Data Synchronization of Mobile Peer-to-Peer Application: Experiments on the Android Platform

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Abstract

Traditional resource synchronization processes exchange files between PCs and enterprise mainframes. In recent years, smart devices have increased employee mobility, allowing them to carry out work in a ubiquitous environment. Resource synchronization has thus become an important focus of investigation, particularly in terms of which network transmission protocol is most suitable for use by smart devices. A peer to peer network is a type of decentralized and distributed network architecture. Individual peers in the network act as both suppliers and consumers of resources. In a ubiquitous environment, a reasonable solution for file resource synchronization is to construct a mobile peer to peer network (MP2P) based on a distributed peer to peer architecture that provides a secure platform. This study explores network transmission protocols, including Juxtapose (JXTA), Session Initiation Protocol, Bluetooth, and WiFi Direct, in order to construct a MP2P network of Android-based smart devices for data synchronization. The experiment demonstrates that the JXTA protocol provides more functionality for Android-based smart devices. The contribution of this study is to demonstrate that JXTA implementation strengthens an enterprise mobility and synchronizes data using mobile device from any location.

Keywords: Ubiquitous, Mobile peer to peer, Resource synchronization, Juxtapose, Google Android

1 Introduction

As information technology today constantly develops, so smart device functionality is constantly increasing. Furthermore, more and more people are using smart devices for a great number of varied functions (e.g., accessing multimedia resources and reading documents). In the industrial field, enterprises are trying to integrate smart devices into enterprise resource planning (ERP) systems because of their convenience for the employees in performing specific business processes and accessing internal resources. Employees carry out workflow tasks, which produces information or file resources in the business process. ERP systems are collaborative working environments that deal with many file resources among different tasks. After a file resource is processed, comprehensive information will be provided to employees for decision-making or processing other tasks. Thus, workflow tasks require file resources before employees can process them. Therefore, file resources produced by employees in the workflow should be shared with relevant employees in ERP systems.

As a result, ERP systems that integrate smart devices have improved enterprise mobility, so when employees execute specific business processes, they can access the required file resources through smart devices from almost anywhere. Therefore, the combination of ERP systems with smart devices in order to carry out business processes has gradually become an important trend. However, a critical concern is how to effectively and securely share information over a secure platform using smart devices as an auxiliary tool. In addition, satisfying the comprehensive requirements of relevant employees is another issue worth exploring. A viable option in this case would be to construct a Mobile Peer to Peer (MP2P) sharing environment based on the Distributed Peer to Peer (DP2P) architecture over Cloud Computing, which provides a secure platform for file resource sharing. Juxtapose (JXTA) could then be used to transfer the shared file resources.

In [12], an optimal mobile service framework was proposed, which automatically synchronizes telecare file resources among discrete mobile services. In addition, a prototype system was implemented in [13] to examine the optimal mobile service. The experiment result showed that the mobile service was effective and useful for automatically collecting telecare file resources from discrete mobile devices. This study explores network transmission protocols, including Juxtapose (JXTA), Session Initiation Protocol (SIP), Bluetooth, and WiFi Direct, in order to construct a MP2P network of Android-based smart devices for telecare data synchronization. An MP2P resource sharing mechanism is implemented to share files based on the optimal mobile service framework [12] and deployed in the prototype system [13]. When employees execute specific healthcare processes, they

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can use the MP2P features to synchronize the system file resources through a smart device from anywhere, and thus improve the efficiency of file resources sharing. During file resource syncing, a log file of resources is updated in order to maintain the consistency of the file resources. In [12], the security issues of telecare data synchronization in the prototype system [14] related to Data Encryption Standard (DES), Triple Data Encryption Standard (Triple-DES) and Advanced Encryption Standard (AES) were discussed. The AES demonstrated the best performance. Therefore, in this work, all file resource encryption/decryption follows the AES symmetric data encryption due to its superior performance. The contribution of this study is to offer a secure resource sharing mechanism to enhance the effectiveness of enterprise systems. In addition, enterprise mobility will be improved, allowing employees to access file resources through smart devices from anywhere.

The remainder of this paper is organized as follows. Section 2 reviews related works on mobile peer to peer techniques. Section 3 introduces the experimental resource synchronization application for Android-based smart devices. Section 4 presents the experiments and relevant discussions. Finally, in Section 5, we present our conclusions and indicate the direction of future work.

