"A Comprehensive Simulation Based Study of Single and Multichannel MAC Protocol for MANETs"

By

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1- Protocols; interfacing

2- Computer network protocols

Preface

This thesis is submitted in the partial satisfaction of degree requirement, Master of Science in Computer Science at Department of Computer Science & Software Engineering at International Islamic University Islamabad.

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Final Approval

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DEDICATION

To my family, my friends and my teachers.

Thanks for understanding the stressful moments I had, for the prayers and support to overcome them and for all the joy you have brought to me.

ACADEMIC THESIS: DECLARATION OF AUTHORSHIP

I, M.ASIF declare that this thesis and work presented in it are my own work and have been generated by me as a result of my own original research.

"A Comprehensive Simulation Based Study of Single and Multichannel MAC Protocol for MANETs"

I confirm that:

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2. Wherever any part of this thesis has previously been submitted for a degree or any other qualification at this Department or any other, it has been clearly stated;
3. I have acknowledge all main sources of help;
4. Where the work thesis is based on work done by myself jointly with others, I have made clear what was done by other and what I have contributed myself;
5. None of this work has been published before submission.
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I would like to thanks my supervisor **Mr. Qaisar Javaid** Assistant Professor and Co-Supervisor **Mr. Shehzad Ashraf Chaudhry** Lecturer for his support and guidance through out of my study at International Islamic University Islamabad. I would also like to Special thanks of my friend **Israr Ullah** who help me during my hard times when I need his support during thesis study and simulation.

I would also like to thanks my parents, my brothers, who had always given me the courage, best wishes and support during my career.

Muhammad Asif

Project in Brief

Project Title:	**"A Comprehensive Simulation Based Study of Single and Multichannel MAC Protocol for MANETs"**
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Starting Date:	April 2010
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Tool Used:	Network Simulator 2.33 C++ MS Office
Operating System:	Linux Fedora 6
System Used:	Pentium IV (2.4 GHz, RAM 3 GB, HD 250 GB)

Abbreviations

MANET	Mobile Ad Hoc network
PRNET	Packet Radio Network
DOD	Department of Defense
SURAN	survivable Adaptive Radio Networks
VANET	Vehicular Ad Hoc Networks
InVANETs	Intelligent vehicular ad hoc networks
iMANET	Internet Based Mobile Ad-hoc Networks
PAN	Personal area network
LAN	Local area network
MAN	Metropolitan area network
WAN	Wide area network
WLAN	Wireless Local Area Network
MAC	Media Access Control
QoS	Quality of Services
RTS	Request to Send
CTS	Clear to Send
MACA	Media Access Control Avoidance
CSMA	Carrier Sense Multiple Access
MACAW	Media Access Control Avoidance Wireless
BEB	Back off Exponential Binary
DS	Data sending
FAMA	Floor acquisition Multiple Access Protocols
BTMA	Busy Tone Multiple Access
DBTMA	Dual Busy Tone Multiple Access
RI-BTMA	Receiver Initiated Busy Tone Multiple Access
MACA-BI	Media Access Control Avoidance By Invitation
MARCH	Media Access with Reduced Handshake
D-PRMA	Distributed Packet Reservation Multiple Access Protocol
CATA	Collision Avoidance Time Allocation Protocol

HRMA	Hope Reservation Multiple Access Protocol
HR	Hope Reservation
SRMA/PA	Soft Reservation Multiple Access Priority Assignment
SR	Soft Reservation
RC	Reservation Confirm
FPRP	Five-Phase Reservation Protocol
CBR	Constant bit Rate
TCP	Transfer Control Protocol

Abstract

Mobile Ad-hoc Networks (MANETs) are unique kind of wireless networks with no centralized control. They are ideal candidate for several real world applications where network need to be established on the fly e.g. disaster hit areas, hospitals, military surveillance etc. Researchers have been actively working in this area for a decade or so to make this thought a reality. MANETs differ from conventional fixed networks and therefore pose several challenges to the researchers working in the area. For instance, topology is dynamic as nodes are free to move with a given geographical region. Nodes are equipped with a limited power battery and therefore energy efficient network operation is another challenge that needs to be addressed. Environmental conditions and wireless nature of these networks also complicate the situation.

Among many others right to use to the shared media is the chief problem in MANETs. Access to the shared media is critical issue in MANETs In such networks MAC layer protocol acting a significant role in efficient utilization of shared media in distributed approach. At the MAC layer we have three contradicting requirements, Maximize channel utilization, Minimize Control overhead and Fairness. Multi-Channel MAC protocols is considered as the most suitable solution to achieve the desired objectives but channel assignment and reservation in a distributed fashion is still a major issue. Hence the focus of this thesis is how to assign the channel. We have proposed a Multi-Channel scheme to address the problem of channel assignment. The proposed scheme assign the channel on Node ID based. The proposed Scheme has been compared with conventional single channel scheme using ns-2 simulation and results shows that the proposed technique gives better performance.

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Chapter 1

Introduction

Introduction

1.1 History

Though not very common, Ad hoc networks have become a subject of hot debate and research these days. The MANET architecture in particular has become the center of interest of many. In 1970 the US Department of defense, also called DOD, proposed the packet radio network project which is based on the idea of Ad hoc networks. This Project accesses the channel by using medium access protocols called CSMA and ALOHA [17] [13].

Some modifications were made in the Ad hoc networks during 2nd generation i.e. 1980 which was implemented as part of the SURAN, short for Survivable Adaptive Radio Networks.

The 2nd generation provided packet switched network to the mobile for communication without infrastructure. Routing protocols that were used in SURAN were highly scalable.

In the 1990s, these new concept of building networks got great attention from researchers.

The concept of marketable ad hoc networks emerged when laptops having powerful wireless cards came to the market; this caused the need for ad hoc networks more sensible and demanding. People used this network in many organizations because of easy installation in many different many application areas. The name Ad hoc network was suggested by IEEE 802.11. Later on, many real world applications of these networks were devised.

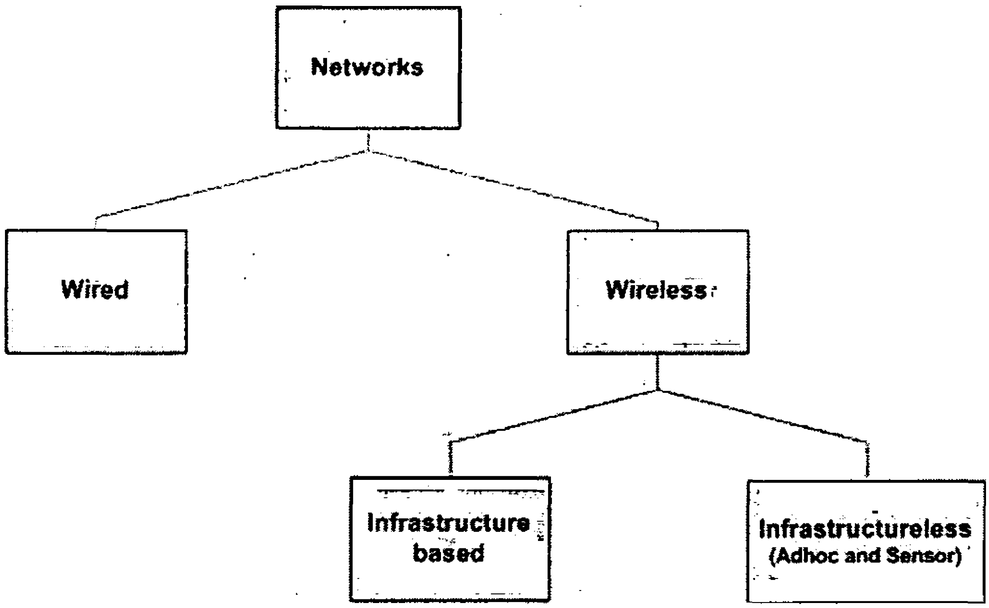

Figure 1.1: Simple classification of network on the basis of connectivity and infrastructure.

1.2 Network classification

A network is a collection of different electronic devices, linked in one way or another, to share information and resources while common example of the resources are CDs, printer and exchanged files. There are two common types of networks [1].

1) Wired Network

2) Wireless Networks.

1.2.1 Wired networks

In the wired networks, cables and wires are used for the connectivity. The CAT5 and CAT6 types of cables are used. For efficient and high connectivity switches and hub are used Wired networks is considered as more suitable as compared to wireless network because of its high speed efficiency and protection .However wired networks are costly than wireless networks. Wired networks offer a speed of 100Mbps to 1000Mbps [22].

1.2.2 Wireless networks

In spite of wired network, wireless network did not use physical media to send and receive information; however it used radio waves and air to send out information from one location to another location. Wireless' setting is easier and quicker than the wired. The networks can easily be complete. Wireless networks are more elastic than the wired. The arrangement of wireless networks is easier to change as compared to the fixed wired ones. The main disadvantage in the wireless is the interfering: throughput can be affected due to common media [22].

There are two subtypes of wireless networks such as infrastructure based and infrastrucureless. The structure is presented in Fig1.

One common example of wireless network is MANETs, short for Mobile Ad hoc Networks, in which nodes are mobile and the mobile nodes move from one station to another station, and it have no centralized infrastructure. It may also be called as decentralized Networks [1].MANETs discussed in section 1.3 with detail.

A cellular network is another type of wireless radio networks. It is separated into different cells where a cell in the network is spread. Each cell is served by a fixed-location transceiver called a cell site.

Wireless networks can further be divided into many different ways, for example on the basis of coverage area they are categorized as LANs, MANs, WANs, and PANs [Wikipedia]. Similarly on the basis of topology, there are Bus, Star, Mesh and Ring Networks.

Table 1.1: Comparison of Cellular networks and Ad hoc wireless

Cellular Networks	**Ad hoc networks**
Fixed infrastructure based	While Ad hoc based on less Infrastructure
Single Hope Wireless links	Based on Multi-hope communication
Guaranteed bandwidth	Shared radio channel
Centralized Routing	Distributed Routing
Circuit-switched	Packet-switched
Seamless connectivity	Frequent paths breaks
High cost and time deployment	fast and easy deployment
Reuse of frequency spectrum	Shared frequency (channel) reuse
Synchronization performed easy	Synchronization is difficult

Bandwidth reservation is easy	Bandwidth reservation is difficult
Network maintenance require high cost	Self organization and maintenance
Mobile nodes are of relatively low complexity	Mobile nodes require more intelligence

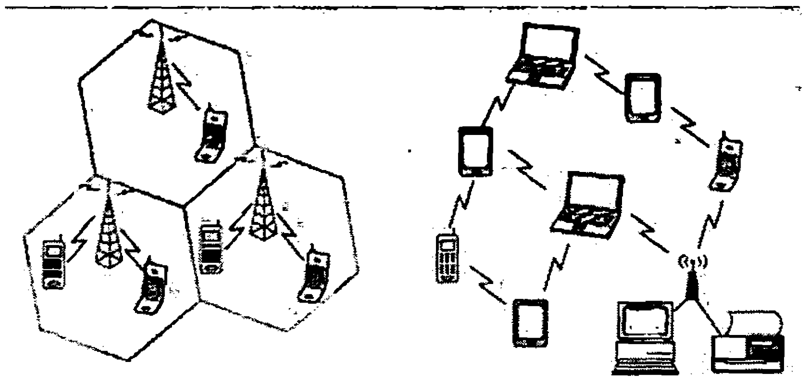

Figure 1.2: Cellular Networks versus mobile ad hoc networks [22].

