An analysis of Node/Peer Discovery Approach and Routing Algorithms in Mobile & Traditional Peer-to-Peer Networks

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An analysis of Node/Peer Discovery Approach and Routing Algorithms in Mobile & Traditional Peer-to-Peer Networks

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ABSTRACT

Mobile devices are becoming an increasingly indispensable part of people's everyday life, in the form of mobile phones, PDAs and laptop computers to communicate or share data between them. Centralized client-server networks are being transformed to distributed peer-to-peer networks. Lessons learned from fixed networks have been applied in cellular network. So, there are many challenges faced by traditional and mobile peer-to-peer networks therefore, in this study we examine a comparative analysis of node/peer discovery approach and routing algorithms employed in both traditional and mobile peer-to-peer networks. A qualitative methodology approach was used for data sources. Documents related to node/peer discovery approach and routing algorithms were studied. A comparative method and content analysis were used to analyze the data collected.

Findings of the study indicated that there are two clear differences in the aspects of neighboring node/peer discovery approach beside the similarities. The study also showed another differences and similarities in the aspect of routing algorithms. This thesis hopes to offer all necessary useful tips of the divergence on these two aspects and thus to make a contribution allowing researchers to know such divergence.

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"Sometimes our light goes out but is blown into flame by another human being. Each of us owes deepest thanks to those who have rekindled this light."

Albert Schweitzer

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LIST OFABBREVIATIONS

PDA	**P**ersonal **D**igital **A**ssistant
P2P	**P**eer-**To**-**P**eer
ARPANET	**A**dvanced **R**esearch **P**rojects **A**gency **Net**work
IMPs	**I**nterface **M**essage **P**rocessors
C/S	**C**lient/**S**erver
SRI	**S**tanford **R**esearch **I**nstitute
UCLA	**U**niversity **C**alifornia, **L**os **A**ngeles
UCSB	**U**niversity **C**alifornia, **S**anta **B**arbara
UUCP	**U**nix-to-**U**nix **C**opy **P**rotocol
TCP	**T**ransmission **C**ontrol **P**rotocol
IP	**I**nternet **P**rotocol
NNTP	**N**etwork **N**ews **T**ransport **P**rotocol
DNS	**D**omain **N**ame **S**ystem
NAT	**N**etwork **A**ddressable **T**ranslation
ADSL	**A**symmetric **D**igital **S**ubscriber **L**ine
DHS	**D**istributed **H**ash **T**able
CAN	**C**ontent **A**ddressable **N**etwork
WLAN	**W**ireless **L**ocal **A**rea **N**etwork
IEEE	**I**nstitute of **E**lectrical and **E**lectronics **E**ngineers
LAN	**L**ocal **A**rea **N**etwork
WAN	**W**ide **A**rea **N**etwork
CPU	**C**entral **P**rocessing **U**nit
UCP2P	**U**ser-**C**entric **P**eer-to-**P**eer
DCP2P	**D**ata-**C**entric **P**eer-to-**P**eer
HSDPA	**H**igh-**S**peed **D**ownlink **P**acket **A**ccess
GSM	**G**lobal **S**ystem for **M**obile
CSD/GPRS	**C**ircuit **S**witched **D**ata/**G**eneral **P**acket **R**adio **S**ervices
LTE	**L**ong **T**erm **E**volution
Wi-Fi	**Wi**reless **Fi**delity
WiMAX	**W**orld **W**ide **i**nteroperability for **M**icrowave **A**ccess
TDMA	**T**ime **D**ivision **M**ultiple **A**ccess
FH	**F**requency **H**opping

DS	**D**irect **S**equence
IF	**I**nfrared
OFDM	**O**rthogonal **F**requency **D**ivision **M**ultiplexing
SNR	**S**ign to **N**oise **R**atio
MAC	**M**edium **A**ccess **C**ontrol
DCF	**D**istributed **C**oordination **F**unction
CSMA/CA	**C**arrier **S**ense **M**ultiple **A**ccess/**C**ollision **A**voidance
RTS	**R**eady-**T**o-**S**end
CRT	**C**lear-**T**o-**S**end
TTL	**T**ime-**T**o-**L**ive
DBF	**D**istributed **B**ellman **F**ord
DSDV	**D**estination **S**equenced **D**istance **V**ector
DSR	**D**ynamic **S**ource **R**outing
AODV	**A**d hoc **O**n-demand **D**istance **V**ector
RREQ	**R**oute **R**equest
RREP	**R**oute **R**eply
OSI	**O**pen **S**ystems **I**nterconnection
FEC	**F**orward **E**rror **C**orrection

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CHAPTER ONE

INTRODUCTION

1.0.INTRODUCTION

The emergence of mobile devices has changed the landscape of Peer-to-Peer computing. Traditionally, Peer-to-peer network is another network model which provides the architecture of traditional client-server [1]. Peer to peer networks use a form of decentralization where each machine, referred to as a peer, functions as a client with a layer of its own functionality of the server. The role of a client and a server will be played by a peer at the same time. Therefore, request initiation to other peer, and despite this, responses to the incoming requests from other peer will go through on the network. It is different from the traditional client-server model which only clients can send request to a server and then wait for the response of the server.

Now, with the drastic increment of mobile devices, Peer-to-Peer works differently and has shown their advantages and possibility over centralized approaches. Inspired by the fixed domain, peer-to-peer networks are now penetrating the wireless and mobile domain which is interesting to be studied.

With the approach of a client-server, the server performance degradation as the number of clients requesting services from server increase [2]. However, in Peer-to-Peer networks, the overall performance of the network actually improves as is added to a growing number of his peers to the network. Such peers organize themselves into ad hoc groups as they communicate and collaborate and share their bandwidth with each other to accomplish the tasks at hand (such as file sharing). Each peer uploads and downloads at the same time, as well as in such an operation, and the new peer can

join the group while the peers from age can leave at any time. This dynamic reorganization of the members of the peer group is transparent to end users.

Other feature of peer-to-peer network is its ability in terms of fault-tolerance. The Peer-to-Peer application will continue by using other peers whenever a peer goes down or disconnected from the network. In a Bit-Torrent system, as an example, any client acts as a server even if it is downloading a certain files. When one of the peers not responding to client, the client tries to find another peers, collects some parts of the file where the old peer was, and the downloading process continues. All communications will stop compared to client-server architecture if the server is down; the peer-to-peer is more fault-tolerant.

Peer-to-Peer networks have many advantages over other model of network the client-server and we summarized here below [1, 2]:

1. *Peer to Peer Networks are simple and easy to install or set up and so is the configuration of computers on this network and only require a Hub or a Switch to connect all the computers together.*

2. *You can access all the resources and contents on any of the computers as long as it is set to shared folder, unlike server-client architecture where Server shares all the contents and resources.*

3. *The over-all cost of building and maintaining this type of network is comparatively very less. Means the requirements for a Peer to Peer Network are that you have a 10 Base T Ethernet cable and an Ethernet hub/ switch. This is rather cheap than having a server.*

4. *The architecture of the lay out (How it connects) is simple. There is no need for full-time System Administrator. Every user is the administrator of his machine. User can control their shared resources.*

5. *P2P is more reliable as central dependency is eliminated. Failure of one peer doesn't affect the functioning of other peers. In case of Client –Server network, if server goes down whole network gets affected. If one computer fails to work all the other computers connected to it continue to work.*

6. *On the Internet, peer to peer networks handle a very high volume of file sharing traffic by distributing the load across many computers. Because they do not rely exclusively on central servers, P2P networks both scale better and are more resilient than client-server networks in case of failures or traffic bottlenecks.*

The aim of Peer-to-peer (P2P) system is to share information between a huge numbers of users without support from a central server. In recent years it has attracted the researchers over and over again, motivated by the popularity of file-sharing applications over the internet, such as Gnutella and Napster [1]. Over the last decade, so many research issues on Peer-to-Peer networks have been conducted along with the routing algorithm which is the central topic.

We become aware of some similar features for both Peer-to-Peer networks. Despite, file sharing approach in peer-to-peer networks are not adequate like this situation [2];

- There is no central server that acts explicitly for peers in both traditional Peer-to-Peer network and mobile, and in order to make the whole system work, every peer should collaborate with other peers.

- There is no infrastructure required to form such a network anytime and anywhere.
- There is frequently location change that nodes tend in such network.
- There is scalability problem raise when exchanging data or routing information among different peers and flooding or broadcasting employed to some extent in both systems [3, 4].

The main aim of this research is to study thoroughly and demonstrate traditional and mobile peer-to-peer networks and identify the major differences and similarities between them as well as understanding node discovery approach. The study will however compare the routing algorithms employed in traditional and mobile peer-to-peer.

1.1.BACKGROUND OF THE STUDY

One of the hottest issues in the research arena of a computer communication is peer-to-peer networking (P2P). Though, Peer-to-Peer networking is not a new concept. We can trace back its origin to the late 1960s. As Andy [5] stated, and their origin from the US defense department funded projects, whose main objective was resilient military networks constructions. Since then a lot of progress has been achieved, both in research and development, at the same time the two network type's application [5]. Three stages which the history of P2P networking can be roughly divided: 1969–1995, 1995–1999, and 2000–to present thus, to make the concept clearer the three different stages of history of Peer-to-Peer networking are below and brief overview for both Traditional peer-to-peer and mobile peer-to-peer network types:

– 1969–1995 Before history: Thought of Peer-to-Peer is growing;

– 1995–1999 Internet explosion: Peer-to-Peer concept retrogressive;

– 2000–? Peer-to-Peer widely used term: Peer-to-Peer -based applications flourish.

During the first stage of Peer-to-Peer networking (1969–1995), through several systems burgeoned the thought of Peer-to-Peer, even though was not adopted the so-called "Peer-to-Peer" term at that time.

When Advanced Research Projects Agency Network [6, 7] was originally initiated the precursor of the current Internet in the late 1960s, it was a real Peer-to-Peer system. The ARPANET was original designed to share the computing resources around the United States efficiently and widely. It was known as Interface Message Processors (IMPs) composed by small computers, connected as equal players, which are now called routers instead of under Client/Server (C/S) relationship. The four IMP sites which early ARPANET consisted of include Stanford Research Institute (SRI), University of California, Los Angeles (UCLA), and the University of Utah in Salt Lake City, University of California, and Santa Barbara (UCSB) [8].

Another example which utilized the relatively simple administration and decentralized control during the first stage was Usenet. By two graduate students was conceived first the Usenet in 1979 from Duke University and in 1980 was established publicly at the Duke University and University of North Carolina [5], [9]. To exchange information with no central control in the Unix community was Its original purpose. Automatically one Unix machine could set up a connection with another machine by utilizing the Unix-to-Unix Copy Protocol (UUCP), exchanging files or other messages with it, and then disconnect. A Transmission Control Protocol (TCP)/

Internet Protocol (IP) utilized by the current Usenet, under the name of Network News Transport Protocol (NNTP) as based protocol, to exchange new messages in each group and discover newsgroups [5]. For example Freenet and Gnutella of the current P2P applications could be seen Usenet as the grandfather, in the sense with no central authority control that it originally copied files between computers, and based on a rigorous democratic voting process the new newsgroups was addition.

In the naturally hierarchical even Domain Name System (DNS), the shadow of Peer-to-Peer networking we could see as well. The mapping relationship between an IP address to a user-friendly domain name, e.g. oulu.fi, in the early days of Internet which was copied around the Internet periodically was recorded in a single flat file, *host.txt*. To deal with the ever-increasing hosts on the Internet DNS was forward in 1983 [5]. In the hierarchical architecture of DNS, one name server could forward the request to its upper-level name server if it could not map the domain name to an IP address from its own namespace. From this point of view, the name servers, except the root name servers, operate as both clients and servers, which is the fundamental thought of P2P networking.

In the era of the second stage of Internet explosion (1995 1999), P2P concept in line with networking was retrogressive and gradually denotes a way to C/S network model. It specifically resulted based on the following reasons [5]:

Firstly, the Internet becomes a mass medium from the middle of the 1990s as the Internet explosion. Millions of ordinary individuals grouped into the Internet to generate information. They were not well literate enough or were not interested in to

be able to upload information or to publish to the Internet just then. At this junction of views, the asymmetric C/S network model fulfilled the basic requirements of the ordinary individuals to a huge amount and accelerated the expansion of the C/S model respectively.

Secondly, the separation of the cooperation between the Internet participants made the Internet least open than it was originally designed for. The real main Internet version was established simply to cooperate and exchange information among researchers across the globe. It was however symmetric in the sense that if and only if one computer could access the Internet, then every other computer connected to the Internet could access this computer as well. As time goes, the Internet became more and more public and commercialized, together with which was the ever increasing unsolicited commercial information or spam advertisements. The "green card spam" occurred on April 12, 1994 on Usenet symbolized the end of the innocent Internet [5]. However, based on this scenario, to filter the spam information, you need to deal with the IP address scarcity problem and protect the main networks from any kinds of malicious attacks; firewalls, dynamic IP addresses, and Network Address Translation (NAT) were first realized into use accordingly in the mid-1990s. As a result of this, many of the Internet participants acted as clients.

Thirdly, technical push augmented the asymmetrical property of the Internet. Network bandwidth was one of the most precious and scarce resources in the age of Internet explosion. Therefore, to make absolute use of the limited network bandwidth, network manufacturers decided to provide asymmetric network connections, for instants, Asymmetric Digital Subscriber Line (ADSL) and cable modem, together with the

speed of downlink multiple times of that of uplink. This feature benefited C/S model and augmented its popularity consequently.

More so, the third stage of P2P networking (1999–?) is the stage in which the concept of P2P was previously used and accepted worldwide. Thanks to the high popularity, worldwide attention given to Napster, the Internet environment started to draw back to P2P climate in 1999. In May, 1999, Napster was developed by Shawn Fanning, a freshman at Northeastern University, for purpose of sharing music files freely among the music enthusiasts across the world. Napster was labelled as the first-generation of P2P system. A centralized index server was adopt, which was originally called hybrid architecture, just to record the indices of the shared music files. At its end time, in the early 2000, Napster got together about 60 million registered users all over the world. However, it was around that period, *P2P* was associated with applications such as Napster [10]. It was since then; there were so many researches around P2P-related topics and the associated commercial products areas emerged like bamboo shoots after a spring rain.

1.1.1. Traditional P2P Networks

The Peer-to-Peer network can be defined according to G. Kortuem, & R. Schollmeier As "an application layer overlay network in which all entities are equal and all contribute some of their resources, thus giving rise to a network in which each entity (peer) is both a content requestor and a content provider" [1,11].

Peer means as a definition something of equal worth or quality [12]: the importance therefore, peer-to-peer is equality in communications [2]. The essence of the

definition lies the word "equal", as it describes we don't have any differences goes theoretically between peers that build the network. Peers are both suppliers and consumers of resources means, any peer can provide data or services to other peers and he can get also data or services from other peers.

Peer-to-Peer network overlays are generally divided into the two main categories: unstructured and structured Peer-to-Peer network as argued by Androutsellis-Theotokis and Spinellis [13]. The content is distributed randomly and the network connections are based on availability in unstructured Peer-to-Peer networks. In structured peer-to-peer network the peer-to-peer protocols are strictly determined by the network topology and location of content. Most unstructured and structured Peer-to-Peer networks require from the node want to join the overlay network must know the address of the nodes already in the network.

1.1.1.1.Structured P2P networks

Key/value-pairs managed by Structured P2P networks. A subset of the peers participating in the system knows by each peer, and a subset of the content administers it. Deterministically Content is distributed among the peers often according to their keys that assign content to peers through a hash function. The peer-to-peer protocol is determined strictly the distribution of content which the overlay network topology also dictates. Structured peer-to-peer can be divided into Distributed Hash Table (DHT), CHORD, and Content Addressable Network (CAN).