2 Related Work

This section discusses related technologies, including Juxtapose (JXTA), Session Initiation Protocol (SIP), Bluetooth and WiFi Direct. We then examine related literature on peer to peer communication applications.

2.1 Juxtapose (JXTA)

Juxtapose (JXTA) is an open source peer to peer protocol specification started by Sun Microsystems in 2001. XML is used to define the JXTA protocols as a set of messages which allow any device to be connected to a network [1-2]. JXTA protocols introduce the concept of group, and create a virtual group environment in a network. The virtual group environment is called a peer group. A peer group is composed of various connected devices, and facilitates the secure exchange of messages between devices A device in a peer group is called a peer. A peer can join multiple peer groups to collaborate independently of the underlying network topology. The JXTA layer structure [15-16], including three layers. From bottom to top are the JXTA core layer, the JXTA services layer, and the JXTA applications layer. The JXTA core layer constructs the peer group and manages transmissions, e.g., monitoring a peer and constructing a peer group. The JXTA services layer processes the community services, e.g., indexing service, searching service, and file resource sharing service. Most of the functionality of the JXTA services layer is provided by the JXTA core layer, and only some functionality is provided by the JXTA services layer. The JXTA applications layer provides an interface that allows users to develop their functions, e.g., message transmission, data records, e-mails [8-9].

2.2 Session Initiation Protocol (SIP)

Session Initiation Protocol (SIP) was developed by the Internet Engineering Task Force (IETF) in 1993. SIP is able to construct two or more participations in a multimedia communication [11, 24-25], e.g., video conference, real-time message transmission and video calls over Internet protocol. In addition, SIP components assist in transmission [17, 28]. The user position function allows SIP to record user positions on registration. When users want to send messages by connected devices, the registration message will be sent to the SIP server, and the user location will be different according to the network segment of the sending registration message. The user availability function confirms the user intention to construct the communication. If a user wants to communicate with other users, but has had no response in a long time, SIP determines that the user is invalid. A user can register in several positions, but can only receive a single device message once. The user capability function confirms the communication capability of a user device. The session setup function constructs relevant SIP communication parameters for user configuration by both sides of the communication. The session management function provides users with a method to control the start and end of the communication. This function can also change the communication mode, e.g., change the communication from voice mode to video conference mode.

2.3 Bluetooth

Bluetooth transmission protocol was developed by the Bluetooth Special Interest Group (Bluetooth SIG) [30-31] in 1994. The purpose of the protocol is to allow mobile devices to communicate with each other over a short distance with low power consumption and low cost [30]. The Bluetooth transmission protocol has four parts, including core protocols, cable replacement protocols, telephony control protocols and adopted protocols. Core protocols are designed for message transmission between Bluetooth devices. Cable replacement is used to simulate the serial communication of cable devices using RS-232 serial ports. Telephony control protocols define the control signals of voice communication, which are used to construct voice communication and data transmission in Bluetooth devices. Adopted protocols are composed with other Bluetooth transmission protocols. These protocols are confirmed by Bluetooth SIG.

2.4 WiFi Direct

WiFi Direct is a peer to peer protocol developed by WiFi Alliance in 2010. It is also called WiFi point to point protocol, and allows two devices to communicate directly without an access point. WiFi Direct uses peer to peer mode to connect another WiFi devices and transmit data with high speed, and to facilitate sharing, synchronization and print operation. WiFi devices act as a WiFi access point and a WiFi Client at the same time [5]. The WiFi Direct specification has defined the concept of a component group. The WiFi device that is the group creator acts as a wireless access point for connection with other WiFi devices. The group consists of three components, including P2P devices, P2P groups, and P2P clients [32]. P2P devices indicate devices with a WiFi Direct transmission function, and can act as a peer to peer group and a peer to peer client. P2P groups indicate a set containing many peer to peer devices, including the P2P group owner and zero to multiple peer to peer clients. P2P clients indicate the peer to peer devices connected to a peer to peer group.