1.3 MANETS called (Mobile Ad hoc Networks)

Though not very common, Ad hoc networks have become a subject of hot debate and research these days. In this section we discuss few important qualities of ad hoc networks. All the nodes are peers. It has no centralized management. Every nodes serves as sources/target as well as a router for packet delivery. The common devices like laptop computers and personnel digital assistants (PDA) used as nodes in ad hoc networks that communicate directly with each other [1].

To explain the communication of ad hoc network among three nodes as shown in Figure 4. The mode node performs the function of router and forwards packet to outmost node. Outmost nodes are not in direct range [19]

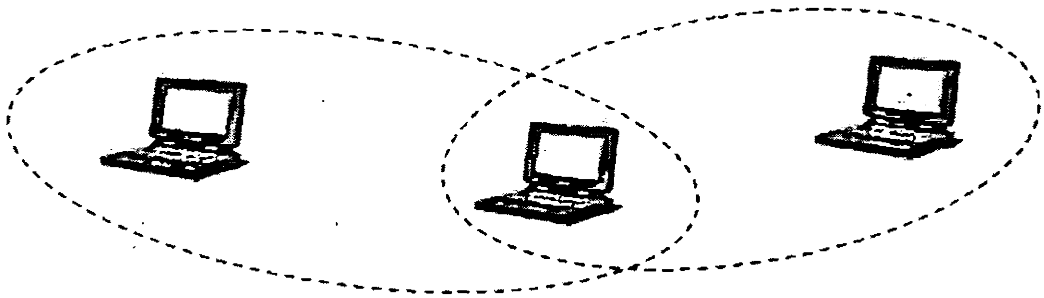

Figure 1.3: Example of ad hoc networks communication among three nodes [19].

1.3.1 Characteristics [3].

Properties of Ad hoc network are described as under:

- Work without central manager.
- Multiple hops in-between the communicating nodes
- Link breakages due to the in-between node mobility
- Compromise on resources like bandwidth, computing power, battery lifetime, etc.
- Easy and immediate deployment

1.3.2 Applications [3].

- Military applications
- Collaborative computing
- Emergency rescue
- Wireless mesh networks
- Multi-hop cellular networks
- Wireless sensor networks

Table 1.2: Example of MANET applications [1].

Application	**Possible services**
Clever networks	• Military operations • Automated scenarios
Emergency situations	• Search and rescue operation • Disaster recovery • Now e days used in hospital
Sensor networks	• Body area networks (BAN) • Data tracking of environmental conditions, animal • movements, chemical/biological detection

Ad hoc networks are little in cost, have easy service, and forceful nature, but at the same a lot of several challenges to be faced on the way, which do not allow theses networks to be common and popular some of the major challenges and issues are given [3]:

1. Hidden terminal trouble
2. Exposed terminal trouble
3. Channel good organization
4. Access delay and fairness
5. Differential service
6. Realistic mobility modeling
7. power-aware routing
8. Protection

1.4 MANETs Research Areas

Now a day's MANET have become very well-liked. There is a hot research area going on MANETs. MANETs have a lot of advantages but there are some areas which need to be worked out to make useable in commonly. Researchers are working in many different areas of MANETs, few of which are listed below:

- MAC
- Routing
- Resources Management
- Security
- Power Control
- Battery life time
- Disconnected operations etc.

Most of them now open problems for researchers.

1.5 About this Work

This work builds a solid foundation for the basic who are interested to work on MAC protocols in MANETs. In Chapter 2, different challenges have been discussed in detail. In Chapter 3 presents a brief overview of chosen protocols in literature survey. Protocols are selected from different categories so that the reader can have an idea of different possible approaches that have been working by different authors. After this reader will be able to have idea of there working and can examine and compare them to choose one best for a particular scenario. The problem definition and proposed solution discuss in Chapter 4. In Chapter 5, I talk about the various simulators. In Chapter 6 and 7 we discuss various parameters for the whole simulation and the Experiments and Results of a channel assignment technique. In Chapter 8 discus a concluding summary of this report and also the future work is discussed.

Chapter 2

MANETs Major Challenges and Future

MANETs Major Challenges and Future

It was observed that wireless network gets more popularity as compare to wired network especially wireless Ad hoc network gets more attention because of its high usage in the field of mobile communication and research. Although ad hoc network have a lot of advantages but still there exit a lot of issue in this required a careful attention. The major open issues are listed as [3] [20]:

1. Quality of service
2. Energy efficiency
3. Security
4. Mobility
5. Limited Bandwidth
6. Count to infinity problem
7. Routing Loops Problem
8. Self organization

2.1.1 Scalability.

The performance of the network is affected when a large number of nodes are participates. [3] [20]. To maintain constant performance in ad hoc network is challenging task when a large number of nodes participate in the network. Mobile Ad hoc Wireless networks (MANETs) MAC protocols requires to take some actions to create notable overhead, which grows fast with increase the amount of nodes in the network. If nodes are exchanging more control traffic than data transmission then Ad hoc network is only an idea. Table-driven protocols are rejected due consuming more bandwidth in such large networks. The latency of path finding involved with On-demand routing protocols in large Wireless Ad hoc networking may be unacceptable high. We can get a appropriate level of scalability by dividing the network in to hierarchical topology based system. The hierarchy could be based on the hop distance or geographical information's. This includes the protocols like ZRP and ZHLS etc.

2.1.2 Quality of services

The performance level of services provided by the network is called QoS (Quality of services) [3] [20]. The QoS can be in term of bandwidth, jitter, delay, packet loss. This type of guaranteed services is not easy in the wired network and now also more challenging task in the Ad hoc Wireless network.

There are few protocols which return the routes that can provide the required level of the guaranteed services. As in ad hoc wireless network a node is free to moves anywhere in the network thus they can provide quality of service for nodes whose route are static in the network. When a node changes his position in the network then the Quality of service is not same as before and results in re-establishment for efficient route. An ICMP message is used for such type of problems like "QoS lost". When node changes its place in the network then this node originates a message to sender node. Upon receiving a message the sender node looks for an alternate route.

As a single radio-media is shared among all the nodes in the Ad hoc Wireless network and QoS in this network can be on per node basis. Thus the flow is used by all the nodes and does not permit a flow to maintain a QoS level.

It is the duty of network traffic engineering to provide QoS is in wired network. In network engineering the traffic is divided into different types and each type is assigned its own priority. Two main techniques used by the traffic engineering are integrated services and differential services in provision of QoS. The integrated service depends on the bandwidth reservation and provides guaranteed bandwidth to flow. The differential services provides hard guarantee to services.

A technique depends on cross-layer architecture is used to solve the problem of the QoS at all layers. In cross-layer architecture, different information's are collected from different layers to improve the QoS operations.

2.1.3 Security

Security [3, 20] is one of the basic issues in networking. As these networks are without any central coordinator, so security is more critical in such type of networks especially in the military applications. Due to the absence of central coordinator and shared wireless medium, these networks are insure and open to different types of attacks than wired networks. The attacks such as Denial of service (DoS), information's disclosure and host impersonation attacks may be possible.

In wired network the security solution focuses on the secure transmission of data. In wired networks data is encrypted first so that unauthorized users cannot understand it. But in MANETs the focuses should be on how to trust on node and to determine the malicious and original nodes in the network. The malicious node falsely advertised some routes to the destination node in the network. Such types of malicious node are avoided to join the network. If the malicious node once enter the network then it is not easy to exclude it from the network. Thus a malicious node in the network can provides false routes information's to all others nodes especially the source node and hence create different types of attacks in the network.

One important solution to these problems is self-organized public key method to achieve security in MANETs. But this method is not scalable. The other solution to these problems is to divide the data into small pieces and send them towards the destination along different routes. When these pieces are received by the intended destination, they are reassembled in to its original form. In this case damage caused by malicious node is avoided.

2.1.4 Mobility

In mobile ad hoc network (MANETs) the nodes are dynamic and can move in any direction. [3][20]. The mobility of nodes based on the types of applications. For every application, nodes follow different types of movement pattern which is called mobility model. Protocol performs differently in different mobility models. The mobility of nodes result in path breaks which needs maintenance through route re-establishment process. This causes load on the wireless channels and delay in transmission of data in the network. So MANETs routing protocols should be able to solve all these problems.

2.1.5 Energy efficiency

The energy efficiency is the procedure of managing the sources and power consumed in a node and in the network to make the network lifetime long. In the mobile ad hoc network the node not only forward its own data but they also route packets on behalf of other nodes. Most powerful batteries provide long duration is specifically designed for such type of nodes.

In MANETs we means how to decrease the power consumption by radio transceiver which actually a largest consumer. To manage the power in well way and for energy efficient solutions at both the network and node level we need Energy aware routing protocols try its best to divide the packet routing among all the nodes in the network. It avoids using single node as a router for all the other nodes in the network because the node will run out of battery. Thus the energy aware routing tries to increase the overall network life.

2.1.6 Limited Bandwidth

Nodes in the MANETs are connected to one another through wireless media and have a very limited bandwidth [3] [20]. Due to the shared medium and broadcasts nature, only few nodes are permitted to communicate at one time means only fraction of available bandwidth is available for every node. There are more chance of collision due to the hidden nodes and then can be resolved by the control signal called RTS and CTS. Wireless medium is insecure and frequently create troubles such as interference and multipath fading. These problems cause packet losses. Thus MANETs routing protocols should not effected by such types of problems.

2.1.7 Count to infinity problem

Consider the figure in which the link between X and Y is broken and node Y wants to send some data to the node X. Node Y actually know that another node Z has a route to the node X. But the main problem here is that the node Y does not aware of that route Z to X passes through node Y. Thus the router Y increased cost from 1 to 2 hops. But as Z route to X is passes through node Y so at router Z distance to node X will becomes Y +1. This will changed the routing table of node Y again to 3. The same process continues till infinity if not solve properly. This is called count to infinity problem [3] [20].

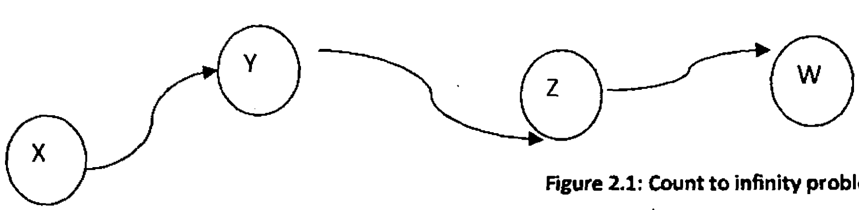

Figure 2.1: Count to infinity problem

2.1.8 Routing loop problem

Consider the figure in which node X has shortest path to node Z and passes through node Y. If the link between node Y and node Z is fail, and node X does not know about it. Now node X forward packets to node Y but node Y has a path to node Z passes through node X. Thus the packets are exchanged between node X and node Y in a loop. Loops are easily formed in MANETs [3][20].