1.1.1.2.Unstructured P2P networks

No well-defined network overlay topology and decentralized control characterized by the Unstructured P2P networks. Based on availability are created randomly the connections between peers. Due to higher availability some of the peers they become known as may gain a higher number of connections by other peers over time in the network. Super peers are often called by these high degree peers. The emergent self-organized overlay network has some desirable features such as resilience to random failures and frequent peer arrival and departure. In the topology maintenance needs little overhead and to implement they are also simpler. Unstructured peer-to-peer can be divided into Centralized, pure, and hybrid peer-to-peer networks.

1.1.2. Mobile Peer-to-Peer Network

The mobile P2P wireless networks are depending on the direct mode of transmission of the devices regardless of their type. The current mobile transmission and communication architecture are having central base stations by the support of already installed infrastructure explained for mobile peer-to-peer (P2P) networks. The peer-to-peer mobile networks which are enthused by the fix domain are dominating the wireless communications and mobile networks.

The understanding of the features and properties of the mobile peer-to-peer networks is very important for the extensive available infrastructures. The network service and mobile operators are ought to consider the networks like mobile peer-to-peer instead of seeing it as an threat to their services but the features and properties offered by the mobile peer-to-peer network for improving their services in nature of robustness, less resource consumption and quality of service. The peer-to-peer networks are

providing infrastructure for various kinds of the services and applications provided by the mobile and service operators.

When we look at the history, initially the first application developed was dating client in the mobile peer-to-peer networks [14]. The Symbian operating system enabled to achieve the goal of that dating client application were people of similar interest could specify their needs or interest related to the usage of the mobile application to meet or find their partner of the life [15].

The Bluetooth technology was used for the communication of that mobile peer-to-peer network communication for the searching of the partners which are having same interests, that kind of application which was very useful in terms of goal by the usage of peer-to-peer application. Nowadays the peer-to-peer application is spread in terms of their domains like cooperative networks and social networking related to this area.
Nowadays the cellular or mobile communications are based on the central base stations, by the working principle of the mobile communication as the mobile device is switched on that will automatically locate the nearest access point or base station to register for the communication. As soon as the link or connection is established the mobile devices can search the contents available in the central storage [16]. The large areas of the communication are covered by the base stations by spreading various mobile devices on it, a single base station can provide spanning of various cells over it by the sectoring of the antenna types.

When understanding the infrastructure one question arises that what are the origins of the central architecture of the centralized communications. There are two types of

usage of the centralized communication the one is the created links and communication for providing audio or voice service for the communication between the one or more nodes for example walkie talkies. To establish the communication links between the people which are having devices through the fixed networks that are developed already since long time ago. Nowadays the bridges came to the mobile communication globe for the wireless communications.

The second type which is pertaining to only the wireless communications like radio propagations which are having the limits of the mobile to mobile device transmission with the constrains of the energy consumption [15]. The fixed networks made possible communication of the more than one device for the long distance and to create virtual tunnels with the help of the bridges.

1.2.PROBLEM STATEMENT

There are many high performance handheld devices which communicate through the mobile and traditional peer-to-peer communications that are available in today's world. So, both networks face a lot of challenges for such an environment of peer-to-peer file sharing. Peer-to-peer networks are decentralized and it's opposite to client-server network which is centralized to increase reliability and availability. Despite, file sharing approach in peer-to-peer networks are not adequate like this situation since:

- There is no central server that acts explicitly for peers in both traditional Peer-to-Peer network and mobile, and in order to make the whole system work, every peer should collaborate with other peers.

- There is no infrastructure required to form such a network anytime and anywhere.
- There is frequently location change that nodes tend in such network.
- There is scalability problem raise when exchanging data or routing information among different peers and flooding or broadcasting employed to some extent in both systems [3, 4].

1.3.RESEARCH QUESTIONS

For the above inadequate situations the following questions will arise:

- How mobile peer-to-peer network differ from traditional peer-to-peer in terms of node discovery?
- How routing algorithms employed in traditional and mobile peer-to-peer?

1.4.OBJECTIVES OF THE STUDY

The challenges face by traditional and mobile peer-to-peer as they characterized an infrastructure-less network, both traditional and mobile Peer-to-Peer network have no intermediate server, and in order to make the whole system work every peer should collaborate with other peers and frequently nodes tend to change locations raised the above questions in the Research questions. So, these questions lead to study the following:

- To study thoroughly traditional and mobile peer-to-peer networks and identify the major differences and similarities between them as well as understanding node discovery approach.

- To compare the routing algorithms employed in traditional and mobile peer-to-peer.

1.5.SCOPE OF THE STUDY

Traditional and Mobile Peer-to-peer networks are areas gaining great concern with many challenges accrue due to lack of intermediate server, and in order to make the whole system work every peer should collaborate with other peers. The infrastructure less for such a network anytime and anywhere, the frequently location change that nodes tend in such network, and the flooding or broadcasting employed to some extent in both systems and scalability problem arises when exchange data or routing information among different peers leads and raises inadequate situation. This research will be limiting by the following:

To study thoroughly traditional and mobile peer-to-peer in terms of similarities and differences in terms of node discovery approach for traditional and mobile peer-to-peer networks, as well as the routing algorithms employed in traditional and mobile peer-to-peer.

1.6.SIGNIFICANCE OF THE STUUDY

The following is a summary of the main contributions to this work:

- The key characteristics that comprise traditional and mobile peer-to-peer network will be identified respectively. The innovation in this work because of an emphasis on identifying these two kinds of network in terms of similarities and differences between them,

- Cases will be compared with the discovery of the node in the traditional and mobile peer-to-peer networks. The fundamental differences between the two is beneficial to identify by a comparison, and
- Routing algorithms which they have and it will be much useful work for the researchers to know such differences and identifies some of the routing techniques that can be applied to one another.

1.7.SUMMARY

In this chapter we presented the emergence of Peer-to-Peer networks with their different stages in history and how they develop into mobiles in our daily life. The challenges faced by traditional and mobile peer-to-peer were presented as they characterized an infrastructure-less network in problem statement section followed by research questions. Therefore, we presented in the chapter what we intend to do as objective section followed by scope and we conclude the significance of our study.

In our study we examine a comparison between traditional and mobile peer-to-peer network in order to understand the differences and similarities between them in terms of node/peer discovery approach and the routing algorithms employed in traditional and mobile peer-to-peer network.

1.8.ORGANIZATION OF THE REPORT

This report consists of five chapters such as:

Chapter 1: Highlight the introduction of the study on node/peer discovery approach and routing algorithms in networks, background, the problem statement, research questions, objectives of study, project scope and the significance of this study.

Chapter 2: Highlight and review the existing published literature. In addition, review the literature related to the introduction to the traditional and mobile peer-to-peer networks and wireless technologies.

Chapter 3: Describe the methodology used to do this study, which is based on the general methodology of content analysis. This chapter contains also details about the methodology and how is the procedure of collecting analyzing the data.

Chapter 4: This chapter includes the data collected about the node/peer discovery approach and routing algorithms employed in traditional and mobile peer-to-peer networks and the comparison analysis or findings (results) of these aspects in both networks

Chapter 5: This chapter includes the conclusion, limitations and recommendations for future work directions.

CHAPTER TWO

LITERATURE REVIEW

2.0.INTRODUCTION

This chapter will examine the main issues surrounding Traditional and Mobile Peer-to-Peer. Most people have a notion of what the term peer-to-peer (P2P) mean. But here we present the architectures and categories of traditional Peer-to-Peer networks, and also Mobile Peer-to-Peer Networks in terms of Mobile communication architecture and wireless technologies in particular WLAN IEEE 802.11 and Bluetooth.

Despite underlying the common concept of mobile and Traditional peer-to-peer networks, so far some research tended to deal with and it may found some of the literatures build the commonalities. We provide here a comparison which is limit to node/peer discovery approach and routing algorithms in mobile and traditional peer-to-peer networks which creates some similarities and differences between both networks.

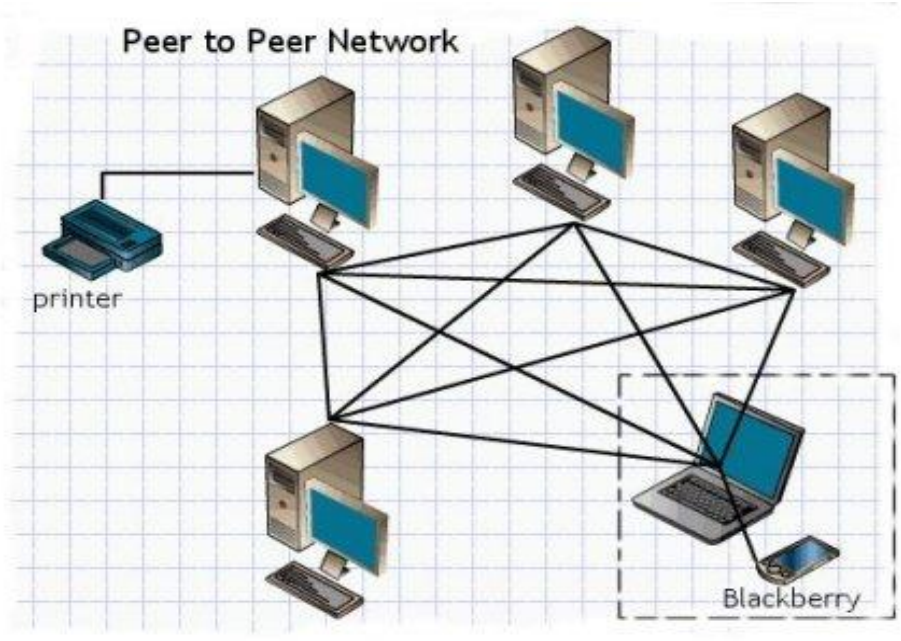
The main aim of this research is to study thoroughly and demonstrate traditional and mobile peer-to-peer networks and identify the major differences and similarities between them in node/peer discovery approach and routing algorithms employed in both networks.

2.1.TRADITIONAL PEER TO-PEER NETWORKS

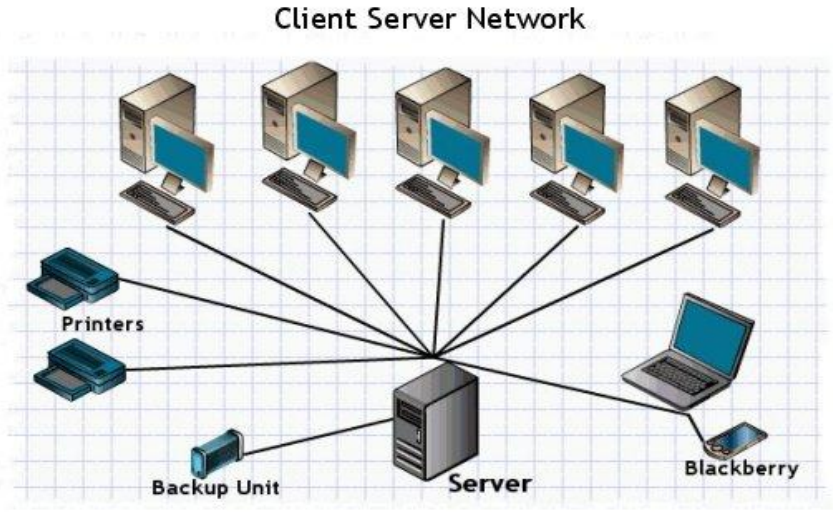
Network of peers is a computers networks so as to extent a moderately small area. Groups of buildings or single building are confined by most of Local Area Network (LANs); nevertheless, one LAN can be connected to other LANs over any distance via telephone lines and radio waves. A system of LANs connected in this way is called a *wide-area network (WAN)*.

Most LANs connect workstations and personal computers. Each *node*(individual computer) in a LAN has its own CPU with which it executes programs, but it also is able to access data and devices anywhere on the LAN. This means that many users can share expensive devices, such as laser printers, as well as data. Users can also use the LAN to communicate with each other, by sending e-mail or engaging in chat sessions.

A class of systems and applications is referred by the term peer-to-peer (P2P) using an architectural model where each participant in a network acts as both server and client having equal responsibilities and rights. More formally this work will adopt the definition made by Schollmeier [1] as: an application layer overlay network in which all entities are equal and all contribute some of their resources, thus giving rise to a network in which each entity (peer) is both a content requestor and a content provider".



(a) P2P model where participants act as both server and client.



(b) Client-server model with one server and multiple clients.

Figure 2.1: The architectures for client-server and P2P networks (Adapted from [17]).

This is different from a client/server model, well-known from the World Wide Web with a Web server having multiple Web browser clients, where the responsibilities and rights are strictly divided between participants acting as servers and participants acting as clients. The two different models are illustrated in Figure 3.1. The concept

of Peer-to-Peer systems is not entirely new even though much attention has been devoted to Peer-to-Peer systems recently. The approach of using a Peer-to-Peer model for applications was dominant in the early Internet as conceived in the late 1960s. Every host on the ARPANET was connected through a common network architecture allowing them to be equal players. All hosts could connect directly to all other hosts. One of the early systems, Usenet for sharing messages under different topics, deployed a Peer-to-Peer model which has many similarities with more recent Peer-to-Peer systems as described in detail in the survey below. An overlay network established every Peer-to-Peer network which is often based on TCP or UDP. The physical network and the overlay network should be separated completely in terms of topology. Peer-to-Peer network overlays are generally divided into the two main categories: unstructured and structured Peer-to-Peer network as argued by Androutsellis-Theotokis and Spinellis [13]. The content is distributed randomly and the network connections are based on availability in unstructured Peer-to-Peer networks. In structured peer-to-peer network the peer-to-peer protocols are strictly determined by the network topology and location of content. Most unstructured and structured Peer-to-Peer networks require from the node want to join the overlay network must know the address of the nodes already in the network.

2.1.1. Structured P2P networks

Key/value-pairs managed by Structured P2P networks. A subset of the peers participating in the system knows by each peer, and a subset of the content administers it. Deterministically content is distributed among the peers often according to their keys that assign content to peers through a hash function. Peer-to-

Peer protocol is determined strictly this content distribution which also dictates the overlay network topology.

2.1.1.1.DHT-Based

Distributed hash tables (DHT) overlay networks are often used inter-changeable with structured P2P overlay networks. To provide an efficient, scalable and robust routing algorithm is the primary goal of DHT networks which are involved in locating certain content which reduces the number of peer hops. Using a hash function associating all content with a unique key is accomplished. For a certain range of keys and storing associated content is then responsible by each peer in the network. The query which results in a key is applied to the hash function when searching for specific content that can be mapped directly to a peer. CHORD and CAN are examples of DHT overlay networks.

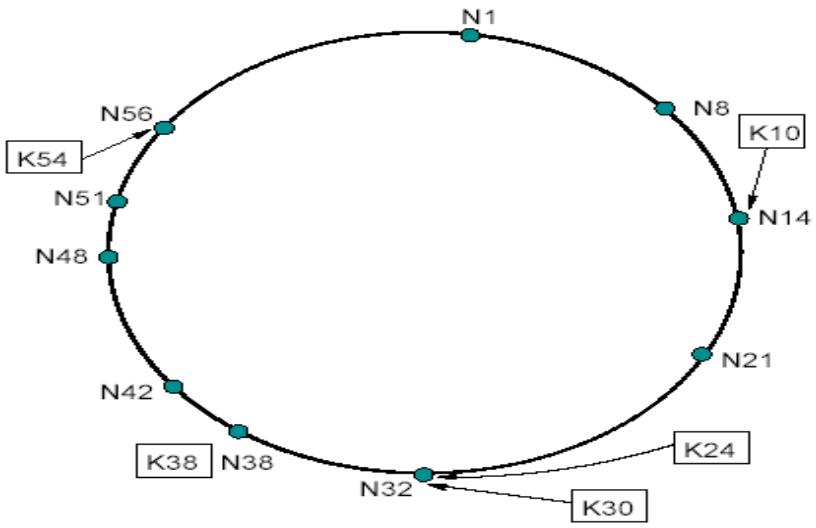


Figure 2.2: A CHORD ring with ten peers storing five keys.