2.5 Related literature

Researchers have used peer to peer protocols to implement applications in several domains. Razavi et al. [20] presented a peer-to-peer design which aimed to support business activities conducted through a network of collaborations that generate value in different mutually beneficial, ways for the participating organizations. Aygün et al. [3] proposed a conceptual model for a peer-to-peer system. The model provided a classification and summary of data management and distribution strategies. Marc et al. [18] provided anonymity to JXTA's architecture in a feasible manner and proposed an extension which allowed deployed services to process two-way messaging without disclosing the endpoints' identities to third parties. Srinivasan et al. [26] proposed a framework for wireless multimedia digital library, built using Grid and P2P technology. The proposed framework stored the digital data in a cluster built of commodity components and users can access those data from any-where, anytime securely. Cheng and Chen [7] proposed a multi-path, multi-seed dissemination approach suitable for the delivery of multimedia electronic advertise-ments. Mechaoui et al. [19] proposed a new cloud service-based approach, called MICA (Mobile Collaboration in the Cloud), to achieve efficient and scalable real-time editing works by allowing mobile users online access to abundant computing power and data storage.

In the mobile peer-to-peer domain, Ke and Lin [12] proposed an optimal mobile service framework which automatically synchronizes telecare file resources among discrete mobile services. In 2015, they implemented a prototype system in [13] to examine the proposed optimal mobile service framework. In addition, Ke and Lin [14] discussed the security issues of telecare data synchronization in the prototype system [13] related to Data Encryption Standard (DES), Triple Data Encryption Standard (Triple-DES) and Advanced Encryption Standard (AES). Wu [29] proposed a distributed Trust Management Model (DTMM) for constructing much shorter and more robust trust chains in mobile P2P networks. With DTMM, each moving object within the same group tends to have a high probability of keeping stable distances from other objects. Rajkumar and Iyengar [21] used JXTA to construct a mobile peer to peer healthcare management system allowing patient and healthcare workers to exchange messages and transmit data. In 2013, Rajkumar and Iyengar [22] focused on integrating cloud services with P2P JXTA to identify a systematic dynamic process for emergency health care systems. The proposal is based on the concepts of a community cloud for preventative medicine, to help promote a healthy rural community. They also demonstrated that medical knowledge management and mobile-streaming application support the continuing mobile medical education (CMME) system through JXTA in [23]. Tsai et al. [27] used JXTA to design a mobile peer to peer social network application which allows students to transmit file resources and share relevant course information using mobile devices. Barolli and Xhafa [4] used JXTA to construct a ubiquitous peer to peer platform for resource sharing and collaborative processing. The platform communicates with remote devices by JXTA, and controls a learning environment for more effective learning. Wang et al. [17] used SIP to construct a mobile learning environment which allows students and teachers to learn at any time. Cai et al. [6] used a Bluetooth and 3G mobile network to design a blood glucose monitoring system which automatically detects the blood glucose status of diabetics. The status is then immediately transmitted to a healthcare center by Bluetooth transmission protocols. If a patient's blood glucose status is abnormal, the system uses GPS to obtain their location, and sends an alert to the healthcare center. Liu et al. [10] composed the IEEE1588 precision timing protocol, WiFi Direct, and used a time of distance arrival measurement algorithm to predict the distance of a wireless real-time location.

3 Experimental Resource Synchronization Application for Android-based Smart Devices

This section describes an optimal mobile service framework [12] and the prototype experimental applications [13] used on Android-based smart devices.

3.1 An Optimal Mobile Service Framework

In [12], an optimal mobile service framework was proposed, which automatically synchronizes telecare file resources among discrete mobile services. Figure 1 shows that the optimal mobile service framework includes the role-based access control model (RBAC), employee-role identification, and resource synchronization modules. A prototype system was implemented in [13] to examine the optimal mobile service framework. The resource synchronization module synchronizes the telecare file resources using the JXTA protocol over a mobile peer-to-peer network. The telecare file resources are transmitted by the JXTA protocol over a mobile peer-to-peer network. There are five processes execute in the resource synchronization module. In the synchronized resource(s) by JXTA process, an application providing resource synchronization among multiple smart devices was implemented, including one device to one device, and one device to multiple devices.