2.1.9 Self-organization

When a link is broken or node is fail then Ad hoc Wireless networking has an important characteristic of organizing and maintaining the network itself such as neighbor discovery and Topology information's [3][20]. Thus routing protocols should be able to recovers itself from any type of failure.

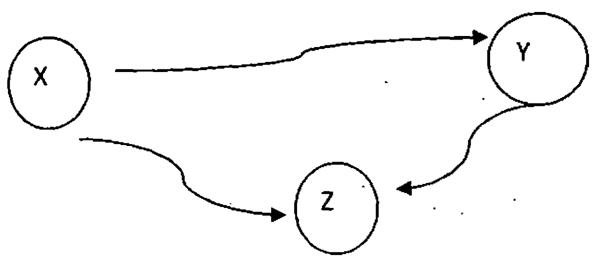

Figure 2.2: Routing Loop problem

In this chapter the major challenges to these networks are briey discussed, how they affect Adhoc networks, then different solutions offered by most popular protocols can be analyzed.

Chapter 3

Literature Survey

Literature Survey

Mobile Ad hoc networks (MANETs) consist of mobile nodes such as laptops, personal digital assistant (PDA) and mobile. All these mobile nodes used the shared media for communication the medium is shared so the available bandwidth is limited in mobile Ad hoc networks. Therefore objectives in Ad hoc networks is that utilize the bandwidth efficiently and fairness to all nodes. In Ad hoc networks the node move from one location to another, the available bandwidth is limited and due to random distribution the hidden and exposed terminal problem may be occur. To coordinate the shared media in MANETs we need the efficient access control protocol. [2] [3].

3.1 Issues in Designing a Mac protocols for Ad Hoc Wireless Networks [2]:

When designing a MAC protocol for ad hoc networks the below issues should be kept in mind:

1. Bandwidth good organization.
2. Quality of Services.
3. Synchronization.
4. Hidden and exposed terminal problem.
5. Error prone shared broadcast channel.
6. No central management.
7. Mobility of nodes.
8. Signal propagation delay.

3.1.1 Bandwidth efficiency:

The bandwidth being partial in ad hoc networks, it should be used well. The Media Access Control (MAC) protocol coordinates the shared bandwidth in a well-organized manner. That fairness to all nodes and the Control overhead should be minimized.

3.1.2 Quality of Services:

The QoS is important issue for some application such as real time and military. But in Ad hoc networks QoS maintaince is very difficult because the nodes are move from one place to another which causes disconnection. So the access media access protocol (MAC) protocol must be designed in such ways that provide better QoS for ad hoc networks.

3.1.3 Time Control (Synchronization):

Time control among the nodes is important for channel reservation. So the proposed MAC protocol must have the quality of Synchronization.

3.1.4 Hidden and exposed terminal problems:

In Ad hoc networks the nodes are distributed randomly, the medium is shared and there is no central management in the Ad hoc networks so the hidden and exposed terminal troubles are unique trouble to ad hoc wireless networks.

3.1.5 Hidden Terminal Problem:

In this case, the two nodes transmit simultaneously to destination node that is in range of both of them but the transmitters are not in direct range hence there is packet collision.

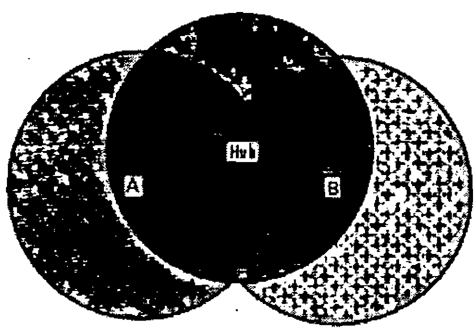

Figure 3.1: Hidden terminal problem [Wikipedia]

3.1.6 Exposed terminal trouble:

The exposed terminal trouble arises due to false think of a node is banned from transmition due to a nearest transmitting. The exposed nodes may be starved of channel access without need, resulting in wasteful employment of the bandwidth resources.

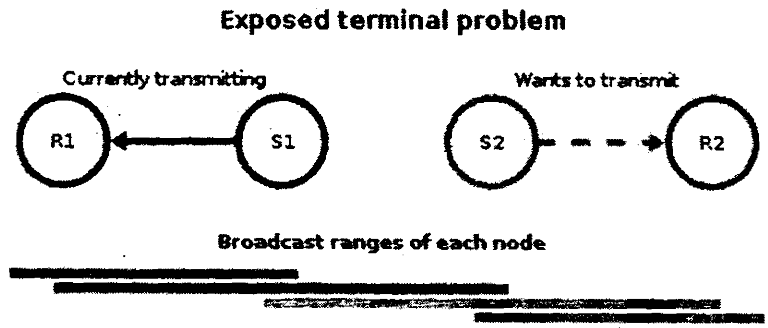

Figure 3.2: Exposed terminal problem [Wikipedia]

3.1.7 Error-prone shared broadcast channel:

We know that ad hoc networks allocate a general broadcast radio channel. When one node transmits some packets, this transmission hears all the neighboring nodes because the medium is shared if two nodes transmit at the same time it would be interferences. The MAC protocol will reduce them and make sure equality to all nodes.

3.1.8 No central coordination:

The Mobile Ad hoc network works in distributed manner so it is also called decentralized networks, no middle coordinating point between all the nodes. Therefore nodes must right to use the channel in scattered manner.

3.1.9 Mobility of nodes:

The Ad hoc Network is the combination of mobile nodes that can move from one point to another .Due to mobility affect the performance of the protocol. The QoS reservation becomes useless.

3.2 Design principles for a MAC protocol in ad hoc networks [2]:

Following points should be considered when designing an Access MAC Protocol for Mobile Ad hoc Networks (MANETs).

1. The designed Protocol must function in disturbed manner.
2. The designed Protocol must have the quality of QoS.
3. The designed Protocol must have the possibility of minimum delay.
4. The bandwidth should be allocated fairly to each node.
5. The designed Protocol must have the quality of minimum Control overhead.

6. The designed Protocol must be scalable to large networks.
7. Energy expenditure of the nodes should be utilized efficiently using power control mechanism.
8. The nodes should have time synchronization.

3.3 Type of MAC Protocols

The Media Access Control (MAC) Protocol can be divided into various classes depending upon certain criteria such as synchronization, beginning approach and reservation approach. [2][3]

- **Contention-Based Protocols**
- **Contention-Based Protocols with Reservation Mechanisms**
- **Contention-Based Protocols with Scheduling Mechanism**

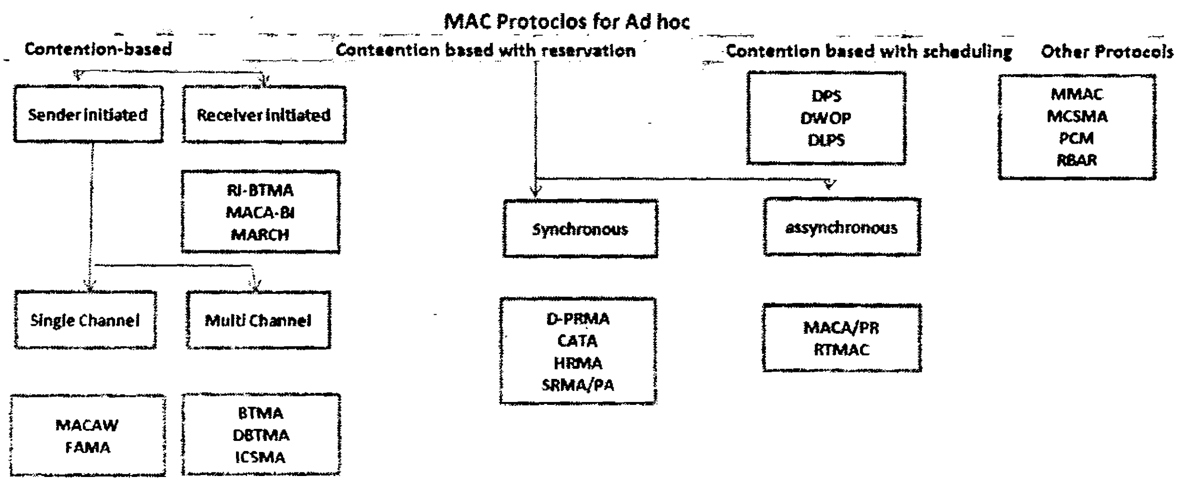

Figure 3.3: Mobile Ad hoc Networks (MANETs) MAC Protocols Division.

3.3.1 Contention- Based Protocols:

There is a large amount resource conflict in such protocols. This places a question mark on the QoS.

3.3.2 Contention -Based Protocols with Reservation Mechanisms.

First, the channel reservation is done. Then, the node accesses the reserved bandwidth, enabling it to provide QoS support. These are further classified as:

Synchronous protocols: All the network nodes are synchronized in terms of time. All the neighboring nodes get the reservation information.

Asynchronous protocols: All the network nodes use relative time for reservation. This castoffs the need of global synchronization.

3.3.3 Contention -Based Protocols with Scheduling Mechanisms

The node access the channel according to the scheduling mechanism such as packet scheduling and node scheduling.

3.4 Contention-Based Protocols

Contention based protocol have no mechanism to use for the reservation of the bandwidth. All the ready nodes waiting for transmission simultaneously contend for the channel. Only one of these is lucky enough to be granted access to the channel. And the other nodes suffer starvation.

The first one is the CSMA Protocol proposed by A.Nasipuri, J.Zhuang and S.R Das [4]. According to this protocol when the correspondent sends some information the correspondent first senses the medium. If the correspondent found that medium is engaged (reserved for communication) then the correspondent wait for the channel reservation and will try after some period of time else if the correspondent found that no carrier being present (Channel is free) then the correspondent starts transmission to the desired distinction.

In the carrier sense multiple accesses (CSMA) the correspondent sense the channel only when it wants transmits some information but in Ad hoc Networks the nodes are distributed randomly so the sender and receiver not near all times.

The hidden terminal problem arises in the CSMA. The hidden terminal problem is the major issue for Mobile Ad hoc Networks. Later this problem was solved by the Media Access Control Protocol (MACA) [3].The below diagram show the transmission function of the CSMA.

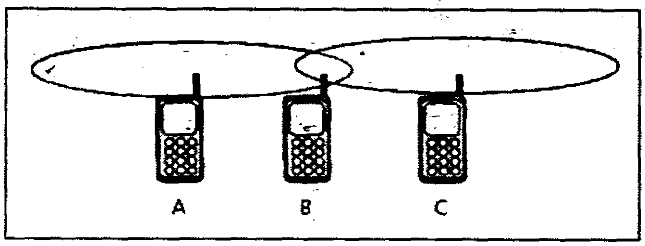

Figure 3.4: Hidden terminal problems.

The MACA is presented by Karn [5]. It does not make use of carrier-sensing for channel access. It will use the two control signal for this one is called the request to send (RTS) transmit by the sender and other is called clear to send (CTS) respond by the receiver. When a node wants send out some information to the target node. To provide synchronization between sender and receiver first then sender send control signal Request to send (RTS) to the target node and wait for the control signal Clear to send (CTS) If unfortunately the receiver is busy it will not responds through CTS then the sender wait for some time period and then try again.