2.1.1.2.CHORD

According to Stoica et al [18] one of the structured Peer-to-Peer search algorithms is CHORD protocol. As responsible for a given key, it gives permission to concur a disseminated set of member on a single peer without any central coordination. Peers are organized in a ring fashion in the CHORD overlay network. CHORD protocol describes how peers locate and store data, and how peers can join or leave the ring. A lookup function is the only function that CHORD provides for application developers which maps it the given key onto a peer. Peers are usually responsible for storing the information on where to find the content or storing content associated with the key.

2.1.1.3.CAN

According to Ratnasamy et al [19] Content Addressable Network (CAN) is similar to a CHORD, as Peer-to-Peer protocol derived from the DHTs concept. The major characteristic that CAN implement is to map a key k onto a point p in d-dimensional Cartesian coordinate system. Therefore, CAN a coordinate space is partitioned between each and every one of the peers in the network instead of using a ring topology to distribute keys as CHORD. A certain zone of the coordinate space is then responsible by each peer. In the coordinate space, a d-dimensional hash function is in use to map k onto a point p to store a key k in CAN. The peer responsible for the zone is then stored on the key k which p lies within. In CAN, a routing table maintained by Each Peer of its immediate neighbors. To direct the query to a point of destination, the peer sends the query to the neighbor closest to the destination point of query. In case of losing availability of one or more peer neighbors, the query is routed to the neighbor next best available. A restricted flooding in the overlay network is used

if every one of neighbors fails which are closer to the point of destination to locate peers in network.

2.1.2. Unstructured P2P networks

No well-defined network overlay topology and decentralized control is characterized by Unstructured P2P networks. Based on availability between peers are connected together randomly. Some of the peers may become known and gain a higher number of connections due to higher availability, ultimately, via another peers inside the network. Frequently super peers are called by those peers with the high degree. There are some desirable features for this self-organized emerging overlay network for example frequent peer departure or arrival and resilience to random failures. They are also requires small overhead for maintaining the topology and simpler to implement. Unstructured networks can be further subdivided into hybrid and pure P2P networks as argued in [11].

2.1.2.1.Pure P2P

Single point of failure is the major architectural disadvantage of centralized P2P networks. Pure P2P networks were developed without central entities to overcome this drawback. From a theoretical point of view; this network is the only true Peer-to-Peer, and one that agrees well with the definition given [20]. Any arbitrarily chosen node within a pure Peer-to-Peer network, it can be removed from the network without affecting the operation of the network [11]. An atomistic Peer-to-Peer network is also referred to pure Peer-to-Peer network, which means that each node itself has the list of all features necessary to participate. Among those pure P2P networks are Usenet and Gnutella.

2.1.2.2.Hybrid P2P

For data dissemination Hybrid peer-to-peer network use a server to perform peer or content discovery. For the above reason, a server-mediated peer-to-peer network is also referred to as for this kind of peer-to-peer network at the same time. Typically the peers can be queried a database which the server consists of and it can be categorized as User-Centric Peer-to-Peer or Data-Centric Peer-to-Peer [20].

All peers Database maintained by User-Centric Peer-to-Peer server. Whenever the peers needs to obtain connection parameters, search for other peers, or inquire about their current status this database is used. The database of content and corresponding peers is maintained by a Data-Centric Peer-to-peer from which the content may be obtained. To obtain connection identifier and search for content for the peers that store the desired content, all peers use this database, by the time found the required content. Typically the User-Centric Peer-to-peer server is used instant messaging peer-to-peer network, while the content sharing peer-to-peer is used for Data-Centric Peer-to-Peer.

2.2.MOBILE PEER-TO-PEER NETWORKS

For the mobile devices in order to develop peer-to-peer applications some interests raised by the huge improvements of mobile systems in terms of the new capabilities of these mobile devices and bandwidth such as mobile phone or Personal Digital Assistants (PDAs) [14]. For the point of view, Mobile Peer-to-Peer networks are networks without the involvement of a central server all the mobiles with the fixed devices can work and collaborate together. To connect and collaborate with other fixed peers the mobile peer-to-peer networks can use telecom operators, or either can

connect together in Ad Hoc fashion which is self organizing and healing wireless network as it is responsible for discovering each other and cooperate to become the communication easier [20].

2.2.1. Mobile Architecture

2.2.1.1.Cellular Networks

Figure 3.2 illustrates a cellular network mobile architecture. Having a fixed frequency plan assigned to avoid interference; these networks cover a larger area through multiple base stations. Each mobile device will be connected to only one base station at a time, if a mobile device starts to move with potentially, it will then handovers' to other base stations directly. The moment this mobile device connected to the base station by the use of the relay, they may probably connect to other fixed or mobile devices respectively. In addition, the mobile devices are able to use services which are offered by core network. Implementation of the core network can be differs, it can be 2G or a 3G system [14].

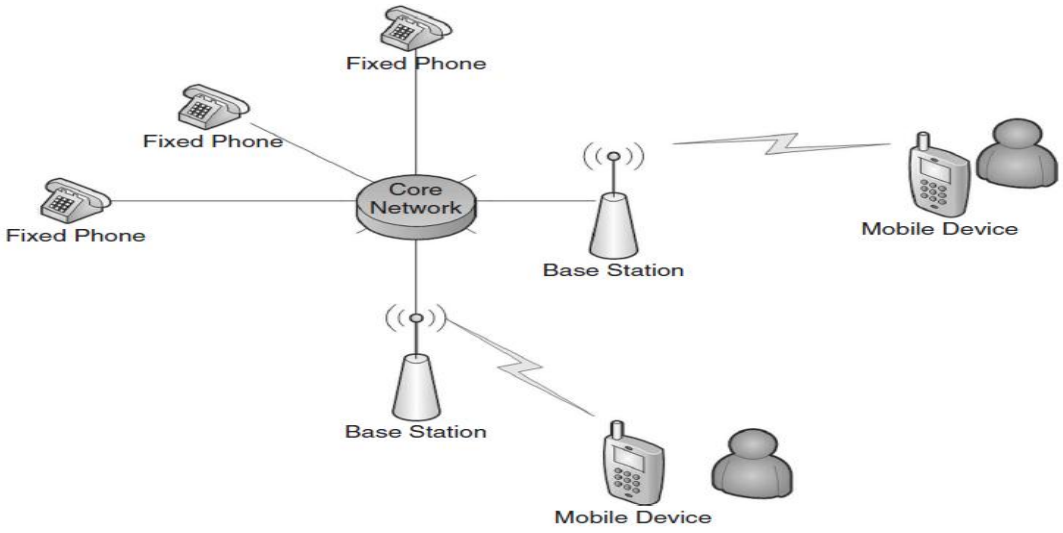


Figure 2.3: Fixed network with wireless extension (Adapted from [14])

2.2.1.2.Short-range Point-to-Point Networks

As Marconi's experiments demonstrated "Point-to-point communication" in 1985 was the first form of wireless communication [14]. As shown in the Figure 3.3 the point-to-point communication radio, for a fixed power margin it has some sort of limitations in range. The walkie-talkie as an example of point-to-point communication, which is voice communication means of half-duplex between users in close proximity. These days, exchanging pure data and information are also able by mobile devices in a point-to-point style, except like this event is always user driven e.g. exchange of pictures, songs, etc. Like this event built-in technologies can be realized such as Bluetooth, IEEE802.11b, or infrared. However, it shows that in the absence of basic required direct line of sight, a large number of the customers may use Bluetooth rather than Infrared. This is because many mobile devices can be found which is quite opposite to IEEE802.11.

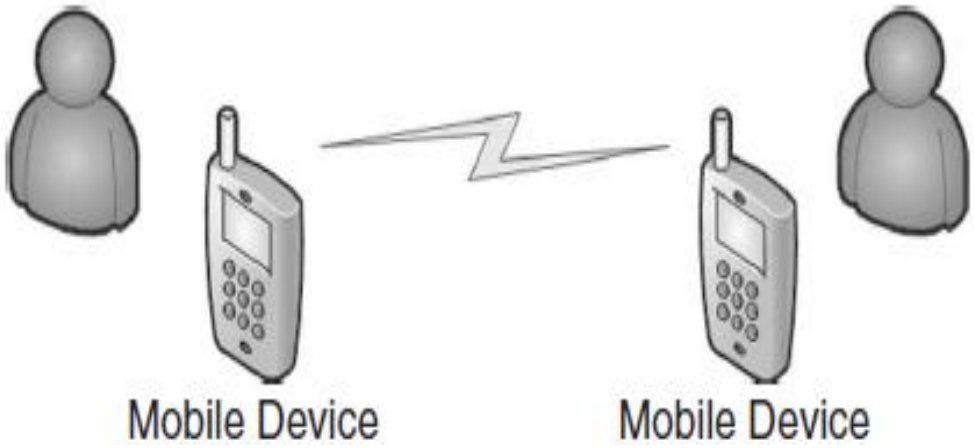


Figure 2.4: Direct communication between two mobile devices (Adapted from [14])

2.2.1.3.Wireless Technologies

There are various types of wireless technology deployed on mobile handsets. Some of the most popular technologies are 2G, 3G, 4G, Wi-Fi and WLAN technologies. In Figure 3.4 different wireless technologies are given for the communication range versus supported data rates. Some part of the world already get the new trends of wireless technology which also known as 5G, which claims to be three times faster than previous generations and deliver interference-free connectivity, faster throughput and broader coverage [42]. For example 3G technologies such as HSDPA and 2G technologies like GSM CSD/GPRS are shown in the figure. In addition, the latest technologies which are 4G containing long-term evolution (LTE) and worldwide interoperability for microwave access (WiMAX). Moreover, WiFi and WLAN technologies are illustrated also like Bluetooth and various versions of IEEE802.11 [14].

At this point, we present the fundamental ideas of WLAN using Wi-Fi (*IEEE* 802.11) and Bluetooth. By finding *IEEE* 802.11 and Bluetooth technologies in many mobile phones already we will mainly take a look into it. At the same time as Bluetooth is definitely the majority of the mobile devices are using widely in today life, IEEE802.11 is only in some position like smart phones those who are more advanced mobile devices.

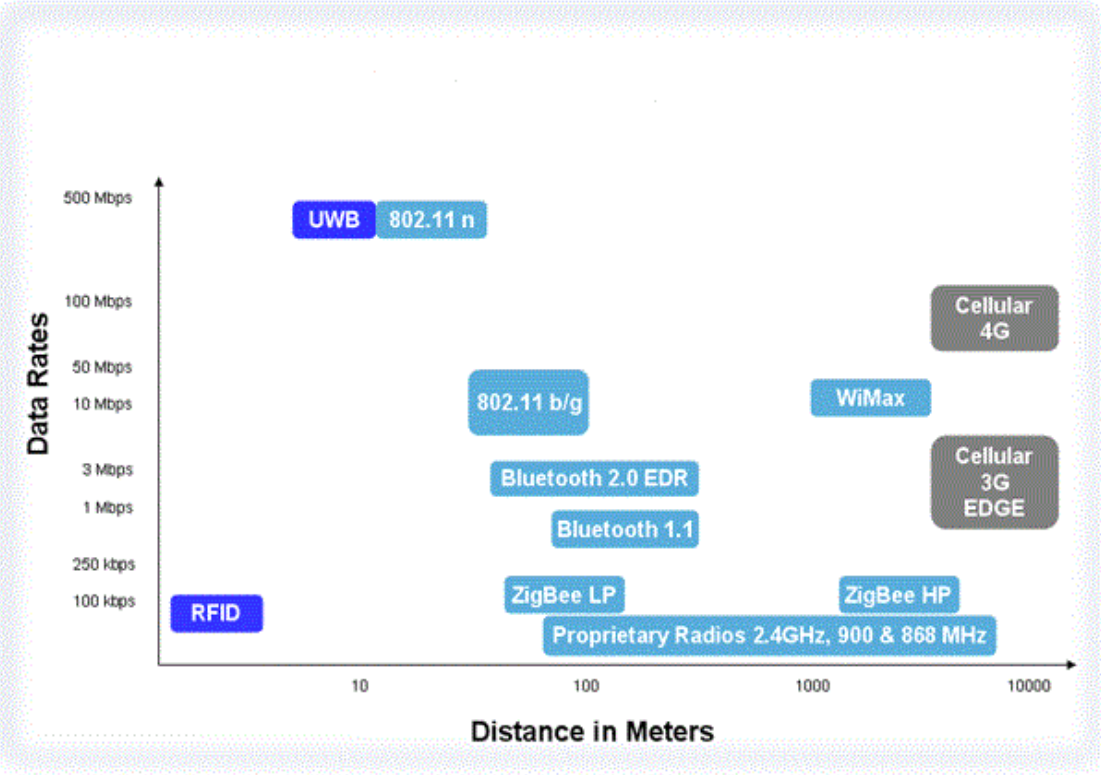


Figure 2.5: Wireless technologies and the supported data rate and range (Adapted from [29])

2.2.1.3.1. Bluetooth

As it often referred to a short-range communication the "Bluetooth is a radio technology that operates in the 2.4GHz band" [14]. As compared with cellular systems the range of communication is relatively small. The power class of the Bluetooth module is determined the communication range. Namely there are three different Bluetooth classes, which are class 1, class 2, and class 3. Communication ranges of 100m and even more can be in Class 1 devices, whereas class 2 devices are limited to 10m and class 3 are limited to less than 1m. Bluetooth access points are class, while1 most mobile devices are class 2.

Initially, the Bluetooth was planned to replace or change the cables [14]. As described the Bluetooth first applications was connecting laptops and PCs to printers. Since then Bluetooth has shown to a great extent range of applications. Such as GPS modules or headsets Bluetooth eases the process of connecting cordless peripherals.

At a given time to define which service can be supported, Bluetooth offers different communication profiles. The IP traffic between two peers for data communication the LAN profile is used, while the headsets connected to a mobile phone are used for voice profiles.

At the present time the majority if not the entire devices support multi-profile, whereas at the beginning of the Bluetooth, the devices were only supporting one profile [14]. It can be desirable, for instance, by the time of the mobile phone connected to a headset and a PDA at the same time. Selecting from the PDA the phone number, over the phone setting up the call, and make conversation using the headset can only be possible with multiprofile Bluetooth chipsets.

One and at least one master device the Bluetooth communication can take place with the maximum of seven devices as active slaves [28]. Only the master device can be connected by all slave devices. The master device can be able to connect theoretically more devices, as the master is able to park a device, except there is restriction of the number of ongoing communication associates to only seven active devices. Seeing that outcome of this structural design, there is no direct communication between slaves and to relay information is reliant on the master. Keep in mind the possible communication can be point-to-point communication, and there is no possibility to

multicast or broadcast from slaves. At the same time the master device can broadcast information to all slaves allowed by some Bluetooth.

In the surrounding area to discover other Bluetooth devices, service discovery can start each device [28]. Other devices will be searched by the service discovery and categorize them into PCs, mobile phones, headsets, etc. They can be paired once these devices are found, as communication partner procedures are approved by devices. The discovery process can take quite a long time, in the case of a large number of Bluetooth devices. To discover all neighboring devices with more than 10 devices around, it can take minutes.

Eight asynchronous or three synchronous communication channels can be supported by one Bluetooth device and has the ability to support. Data communications are used by the asynchronous channels, whereas voice services used mostly the synchronous channels.

