Framework for Enhancing P2P Communication Protocol on Mobile Platform

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ABSTRACT

Peer-to-Peer (P2P) communications and its applications have become conventional architecture in the wired network environment. However, they have not been effectively adapted to the ensemble mobile environment which composed of various devices such as smart mobiles devices, laptops, and device with embedded software. In P2P systems, each node can act as a client and as a server at the same time and shares with others its own data or resources. Many P2P applications are widely used in mobile devices for examples IM, VoIP, file sharing, social networks, and video streaming. In this paper, we present the existing P2P protocols for mobile environment along with its categorizations and applications. In addition, we consider the designing and implementation issues to enable P2P protocol to be implemented over heterogeneous mobile devices. Furthermore, we present the limitations in the mobile devices and the challenges to adapt the P2P communication technology to the mobile environment. Finally, we conclude this paper with illustrations of the future research directions, which is to develop a middleware with necessary APIs and implement an enhanced P2P protocol in the proposed middleware on Android-Based mobile devices.

KEYWORDS

P2P Protocols, Ensemble mobile environment, Wireless technologies, Middleware, Android OS.

1 INTRODUCTION

The popularity of P2P communications and applications has been steadily increased in the wired network environment for the past few years. However, there is no effective adaptation of these new technologies to the ensemble mobile environment. Currently, smart phones and tablets have become a commodity and highly-capable multimedia devices in the ensemble mobile environment. In addition, the introduction of Wi-Fi Direct protocol on top of the existing wireless technologies has provided users with more opportunities to utilize the P2P communication with mobile devices at anytime and anywhere in a direct manner without any interface router or access point Figure 1 [1],[2],[3].

It is indicated that employment of P2P protocols and applications in the platform of the ensemble mobile environment is becoming a promising solution which permits a wide number of users to share their own contents (data, audio, video, etc.) and communicate with each other without using costly and centralized network infrastructure. Even in the absence of the Internet, the spontaneous mobile devices provide users with the potential opportunity to connect in ad-hoc manner via short range wireless protocol such as Wi-Fi Direct, IEEE 802.11, Bluetooth, or ZigBee. This feature encourages wide

range of applications for P2P computing in mobile environment [4], [5].

The development of P2P systems has been initiated in simple systems of file sharing among the Internet users in the wired networks and has moved to disruptive technology for collaborative and social activities such as VoIP, IM, multi-player games, video streaming and Video on Demand. Indeed, such systems are distinguished by their capability of content delivering, profiling, grouping, and controlling to mobile users in smart and interactive environments. Thus, the potentiality of P2P technologies lays the basis for developing applications to support any group of people who share technical, scientific, cultural, and political interests [6]. In addition, the P2P technology has become a major paradigm in network architecture and has the potential to achieve highly scalable, extensible and efficient distributed applications in comparison to traditional server-client technology on the Internet. The majority of previous studies are focused on the particular case of internet-based P2P communication protocols and applications in the wired and wireless networks. Therefore, during lack of Internet access situation, the users prefer the using of free P2P wireless links for their communication versus expensive packet data networks that provided by cellular networks.

However, the increasingly growing demand on P2P applications over the mobile devices brings up new challenges to P2P networking. In comparison to desktop computers, mobile devices have many limitations: network bandwidth, memory, processing capacity and battery life are limited. Also the network barriers, NATs (Network Address Translator) and firewalls convey challenges to mobile P2P networking.

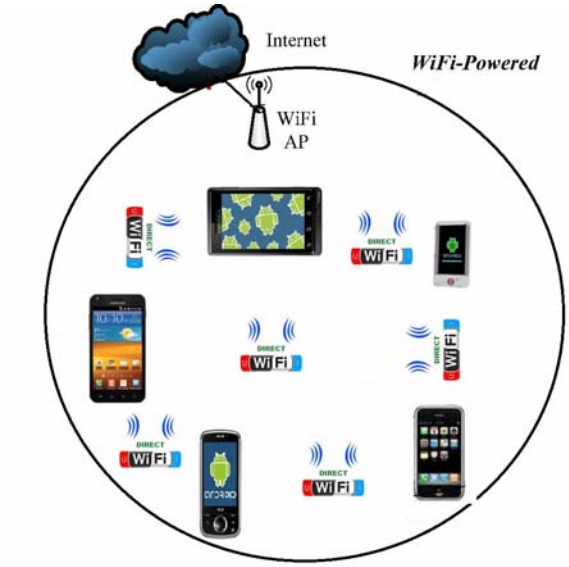

Figure 1. Ensemble Mobile Wi-Fi Direct P2P network.