The MACA used the binary exponential algorithm shortly called BEB for retrying the sending packets. If the receiver is not busy and respond quickly through control signal CTS to the sender. When synchronization is done between sender and receiver then it starts transmission, the diagram show the transmission functionality.

The starvation problem arises in MACA due to BEB algorithm. When one node occupies the channel then the second will start BEB algorithm which is completely blocked.

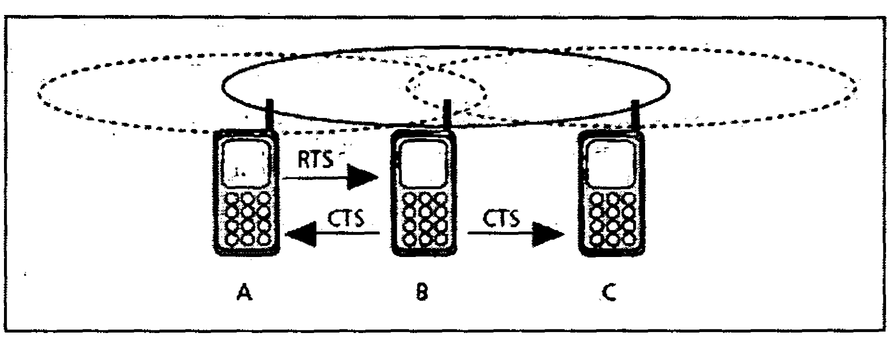

Figure 3.5: MACA function

The Media Access Control Avoidance Wireless Protocol (MACAW) was proposed by V.Bharghavan it customized the BEB algorithm [7]. According to MACAW when the control signals RTS and CTS are successful the BO decrease it by 1 and increase BO by 1.5 after the time out. To solve the starvation problem the MACAW changed the backoff counter from single counter to per distinction.

The advantage of the backoff counter is it measures the congestion.

The MACAW used the control packet called ACK when the sender send out some information to the target node if the target node receive the information correctly without any error the target node responds by ACK packet which shows that the information was received successfully else the sender retry after some time period.

The MACAW used control packet data sending (DS) to solve the exposed terminal problem. The DS packet is send before transmitting information exposed node overhearing this DS packet understands that previous control signal CTS exchange was successful.

The MACAW uses one another control packet called RRTS (Ready to Request to send).

In the MACAW control overhead ratio are more as compared to other reservation protocol. When the overhead more the performance will be poor so the extra bandwidth is used for the control packets. The below diagram show the basic communication function of the protocol.

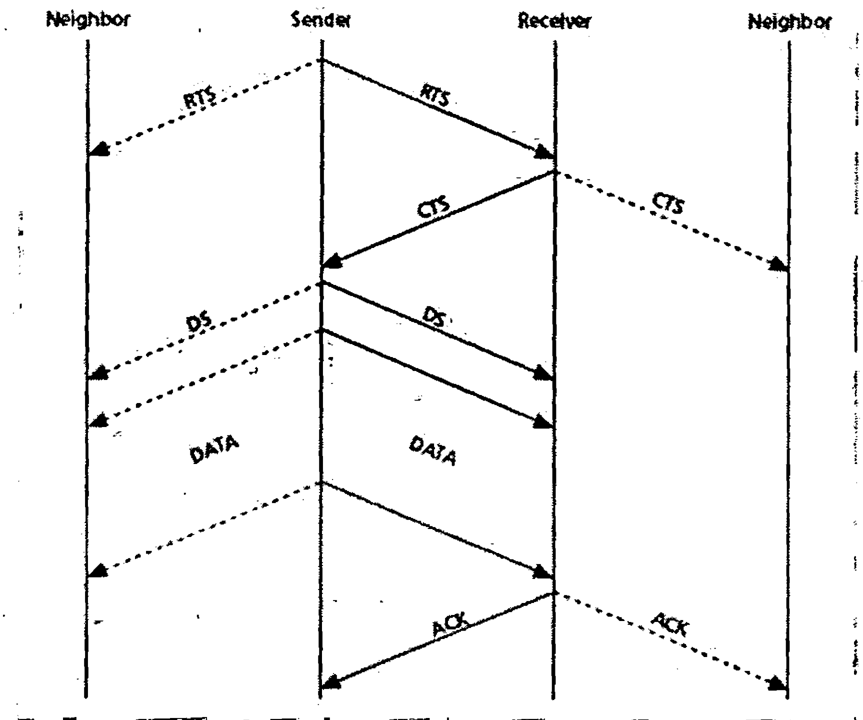

Figure 3.6: Control packet exchange in MACAW [7].

The Floor Acquisition Multiple Access Protocols FAMA was proposed by C.L Fullmer and J.J Garcia Luna-Aceves [8] is the hybrid of both CSMA and MACA means it used sensing and control signal method to reserve the channel. Only one node can control the channel at a time. This lucky has the advantage to sending information to various destinations without any packet collision.

- **MACA**
- **FAMA-Non Persistent Transmit Request**

By the rules of FAMA the data transmission is free of conflict, RTS duration double the maximum bandwidth delay transmission. The burst packets' transmission is not possible in MACA. In FAMA, the MACA is modified in a way so that it to permits bursts by enforcing waiting periods on nodes.

In FAMA-Non Persistent Transmit Request (FAMA-NTR) is the hybrid of CSMA and MACA .It first sense the channel then transmits the control signals. When a node tries to send some information, it first senses the channel. If the node found that channel is busy then the node try after some time period else the node send the control signal (RTS) and wait for the control signal CTS if the node was not received the control signal CTS then try again after some time of period else starts the transmission. When the transmission is complete then the node releases the channel. It has then to contend with the other nodes to again acquire the channel.

The limitations of the FAMA-NTR are the bandwidth employment is inefficient because of back off random time period, and control packets overhead are more.

The busy tone multiple accesses (BTMA) were proposed by F.A Tobagi and L.Kleinrock [3]. According to the BTMA the whole bandwidth is divided into two portions the data portion and the control portion. The actual information is transmitted through data portion and the control signals (RTS and CTS) are transmitted through control portions.

When a node want to transmit the some information before the transmission the node first reserve the channel for transmission for reservation the node sense the channel wither the busy tone in control channel is active or not if yes then try again after some time of period else transmits the information. The advantage of the BTMA is that at the same time transmission is not allowed. So clash ratio is low in BTMA. Limitations of BTMA are: Bandwidth use is very inefficient, transmission is blocked when one node occupies the cannel and others will wait until the channel being released, and control packets overhead is more. The bandwidth division and transmission is shown in the below picture.

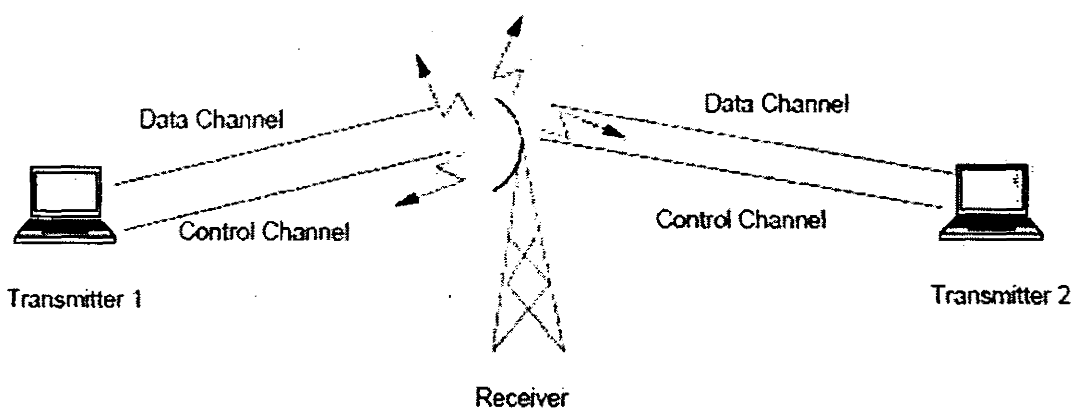

Figure 3.7: Channel Division of BTMA.

Dual Busy Tone Multiple Access (DBTMA) was proposed by J.Deng and Z.J Hass [12] is an absolute version of the BTMA scheme. Just like the BTMA the DBTMA bandwidth is divided into two parts. One is called control guide and the other is called the Data guide. Just like the BTMA the Data guide is used for data packets and the control guide is used for the control packets communication (RTS-CTS). For transmitting busy tones, DBTMA will use the two busy tones on the control channel. The busy tones are BTt and BTr.

BTt and BTr point to the status of node. The BTt tone indicates that the node is transmitting on the Data guide and the BTr indicates that the node is receiving Data on the Data guide.

The two busy tone signals are two sine waves at different well separated frequencies.

When a ready node wants to send out few information packets, the ready node senses the channel to find out the BTr signal is active or not. If it is active then it indicates that a node in the neighborhood of the ready node is currently getting data. On the other had if BTr is found not to be active then sends RTS packet on the control guide. On receiving the RTS packet, the node the RTS was destined checks whether the BTt is active in its region. If found active then he know that some other node in its neighborhood is transmitting packets and so it can't receive packet for the moment. If finds no BTt signal then the node will send CTS packet, turns on the BT signal (which inform the other node that now he is receiving packet).The sender node receiving CTS packet turns on the BTt signal which show that now he is transmitting. When the whole process was successful then starts transmitting data packets. When the transmission is completed successfully the sender node turns off the BTt signal and the receiver node turns off the BTr signal. The Limitations, Control packet overhead is more, Starvation problem will occur, not best for the real time traffic.

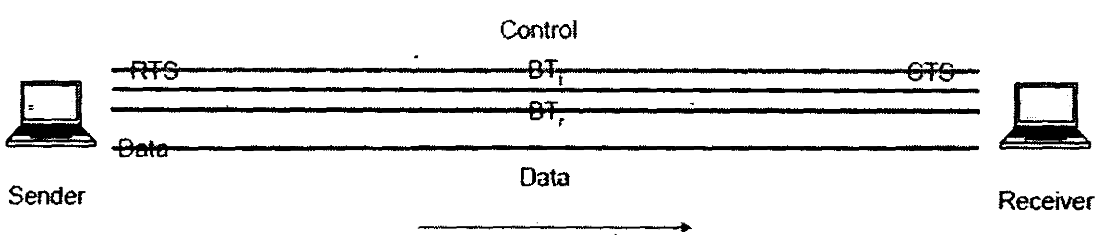

Figure 3.8: Channel Division of DBTMA

The RI-BTMA was proposed by C.S Wu and V.O.K.Li [3].The bandwidth division of the RI-BTMA is same just like BTMA. The node which want to send out some information it first check that the busy tone to be absent on control guide. In the RI-BTMA the Data guide is divided into two portions: a preamble and the actual Data packet. The preamble carries the identification of the wished-for target node. The both sub channel of the bandwidth Data channel and Control channel are slotted with each slot equal to the length of preamble .Data transmission consist of two steps. First the sender will transmit preamble once the receiver node reply the welcome of this preamble by transmitting the busy tone signal on the control guide then actual information is transmitted. The sender node which transmit some Data packet first he finds a free slot in which the busy tone signal is absent when he find a such slot then he transmit the preamble packet on Data guide when the receiver node receive this preamble packet without any error then it transmit the busy tone on the control channel. If the preamble transmission fails the receiver does not acknowledge with busy tone and the sender node will waits for free slot and tries again. Here the busy tone will perform two functions.