It employs frequency hopping, since the 2.4GHz bandwidth that Bluetooth operates to make less error prone for the entire communication in the company of other technologies by means of this open ISM (industrial, scientific, and medical) band. Time Division Multiple Access (TDMA) style is organized by the medium access in which splits the channels into 0.625ms slots. At whatever time the receipt of the information needs to be acknowledged in the next slot by the time one device try to send information to another device.

The Bluetooth SIG also released the Bluetooth v4.0 specification [29]. Two forms of wireless technology systems are adopted in Bluetooth v4.0, namely Basic Rate (BR) and Low Energy (LE). The BR system includes optional Enhanced Data Rate (EDR) Alternate MAC PHY layer extensions. The BR system provides three different data rates of 721.2 kbps (BR), 2.1 Mbps (EDR) and up to 24 Mbps (High Speed, HS) [29]. The HS technology provides better power optimization, better security, enhanced power control and lower latency rate [29].

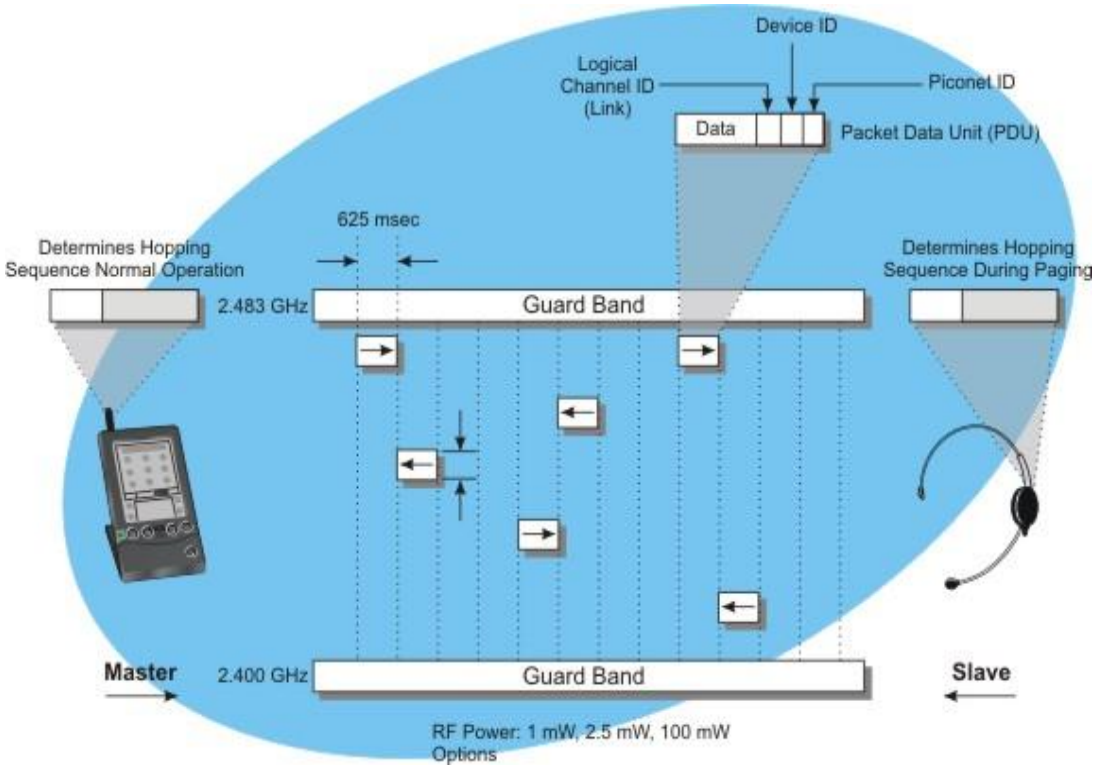


Figure 2.6: Bluetooth Operation Diagram (Adapted from [21])

2.2.1.3.2. IEEE 802.11

This wireless technology consists and defines a bunch of products in a family [14]. The family of 802.11 is depending on the medium access protocols and various physical layered implementations. In the start of this technology was having 3 forms

apprehension at the level of physical layer, the first was frequency hopping (FH) , second was direct sequence spreading (DS), and infrared (IR). The limitation of IR was that it was bounded to line of sight and FH the more complexness of realization as compare to DS, the chipsets of the technology was using DS. The design of the FH and DS was not designed to realization of medium access but for the improvement of the multipath interference. The data rate offered by DS realization was at first from 1 to 2 Mbit/s functioning over 2.4GHz frequency band. After the introduction of the 802.11b the data rates inclined to 11Mbit/s. To avoid the interference regarding their neighbors the three full orthogonal channels are used. The frequency band of the 2.4GHz had become crowded, by introducing IEEE 802.11a the frequency band was increased to 5GHz. The availability of the orthogonal channels increased to the 12 channels available for the indoor usage but it depends on the region, the support of data rate was increased to the 53Mbit/s. The 802.11a came up with OFDM to provide higher efficiency. The OFDM technology is having various advantages as compare to the DS technology later on the IEEE 802.11g introduced which was also based on OFDM technology and using the band of 2.3GHz. By looking inside the technologies of 802.11b and 802.11g both are working on the same band of frequency and also having same MAC protocols but both of them often comes in the same chipset nowadays [29].

The maximum data rate of the 54 Mbit/s is for 802.11a as well as 802.11g shall be achieved if the communication points are having higher sign to noise ratio (SNR) for their communication carrier, the SNR is responsible for the decrement of the distance between the communication points [14]. There are various factors which are affecting like multipath, interference and shadowing, etc are very crucial but making it simple

let us talk about distance. The stations will be adapting the coding scheme and modulations based on the SNR values. For that reasons the data rate will decline with the decrement of the SNR which is actually depending on the distance of the communication points. Another IEEE 802.11n is introduced later on after IEEE 802.11g which was also based on OFDM technology and using the band of 5GHz with 600Mbps data rate but most common to 150Mbps [29]. IEEE 802.11n is already available and implemented by vendors. After IEEE802.11n there is outstanding release of new 802.11ac technology, also known as 5G Wi-Fi, which claims to be three times faster than 802.11n and deliver interference-free connectivity, faster throughput and broader coverage [42].

If we look into the medium access control (MAC) of the IEEE 802.11 in terms of the distributed coordination function (DCF). The MAC is depending upon the multiple access with collision avoidance (CSMA-CA) carrier sense, which shows that all the communication points are sensing the medium in a way to determine that the medium is free or not.

In this situation the sensing communication point will be not sending to all the points to avoid the possible collisions [14]. The collisions are occurring if many stations are using the same wireless medium at the same time and the sender will be receiving various overlay signals and the sender is not able to receive them completely. If the wireless medium is sensed as free then the communication station will prepare for sending to the medium but there is possibility that at the same time other stations are waiting for the usage of medium therefore every station is having wait time before communicating anything. The waiting time can vary point to point. That station which

is having the less waiting time that will transmit first and by that the medium will become busy so that the other stations need to wait that time and they will become freeze until the medium is free. After sending a packet from the station that station will wait until it gets acknowledgement from the other transport device. In case if the acknowledgement is not found that then the sender will assume that the already send packet is not reached due to the collision occurred by any other station. These collisions are possible because of the communication points can have the same random timer. The waiting time of another packet is doubled for the production of the diversity. In the Bluetooth technology the channel is not in slot equal. The communication point will be occupying the medium as far as it is table to transfer the packet. The time of the packet transmission will be depending upon the length of the data sent and the maximum data rate support in carrier. The acknowledgement time is very important to consider and count in the sending time which is the small time between the sender and acknowledgment at the time when the medium is not in use. For the prevention of the collision occurrence before the start of the transmission there is pause and intervals introduced by the 802.11. The acknowledgement sent by the station will be having priority to access the medium as soon as the receipt of the packet is confirmed. At that time the other communications points will be waiting more time and until the timer is expired the acknowledgement will be in the way and stopping the other communication points to access the medium.

For the reduction of the possible collisions the 802.11 is using ready to send (RTS) and clear to send (CTS) messages for the elimination of the possible collision occurrence [14]. The RTS messages are sending through the sender point to ask permission from the receiver that is free from the other communication stations which

are unaware. As soon as the receiver is ready to receive the packets then it will send to sender the CTS message. When the sender receives the CTS message then it will begin sending the data. In this case the neighbors will be informed also by the CTS and RTS messages that medium is busy for how long.

The IEEE 802.11 is also using broadcast and unicast messages for the reduction of collisions [14]. Unicast allows transmission between the two communicating points and the broadcast the sender will be one but the receivers can be multiple. In the unicast to determine the data rate the SNR is used between the two stations and the broadcast data rates are depending upon the signal strength. Mostly the 802.11 technology is having least possible data rate if the broadcast messages are passed. A small number of chipsets is permitting the data rate in the form of the broadcast communication.

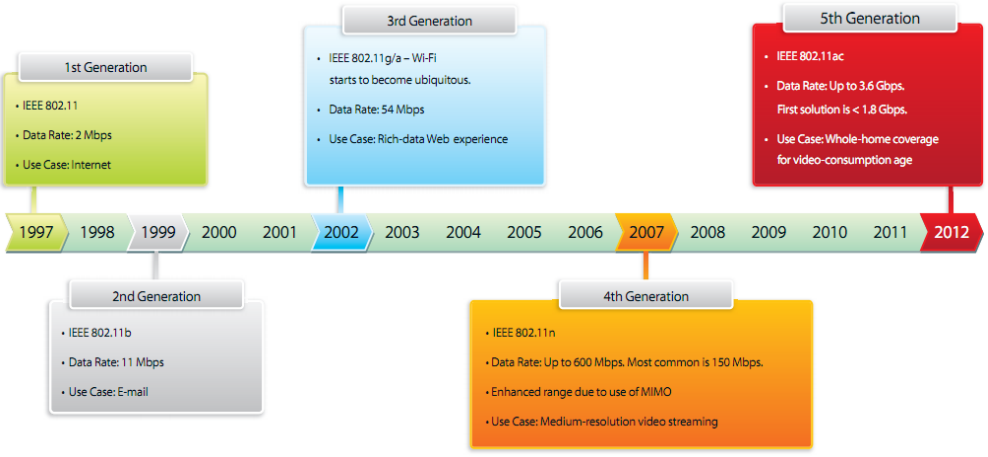


Figure 2.7: The Generations of the IEEE 802.11 standard (Adapted from [42])

2.3.SUMMARY

This chapter has provided an overview over existing P2P systems and a classification of them into the two main categories: unstructured and structured P2P overlay networks. In unstructured P2P networks the content is distributed randomly and the network connections are based on availability. In structured P2P networks the network topology and location of content are determined by the P2P protocol.
Unstructured P2P networks were further subdivided into two categories: pure P2P networks with no central authority, where flooding was necessary to route queries, and hybrid P2P networks, where routing of queries was performed among super peers in the network.

Structured P2P networks included DHT-based systems which provided a deterministic mechanism of locating content in the network. This was accomplished by using a hash function on content meta-data resulting in a finite key space. The key space could then be distributed among peers in the network, making the peers responsible for a subset of the key space and the associated content. Routing of queries in DHT-based networks was realized by finding shortest path to the peer responsible for the content searched for.

On the other hand an overview of mobile P2P were provided as we discussed the mobile P2P is networks without the involvement of a central server and all the mobiles with the fixed devices can work and collaborate together. To connect and collaborate with other fixed peers the mobile peer-to-peer networks can use telecom operators, or either can connect together in Ad Hoc fashion.

Mobile architecture was discussed as cellular systems which covers a larger area through multiple base stations. Each mobile device will be connected to only one base station at a time, if the mobile device starts to move with potential it handovers to other base stations. By the time mobile device connect to a base station using as relay they can also connect to other fixed or mobile devices. In addition, the mobile devices are able to use services which are offered by core network. Implementation of the core network can be differs, it can be 2G or a 3G system, and Point-to-Point Networks which is point-to-point communication radio. By the time these days, exchanging uncontaminated data and information are also able by mobile devices they use a point-to-point style, and it is user driven forever e.g. exchange of pictures, songs, etc. In-built technologies can be realized by such as Bluetooth, IEEE802.11b, or infrared. Without require direct line of sight most customers are using Bluetooth, other than Infrared, because most mobile devices can be found it, quite the opposite to IEEE802.11. Finally, Wireless technologies and we classified into 3G technologies, 2G technologies, 3.5G technologies and WiFi & WLAN technologies but we mainly took a look into WLAN and Bluetooth as Bluetooth is definitely the majority of the mobile devices are using widely in today life, WLAN IEEE802.11 is only in some position like smart phones those who are more advanced mobile devices.

CHAPTER THREE

METHODOLOGY

3.0. INTRODUCTION

Research methodology is one of the important parts that need to be carried out in every research paper as it deals with procedures in order to achieve its objectives. There are various techniques and methods that can be used as guidelines to achieve the research objectives. As for this topic, it mainly concern about comparing traditional and mobile peer-to-peer networks and I suggest, these are the areas gaining great concern with many challenges accrue due to lack of middle server, and each node must work together with other nodes with the aim of achieving the complete system work. Therefore, in this research we try to compare mobile and traditional peer-to-peer networks in terms of similarities and differences. Also we will compare in terms of node discovery approaches and the routing algorithms employed in mobile and traditional peer-to-peer. In our study we have chosen Yin methodology [23] as our methodology. This methodology describes four stages in the following: design the case study, conduct the case study, analyze the case study evidence, and develop the conclusions & recommendations as figure below.

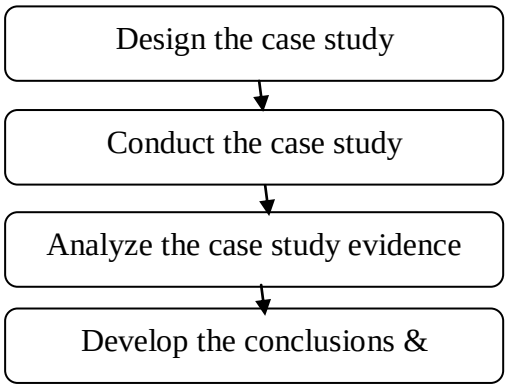


Figure3.1: Yin Methodology (Adapted from [23])

We will use research papers, proceeding, and journals for our objectives and goals to collect the data, do the comparative analysis and develop conclusion.

3.1. DESIGN THE CASE STUDY

In order to establish a good research where the intention of the researcher will tend to multi aspect phenomenon and the research in the initial stage, the researcher has to exactly understand the issue. The researcher must understand clearly about the problem to come up with the research questions pertaining to the goal to be achieved. This means that achieving the goal for any research depend largely upon the research understanding for the exact problem associated to the case study. However, for any design whether theoretical or empirical study the researcher must precisely shows problem solving ability within the stated objective. After understanding the issue the researcher must develop an effective and sufficient research questions which will focus only on the problem.

The interpretation and understanding of each issue related to the traditional and mobile peer-to-peer particularly the objectives of this study is designed in this stage. It is indeed, once the problem has been identified and questions has been developed therefore, the clear understanding of traditional and mobile peer-to-peer networks become imperative to the researcher. However, it is clearly understand that for study like this (comparative analysis), details and enough information must clearly be stated and diagnose with appropriate tools in order to achieve or solve the research question that has been developed.

3.2. CONDUCT THE CASE STUDY

Systematic and comprehensive way is required from the researcher to gather facts related to the problem from various sources, those can be properly reference and cited to reach the solution to the problem. At this stage of the methodology we will collect the data that we need to thoroughly examine for the traditional and mobile peer-to-peer networks.