Although they have limitations, the evolution of mobile network technologies and devices has decreased hardware limitations, thus making it possible to use P2P applications also in mobile devices. Moreover, mobile environment also opens new creative ways to use P2P technology, which many seem to ignore [8].

In fact, P2P protocol design in mobile environment mainly depends on the underlying radio technology such as Wi-Fi and Bluetooth. However, designing the P2P applications for various devices depend on the Lightweight Operating Systems running on these devices [9]. Due to competition, demand and critical mass, the manufacturers have developed and produced smart devices which are relatively cheap. In the proposed research, the Android-Based mobile devices have been chosen for many reasons such as the widely opened source nature of Google Android platform [10] where the whole operating system is open and accessible to developers and application writing is supported by the programming language

Java, and the easy access to software development kits (SDKs), which all have resulted into an explosive revolution of android applications. What matters most is how to be able to develop new applications as a necessity, thus, implementing them to the platform libraries.

In addition, P2P communication is considered as one of the most important and suitable networking technologies for ubiquitous communications, i.e. allows direct communication between devices, free and extensible distribution of resources and distributed search for enormous amount of resources [11]. The current work mainly aims at enhancing the mobile P2P protocol and a middleware platform that enhances the communication capabilities for mobile clients. This can be achieving by utilizing network resources efficiently and supporting mobility in an integrated and practical way.

In this paper, we will review the existing P2P protocols and figure out how the principles of P2P networks can be apply to the ensemble mobile environment and how they can be used to facilitate seamless communications among smart devices across various networks, i.e. heterogeneous network environment. The rest of the paper is organized as follows. Section 2 provides a brief description of the traditional P2P systems architecture and properties. The P2P applications are described in section 3 and the challenges and the direction of the current research are presented in Section 4. The proposed middleware with P2P protocol is described in Section 5. Section 6 presents research methodology and hypothesis. Finally, the conclusions are drawn up in section 7.

2 P2P SYSTEM ARCHITECTURE

2.1 System Architecture

Typical P2P systems have been constructed employing various types of architectures and internal logics. Figure 2 shows a basic architecture of Mobile P2P networks. The purpose of designing such systems is to adapt to the specificities of the networks on top of which they operate and to the characteristics of the applications using them. For example, the ability to identify a single node quickly in a large network size is required by some applications especially for real time communications, while the focus of others such as file sharing is placed on locating the same resource in different end nodes for more reliable retrieval of the resource. In order to address these challenges, various approaches have been adopted in P2P applications. The approaches can be categorized into two main classes: *structured* and *unstructured.* The *structured* P2P network is an overlay in which nodes cooperatively maintain routing information about how to reach all nodes in the overlay and the contents sharing are placed only at specified peers. This architecture maintains the sending messages to reach to the correct and accurate destination even if the network contains a huge number of nodes. Distributed Hash Tables (DHTs) [12] are examples of such structured P2P networks such as Chord, Pastry and Kademlia. However, the *unstructured* P2P network lacks of prior knowledge about the topology of the network and the node is dependent only on its nearby nodes for delivery of messages to other nodes in the overlay. Its simplicity, easiness and dynamism are some of the advantages of this overlay.

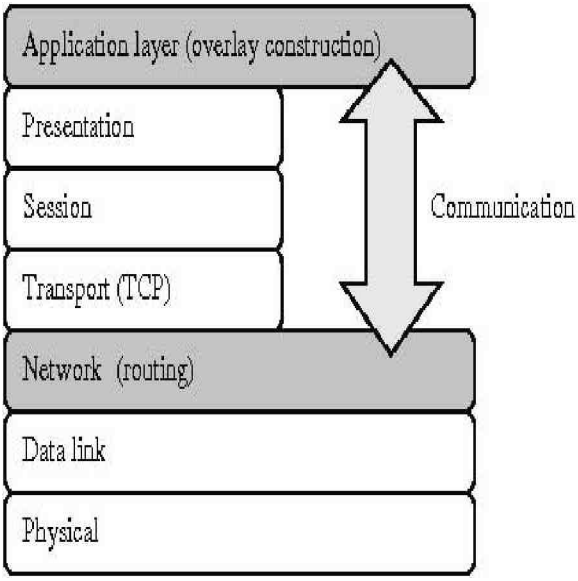

Figure 2. Basic architecture of Mobile P2P networks [13].