First it acknowledges the sender about the successful reception of the preamble.

Second it will informed the neighbors node that current slot will reserved for the transmission.

RI-BTMA protocol is divided into two sub types:

- Basic protocol
- Controlled protocol

The basic packet transmission system is same in both protocols. In the basic protocol nodes can't have backlog buffer to store Data packets if some conflict will occur it can't be retransmitted .So this protocol will not best for when the network load is high.

The backlog buffer facility is available in the control packet at the node level. The suffer collision and those that are generated during the busy slots can be queued at nodes. Suppose a packet arrives at anode from its high layer during busy slot. The packet is just put into the backlog buffer and waits for free slot. The Limitations, are its not best for a heavy load network, Control packets overhead is also more, Backlogs mechanism used in RI-BTMA is a time starves flows it means that all application data will give the same priority.

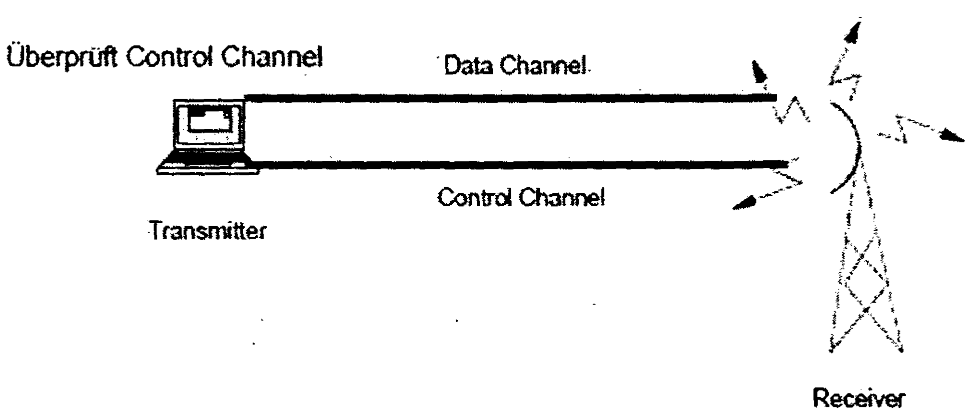

Figure 3.9: RI-BTMA.

The Media Access Control Avoidance -By Invitation (MACA-BI) was proposed by F.Talucci and M. Gerla [6].It will reduce the no of control packet used in the MACA. It will reduce the need of RTS packet. In the MACA-BI the receiver node initiates data transmission by transition control signal ready to receive (RTR) to the sender. If ready to transmit the sender node answer by sending the data packet. The transmission occurs using only two way handshake mechanism. The receiver has no knowledge about the traffic rate of the sender for providing such information to the receiver the Data packet is modified to carry the control information. The information will be such as no of packets queued, packet length, backlog flows and so on. When such information will available to the receiver he easily estimated the average flow rate.

The control signal (RTR) carries information about the time. During this time the data packet would be transmitted when a node receives RTR it can obtain such information. Since it has the information about transmission by the hidden terminal, it stop from transmitting during those period's hidden terminal problem is overcome in MACA-BI. The Limitations of the hidden terminal problem still affects the control packet transmission. Reliability is less.

MARCH was proposed by C.K.Toh, V.Vassilion [14].It will decrease the overhead of control packet. When a sender send out some information the control signal (RTS) is used only for the first packet of the flow. After that only the control signal (CTS) is used for the second packet and onward.

Suppose in simple topology there are four nodes .The four nodes are named as A, B, C, and D. When a node B transmit CTS1 packet this packet is also heard by node C. The CTS packet carries information about the duration of the next data packet. Node C therefore determine the time at which the next data packet would be available at node. It sends the CTS2 packet at the point of time. Once receive the CTS2 packet. Node B sends the data packet directly to node C. We see that time taken for packet transmitted from A to reach node D is Tmarach is less compared to the time taken in MACA, Tmaca.

The CTS packet carries the MAC address of the sender and the receiver node, and the route identification number (RTid) for that flow.

When there are two routes and C hears a CTS packet transmitted by node B, by means of the RTid field on the packet, it understands that the CTS were transmitted by its upstream node. The Limitation, The control overhead is much less but when network is heavily loaded, the transmission delay in packet delivery for MARCH is very low compared to that of MACA.

The D-PRMA was proposed by Dajiang He, Xinhua Ling. It is Just like Packet Reservation Multiple Access protocol [3] the D-PRMA (Disturbed packet multiple access protocol) [14] is used for voice traffic support in ad hoc network it is the scattered schema that can be used in ad hoc network. The wireless LAN with a base station used the packet reservation multiple access (PRMA) is used for voice traffic. It is the centralized packet reservation multiple access.

According to the study of the D-PRMA is a TDMA based protocol. The time partition of channel is done into frame. The frame is further separated into slots and the slot is further separated into minislots and the minislots are further into two control fields.

RTS/B1 and CTS/B1 the B1 show the busy signal when a standing by node want a reserve a slot for transmission then these control fields are used for reservation and for overcoming hidden terminal problem.

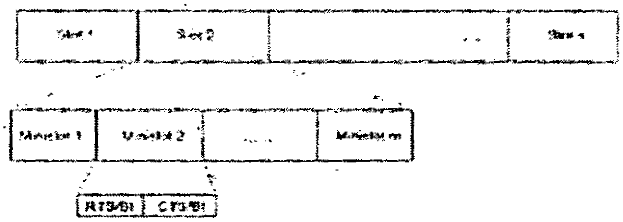

Figure 3.10: Time Division in the D-PRMA Protocol [2].

For the channel reservation the ready node try to occupy the first minislot if the ready node successful in occupation then the node send control signal RTS/BI in the first mini slot and wait for the control signal CTS/BI if the receiver respond through CTS/BI then the remaining (m-1) will be reserved for the communication and starts transmission.

If a node wants transmit voice traffic the D-PRAM use two rules for the voice traffic reservation.

1).Voice nodes are permissible to start try for the first minislot with chance 1 and smaller probability for other traffic.

2).The reservation of a minislot brings reservation of the subsequent slot only if the winning node is a voice one. The Limitations are its is best for channel with a high and medium traffic loads (all slots are likely to be utilized) but it his bed performance at low traffic loads (all slots are not utilized so it increase delays), Starvation problem is also possible .when a slot is reserved for transmission other waits for release the slot, Control packet overhead is also more.

Collision Avoidance Time Allocation Protocol proposed by Zhenyu Tang and J. J. Garcia-Luna-Aceves. The node reserves the channel through handshake and distributed method. The bandwidth division is same the DPRMA .The time is divided into frame and frame is further divided into slots and slots is further divided into five control field. The first four are called the control minislots and the fifth one is called Data slots the control slots are called CMS1, CMS2, CMS3, CMS4 and the data slot called DMS .The size of the DMS is larger than control slots. The DMS is used for the information transmission.

CATA support the unicast transmission, broadcast and multicast simultaneously. CATA has two basic ideologies:

1). the sender must telling about the interferences in the slot and the receiver of flow must tell other possible source nodes about the reservation of the slot.

2).Negative acknowledgment is used if the slot is not reserved.

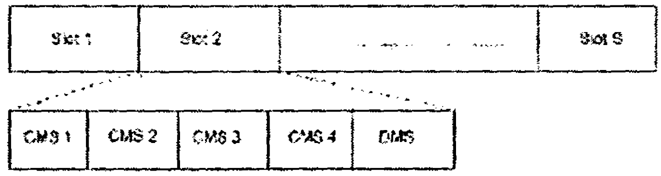

Figure 3.11: Time Division in CATA Protocol [2].

When a node wants transmit some information the control signal (SR) slot reservation sent through control mini slot CMS1 which inform other node that current slot is reserved and it will preventing neighbor node for attempting current slot. The node which want some transmission during the control mini slot (DMS) of the current slot send RTS packet during CSM2 of the slot to jam any possible RTS addressed to its neighbor who may not notice that sender his reserved the current slot which can in turn causes intervention to the neighbors.

It means that these two control fields told about the reservation of the slot.

The other two control minislots (CMS3, CMS4) are used for channel reservation. If the sender sense the channel to be idle during CMS1 transmit RTS packet during CMS2.The receiver node of a unicast session transmits a CTS packet during CMS3.Once this packet received the sender know that reservation was successful and transmit information during the control minislots DMS of the slot. If a node receive an RTS for broadcast or multicast during CMS2,it finds that the channel is free during CMS2 then it remain quiet in CMS3 and CMS4 otherwise it send NTS packet during CMS4.The purpose of NTS is that the reservation request is unsuccessful and the node try again for reservation. The main shortcoming of CATA is more control overhead for reservation, when the slot will reserved for transmission so starvation problem again occur here.

Hope Reservation Multiple Access Protocol was proposed by Zhenyu Tang and J. J. Garcia-Luna-Aceves [15] .The time is divided into frame and frame is divided into slots and slot is further divided into control fields.

Suppose the total on hand frequency channel is say L from the total frequency channel one frequency channel say f_o as keen synchronizing channel where node exchange synchronization information on f_0. Now the reaming frequency L-1 are split into two paired say M=L-1/2= [fi, fi*] so now here the fi is used for hope reservation (HR) packets and fi* is used for ACK packet. In HRMA time is slotted and each slot given a separate frequency hop which is given from M frequency hop. Now again the slot is further divided into four periods SYN, HR, RTS, CTS and these are used for slot reservation.

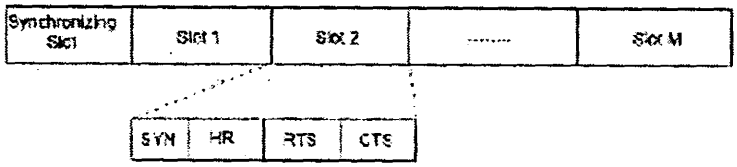

Figure 3.12: Time Division in the HRMA Protocol: [2].

When the reservation method complete. The successful node used the same frequency for transfer data and ack.

If a new node desires to join the network, it listens to the dedicated frequency and gathers information. Now this node wants send some data it listen to the hope reservation period if there is packet there then it retries after some random amount of time, otherwise send RTS packet and wait for CTS packet in the CTS period of the similar frequency channel.

In simple word if a node receive data to be transmitted first listen to HR period if hear some HR packet, it backs off for a random chosen period if find free it transmit control signal RTS packet during the RTS period of the slot and wait for CTS when the CTS received correct the it means that source and receiver node have successfully reserved the current hope. Once the data sent and response the receiver send ACK to sender means the transmission is successful. The Limitations are Bandwidth utilization is poor because the frequency channel is divided into a pairs and some of used for control packet, ACK, Data packet .The overhead of control packet is also more.Deley problem is also occur.

The SRMA/PA was proposed by C.W Ahn, C.G Kang and Y.Z.Cho [16] was developed with the main purpose of supporting both real time and non real time application in ad hoc wireless networks it will best for real time application because it will used priority assignment for traffic. For time slot reservation it uses the collision avoidance handshake and soft reservation (SR) mechanism.

