited to the session. The invitation and the SessionId will be delivered using multicast.

Once a user has access to a session, a local shared folder of the session (AdhocShareResource class) becomes visible to the rest of the session members (Fig. 3b). Thus, that user can synchronize her shared resources with the resources of a specific partner or with the rest of the session members. The attributes of each shared object are analyzed and compared in order to carry out the synchronization process.

However, the synchronization of files that are not composed of COM objects (e.g., plain text documents) is done using an XML descriptor of the files as support.

Remote shared resources can be downloaded or remotely accessed using the local session manager. When a user leaves a session, the local shared resources are kept available for the local user who can work asynchronously. The COM objects included by the user in the local copy (e.g., comments on a MSWord document) can be transferred to the master copy next time the user with the master copy and the user with the comments are reconnected to the working session. Every working session is potentially alive even if no users are currently connected and it gets available when the first user gets in. A user can leave a working session for good indicating that decision to the local session manager. A session is potentially alive while a registered user exists (even if he is not connected).

4.3 Groupware Applications Layer

Several groupware applications can be developed using PASIR services. Even some commercial products are able to interact with the platform using the services. As an example, this section briefly describes the design of SPT (Shared Presentation Tool). This tool makes shared PowerPoint documents accessible to several users in a session. Such users are also able to link comments to this shared document. This process can occur both when the document is being edited and when the presentation is being delivered. Author and presenter use the regular MS PowerPoint product, whereas reviewers connected to the same session use the commenter module to make comments. Every comment is linked to a slide. Comments made by reviewers are linked on-demand into the master copy of the PowerPoint document, that is the one used by the presenter. The synchronization process can be done following four strategies: one sender and one receiver, one sender and many receivers, many senders and one receiver, and many senders and many receivers (whole synchronization). Every comment can be a COM object or an attribute specified in the XML descriptor depending on the .Net framework version being used (full or compact version). These comments can be anonymous or not. Moreover, the same strategy can be used to make comments or corrections to a paragraph of a shared MS Word document. This tool can be useful to support collaborative activities such as software technical reviews, paper presentations or meetings for decision making. This implementation has the same user interface for notebooks and PDAs.

4.4 Discussion

The PASIR platform is easy to deploy in notebooks and PDAs communicated through a MANET. It allows sharing the information resources and keeps a high availability of both shared information resources and services. That functionality can be considered a basis to develop solutions to support the groupware design aspects and also collaboration among people. The PASIR current implementation supports distributed asynchronous work because of the services currently available in the coordination layer. Nevertheless, prototypes of synchronous coordination services are under construction.

The relationship between PASIR and commercial frameworks and applications allow developers reuse functionalities from these commercial products to support collaborative activities or to create new groupware applications. Although this reuse constrains groupware systems, usually it also represents a reduction in development effort and an improvement on the product quality.

The main limitation of this proposal refers to the fact these advantages can be obtained only by using the MS Windows family of operating systems. Furthermore, the integration of PDAs and notebooks and the synchronization mechanisms also depend on it, because most of them are provided by the .Net framework.

The proposed platform can also be used in stable (wireless or wired) communication settings, using several computing devices and desktop PCs. The platform functionality in that case is the same. However, the stability of the communication services allows including the server in the network to ease and to improve the efficiency of the information sharing process.

5 Conclusions and Future Work

A platform easing information resource sharing in MANETs using notebooks and PDAs has been presented. The platform functionality can be considered a basis to develop solutions to support the groupware design aspects and also collaboration among people. Unlike other initiatives, the proposed platform takes advantage of the relationship between .Net and COM frameworks [16] and well-known commercial products in order to provide a scenario to assist collaborative activities.

The main advantage of PASIR is the relationship it has with commercial frameworks and applications. It allows developers to reuse functionality available in these frameworks and also in the applications. However, these advantages are only available for the MS Windows family. It restricts the portability of the groupware systems and programming languages that can be used to develop, extend or integrate these systems. Although PASIR was designed for MANETs, it is also possible to use it in stable communication settings including desktop PCs.

In order to complete the PASIR support for synchronous and asynchronous information sharing, the authors are currently working on the implementation of new coordination services that will allow synchronous sharing of the COM objects and files. Future work includes embedding awareness components in monolithic commercial applications, using add-in capabilities to improve the support for the collaborative work. Moreover, the groupware services provided by the coordination layer will be increased and improved. Finally, experimentation in real scenarios should be carried out to evaluate the proposal and get feedback to improve it.

Acknowledgments

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