Most of the deployed P2P applications are based on unstructured overlays for examples KaZaA, Gnutella, and BitTorrent [5], [12].

2.2 Properties of P2P Systems

The majority of P2P systems are characterized by the following properties [12], [14]:

Resource sharing: Network resources are shared by each peer to the operation of the P2P system. Ideally such resource sharing is stated to be proportional to the peer's use of the P2P system. However, many systems suffer from the free rider problem.

Networked: this feature or property refers to the interconnection between all nodes and other nodes in the P2P system. Moreover, the full sets of nodes are members of a connected graph. When the graph is no longer connected, the overlay is said to be partitioned.

Decentralization: the collective actions of peer nodes function to determine the behavior of the P2P system and there is no central control point. However, the P2P system is secured by some other systems using a central login server. Effectively managing the overlay and monetizing its operation may demand centralized elements.

Symmetry: this property refers to the equal roles the nodes assume in the operation of the P2P system. In many designs special peer roles such as super peers or relay peers are used for the purpose of relaxing this property.

Autonomy: it refers to the local determination of the participation of the peer in the P2P system with no single administrative context for the P2P system.

Self-organization: there is a gradual increase in the organization of the P2P system over time employing local knowledge and local operations at each peer, and there is no dominance of one peer over the other. However, the majority of the existing P2P systems do not exhibit most of self-organization properties.

Scalable: This is a pre-requisite of operating P2P systems with millions of simultaneous nodes. The resources used at each peer exhibit a growth rate as a function of overlay size that is less than linear.

Stability: Within a maximum churn rate, the P2P system should be stable, i.e., it should maintain its connected graph and be able to route deterministically within a practical hop-count bounds.

2.3 Evolution of P2P System

The evolution of P2P architecture involves development from the first generation of file sharing protocols like Napster, were released, in the late 90s. Napster is a typical first-generation P2P application, Later it became very popular for sharing music files between millions

of users. Also the SIP protocol, which can roughly be considered as the first generation of P2P was standardized in 1999. These file sharing systems are, however, more like a combination of traditional client-server and P2P models. This denomination comes from the fact that, in these systems, many of the functions related to peer and discovery of resources were made in centralized servers or server pools [12]. This generation is followed by the second generation started in 2000 by the development of pure P2P systems where all peers share same functionality like the peer discovery mechanism and query distribution without any dedicated servers needed. Gnutella protocol is an example of second-generation architectures which was developed and published as open-source protocol. After that, it has been widely used in many P2P applications. Gnutella's overcomes some difficulties of Napster's architecture and it is totally decentralized P2P architecture. The main advantages of the Gnutella architecture over the first generation P2P protocol are its independency of central servers, and thus cost-effectiveness, fault tolerance and ability to work without maintenance. There are many newer second-generation protocols, with more sophisticated search methods, for example CAN, Chord, Pastry/Tapestry, BitTorrent and Kademlia. Several models have also introduced mobile agents to enable mobile use of second-generation P2P architectures. This evolutionary process has continued to adapt these generations to the new wireless communication technologies as a basis for future development [1], [15], [16].

The current generation of P2P protocol, i.e. the third generation of P2P systems, is a mixture of the previous generations. In third-generation systems, some of the peers are called super-peers and these peers are organized dynamically. Unlike in the earlier generations, only super-peers are used in the discovery functions of peer and resource, which significantly decreases the stress caused to the network. In addition, several binding and routing optimization methods are used to minimize the overhead. JXTA (Juxtapose) and JXME are examples of the 3rd generation P2P. [6], [22].

The development of JXTA began in 2001 and is still going on. JXTA is a set of open protocols that enable the creation and deployment of P2P networks and it represents a generic set of functionalities that can be used by developer to deploy P2P applications by using XML messages. Peers organize automatically or manually into peer groups that are either protected privately or public groups of peers that are visible to each other. The next JXTA project, which is JXTE for J2ME is known as JXME [18] which defines relay peers to connect mobile peer with limited capabilities such as processor, memory and battery life to the JXTA environment. This project developed two versions of JXME *proxied* and *proxyless* depending on the way that mobile JXME peer can access the service of JXTA network. In the first version the peer needs to use a fixed relay peer to get the service and the relay acts as a gateway for the communications between two peers belonging to the same JXME. However, in the second version of JXME, the Proxyless provides a light P2P framework for mobile environments and does not need any infrastructure such as the relays [16], [19], [23].