The researcher is expected to collect enough and comprehensive data from various literatures that will support the identified problem and helps to overcome such problem. Such data can be generated from theoretical and empirical study related to traditional and mobile peer-to-peer networks. An experimental data can equally helps to support the researcher for the analysis of various node/peer functions. Moreover, comprehensive and sufficient analysis for any research work depends absolutely on the richness and understanding of data collected by the researcher.

3.3. ANALYZE THE CASE STUDY

For the purpose of analyzing the case study, the researcher will use various interpretations to examine raw data in order to find linkages among the outcomes and the research object with reference to the original research questions. The researcher remains open to new opportunities and insights throughout the evaluation and analysis process. After collecting data in the previous stage, analyzes will go through to determine or examine the data collected.

In this scenario the researcher will carefully read the data collected from theoretical and empirical study in order to have clear understanding of mobile and traditional

peer-to-peer networks. Furthermore, the researcher now examine and analyze the node and peer discovery approach and routing algorithm of mobile and traditional peer-to-peer networks. This analysis can be carry out based on the data collected from various literatures. Diagrams with written explanation will be included for precise and clear understanding. Each analysis will be supported with a particular literature (source).

3.4. DEVELOP CONCLUSION AND RECOMMENDATIONS

The most important from the user perspective perhaps is the reporting aspect of the study. In the last stage, after thoroughly analyzed and examined all the data that has been collected, the conclusion and recommendations will be given based on that analysis and examinations.

This means that based on the findings, the researcher will draw the analysis phase and compare with the initial objectives to full testify whether such objective has been achieved or not. Once the research questions were answered according to how it is stated respectively, and objective has been achieved accordingly with utmost satisfactions, then the conclusion and recommendation will be highlighted rich enough.

3.5. SUMMARY

In this chapter, we explore Yin methodology to apply in our study which consist four stages that we have discussed above. However, we discussed the design case study with precise and clear explanation pertaining the understanding of the problem from literature prospective. Conducting the case study was elaborated which talks about the

comprehensiveness and richness of the data collected from theoretical and empirical study with clear understanding. Furthermore, the chapter explains the analysis phase concerning the techniques used to study and analyze the node or peer discovery approach and routing algorithms. Moreover, the last stage of the chapter elaborated on examining whether the research questions has been answered and objectives were achieved accordingly, hence conclusion and recommendations were explain and how to elaborate.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

4.0. INTRODUCTION

The Mobile and Traditional Peer-to- Peer networks are having similarities and distributed not centralized connectivity. They are having similarity in terms of the nodes or peers which are able to perform discovery of the other nodes of peers in their region or network. In this chapter, we elaborated the techniques of node/Peer discovery in the Mobile and Traditional Peer to Peer networks. In addition, we discussed other aspect which is routing algorithms in both network. Therefore, the different routing algorithms employed in both networks were discussed to compare the node/peer discovery and routing algorithms in these two networks.

4.1. PEER DISCOVERY IN TRADITIONAL P2P

The methods applied for the accomplishment of peer discovery in the peer to peer networks is significantly more diverse as compared to the methods available or used in the achieving neighboring node discovery in the field of the Mobile Peer-to-Peer networks. The peer discovery operation is carried out in the application layer making it a basic cause behind the neighboring node discovery in the peer to peer networks, due to that no any suppositions are made regarding the functions offered by the network and the data link layer. The following section is describing the review of the peer discovery in the atomistic Peer to peer network and UCP2P networks.

4.1.1. Atomistic P2P

In the atomistic model (AP2P), all nodes are equally server and client. There is no central administration or connection arbiter, although such might be implemented as distributed services within the network. For purists, this model is the original and only "true" p2p architecture. Each node in the atomistic model is autonomous and fully manages its own resources and connectivity.

4.1.1.1. Bootstrapping in Atomistic P2P

As demonstrated by Luo et al [24] "Bootstrapping is a process in which a new peer who intends to join a P2P network tries to discover contact information of other peers that have already been in the network". The method in atomistic peer to peer network, firstly the bootstrap is required to the at least one another peer node which is already registered in the peer to peer network for the peer who wish to join the peer to peer network. This is performed through two ways. Whenever the peer to peer application is anticipated for the localization of the environment like Local Area Network (LAN), a broadcast message is sent to the network to find out other peers in the network. The broadcast at application layer will translate to the data link layer broadcast with the condition that the data link layer protocol is supporting the broadcast for example Ethernet. This is used in many types of P2P application like online multiplayer games [2]; the major disadvantage in this approach is that the P2P application will be limited to the local environment.

The usage of the broadcast to join the peer-to-peer network is not having facility of spanning multiple internet protocol (IP) subnet. On the internet the usage of the overlay network in the P2P network is added. The major issue in this fact is about

various other network applications like broadcasting in switched networks. The atomistic peer to peer network is broadcasting packets which are not being forwarded by the routers in the IP network is major issue in this network.

To encounter this issue the peer who wishes to join atomistic peer to peer network must know at least one peer which has already joined the network. This provides the more stable network peers which are relying on the other already joined in the peer to peer network. This type of stability is acquired by the usage of peer having a static IP address and connectivity without interruption in the peer to peer network. These types of peers are known as “Host Cache” Gnutella [25] or “Portal in Fast_Track” [3].

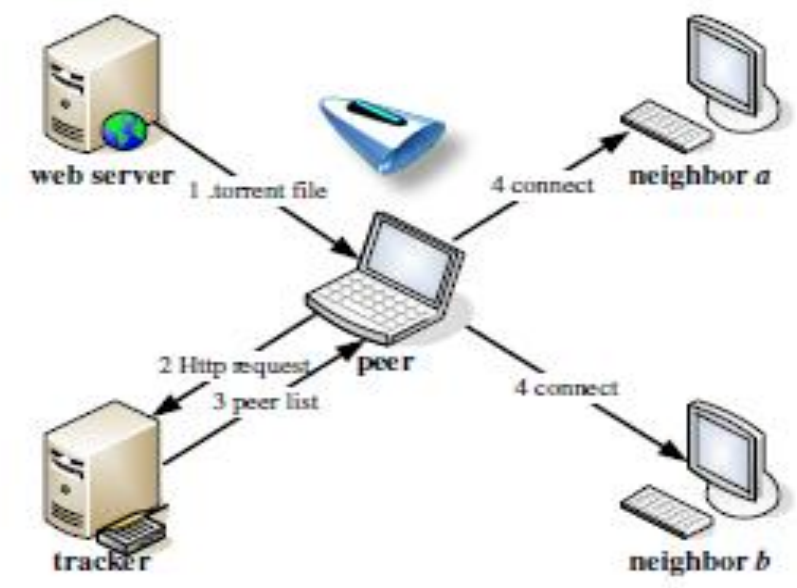


Figure 4.1: A Bootstrapping p2p network (Adopted from [24])

4.1.1.2. Flooding Technique in Atomistic P2P

If a peer has joined the P2P network successfully, then to discover the other peers a flooding methods can be used. The scenario provided here depends upon the Gnutella

implementation of the flooding technique. Hence, two types of message are provided by the Gnutella protocol to discover the peer and this include Ping and Pong messages. For the discovery of the other peers, ping message is used while the reply of the ping will be pong. The IP address and the information related to the data which is to be transmitted between the discovered peers are contained by the pong message [26]. All these types of messages which belong to the Gnutella protocol are having Time-To-Live (TTL) attribute which is limiting the maximum range propagation of message. To differentiate the value of this property has to be done through the hop (application-layer) in which when it's at the level of value zero then the message is dropped automatically [26]. To identify every message for ensuring that peer is not being forwarding the same messages repetitively, the Message ID is included.

When the stable peer starts to receive Ping message from another peer which is having connectivity with the sequence of events will initiate. The message will be forwarded by the stable peer to the other all peers who are having connectivity to it, apart from the peer which has receipt of the Ping message [27]. All those peers which receive this message will perform the same action and after that they will reply to the peer which has sent the Ping message to them by the sending message of the Pong. The Ping message propagates the messages up to the TTL is expired. For the minimization of the expansiveness of the flooding technique the pong message will propagates in the same way as they were received by the Ping message. If the Pong message is received by the peer without the Ping message it the Pong message will be dropped [27]. In Figure 4.2 illustrates the Ping/Pong procedure.

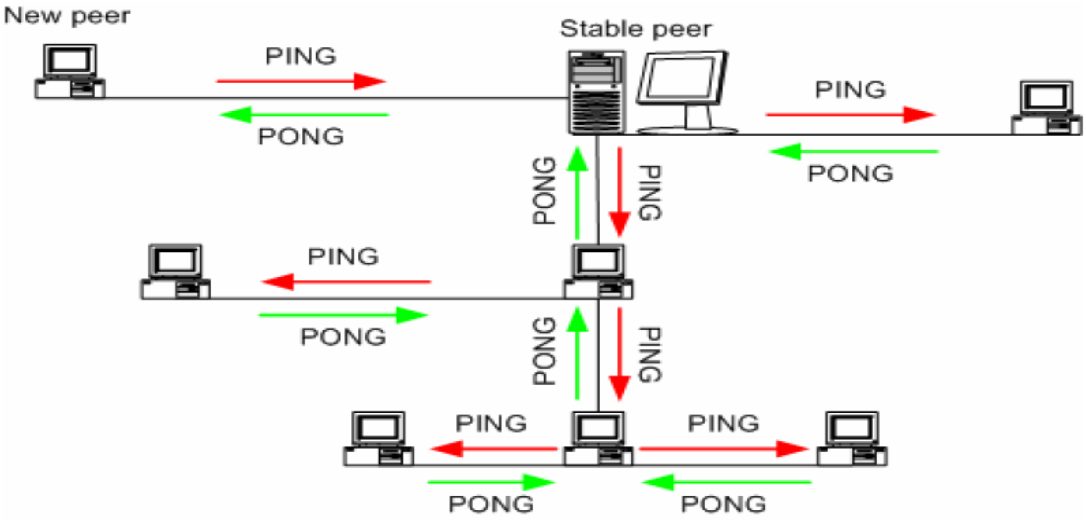


Figure 4.2: Flooding technique Ping/Pong procedure (Adapted from [27])

When the Pong message is received a new peer is allowed for the connectivity to the already discovered peer through the sending the request of GNUTELLA CONNECT. If the response is in the form of GNUTELLA OK then the direct connection will be created.

The degree is 4 of 4 for the average node of the Gnutella node [26]. But the nodes are having low degrees in the reality the content queries are being flooded in this way, to assure that the query will reach to the more than 4 peers.

The scaling of the flooding technique is considered because of the average node degree of 4 and the usage of the TTL attribute. In the flooding technique the major issue is the scalability, in Gnutella where this technique is also used for the peer discovery [26].

4.1.1.3. Rumor Mongering Technique in Atomistic P2P

The rumor mongering technique is from the protocols class which is gossip protocols [27]. The selection of the peers is done randomly to those peers where the message is

to be forwarded is done in the gossip protocols different from the technique of the flooding because it was using the Ping message to whole the peers only leaving the peer from where it was received. This type of class of protocols is also used and beneficial in the other application like database consistency management, but in the concept of peer to peer networks it is new [27].

One type of the gossip protocol which is said to be blind counter rumor mongering is reviewed here [27]. The working principle of these protocols is somehow similar to the flooding technique which was used in the Gnutella but it is having two other properties which are defined below:

1) B: Specifying that how many peers to forward the message. The selection is done randomly to the selection of the B peers from the whole peers where the connectivity is available.
2) F: Specifying the maximum limit of the peer for the same message forward. This attribute is must, disparate from the flooding technique where the whole peers were not exhausted for the forwarding of message first time.

For the minimization of the cost in the selection of the peers where the message is expected to be forwarded includes following:

- It confirms that the message which is not received from the next hop peer.
- It confirms that the message is not already sent to the next hop peer from the peer who is forwarding during the last forwarding try.

The understating of [27] the rumor mongering technique gives a technique which is scalable as compare to the flooding approach. However this will reduce the reach but

it increases the delay. To control the problem the modification in the attributes of the B and F, if the B is changed to the degree and F is set to 1 then this protocol will operate similar to the flooding technique.

4.1.2. User-Centric P2P

In our previous discussion related to Peer discovery approach, atomistic P2P was explained clearly. However, the technique used in UCP2P for the peer discovery basically a trifling one which is having a server that is central and depend on the provision of service. As mentioned recently UCP2P server employs a database for the provision of the services. The database of the whole registered users is maintained by the UCP2P. The specification and configurations of the databases like that are secured and not revealed. The database is consisting of the entries for the each node identification registered within the system. For the searching and sorting purposes the index number of the every entry is indexed. The TCP port number and IP address is stored and maintained for the each entry to make sure that the node is online. The status of the node is recorded in the database to make sure that the other nodes are able to access the node.

A query is done by the other peer registered in this server to this database for the peer connection identifier to connect with the peer for the establishment of the connection with the peer. For instance if the node A wants to communicate with the node B, the query from the node will be sent to UCP2P server with the provision of the required node identity. Considering this case the UCP2P server will return TCP port number and IP address at the time of searching of the required entry of the node. After that the node A will be able to establish the direct connection with node B.

The server arbitration is providing a simplest form or solution of the discovery of peer, which is scowl upon when it is introducing the point of failure and the benefit of the usage of P2P network conflicting to use a client and server network is gone. Another thing is the expansion of the bandwidth at the level of the server low as compare to the client and server networking transmission which happens in the peers. The provision of the information and computation related to the maintenance of the database in server is complex with the provision of the high search capabilities. In the instant messaging P2P networks the UCP2P is very popular to use.

4.2. NODE DISCOVERY APPROACH IN MOBILE P2P

The Mobile Peer-to-Peer networks are wireless networks which are having range of radio which has the limits of the maximum transmission limit between the two nodes for the communication. In the Mobile Peer-to-Peer wireless networks jargon, the nodes are residing in the limit or range of the radio closer to the neighbors. To discover the nodes which are not neighbors is also possible but it will need routing protocols.

Discovering the neighboring node in the Mobile Peer-to-Peer networks is resides in the data link layer. There are various ways in which Mobile peer-to-peer discovers its peers Therefore, the techniques of the IEEE 802.11 and Bluetooth are discussed below.

4.2.1. Node Discovery using IEEE 802.11

To discover the available nodes in IEEE 802.11 which provides the set of standards with two possible dimensions are described below:

1. *Passive scanning*: In the passive scanning method, the node will be waiting the receipt of the Beacon frame coming from another node [28]. The Beacon frame is frames that are having information of clock about the receiver node to use the clock in the synchronization according to the other nodes. In the result the nodes will be able to know about the possibilities of the other neighboring nodes.

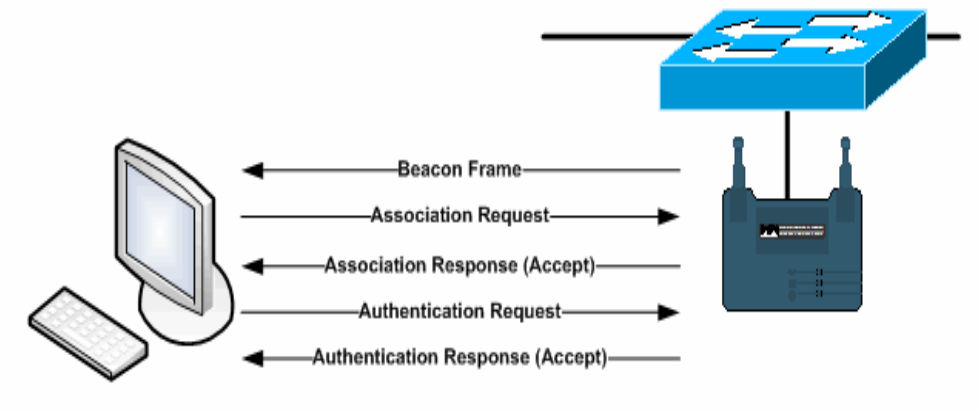


Figure 4.3: Passive scanning in IEEE 802.11 (Adopted from [28])

2. *Active scanning*: In the active scanning the nodes on other hand will be asking for the information regarding neighboring nodes by the transmission of a Probe Request [28]. The node who receives this Probe Request will be replying through the Probe Response mechanism. The response of Probe will be having identification and related information.