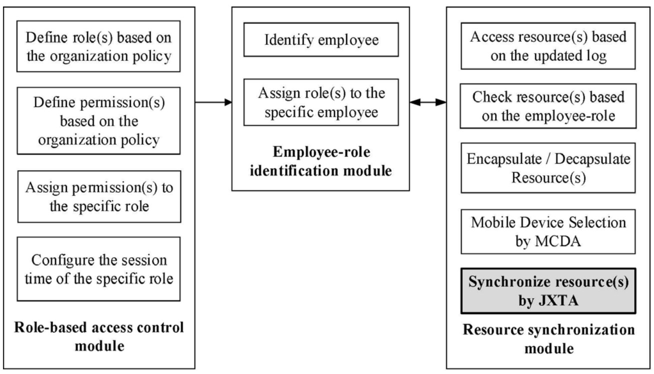

Figure 1. An optimal mobile service framework in [12-13]

In [12-13], the authors found that it was worth further exploring the possible enhancement of the optimal mobile service framework robustness. The issue is to prove that JXTA is a reasonable network transmission protocol for resource(s) synchronization among current popular network transmission protocols. This study examines several network transmission protocols, including Juxtapose (JXTA), Session Initiation Protocol (SIP), Bluetooth, and WiFi Direct, in order to construct a MP2P network of Android-based smart devices for telecare data synchronization. However, the Bluetooth and WiFi Direct protocol Android APIs do not support one device to multiple device resource synchronization. Therefore, only applications which provide the function of one device to one device resource synchronization are implemented with Bluetooth and WiFi Direct protocols. In addition, because the SIP protocol does not support file resource sharing, we do not implement the experimental SIP application for evaluation.

4 Experiments and Relevant Discussions

In [12], an optimal mobile service framework was proposed and a prototype system was implemented in [13] to examine the service framework. This section illustrates some experiments and relevant discussions on file synchronization between smart devices in JXTA, Bluetooth, and WiFi Direct protocols in the mobile peer-to-peer network environment built in [12-13].

4.1 Resource Synchronization Experiments

These experiments focus on the transmission time of the JXTA, WiFi Direct, and Bluetooth protocols, and analyze the output data. The sizes of test files are 1KB, 10KB, 100KB, 1MB, 10MB, 20MB, 50MB, 100MB and 200MB. In [12], the security issues of telecare data synchronization in the prototype system [14] related to Data Encryption Standard (DES), Triple Data Encryption Standard (Triple-DES) and Advanced Encryption Standard (AES) were discussed. The AES showed the best performance. Therefore, in this work, all file resources' encryption/decryption follows the AES symmetric data encryption due to its superior performance. The implementation library dictates that peerdroid1.1.jar is used for JXTA, and Android SDK API is used for WiFi Direct. The smart device used is an Asus Eee Pad Transformer TF201. Table 1 shows the transmission times of JXTA, WiFi Direct, and Bluetooth protocols in one vs. one device and one vs. multiple devices experiments. The unit of measurement is seconds, and the unit of file size is Bytes.

Table 1. The transmission times of JXTA, WiFi Direct, and Bluetooth protocols in one vs. one device and one vs. multiple devices

File size	Protocol				
	JXTA (1 vs. 1)	JXTA (1 vs. 2)	JXTA (1 vs. 3)	Bluetooth (1 vs. 1)	WiFi Direct (1 vs. 1)
1 KB	0.26	0.28	0.32	0.001	0.001
10 KB	0.30	0.35	0.37	0.002	0.003
100 KB	0.59	1.10	1.14	0.307	0.042
1 MB	2.48	5.77	9.19	7.409	0.799
10 MB	23.76	29.96	48.8	55.179	4.238
20 MB	55.57	81.61	91.08	180.955	9.286
50 MB	115.73	203.06	192.97	414.164	22.977
100 MB	250.9	349.88	460.52	965.297	55.968
200 MB	480.77	748.45	802.66	1770.023	83.658

Note. The unit of measurement is second(s), and the unit of file size is Byte(s).

Based on Table 1, Figure 2 shows an overview of the transmission times of JXTA, WiFi Direct, and Bluetooth protocols.

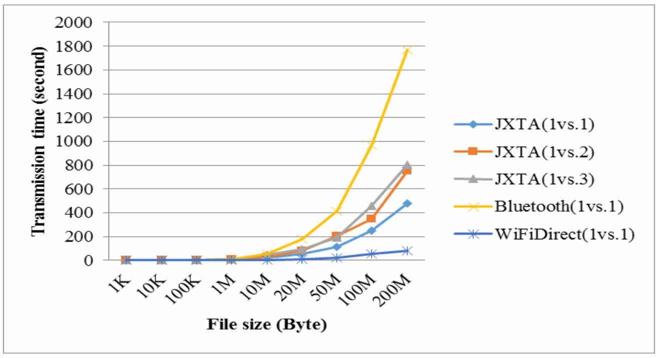

Figure 2. The transmission times of JXTA, WiFi Direct, and Bluetooth protocols in one vs. one device and one vs. multiple devices