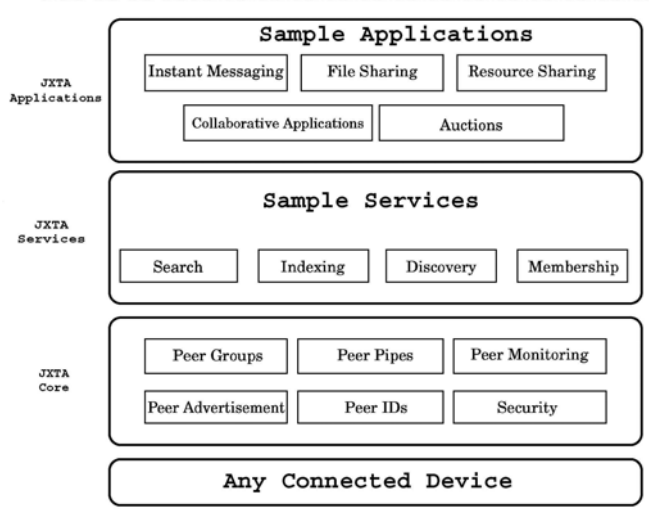

Figure 3. JXTA layers and services [6].

3 P2P APPLICATIONS AND SERVICES

Most of the widely used P2P applications are for file sharing services which started from Napster via Gnutella and KaZaA to BitTorrent. Moreover, the voice-over P2P applications (VoIP) to make voice calls such as Skype are other services of P2P applications which will benefit from mobile P2P and could be adapted to run in the mobile P2P environment which rely on direct communication among mobile devices of any kind [20]. The heterogeneity of mobile devices and the desirable compatibility of the P2P system with stationary hosts could create a pool of different features, with peers complementing each other. The following possible areas of P2P applications that can be considered:

Voice communication: The P2P networks have highly potential to provide real-time audio and video calls through many VoIP applications such as Skype. Voice communication services do not certainly need a dedicated in-frastructure, nor a lot of computational power or bandwidth.

Text messaging: Instant Messaging (IM) is another widely used category of mobile P2P applications. In order to be a time-insensitive service, IM can easily be implemented to mobile devices. Each peer would buffer a message only until it can be forwarded to another peer closer to the destination according to routing protocol. Many IM applications have implemented to the current mobile platforms but all are Internet-based applications.

Photo/video sharing during an event: This category of P2P applications may be one of the most popularly so far. Some events such as sports or any other occasions motivate people that share a common interest to gather together. Their proximity allows a local mobile P2P network to be molded, and thus peers can share photos or videos (or any other type of information relevant to that event). It is well known that such occasions represent a tough challenge for mobile networks because of the high number of connections within a small area. Video streaming or video on demand (VoD) are currently representing a big portion of the mobile traffic and are rapidly growing.

Local social networking: Facebook and Twitter social networks are becoming widely used to connect people who have common interests and the addition of location information, while still unformed, will provide influential capabilities. In addition to encouraging these capabilities, the social networks should be adapted to run over the mobile platform of ensemble mobile environment regardless of the ability to access the Internet.

Multi–player gaming: The proposed adapted P2P applications for the games requiring more than one player will be available in both cases Online through

the Internet and Offline in the local P2P network in the ensemble mobile environment.

Last–mile connectivity: Many rural areas are out of coverage of the cellular or data networks and there is no Internet connection, such as farms. There is a necessity for self-organizing mobile P2P network to connect peers with others who have Internet connection or cellular network coverage.

Many other P2P applications can be adapted to be used in the ensemble mobile environment for dissemination of data about traffic, emergency situations, and daily activities.

4 CHALANGES AND IMITATIONS

Since the P2P concepts have been increasingly realized in the ensemble mobile environment, many challenges arise in this particular domain. It can be summarized that the majority of such challenges are constituted by the *heterogeneity* of the mobile environment (networks, devices, users). Thus, in the current paper concerning with mobile P2P, we especially refer to heterogeneity compared with conventional, fixed network P2P systems in which, to the largest degree, homogeneous nodes are assumed. There are requirements which have to be taken into consideration for P2P in ensemble mobile environments, and they are listed as follows [7], [22]:

- Reducing the traffic overhead of P2P lookup as much as possible, in order to increase the transmission data rates of mobile devices.
- Addressing the high churn rates due to the open and non-deterministic nature of the nodes which joins and leaves frequently.
- Considering the limitation of mobile device resources and the heterogeneity of nodes and their diverse device capabilities.
- Managing the probability of failure increasing of mobile devices due to breaks of link, discharged energy of batteries etc.
- Reducing the traffic generated in the physical layer of the network, by taking into account characteristics of the physical network.
- Providing trust and reliable models to support users' desires to comply with the protocol rules.