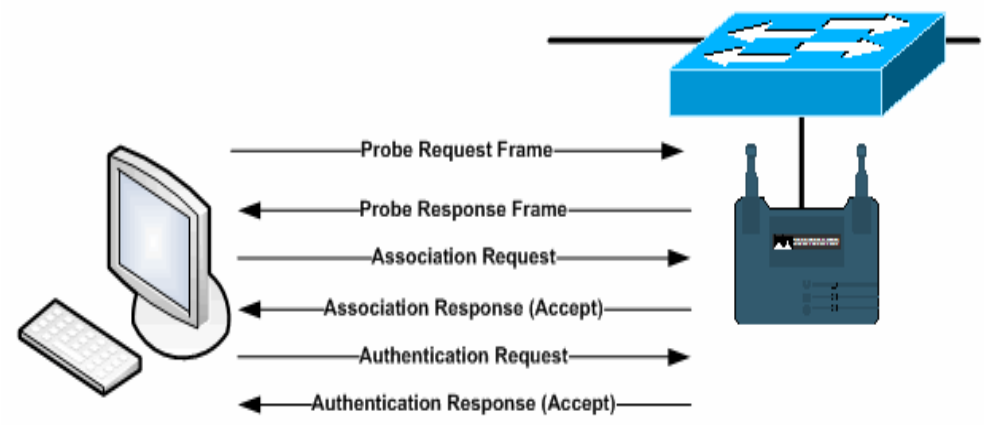


Figure 4.4: Active scanning in IEEE 802.11 (Adopted from [28])

4.2.2. Node Discovery using Bluetooth

The Bluetooth is using different technique. The Bluetooth network is based on piconet which is the combination of the 8 Bluetooth devices. From these 8 devices or piconet that one device will serve as a leader or master who will lead the other devices and other devices will be behaving as slaves to master. The master device is responsible to take care of addition of other new devices into the network and also enter the Inquiry for the checking of the other nodes which are near. Any new node which wants to join the piconet it will be turn into the Inquiry Scan state, after the receipt of the Inquiry frame from the master device the new node will send the Bluetooth device address to the master to join [29]. After that the master device will enter into the Page state and by making Paging frame along with the new node of Bluetooth device address which was sent by the new node which will turn the whilst responding in the state of the Page Scan [29]. The master device will send the information of the new node slave synchronization info after that the new node can join the piconet.

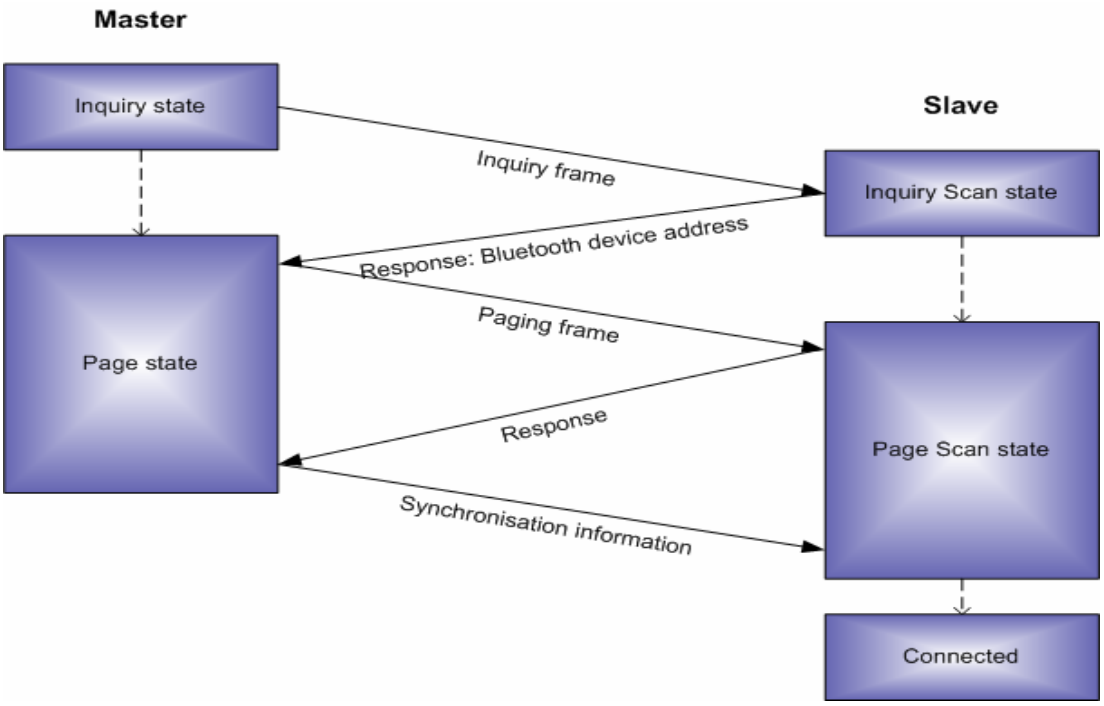


Figure 4.5: Node discovery using Bluetooth (Adapted from [29])

4.3. ROUTING ALGORITHMS IN MOBILE & TRADITIONAL P2P

There are various routing protocols and algorithms for traditional and mobile peer-to-peer networks having significant features and limitation proposed by various researchers. The routing protocols available for the mobile peer-to-peer networks are divided in two classifications, one is proactive which are making routing table and second is reactive which is on demand routing protocols. A node in the proactive routing protocols is having access to all over the network at any time, similar to a normal router for the internet. If there is topology update that will be broadcast immediately or with a small span of time to all the nodes in the underlying network, then the path discovery is done very fast. The limitation of the proactive routing protocols is having the number of required topology updates within a time period. If the number of nodes belonging to a network rises over a certain threshold, this kind of routing algorithm is not feasible anymore. Putting light on it the nodes are not sending any information of the updates or changes in the topology to the neighboring nodes. If the path is already set to another node, it will flood the network path by its request by sending response destination which already knows the route which request sent. Here we present and discuss the routing algorithms in both networks. First we present traditional peer-to-peer then Mobile peer-to-peer network.

4.3.1. Traditional P2P Routing Algorithms

4.3.1.1. The Gnutella Protocol v0.4

In the peer to peer (P2P) networks the flat routing techniques is used by the Gnutella protocol [29]. This protocol is establishing Gnutella network which is having various distributed devices connected by the TCP/IP connection. This is virtual overlay

network which is providing service of the content and performing routing jobs for the networking. Each service is connected in a dynamic way to the seven servants [28], which are considering the bandwidth of the network connection. The routing of the messages is broken into two parts in these connections. The first type of the routing message is query message and another part is respond messages. The query type messages are exploring the architecture of the ending neighbors by the help of sending ping messages. The searching of any content like video, audio and files in the network is searched by the usage of query messages. The Gnutella network is having routing basics which is said to be "vital propagation" of the query messages. The servants are searching for the contents in the network and sending a query message or ping message to the all neighbors of the servants in the current TCP/IP connected virtual overlay network. The each servant is exploring the fully decentralized way which does not need any central point which enables it saved from the network flooding. The another type of messages in the Gnutella network is the respond messages which are sent in the reply of the query messages which are received by the destination. The QUERY_HIT message is sent if the query is received and content is demanded. The PONG message is used for answering a PING message for the awareness of the client which is querying. The respond messages are not related to the entire network only they are sent to the servant who is querying. For avoiding the flooding the respond messages will be sent from the destination to the source back. The backward transmission will be same as they received query message in the same path. The signaling messages and application routing the response and query messages the content is query by the servant in the distributed vital overlay network. For the minimization of the load over the network is achieved by the data transmission by the "out-band" which is having address of the QUERY_HIT message

and using direct IP for the route and creating connection of the sender and receiver servant. This established connection will be used for the direct transmission between the peers. A main problem arises in the Gnutella protocol that it parts of the network are being flooded at some extent due to ping and query messages and that is giving high load in signalizing. For the reduction of this load the Time-To-Live (TTL) is sent in the attachment of the query message in this protocol because the query message will be only sent to the servant and when the TTL value is declined for each hop that is not zero then the transmission range of these messages is stated in the time values that is avoiding the flooding of the query messages in the network, that can cause the problem of scalability for those servant which having limited bandwidth connection.

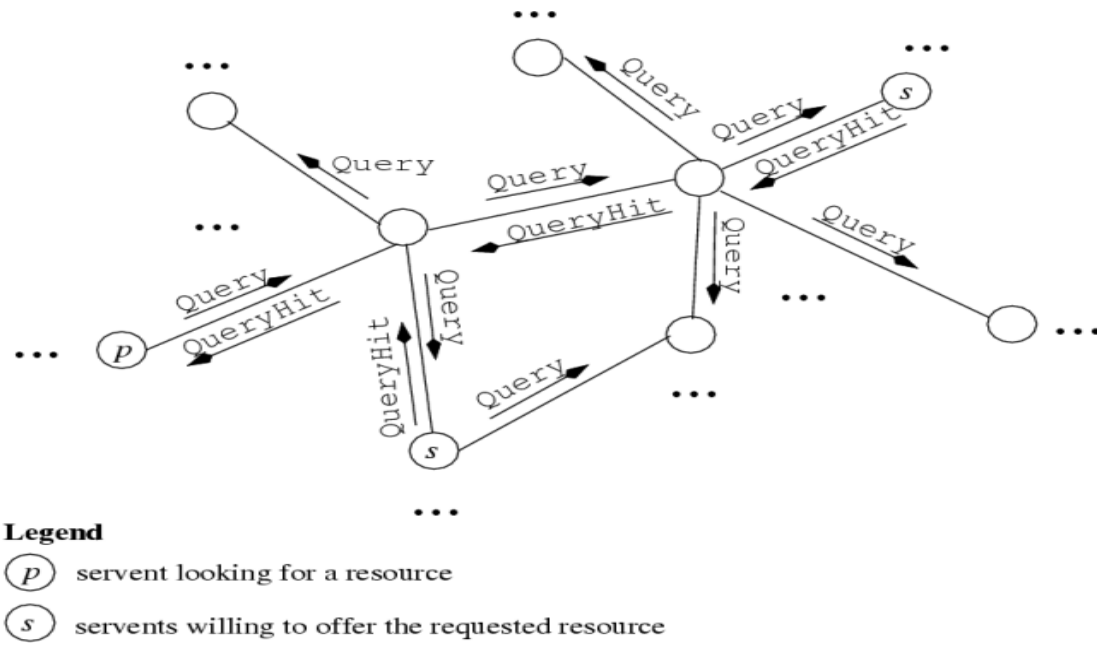


Figure 4.6: Sending and Receiving query message (Adopted from [28])

4.3.1.2. Query Routing

The idea of reducing amount of flooded query messages presented by Rohrs [31] by using routing queries depending on the search keywords. The virtual overlay network

which having query routing is the fundamental idea of routing the query that has the servants be able to exchange the query routing tables to their neighboring nodes. The metadata of the host content is stored in the query routing tables along with the IP address of that servant which sends the metadata. The incoming query messages are understood by the search keywords which are being compared by the local query table. Once the search keyword is matched with any entry in the routing table then the query will be forwarded to that direction which is available in the routing table, by not sending to all the neighbors it will avoid the flooding. If the search keyword is not matched in the routing table then the query will be sent to all the available neighbors up to the TTL value for the query message is alive after that the message will expire. For the minimization of the bandwidth utilization the propagation of the routing tables is done by the Bloom Filters. The hashing for the every keyword is used of the contents which will be in the shape of the image or bitmap [31]. The exchange of the whole IP address and reduction is done. For the small bitmap the incremental updates will be used. If the small changes are occurred it will be updated by the nodes. The main issue with the implementation of the query routing table is difficult to make them dynamic. The routing information of any file which is send by servant B can have propagation in the network even the B servant is not member of the network. The direction of the queries can be wrong, that will affect the data traffic and frustration in the users for the content which they are searching will not found by them. The solution of this issue can be by setting timer for the table entries. When the expiry is occurred for the entry that time it should be deleted from the table for the prevention from the wrong directions. The limited propagation of the every table is preventing routing table to propagate the entire network. The usage of the hop counter

will be helpful in this condition for the reduction of the spread of the routing table in the network.

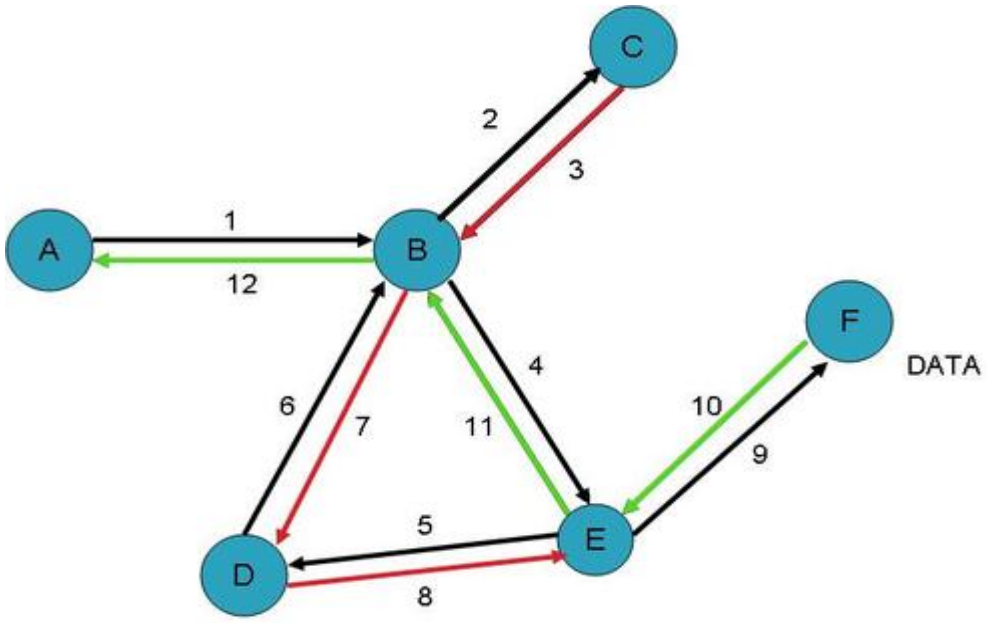


Figure 4.7: query flow (Adopted from [31])

4.3.1.3. Dynamic Hierarchical Routing

Considering scalability issues of the flat routing structures, another routing protocol for the peer to peer (P2P) network is introduced which combining the features of the distributed and non-distributed routing. This technique is using fast track [32] approach where the servants will be elected on the logon is known as Super Nodes for the bandwidth and energy consumptions. The list of already available Super Nodes is stored for the connection. The Super Nodes are establishing the network with the higher bandwidth transmission and high processing. The servant is not having enough abilities for logging in the network, it is depending on the one already member Super Node in nearby. The cluster is created based on the "normal" servants and Super Node that has high abilities for the network computation and bandwidth. The

connection with the Super Node will upload the information from the servant for the hosted data in the Super Node which will be “visible” for the whole network. A normal servant is having only connection which is to the Super Node that enables it to query the Super Node for the content in the cluster. On the receipt of the query the Super Node will search the database for the queried content after that the requested content will be in the cluster. The IP address of the normal servant is hosted for the requested content is sent back to the query servant. If not the Super Node is responsible to broadcast the query to the upper layer which is said to be Super Node layer in that the Super Node is having connection to other hops. Each Super Node is that is receiving query will search the database of its own if the query is successful then it will be sent to the IP address of source servant in the cluster for querying again to the Super Node. The response of the query to the servant will be sent by the Super Node. The bandwidth of the successful query is reducing able notably as this query is broadcasting in limited portion of the entire network.