In the SRMA/PA the time is divided into frame and further the frame is divided into n slots and each slot is further divided into six minislots such as SYNC, SR (soft reservation), SR (reservation request), RC (reservation confirm), DS (Data sending), and ACK (acknowledgment).These are called control packets. When a node want some transmission before transmission first he reserve a slot for slot reservation these control packets are used. The SYNC field is used for synchronization purpose. The SR field plays a role of busy tone which informs the other node in the neighborhood that the current slot is reserved. It also carries the access priority value given to the node that he reserved the slot. When ideal node receives data for transmission the node will wait for free slot and will transmit RR packets in RR field of that slot. In case of vice traffic it will take the control of slot from another one which has already reserved but in such case where the priority of voice traffic is greater this is called soft reservation (SR).When ideal node receive RC it know the reservation was successful it finish the hidden terminal problem. The DS is used for Data sending. The ACK packet ensures that Data was received in correct manner. All these play same role as like RTS, CTS, DATA, and ACK in MACAW. The Limitations are ,Not best for the same priority type traffic, The preemption problem occurs, For reservation control overhead is also more, Starvation problem also occur because the priority will be given to high priority traffic.

The FPRP was proposed by C.Zhu and M.S.Corson [21].FPRP is a single channel time division multiple access (TDMA) based broadcast arrangement protocol. When a node require a time slot it use the same conflict mechanism as in SRMA/PA[16].FPRP is fully distributed, and multiple reservation can be done at the same time .No order mechanism is followed among nodes, nodes need not wait for making time slot reservations. The reservation process is localized it involves only the nodes located within the two hope radius of the node concerned.

Time is divided into frames. Frames are two types reservation frame(RF)and information frame(IF) the Rf frame is followed by a sequence of information frame (IF) each RF has N reservation slots(RS) and each IF has N information slots (IS) if a node reserve an IS the node need to try during the corresponding RS. It uses the IF till the next RF.

The frame format is simple. The time is divided into frame further frame is divided into slots and the slots are two types one is RF and IF the RF is further divided into N RS and IF into N IS and RS is further into M RC within RC five phase process are take place if a node reserve slots. If the node wins the contention in the RC it is called to have reserved the IS corresponding to the current RS in the subsequent Ifs of the current frame.

When a node want to take a channel for transmission it first send the reservation request if collision occurs on receiver side it send the collision report if no then sender send reservation confirmation report when then sender receive the reservation acknowledgment message then the channel assignment is done and the node starts the transmission.

The channel assignment process is complex because the more control overhead is involved. So extra channel is used for the control overhead.

A Multichannel Reservation Multiple Access protocol for Mobile Ad Hoc Network (MRMA) was proposed by Kia Liu and Xiaoqin Xing [22].The proposed protocol share the channel in efficient way it employ the RTS and CTS control packets on a common channel and select the free conflict channel for the Data transmission. After successful transmission it will used another control packet Ack replied to the sender on another common channel.

The MRMA used the N_{ch} Channel for use herein two channels say CCH_1 and CCH_2 are used for common channel and the remaining are used for traffic channel say N_{CH-2}.When a node A want to send Data to node B first the node A sense the CCH_1 if the CCH_1 busy it will wait for some time if not then send RTS minislot in CCH_1 in which it designate the ideal traffic channel say TCH_i if the node B successfully receive the RTS packet the node B check the designated traffic channel in channel usage table if not busy then the node B response with CTS minislot on CCH_1 after that the transmission starts after successful transmission the B replies an ACK minislot on CCH_2 which show the packet received correctly. The channel reservation is problem because the overhead are more which cause pure bandwidth utilization. The energy consumption is more because of channel usage table.

Reservation Clash Handling to Optimize Bandwidth Utilization in MANETs is challenging task in Ad hoc networks. The Extended R-CSMA protocol proposed by Ghalem Boudour and Zoubir Mammeri [23].The proposed protocol efficiently handle the channel reservation in the presence of node mobility. The E-CSMA is based on super frame structure. It is composed of SYNC slot followed by reservation indication period (RI), followed by a C period and CF period. The SYNC is used for synchronization and the C period is dedicated to transmission of best effort and C is used to carry real time traffic. The channel access during the contention period and best effort packets transmission is similar to the DCF in IEEE 802.11.For real time traffic the reservation is done in CF period. Each node maintains the table which records the available and reserved slots in the CF period. The reservations are established through ResvRTS/RescCTS/RescConfirm handshake. When the transmission ends the sender stops the data packet on the reserved slots while the receiver stops RI signal of reserved slots when the neighbor hear this conclude that the slot is released. When a sender has no data to send it simply send NULL frame on reserved slot when neighbor hear this automatically know that sender has no data to send now he used the reserved slot. When the reservation clash occur it will used the recovery mechanism for this. Released the reserve slot or repair the slot reservation mean the whole process will repeat for the reservation.

The reservation overhead is more and the channel utilization is not well. The recovery mechanism process is difficult because for repairing the whole process will be repeated. Due to more overhead the energy consumption are more.

Bandwidth Reservation for Heterogeneous Traffics in Mobile Ad hoc Networks (BRPHT) proposed by Ghalem Boudour and Zoubir mammeri [24]. The proposed protocol multiplexes the several transmitting node on the same slot but each node allocated the required bandwidth so it provide more bandwidth to node. BRPHT is based on the super frame structure. Super frame is composed of a Reservation frame (RF) dedicated to reservation of best effort and reservation request packet followed by n sub frame used to carry real time packets and each sub frame is composed of K slots first one is SYNC slot used for synchronization and other each slot is composed of Data and Ack minislots. The channel access during the RF is similar IEEE 802.11 as discussed in previous paper. The BRPHT maintain the slot utilization rate (SUR) and slots table.SUR mean the ratio between the number of sub frames on which slot I is reserved and the total number of sub frames. The SST records the information about reservation. The concept of reservation release is same as previous protocol. The main issue in BRPHT is overhead are more for reservation. Due to overhead energy expenditure are also more.

Multi-Channel Medium Access Control with Hopping Reservation for Multi-hope Wireless Networks (MMAC-HR) proposed by Khaled Hatem Almotairi and Xuemin [25].MMAC-HR optimize the network performance. For the exposed terminal problem it will used the CSMA/CA over all channels. It does not need the time synchronization, does not need sense the control channel in order to determine the whether the data channel is ideal or busy. For reservation the control packets RTS and CTS are used but it will modify the CTS packet which has three new fields: CH_i mean the current channel I of the receiver, WT (the waiting time which is the time to hold before attempting), and RT (the reservation time before releasing the switchable interface).The main issue are the reservation overhead are more .using CSMA/CA on all channel cause the energy expenditure are more.

In the literature survey we have study the various previous papers on channel reservation protocols which discus that how the channel will be reserved for the ready node for transmission here the channel reservation is one of the key problem in mobile ad hoc networks because in mobile ad hoc network the channel is shared. In previous channel reservation technique in some control overhead are more, some cases channel utilization is not best and in some case fairness is not well but these three features our basic requirements on MAC layer.

From the above reading we come to the conclusion that we have require the simple channel reservation technique that have no control overhead, utilization is best and also fairness is best.

Also we study the two types of channel are used multi channel and single channel for transmission in the multi channel we divided the channel into sub channel. In previous study we see that in some cases multi channel are best but in some cases single channel is best for transmission so this is our second target that evaluate these two types channel in well known simulator w.r.t various matrices and see which one will best.

The proposed study is about how the channel will assigned to the ready node and no control overhead is involved in the channel reservations.

Chapter 4

Problem Definition and Proposed Solution

Problem Definition and Proposed Solution

4.1 Problem Definition

In the MANETs, nodes are mobiles and the medium is common. Right to use to this common medium should be prohibited in such way that all nodes receive a fair share of the on hand bandwidth and that the channel is utilized well.

In the MANETs nodes have partial resources in term of power, energy and processing power. In such networks MAC layer protocol plays a key role in well-organized utilization of shared media in scattered way. At the MAC layer we have three contradicting requirements.

a) Maximize channel utilization.
b) Minimize Control overhead
c) Ensure Fairness

After studying a variety of MAC Multi channel reservation protocols we come to the conclusion that the time synchronization among nodes for bandwidth reservation is trouble because control overhead are more, the extra channel is used for the control overhead and also the fairness is not well. The energy expenditure is also more because of the overhead.

4.2 Proposed Solution

In the proposed multichannel MAC protocol the channel assignment is Simple as compared to the previous multichannel MAC protocol assignment reservation.

In our proposed solution, we have divided the given channel into N-sub channels and each sub channel is assigned an id as shown in figure below (channel id starts from 0).

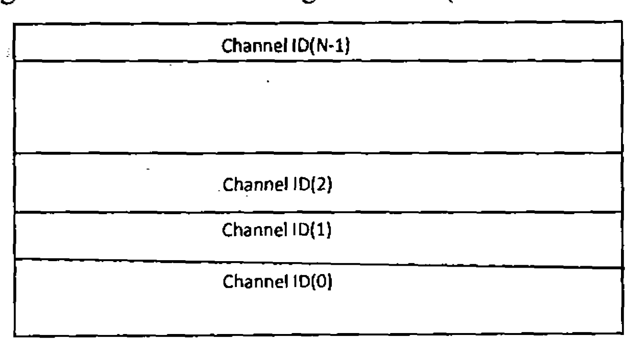

Figure 4.1: Division of Channel into N-sub channel

Each node in the network selects a particular channel for its transmission and can receive data at all channels. Channel selection is done using the following formula.

$$Node_{TX} = Node_{id} \bmod N$$

Where $Node_{TX}$ is the channel used for transmission by $Node_{id}$ and N is the total no. of sub channels.

According to the proposed scheme the channel will be assigned to the node according to the above formula. To select a transmission channel for a node, we divide the $Node_{id}$ by the No. of channels and remainder gives us the channel id for this particular node. For example the node ID is 6 and the sub-channels are 5 then according to the formula the remainder is 1 so the channel id 1 will be used by node-6 for transmission.

The proposed scheme offers a simple and light weight mechanism for solving the problem of channel reservation in multi-channel MAC protocols. This scheme does not reserve a channel rather its selects a particular transmission channel for every node and that is used for ever by the respective node. The scheme not only eliminates the overhead involved in channel reservation but also reduces the no. of collisions between in the network by providing an efficient way of channel selection in a distributed fashion.

Although the proposed scheme does not ensure (guarantee) that a distinct channel will be selected by neighboring nodes. In other words, it is possible that same channel will be selected by two neighboring nodes e.g. if node 6 and node 11 are neighbor nodes and we have 5 sub channels then the proposed scheme will result is selection of channel-ID (1) for both node 6 and node 11. As a result of using same transmission channel both cannot communicate at the same time otherwise it will result in collision. But in Adhoc networks nodes are distributed randomly and the probability of having two nodes communicating at the same time, being neighbors such that the proposed scheme results in selection of same channel for both of them, is very low. According to Amdahl's law, we shall focus to optimize the part of a design that affects the performance at most. In other words, targeting to improve the fraction that rarely happens may results in less gain as compared to the overhead. Therefore we choose to use a simple (kind of random) scheme for channel selection. Remarkable improvement in the simulations results is observed by using proposed scheme.