These requirements should be considered in the proposed mobile P2P protocol for the ensemble mobile environment to overcome the challenges especially the mobility and heterogeneity. These constraints represent parameters that may be tweaked by the programmer of the protocol to optimize it for a particular mobile device.

5 THE PROPOSED MOBILE P2P PROTOCOL

Constructing the proposed P2P communication protocol for mobile middleware in the ensemble mobile environment is based on the assumption that it will empower smart devices to carry out both synchronous and asynchronous patterns and kinds of communication. Each device in this particular environment consists of the layer structure as displayed in Figure 4. Since Android-based smartphones have been increasingly perceived as ubiquitous, there has been an increasing interest among many scholars and researchers to develop the applications for P2P communication in these devices. Moreover, the increasing applications for P2P communication in these devices are attributed to the reason that Google's

Android (OS) is a free and open source for developers to construct their applications employing the Android SDK, thus, adding them to the Android libraries. Therefore, the current paper is mainly concerned with an Android-based middleware as the proposed middleware, which functions as the interface point between mobile nodes and higher application layers for ensemble mobile computing environment. It is expected that the proposed P2P communication protocol in the proposed mobile middleware will be capable of facilitating the P2P communication between various nodes and will be an enhanced version from the existing P2P protocols. For the APIs layer, it will support the interface for P2P and other diverse applications to communicate with the middleware layers. Since the device hardware layer is the lowest layer under the operating system, the lightweight operating system of the mobile devices will be an Android OS and its location is just under the middleware layer.

The formation of ad-hoc networks, which are categorized as a local network for real time communication will be provided by the smart mobile devices. To enable all of these networks for performing synchronous communication , they are proposed to be connected via the Internet. Thus, the current research mainly aims to enhance the protocol for mobile P2P middleware on the top of Android OS together with APIs as to support application development for an Innovative Digital Economy environment. To achieve this, the mobile middleware will use the existing wireless technologies such as Bluetooth, Wi-Fi or Wi-Fi Direct which are supported by Smartphones and the middleware mainly aims to support and

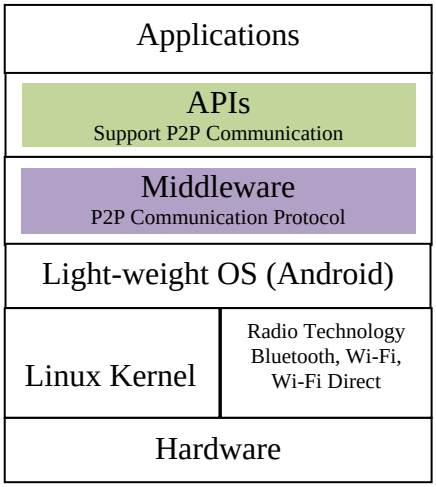

Figure 4. Structure of a node .

enhance the direct P2P communication among users in the ensemble mobile environment. Since there has been an increasing tendency of using Android-Based mobile Smartphones and tablets among many users, the proposed middle-.ware has various applications in the current paper. For example, in a given university campus where students and staffs move around inside the campus between faculties, departments and offices, they usually need to communicate with their colleagues by using their cell phones but the network carrier charges for these calls. However, by applying the proposed middleware for P2P communication in such a university campus, it would be more possible for them to be able to make calls and exchange data at no cost at all by using the available wireless technology supported by their devices easily and free of charge. Thus, to sum up the applications and the developed APIs for the proposed middleware, users will be enabled to make voice calls, IM, and share files such as audio / video files or documents based on Bluetooth or Wi-Fi which depends on the distance between user's devices.

The first key issue was taken into consideration in this research, given the fact that android-based smartphones and tablets have been rapidly advancing for the last few years. Such rapidly advanced smartphones have been increasingly becoming more popular. This increasing popularity is due to certain features characterizing them such as being as powerful multimedia devices, accompanied with rapid processors, effective power consumption , and high-quality, high-resolution touch screen displays with embedded video cameras and sensors. Secondly, there have been a large number of users who are increasingly interested in sharing the multimedia content that they capture. For instance, in developing middleware for mobile P2P communication, one of its potential application attracting the users can be uploading their generated content such as new videos or photos to another smartphone or tablet device. This particular kind of multimedia receiving the content automatically from one particular source can be of a great interest for some users.