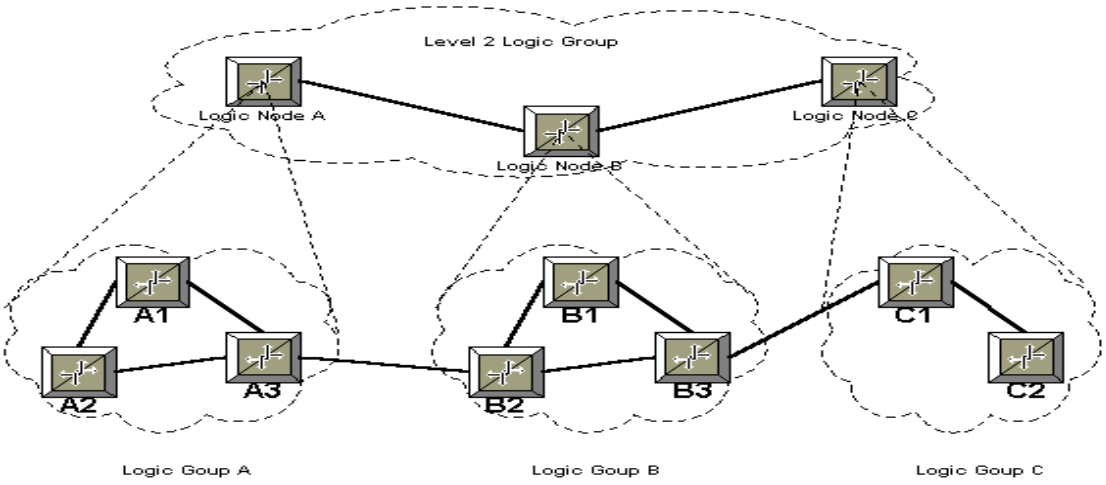


Figure 4.8: Typical Hierarchal Routing (Adopted from [32])

In the above elaboration was about routing algorithms in traditional Peer-to-Peer. Now we turn to Mobile Peer-to-Peer side to understand more and later discuss the comparative analysis.

4.3.2. Mobile P2P Routing Algorithms

4.3.2.1. Destination Sequenced Distance Vector Routing (DSDV)

This protocol is well known protocol and widely used in the branch of proactive routing [33]. It uses Classical Distributed Bellman Ford (DBF) routing technique [34]. This protocol provides facility to avoid the loops in the routing tables, as other routing protocols are also maintaining a routing table for the transmission between the nodes of the network. The routing table is having least number of hop and upcoming hop with the path of destination. Moreover, for every destination sequence numbers are included. Those sequence numbers are facilitating or making able a node to make a difference between the stale and latest paths. This enables to routing table to be updated immediately with the vast information like sequence numbers and eliminates loops of route. The path changes and updates is sent through two ways, first one full route update which is having information of the routing tables where the nodes are having transmission, the second way is incremental updates which is using less bandwidth. By the usage of incremental updates the last changes into the full update can be stored.

The address of the destination, required hops for reaching destination, information of the destination and sequence numbers of path, a unique sequence number for broadcasting are stored in the broadcasted path updates.

The holder of this routing updates will be able to update its own routing tables, if required can broadcast the available routing tables. The each node in the network is maintaining the information of the whole network. This provides a fast processing and setup of the path with the local information. The flooding of the route request is not

done in network like reactive routing protocols and algorithm in this for the discovery of the path from sender to receiver.

4.3.2.2. Dynamic Source Routing (DSR)

This routing protocol Dynamic Source Routing (DSR) is important protocol in the demand protocols [35, 36]. It uses source routing and having two important parts route maintenance and route discovery.

If mobility based nodes is trying to send any packet to any destination in the network that time the route discovery starts. At first the node is checking the cache of routing, the cache is having valid path for the destination and that path is used for the forwarding of the packet. The cache is not maintaining the path but it is broadcasting the path request to the other nodes which are neighboring and having information of the addresses and destinations. The unique sequence number is used to detect the loop. The receiver node will be checking the cache for the path of destination, if that is not having the path then it will add the address of the packet to it then it will forward it, the node is having various copies of the same path request from the neighboring nodes. It is forwarding the request then it will delete other copies of the request. The path reply is sent back if the node is having a real path for the destination and the request will approach to the destination, in case if the node is not transmission destination then the addition of path in the cache will replied as a path as a message. The path reply message is having all the path information for the sender and receiver in vice versa in both directions. The packet which is travelling in the whole network that contains full route addresses of the sender and receiver nodes. The in-between nodes which are not having cache of the route and they are saving storage. This

feature of the on demand is using least memory for the storage is also a limitation due to the size of the each packet will increase to contain the whole information of the full path. Moreover, the path error packets are fulfilling the task of maintenance of the path. If the destination or intermediary node is not available anymore the route error packets will be sent back to the source. The broken hop and other paths of which are depending on this hop are deleted by each node which is forwarding an error packet. The sender node will delete the stale path and any new path request.

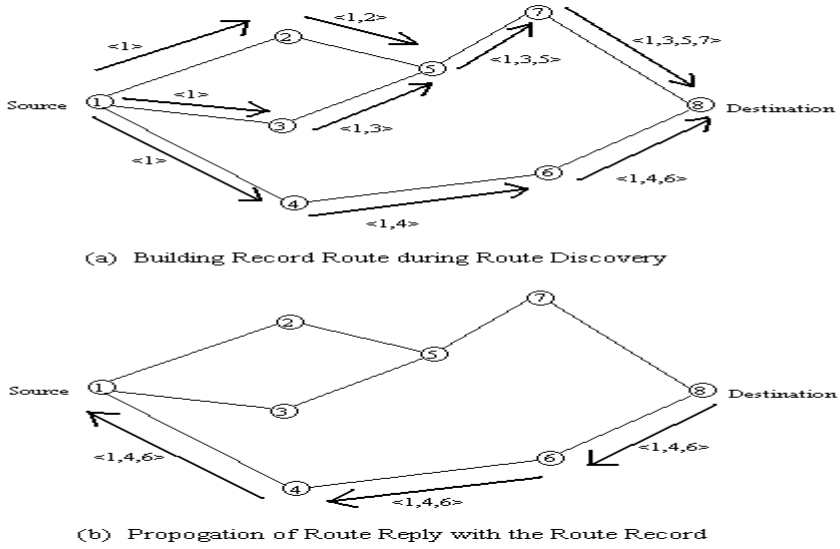


Figure 4.9: Creating a record rout in DSR (Adopted from [35])

4.3.2.3. Ad hoc On-Demand Distance Vector Routing (AODV)

The AODV protocol is demand driven routing protocol which not focusing on the source routing but it is focusing DSR [29, 37]. The information for the next hop is maintained by each hop for the path maintenance. The AODV is using route reply (RREP) and route request (RREQ), the path packet is used for the communication and the source is sending message to the destination. If the path information is not available in the routing cache then it will be broadcasting the route request to the other nodes. The route request is having destination, source address and a sequence

number. Every node which is having receipt of message of the routing request it is saving address of the node that from where the routing request was sent before forwarding message to the destination. The node is receiving various same routing request and then those copies are deleted. The routing request is forward to the all nodes till the route request is reached to the required destination. The destination node are responsible to establish the message of request reply that is send to the node from where the route request was received. The route reply is forwarded in reverse path to the route request source from where the route request was sent. Each node is storing information and address of the received routing reply. If the route reply is arrived back to the source then route is created after that the source is able to send the packets to the destination, instead of having exact route information of the destination. After the time out the information of the route request which was stored by the nodes will be deleted because the route reply is already received by the source. This technique is reducing the overhead for the packet for the full route is not needed the coding in the each packet. The additional memory is required in the nodes for the storage of the next hop for the transmission of the nodes. When the destination node informs the transmission to the downstream node then it will create a request reply packet with a number of next hop. The request reply is traversing upstream to the sender and keeping inform all the related nodes that node is moved or not. The all nodes are able to delete the available paths and establish new route request to the destination nodes.

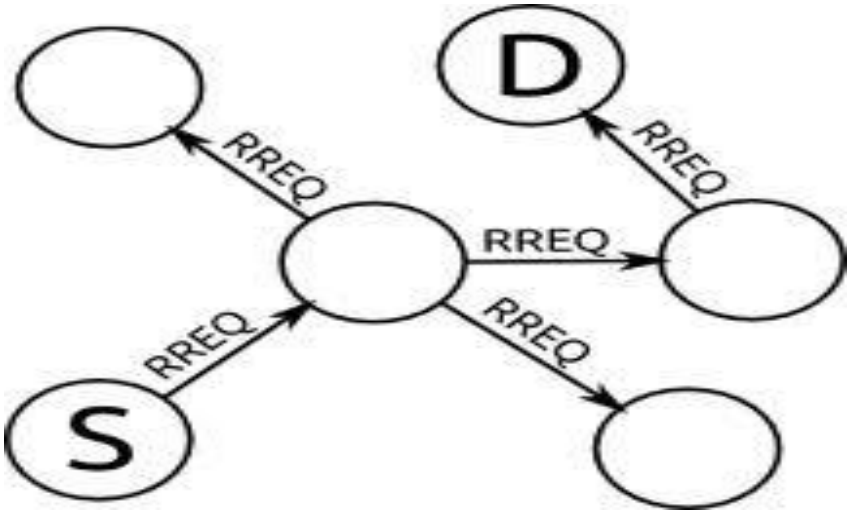


Figure 4.10: Broadcasted Route-Request (RREQ) packet (Adopted from [29])

4.3.2.4. Zone Routing Protocol (ZRP)

The ZRP protocol is also known as hybrid Ad-Hoc routing protocol which combination of the proactive and reactive rudiments is [38, 39]. The local zone routing information maintained by ZRP and creates paths on demand for destinations further than local neighborhood. The boundary of the local zone is defined by the maximum available hop number for the creation of the local zone. The usage of the zone routing protocol is providing maximum available hop counting of the zero for the local neighboring nodes creating a reacting routing protocol and usage of the maximum hop count by $\rightarrow \infty$ provides proactive routing protocol. The path for the receiver is in the local zone and created by the proactively caches tables at the sender node. The routing protocol that is using local zone is having routing table, the extension is provided with the time to live (TTL) information. The description of the maximum hop in the local zone is stored for the paths lying in the local zone and the discovery of the path is done reactively. The sender node will be sending request for the path to the bordering nodes which will have the addresses of their own and the address of the destination along with the sequence number. The border nodes are the maximum number of the hops for the defining the local zone that how far is from the

sender. The border nodes are checking the local zone for the receivers. If the required node is not lying the in the local zone then the local node will add the address to the packet of the request then it will send that packet to other bordering nodes. In case the destination is already member of the local zone of the sender then the route reply is forwarded back to the origin. The source node is having route stored in the route reply packet for sending packets of the data towards the destination. The reduction of the signaling messages in the process of path discovery is achieved by using copy detection technique for the detection and forwarding of the path packets. The important feature of the zone routing protocol is the reduction of the route request messages and the possibilities of the establishment of the new paths by not flooding the network with the messages. The copy deletion which is major feature of this protocol is not easy for the implementation because it is having various requirements for the processing like energy consumption in the mobile nodes.

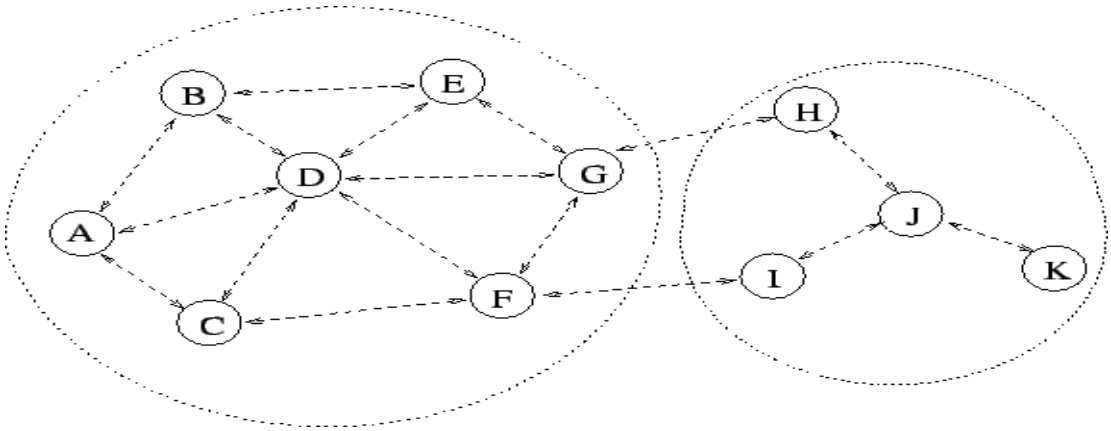


Figure 4.11: A ZRP scenario showing the zones of node A and node J (Adopted from [39])

4.4. Comparison Analysis of Node/Peer Discovery

The aspects of neighboring node/peer discovery in Mobile and Traditional Peer-to-Peer Networks reviewed in this chapter give as two clear differences that emerged from above revision which are:

1) In a Mobile Peer-to-Peer networking, there is a difference between neighboring and non-neighboring nodes which is remarkably missing in traditional Peer-to-Peer networking.
2) In Mobile Peer-to-Peer networking the neighboring node discovery rely on the use of broadcast frames, in which the traditional Peer-to-Peer networks is restricted to LAN applications. Traditional Peer-to-Peer networks cannot rely on broadcast frames which spans multiple subnets for node/peer discovery. For that reason Traditional Peer-to-Peer should utilize a steady peer or a server to offer initial connectivity.

Due to the relevance of OSI layers in mobile and Traditional Peer-to-Peer networks equally is the first divergence. At the Data-Link layer is performed by the neighboring node discovery aspect in Mobile Peer-to-Peer networks. At the network layer therefore, is performed by non-neighboring node discovery which basically part of routing. In Mobile Networking a difference between non-neighboring and neighboring nodes is necessary by the time cannot be discovered the non-neighboring nodes at data-link layer because of restrictions of radio range. There is no need to create this difference above the network layer by the time connectivity to all nodes is offered by network layer itself. Therefore, no need to create at the application layer Peer-to-Peer overlay networks with this divergence.

The transmission medium used stems out the second divergence. In nature an inherently broadcast medium make use of mobile Peer-to-Peer networks: Consequently the wireless medium. Generally the use of broadcast frames support by a Mobile Peer-to-Peer network's data-link layer protocol. On the other hand traditional Peer-to-Peer networks cannot assume use of this data-link layer protocol, in addition, since the traditional Peer-to-Peer networks may cover numerous protocols of underlying data-link layer. Secondly, since IP does not forward broadcast packets across IP routers, broadcast cannot be performed at the network layer. That's why Traditional Peer-to-Peer applications may not in use for broadcast.

The essential to the correct process of node/peer discovery in both network types are both of these divergences in our view. Therefore, it is beneficial this study on node/peer discovery in Mobile and Traditional Peer-to-Peer networks equally is different.

From the prospective of node discovery, to be self-organized one the Mobile Peer-to-Peer networks allowed by the use of broadcast frames. In another way, without relying on any stable node/peer predetermines others all nodes may discover each other. Although this self-organization property is also a desirable for Peer-to-Peer networks, for that reason given above clearly broadcast cannot be used. Therefore, the use of stable peer is justified. In contrast, by the time there is no fixed infrastructure in Mobile Peer-to-Peer Networks, the use of initial connectivity which stable node provides is not possible.