The major design question in our proposed scheme is that how many sub channels will be sufficient to achieve optimal results. Too many sub channels will result in under utilization as most of the channels will remain unused. On other hand, too few channels will results in selection of same channel by neighboring nodes and hence collisions. We have performed simulation with varying no. of sub channels ranging from 2 to 10. We have found no more significant improvement in the results after 5 sub channels and we have reported results with 5 sub channels compared against single channel MAC protocol in chapter 7. We have collected results various parameters such as Packet Delivery ratio, Throughput, Delay, Normalized Routing Load and Energy consumption. The Results show that the performance of the proposed protocol is best for the channel assignments according to new technique.

4.3 Features of Proposed Solution

When the channel is assigned to the node for communication the proposed channel assignment technique is simple and the key feature of our technique is the Zero Control Overhead, Reduced Collisions, reduced the computation among nodes and effective Channel Utilization.

4.4 Algorithm for proposed technique

Algorithmic Description of Each Phase:

This section described detailed algorithm for each step discussed. It explains the channel assignment of the of the proposed technique.

Procedure: A set X of successful channel assignment request and a set of F of the channel free time of N channel in MANETs.

Output: A feasible Channel Assignment

Begin

Step1: The total number the reservation nodes such as n=100

Step2: Divide the available Bandwidth into the multiple channel denoted by N=5

Step3: When a node want a channel for transmission denoted by T_x. The node reserves the channel according to Node ID based reservation formula.

1. $Tx=Node_{ID}\%N$

Where the N denotes the a sub channel

2. $Channel_{ID}=Reminder$

3. $T_x=Reminder\ (Channel_{ID})$

Step4: The transmission node will assign the channel using step3.

$T_x=Channel_{ID}$

Step5: The step3 will be repeated for all nodes when all the channel reservation will complete using formula in step 3.

Step6: Exit the Reservation algo.

4.5 PROPOSED CONCEPTUAL MODEL

The proposed frame work show the reservation flow that how the channel will be reserved for the transmission node.

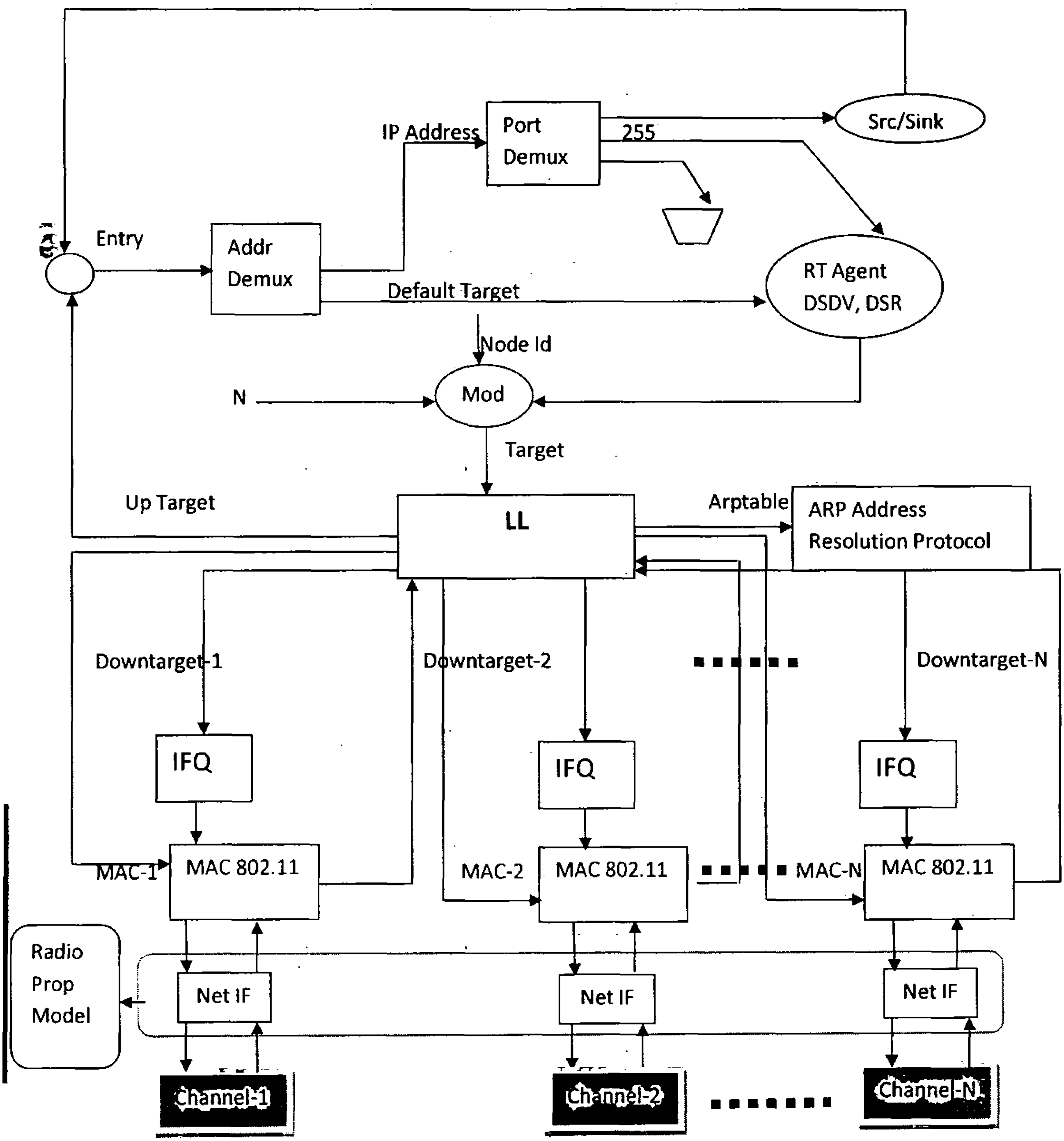

Figure 4.2: Proposed Framework of Channel Reservation

In this chapter we have discussed the proposed solution in detail. We have discussed the simple channel assignment technique based on $Node_{id}$ based and also we have test if we used the multi channel then how many channel will be suitable for networks if we used the more channel what will be the effects. Proposed solution has been implemented successfully in ns-2.33 simulator.

Chapter 5

Implementation

Implementation

Simulation is a very well-organized system, among many others, to expect about the performance of a design that how it is supposed to behave if it is made a physical actuality. It is simulation which has rocketed the modern engineering world to the zenith in which it is today. Everything from the simplest gadgets to most complex circuits are first designed then simulated and then physically made-up and manufactured, thus making simulation the backbone of all engineering works throughout the world.

In the field of communication and networks, simulation is playing a fundamental role. Simulation provides smart start up to large megaprojects that are undertaken by the leading networks operators throughout the world. It costs a little to simulate a scenario but save huge amount of money.

Below we review some popular simulators used for simulating Adhoc and Sensor networks.

5.1 Some well-liked Simulators for Adhoc and Sensor Networks

Many simulators are used in research for simulating the Adhoc and Sensor Networks. A whole chapter can be dedicated to explain the details of each of them. However unable to afford this here, as brevity is more required here, a brief review of the most popular ones of them is presented below only touching their salient features only.

5.1.1 SensorSim

The Sensor networks used the sensor sim software for simulation. The sensor sim provides the sensor network feature like sensor channel models, energy consumers; lightweight protocol stacks for wireless micro sensors, scenario generation and hybrid simulation etc. based on ns-2. The role of sensor channel is to model dynamic dealings between the physical environment and the sensor nodes. The nodes' lifespan is significantly improved by the efficient use of power by the energy clients at each node. Sensor Sim is not in the market and has been stopped developing.

5.1.2 GloMoSim

Global Mobile information system Simulate shortly called GloMoSim. It is used for simulating Ad-hoc and Mobile wireless network. It is written in C and Pasrsec. It can be scaled and supports parallel discrete-event simulation. It consists of a mixture of different library modules. Each of these library modules is used for simulating a particular wireless communication protocol.

5.1.3 TOSSIM

TOSSIM simulator simulates TinyOS Sensor Networks. It is a discrete event simulator. TOSSIM in particular simulates Berkeley MICA mote hardware platforms which run of TinyOS applications for wireless sensor networks. It is used for actuating TinyOS applications in TOSSIM framework on a computer, instead of the mote itself. It is thus cost effective that the developed applications can first be run on the computer in a controlled environment. Debuggers and other advance tools are willingly available to test and develop the TinyOS codes. The four salient features of the TOSSIM simulator are: scalability, loyalty, completeness, and bridging. Although it is sufficient to evaluate high level applications, it is of less or even of no use for MAC.

5.1.4 J-Sim

Formerly known as JavaSim, J-Sim Simulator is used for network simulation as well as emulation by incorpating some sensor devices. It is written in Java. The J-Sim is component based, object oriented, and a compositional simulation setting. The advantages of J-Sim are that the modules can be added and deleted easily in a plug-and-play manner. Among the features that J-Sim provides are: sensor and sink nodes, physical media, wireless communication channels and sensor channels, energy models and power models.

5.1.5 OMNeT++

The wireless sensor network used the OMNeT++ software (Objective Modular Network Test-bed in C++) for the simulation. It is based on discrete event simulation framework. It makes capturing of complex systems a possibility as OMNeT++ collects hierarchy models. These hierarchical models are divided into two categories: simple and compound. Former ones are programmed in C++. The later ones consist of simpler modules programmed in high level language (NED). The exchanging messages, representing the packets used in the network, are used to communicate between the modules. Among many other features, OMNeT++ enables the users to study: the effect of scale, node level architecture, energy sufficiency, communication architecture, system architecture, and protocols etc.

5.1.6 SENS

The wireless sensor network used the high level simulator SENS (sensor environment and network simulator) for the simulation. The SENS consists of interchangeable and extensible applications, networks and physical components. These components have the separate function such as application components simulate the execution on a sensor node, network components simulate the packet the send and receive functions of a sensor node and physical components model sensors, actuators, and power, and interact with the environment. Existing components can be modified or new ones can be written for applications, network models, sensor capabilities and environment.

5.1.7 NS-2

The project VINT (Virtual Interchange test bed) developed the popular network simulator NS-2 (Network simulator-2). The NS-2 is a discrete event simulator. The NS-2 used various protocols such as TCP, UDP, MAC layer protocols, routing and multicast protocols for wired and wireless networks among a lot of other features for simulation.

The procedure to arrangement and run a simulation: An OTcl script is written by the programmer. This OTcl script then initiates an event scheduler, arrangement the network topology by using the network objects and plumbing functions in the library and guide the trace sources about the start and end times of the packets being transmitted through the event scheduler. Thus NS-2 can be regarded as an OTcl interpreter. The NS-2 simulator reads the OTcl script, and then sets the environment parameters following the read script. In order to start a new network project, it will be easier for the programmer to make compound object from the object library, and to plumb the data path through the object than to write a new one. All the data obtained during the simulation process is outputted as text files at the end of the simulation. These text files contain all the simulation data. The result of the whole simulation process can be judged from these files in a bird eyes view. They can also be fed as input to graphical user interface Network Animator (NAM) for further analysis. NAM shows the same result from these files in a way which offer great ease and is less prone to error.