However, the problem still commonly encountered by many users is related to the prohibitively expensive transfers when using a mobile wireless data connection such as 3G and uploading to a traditional web server. It is stated that users are usually subjected to wireless data plans with a limited usage. Finally, it is hoped that by integrating Wi-Fi Direct into some Android-based smartphones as well as Bluetooth and IEEE 802.11 WLAN technology as a short range wireless network technologies, it is possible for users to be given more opportunities to make a good use of the P2P communication with mobile devices at anytime and anywhere in a direct manner without any interface router or access points. However, it should be admitted that there are still some restrictions in the proposed applications such as the limited connection numbers for using Bluetooth and the high energy consumption for using Wi-Fi in an ad-hoc network.

6 RESEARCH METHODOLOGY AND HYPOTHESIS

The research methodology adopted in the current research is illustrated in Figure 5. It is expected that the network routing would become very complicated if there are many nodes in the mobile network. Therefore, the routing protocol of the mobile ad hoc network still remains the major issue for this hypothesis. Based on the aim of this research, it is assumed that by applying the proposed middleware, the functionality and the user experience of the Android-Based Smartphone in several points can be enhanced or improved.

Moreover, it will be able to control the short range wireless connectivity, such as Bluetooth, Wi-Fi and Wi-Fi Direct (if applicable). By applying the middleware, it will be more possible to decide the type of wireless technology to be used based on different tasks and the distance between devices. However, selecting what activity to be performed with other peers via the user interface can be decided by the user. In addition, the proposed middleware will potentially save trusted destinations and black list users in a local database to enhance the security issues for future connections. Finally, the aim of the current research will be also realized through testing another research hypothesis concerning the multi-users gaming support.

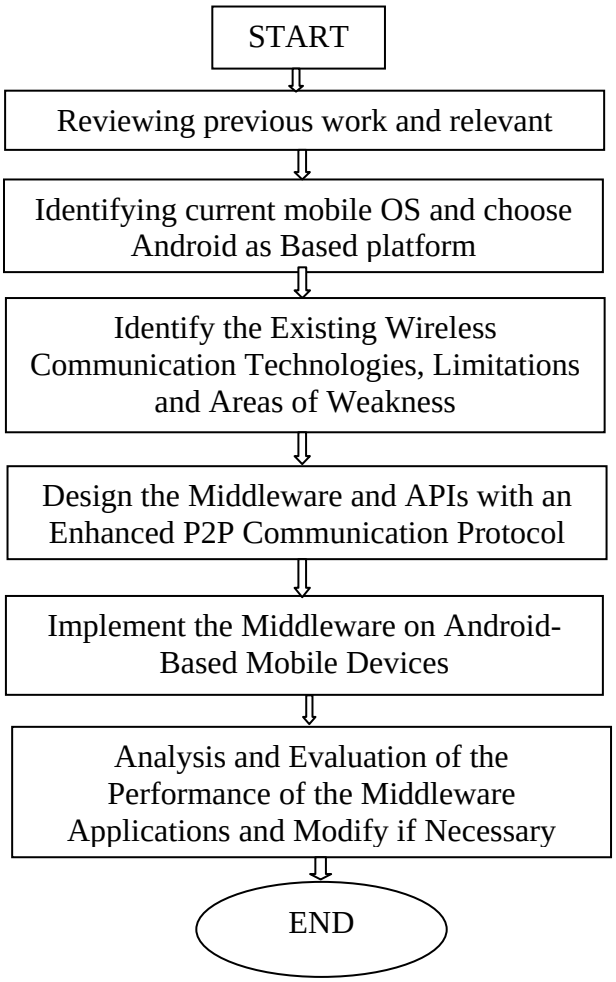

Figure 5. Research methodology flow chart

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7 CONCLUSION

The ongoing subject of the current research is enhancing protocol in middleware for P2P communication in the ensemble mobile environment. It is expected that the proposed protocol will allow smart device users to communicate among each other in real time by using various P2P applications. The current P2P systems, protocols and applications as well as the challenges encountered in adapting this technology to be used in the ensemble mobile environment such as the massive number of heterogeneous nodes, dynamic nature of the devices connections, and the nature of devices, signal processing and system resources have been all studied. Such challenges are not intractable, and it is possible to come up with new promising solutions by advancing the research in this direction.

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