In conclusion, though requiring to perform node/peer discovery in Mobile and Traditional Peer-to-Peer networks is one of the shared similarities, then discovery methods used to do this have to be differ among the Mobile and Traditional Peer-to-Peer network types because of the support for broadcast messages in Mobile Peer-to-Peer Network not in Traditional Peer-to-Peer network and OSI layers at which node/peer discovery is performed in these two kind of networks.

4.5. Comparison Analysis of Routing Algorithms

The essential concept of both networks, the mobile and traditional Peer-to-Peer is self organized networks. In the majority, no central object which acts as intermediary who manages and coordinates the network and without any form of pre-configuration apart from hybrid Peer-to-Peer approach. The network is created, once the single participants decided to establish the network, by creating connections to each other. Therefore, though the nodes/Peers keep on the same, the network changes permanently, since the nodes/peers most likely to alter their connections between them.

By default there are no hierarchies given in both networks. With the assistance of protocols the hierarchies are only being able to introduce virtually. With initiating a better achieving scalability, virtual layers can be added to cluster heads in wireless ad hoc networks or Super Nodes in Peer-to-Peer network for instance. On the other hand, the problem of the hierarchies is that frequently changing network topology, since the information of the network must permanently be collected in routers of the higher layers. To keep this information up to the date might be not easy rather than in a flat architecture.

A further critical issue which arises from the self organization is that flooding which is necessary to a certain extent in both networks. As both networks are based on a continuously changing topology, the network must be periodically probed, whether certain links and nodes are still available. This is only possible via broadcasting or flooding messages, as a central management entity is not available. Thus the question of up to what number of participants the network is able to scale, is of high interest in the wireless as well as in the Peer-to-Peer area.

Beside the similarities, there are some differences between mobile and traditional peer-to-peer networks for using the routing algorithms. Quite a few journal articles [40, 41] demonstrate that the proactive mobile routing system works only in a small size mobile Ad Hoc, among nodes not more than a hundred. Instead of data traffic frequently too many updated messages must be sent if the numbers of nodes is large, so the network is concerned mostly with signaling. Alongside the problem of scaling, proactive routing algorithm are feasible in mobile networks, whereas it is not working at all in traditional Peer-to-Peer network, which is too high for large Peer-to-Peer networks Because of the usage of a Bellman-Ford [13] routing algorithm that leads to generate a load. Using a proactive routing algorithm in a P2P network, would mean, to transmit lists of subjects of all peers to all other peers, which would certainly fail. Even the transmission of all addresses of the members of a network is not possible, due to the numerous changes in the availability of single nodes and the great size of such a network.

As described, Peer-to-Peer routing algorithms can be executed only during search query which then can be declared as pure reactive routing algorithms. The execution

of reactive routing algorithms differs in both networks, despite their similarity in usage. By the time an intermediary node/peer knows the actual route to destination or the destination is found, the request is not forwarded anymore and ends the search in the mobile peer-to-peer network. On the other hand, in the Peer-to-Peer network the query request will not stop, thou the searched file hosted by that servant. The servant still forwards the query request and stops only when the query is utmost number of jumps far away from the source or the time-to-live (TTL) field become zero.

Another difference between the Peer-to-Peer routing architecture and a reactive mobile Peer-to-Peer algorithm exist. The major complexity for creating a new connection is to collect data for the first hop in Peer-to-Peer networks, since there is no possibility to receive information in the Peer-to-Peer overlay network about the structure of the underlying IP network. While in a mobile Peer-to-Peer network can be easily possible to find the nodes from the first hop where the adjacent nodes are within transmission range.

The underling network infrastructure of traditional and mobile Peer-to-Peer networks differs in terms of the reliability of the physical channels. In a traditional Peer-to-Peer network the reliability of the wired links is very high. The probability of an error is tremendously low during packet transmission; in contrast the probability of packet lost due to overflow in intermediary router is very higher. The traditional Peer-to-Peer network layer doesn’t detect any packet failures Because of Peer-to-Peer overlay network are based on the reliable terminal control protocol (TCP).

Causing numerous bit errors, subject of unpredictable changes are the properties of wireless links. Consequently, the bit error rate of a wired link is less than the bit error

rate of a wireless link which is magnitudes. A comprehensive MAC-layer next to a trustworthy transmission protocol like TCP and an appropriate forward error correction (FEC) needed by the transmissions over a wireless link. Therefore the transmission efforts of data are higher than in Peer-to-Peer networks.

For this reason, due to the high reliability of wired links the creation of a new route over multiple hops is easier in a Peer-to-Peer network compared to wireless links.
There are several routing algorithms to improve mobile Peer-to-Peer network's reliability. For only one connection the majority of them build numerous backup routes. The source node is capable of replace another route immediately, if the first connection breaks without establishing a new route. But, maintaining and creating more than one routes is huge in overhead processing, and without ensuring the benefit, for the reason that extra routes will break a lot frequently.

On the other hand, there are no routing algorithms exist in Peer-to-Peer network architectures up to now to improve the network reliability. Because of the node's reliability it is remarkable to be as low as the peer/node in the mobile Peer-to-Peer network. Therefore one of these might be the reason; firstly the reliability of essential physical transmission of the data is still high. Secondly the availability of distributed data is the essential thought of Peer-to-Peer network, thus if there is one node disconnected from the network still there should be sufficient nodes whose can share the searched information. For that reason, actually, in Peer-to-Peer network there is no instant require for improving routing algorithms reliability.

Both networks have also another difference for execution behavior of a broadcast. A unicast network can be defined by a Peer-to-Peer network. For each outgoing connection will have one message that can be generate only virtual broadcast which may consist of a several unicast messages. In contrast to that, a mobile Peer-to-Peer network performs always the physical broadcast. A node sends broadcast message to every neighbor in the transmission range. In contrast to that, the physical broadcast is the logical unicast message, and the receiver has to be decided with the help of the logical address in the message. Therefore, all nodes receiving a message sent out from another node as single cast unintentionally must be discarded. Below tables 4.1 and 4.2 are summarized the differences and similarities in node/peer discovery and routing algorithms respectively.

Table 4.1. Differences

Traditional Peer-to-Peer	**Differences**	**Mobile Peer-to-Peer**
Performed at Application layer in the OSI layers	***Node/Peer Discovery***	Performed at Data-Link layer in the OSI layers
Stops when TTL field is 0	***Routing***	Stops when destination is found
Not possible	***Proactive routing algorithm***	With limitations to the network size possible
Possible	***Reactive routing algorithm***	Possible
Not required, not implemented	***Reliable routing algorithms***	Exist
Virtual broadcast, realized with multiple unicast	***Broadcast***	Physical broadcast performed

Table 4.2. Similarities

Traditional Peer-to-Peer	Similarities	Mobile Peer-to-Peer
principle Virtual broadcast, flooding	***Basic routing***	Physical broadcast, flooding
Flat and frequently changing topology, caused by frequent log-on and log-offs	***Network topology***	Flat and frequently changing network topology, caused by log-on and log offs and additional terminal mobility of the nodes
Hop by hop, via TCP links, whereas the single hop path length is not physically limited	***Connection establishment***	Hop by hop via radio links, which are thus limited by the radio transmission range
Limited by bandwidth consuming signaling traffic (flooding) and additional high user data rates	***Scalability***	Limited by bandwidth consuming signaling traffic (flooding) and additional physical constraints
Low	***Reliability of nodes***	Low

4.6. SUMMARY

In this chapter we have collected the data related to node/peer discovery approach and routing algorithms in mobile and traditional peer-to-peer networks. First, we provide detailed explanations about how peers discover other peers in traditional peer-to-peer networks which is carried out in applications layer. We divided the peer discover approach in the traditional peer-to-peer networks into two categories which are atomistic Peer-to-peer network and UCP2P networks and explained each. Second, we presented node discovery approach in mobile peer-to-peer networks and how it works.

The neighboring nodes discovery approach in the Mobile Peer-to-Peer networks is residing in the data link layer. Therefore, the techniques of the IEEE 802.11 and Bluetooth are discussed and how they operate in the neighboring node discovery mechanism in mobile peer-to-peer networks.

On the other hand, we explored the various routing protocols and algorithms for traditional and mobile peer-to-peer networks. We divided the routing algorithms of traditional peer-to-peer networks into three categories as we explained each and every one of them how it operates. Second, we presented the routing algorithms in mobile peer-to-peer networks in which we categorized into two classifications, one is proactive which are making routing table and second is reactive which is on demand routing protocols. A node in the proactive routing protocols is having access to all over the network at any time, similar to a normal router for the internet. But the proactive routing protocols has a limitations which is having various topology configurations in a small amount of time, because of that threshold will be increased and it's not widely used.

Lastly, in this chapter we have discussed and compared the aspects of neighboring node/peer discovery in Mobile and Traditional Peer-to-Peer Networks. After thoroughly reviewing and presenting a comparative analysis it give as two clear differences that emerged from the comparison and analysis, though requiring to perform node/peer discovery in Mobile and Traditional Peer-to-Peer networks is one of the shared similarities, then discovery methods used to do this have to be differ which are; firstly, for the Mobile Peer-to-Peer networking, there is a difference between neighboring and non-neighboring nodes which is remarkably missing in

traditional Peer-to-Peer networking. Secondly, In Mobile Peer-to-Peer networking the neighboring node discovery relies on the use of broadcast frames, in which the traditional Peer-to-Peer networks is restricted to LAN applications. Traditional Peer-to-Peer networks cannot rely on broadcast frames which spans multiple subnets for node/peer discovery. For that reason Traditional Peer-to-Peer should utilize a steady peer or a server to offer initial connectivity. Due to the relevance of OSI layers in mobile and Traditional Peer-to-Peer networks equally are the first divergence and the transmission medium used stems out the second divergence.

On the other hand, we have presented a comparative analysis of the routing algorithms in both networks. Despite the concept of self organized networks which mean no central entity acts as intermediary who manages, coordinates the network and without any form of pre-configuration and no hierarchies which can only be able to introduce virtually with the help of protocols there are some differences between both networks for using the routing algorithms. The proactive mobile routing system works only in a small size mobile Ad Hoc, among nodes not more than a hundred. Alongside the problem of scaling, proactive routing algorithm are feasible in mobile networks, whereas it is not working at all in traditional Peer-to-Peer network which at the end leads to generate a load. The execution of reactive routing algorithms differs in both networks, despite their similarity in usage. By the time an intermediary node/peer knows the actual route to destination or the destination is found, the request is not forwarded anymore and ends the search in the mobile peer-to-peer network. On the other hand, in the Peer-to-Peer network the query request will not stop, thou the searched file hosted by that servant.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.0. INTRODUCTION

In this chapter, the aspects of node/peer discovery approach and the routing algorithms in Mobile and Traditional Peer-to-Peer Networks were compared, analyzed, and the differences and similarities between both networks were identified in every comparative analysis made in each aspect. Below we summarized the key aspects of the comparative analysis, followed by limitation of the study, and recommendations for future work.

5.1. CONCLUSION

In this chapter we have discussed and compared the aspects of neighboring node/peer discovery in Mobile and Traditional Peer-to-Peer Networks. After thoroughly reviewing and presenting a comparative analysis it give as two clear differences that emerged from the comparison and analysis, though requiring to perform node/peer discovery in Mobile and Traditional Peer-to-Peer networks is one of the shared similarities, then discovery methods used to do this have to be differ which are; firstly, for the Mobile Peer-to-Peer networking, there is a difference between neighboring and non-neighboring nodes which is remarkably missing in traditional Peer-to-Peer networking. Secondly, In Mobile Peer-to-Peer networking the neighboring node discovery relies on the use of broadcast frames, in which the traditional Peer-to-Peer networks is restricted to LAN applications. Traditional Peer-to-Peer networks cannot rely on broadcast frames which spans multiple subnets for

node/peer discovery. For that reason Traditional Peer-to-Peer should utilize a steady peer or a server to offer initial connectivity. Due to the relevance of OSI layers in mobile and Traditional Peer-to-Peer networks equally are the first divergence and the transmission medium used stems out the second divergence.

On the other hand, we have presented a comparative analysis of the routing algorithms in both networks. Despite the concept of self organized networks which mean no central entity acts as intermediary who manages, coordinates the network and without any form of pre-configuration and no hierarchies which can only be able to introduce virtually with the help of protocols there are some differences between both networks for using the routing algorithms. The proactive mobile routing system works only in a small size mobile peer-to-peer, among nodes not more than a hundred. Alongside the problem of scaling, proactive routing algorithm are feasible in mobile networks, whereas it is not working at all in traditional Peer-to-Peer network which at the end leads to generate a load. The execution of reactive routing algorithms differs in both networks, despite their similarity in usage. By the time an intermediary node/peer knows the actual route to destination or the destination is found, the request is not forwarded anymore and ends the search in the mobile peer-to-peer network. On the other hand, in the Peer-to-Peer network the query request will not stop, thou the searched file hosted by that servant.

Another difference is there as we mentioned between the Peer-to-Peer routing architecture and a reactive mobile Peer-to-Peer algorithm. The major difficulty in Peer-to-Peer networks is the need to collect data for the first hop for creating a new connection. While in a mobile Peer-to-Peer network can be easily possible to find the

nodes from the first hop where the adjacent nodes are within transmission range. Also both traditional and mobile Peer-to-Peer networks differ in terms of the reliability of the physical channels. In a traditional Peer-to-Peer network the reliability of the wired links is very high. In contrast the probability of packet lost due to overflow in intermediary router is very higher. Causing numerous bit errors, subject of unpredictable changes are the properties of wireless links. Consequently, the bit error rate of a wired link is less than the bit error rate of a wireless link which is magnitudes. Another thing is in mobile Peer-to-Peer network's reliability, for only one connection the majority of routing algorithms build numerous backup routes which is huge in overhead processing and it is because of the source node is capable to replace another route immediately.

On the other hand, there are no routing algorithms need to improve the network reliability in Peer-to-Peer network architectures. Because of the node's reliability it is remarkable to be as low as the peer/node in the mobile Peer-to-Peer network. There is no instant require for improving routing algorithms reliability in Peer-to-Peer network.

At the end, we have discussed that both networks have also another difference for execution behavior of a broadcast. A unicast network can be defined by a Peer-to-Peer network. One message that can be generate only virtual broadcast which may consist of a several unicast messages. While in a mobile Peer-to-Peer network performs always the physical broadcast. A node sends broadcast message to every neighbor in the transmission range and the physical broadcast is the logical unicast message in mobile Peer-to-Peer network.

5.2. LIMITATIONS

The results of this study clearly indicated that there were some similarities and differences between traditional and mobile peer-to-peer networks in line with routine algorithms and node discovery approach. Meanwhile, this study is based on theoretical approach analysis, due to the time constraint experimental aspect of the study was not conducted that will provide absolute support to the theoretical finding. At the same time, the study focused mainly on wireless technologies associated with WLAN technologies such as IEEE 802.11 and Bluetooth, while other aspect like 3G (HSDPA) and 3.5G (LTE/WiMAX) were not included in the analysis due to the time factor as the study was given short period of time.

5.3. RECOMMENDATIONS FOR FUTURE WORK

This study is based on traditional and mobile Peer-to-Peer network in terms of node/peer discovery approach and routing algorithms, therefore this research should be repeated using another technique such an experiment whether the same conclusion would be experienced and the convergence between research on mobile and traditional peer-to-peer networks are considered beneficial. Another research should be on routing in mobile peer-to-peer network with the content discovery approach of traditional peer-to-peer network. The reason behind this work can be a comparative analysis and modernize all the research approved for the specified aspects in the two respective fields, providing a common foundation intentionally over the research in both networks could be converged. Moreover, these works could include a comparative analysis of the design degree of any required adjustments in addition to which techniques can be applied.

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