One metric is data transmission time, used to compare the transmission speed of a data resource synchronization process of different file sizes (1KB to 200MB). Another metric is data transmission type using to compare the transmission multiplicity among mobile devices (one vs. one device and one vs. multiple devices). WiFi Direct is faster than both Bluetooth and JXTA in terms of file transmission. The Bluetooth protocol facilitates small file transfers with high speed resource synchronization, but when the file sizes are larger, the transmission performance becomes poor. The JXTA protocol provides more functionality to Android-based smart devices, including one device to one device, and one device to multiple devices transmission. The WiFi direct and Bluetooth protocols can only be enforced in one device to one device transmission on Android-based smart devices.

4.2 Relevant Discussions of Experiments

Cai et al. [6] proposed a collaborative middleware application in a Bluetooth communication network. However, there has are still some weak points, with Bluetooth properties limiting the scope of data transmission In Bluetooth version 2.0, the scope of data transmission is from 1 meter to 30 meters, and the data transmission rate is from 1 Mbps to 3 Mbps. These properties are suitable for a small scope environment and longer delay times in data transmission. Although Bluetooth version 3.0 improves the data transmission rate up to 24 Mbps, it still influences the data transmission rate in a collaborative environment. WiFi Direct, on the other hand, has a high speed data transmission rate and a larger data transmission scope. Liu et al. [10] measured the data transmission delay times of WiFi Direct devices without a wireless access point. Using WiFi Direct not only transmits data at higher speed, but also transmits data among WiFi devices more easily. Its maximum data transmission rate is 250 Mbps, and the maximum transmission distance is 200 meters. WiFi Direct is better than Bluetooth in terms of both data transmission rate and scope. However, the limitation of WiFi Direct is that the data transmission can only be enforced in a local network environment constructed by WiFi devices. In addition, when devices transmit data by WiFi Direct, they can either receive or send data separately, and cannot enforce two operations at the same time. Therefore, WiFi Direct may not be suitable for use in a collaborative sharing environment. Wang et al. [17] designed and implemented an SIP-based distance education system. However, SIP does not offer a file sharing function. If users want to share files in this education system, third-party software is needed in order to add a file sharing function. In terms of functionality, JXTA does not support multimedia communication, but does provide a complete collaborative resource sharing function. Barolli et al. [4] deployed JXTA in a peer to peer platform for file resource sharing between heterogeneous devices. The peer group mechanism strengthens the security of data exchange and collaborative processing. The advertisement of a peer group shows service and file resource sharing in the platform. A peer in the peer group can query the desired service or file resource index. The peer can then access the support service or file resource. In this study, the experiments demonstrate that the JXTA protocol provides more functionality to Android-based smart devices, including one device to one device, and one device to multiple devices transmission. The WiFi direct protocol facilitates high speed resource synchronization, and the Bluetooth protocol facilitates small file (1KB to 100KB) with high speed resource synchronization, but when the file size is larger, the transmission performance becomes poor. In addition, WiFi direct and Bluetooth protocols can only be enforced in one device to one device transmission on Android-based smart devices.

5 Conclusion and Future Work

In [12], an optimal mobile service framework was proposed, which automatically synchronizes telecare file resources among discrete mobile services. In addition, a prototype system was implemented in [13] to examine the optimal mobile service. The experiment result showed the mobile service was effective and useful for automatically collecting telecare file resources from discrete mobile devices. This study implements a resource sharing mechanism using MP2P to synchronize telecare files over a secure platform in a ubiquitous environment. When employees execute specific business processes, e.g., healthcare processes, they can use the MP2P features to synchronize system file resources through a smart device from any location, and thus improve the efficiency of file resource sharing. When the file resources are synchronized, a resources log file is updated in order to maintain the consistency of file resources. This study provides a resource sharing solution, JXTA implementation, to enhance the effective and secure sharing of files in an enterprise system. In addition, enterprise mobility is improved, allowing employees to access file resources through smart devices from any location. The experiments demonstrate that the JXTA protocol provides more functionality to Android-based smart devices. Future works will focus on increasing the efficiency of the shared file resources by assessing the performance of each smart device before the syncing processing. In addition, this work will add collaboration analysis methods to the proposed mechanism in order to make it more intelligent and to improve its effectiveness.

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