The files fed as input to NS-2 are solely OTcl language programs; rather C++ is also incorporated there. C++ is used to write and compile the event scheduler and the other network component objects in the data path. This greatly helps reduce the packet and event processing time. OTcl linkage is required for the compiled objects so that for each of C++ object, an OTcl object of same match is created thus these objects can then be read by the OTcl interpreter.

NS-2 basically runs in UNIX environment. In order to run on a windows system, Cygwin is required which provides the required UNIX interface and environment.

A discrete event network simulator is the key to know NS-2. In the NS-2 simulator, physical activities of the network are translated to events. These events are then queued and process for their corresponding scheduled occurrences. As the events get processed, the simulation time also progresses. It is not necessary for the simulation time to the real life time as inputted to it.

Why NS-2

Of all the above simulators all have their own pros and cons but we go for NS-2. NS-2 is the simulator to work the simulation the way we want it to do it. All this we explain below.

The way NS-2 models the traffic models and applications, and other network components in unique to it and almost the way we want it. NS-2 configures routing protocols, transport layer protocols, link layer mechanisms and interface queues. The entire network construction is viewed during the simulation allowing us the ease to decide. At the end of the simulation, NS-2 output trace files which contain the record of the whole simulation. These trace files contain detailed information about the network layer. It is interesting to know that size of a trace file can go up to a few gigabits. These files contains enough records of the simulation to enable to evaluate the performance of the different modules and features of the network like Mac layer load, and routing protocol among many others. An OTcl source file is fed as input to the NS-2 simulator. NS-2 can thus be regarded as an Object-Oriented Tcl (OTcl) script interpreter. The purpose of the OTcl script is to initiate an event scheduler, sets up the network topology using the network objects and plumbs functions in the library, tells about the traffic sources start and end time of packet transmission through the event scheduler. NS-2 has a simulation event scheduler and network component object libraries, and network setup module libraries. The detailed network construction and traffic simulation is done in NS-2. One or more text files outputted by NS-2 at the end of the simulation which contain simulation data, and the data thus outputted is then used for further analysis.

C++ is used to implement the lowest level of the NS-2 as the event scheduler and most of the network components are implemented in C++. This implementation is later made available to the Tcl script. Overview of the network – the simulation scenario - is seen upon the Tcl level. The complete process of simulation is made a lot much easier by NS-2 because of its layered structure which simulates the network agent structure (Src/Sink).

Thus all these features combine together to make NS-2 the best choice for us to opt for our simulation.

Chapter 6

Validation and Throughput Analysis of Multi Channel Implementation

Validation and Throughput Analysis of Multi Channel Implementation

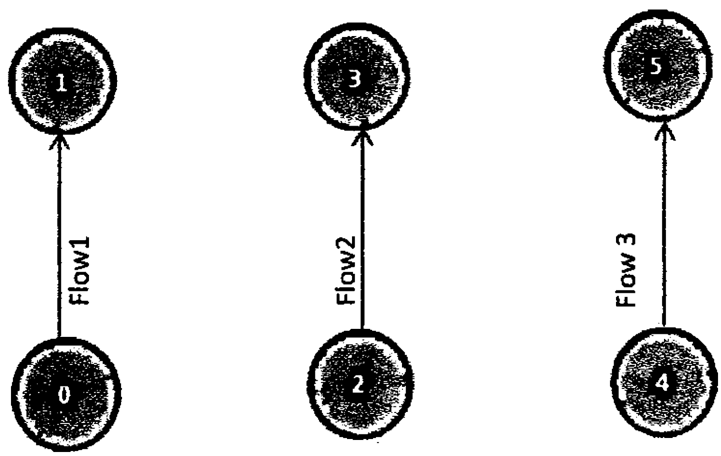

Figure 6.1: Flows Topology

In these experiments we have used the simple topology as shown in figure. It consists of six nodes. Each node has represented by name such as 0 to 5.Here the node-0 is communicating with node-1 on flow1, node-2 is communicating with node-3 on flow2 and node-4 is communicating with node-5 on flow3. The nodes are placed in close proximity (communication range) of each other. The communicating range of the nodes is 100m. In this topology we see if the nodes are communicating on the same channel or distinct channel what will be the affect on throughput.

6.1 Throughput gain by Single flow at varying Bandwidth and Packet Rate

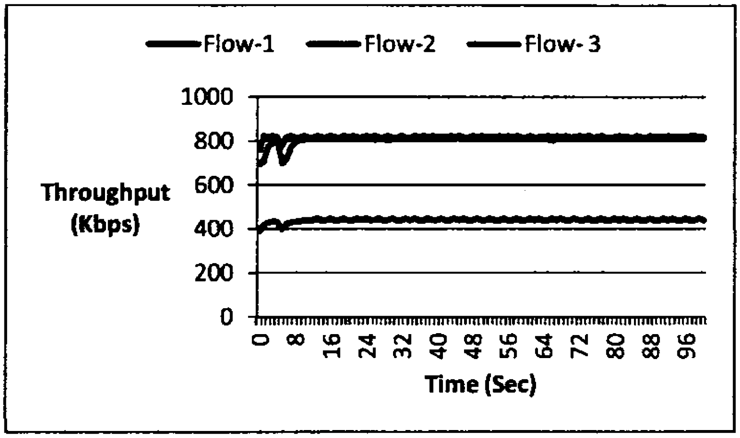

Figure 6.1: Throughput gain by Single flow at varying Bandwidth and Packet Rate.

Throughput gain by Single flow at varying Bandwidth and Packet Rate is evaluated. Here is the single channel between two nodes only we change the packet sending rate .In last simulation we divide the channel into half then we see the throughput analysis. The flow-1 MB can achieve about 820 Kb throughputs when the packet sending rate is 100 Pkt/sec. The flow can't achieve 100% because the MAC layer and Routing header packet is not considered in receives. When we increase the packet sending rate 1000 Pkt/sec then drops occurs more and we can't achieve the maximum throughput because the link capacity as same as for 100 Pkts/sec only we increase the sending rate so it can achieve 820 Kb throughputs. It means the MAC layer achieve maximum 820 Kb throughput.

One flow BW 0.5 Mb rate 0.01 to see max achieved BW and it is about 420Kb, means BW set properly the throughput not reach to 500 because the MAC layer and routing packets are not considered.

6.2 Throughput gain by Two Competing flows on a Single Channel

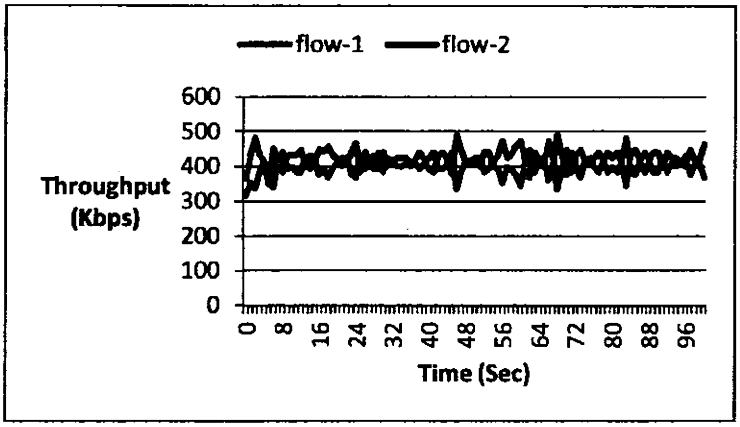

Figure 6.2: Throughput gain by Two Competing flows on a Single Channel.

Here the nodes 0 and 1 are communicating with each other and the nodes 2 and 3 are communicating with each other but all these flow used the single channel now we see what will the affects on throughput if the two competing flows are communicating on a single channel. In this case of two flows on a single channel the throughput graphs show more fluctuations. Two flows rate 0.01 on a link of 1Mbps, to see BW achieved by each flow is about 400Kb, more fluctuations because two flows are competing for single channel some time one flow reserve the channel the other will back off and sometime other reserve the channel the first on backoff it means the both will competing for the channel so the fluctuation occurs during fluctuations the packets are also drops.

6.3 Throughput gain by two flows on a Two Sub Channel

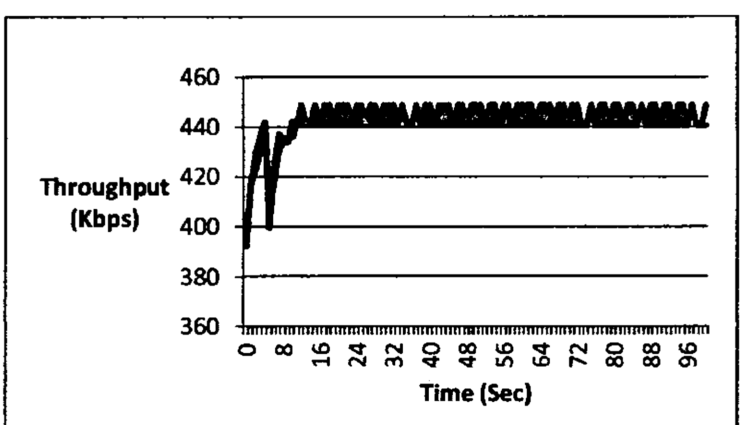

Figure 6.3: Throughput gain by two flows on a Two Sub Channel.

Throughput gain by two flows on a Two Sub Channel here is the same case as in previous experiment but we divided the channel into two sub channel the packet sending rate is same as above now 0 and 2 are communicating on one channel and 2 and 3 are communicating on another channel now we see the throughput graph uniform because there is no competition between the flows. Two Sub Channel, two flows rate 0.01, BW 0.5Mb, to see BW achieved by each about 440Kb, BW halfed. The MAC layer and Routing header packet are not considered in receiving. If we compare with a single channel the throughput graph of a sub channel is well.

6.4 Throughput gain by Three Competing flows on a Single Channel along with their aggregated throughput

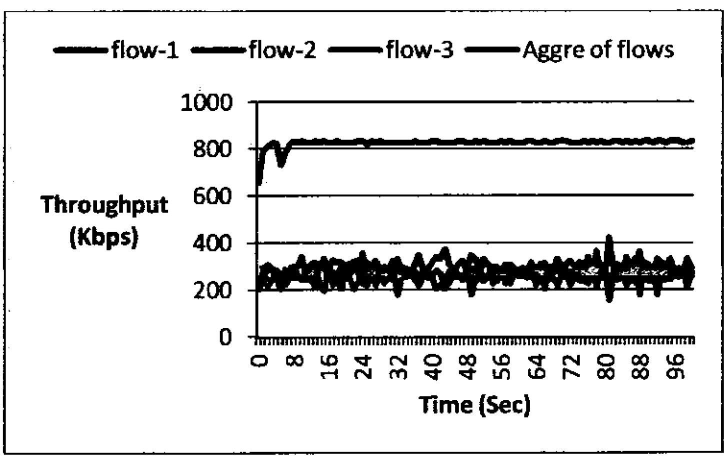

Figure 6.4: Throughput gain by Three Competing flows on a Single Channel along with their aggregated throughput.

Throughput gain by Three Competing flows on a Single Channel along with their aggregated throughput here three flows are communicating but all three flows used the single channel now we see what will affects on throughputs if we increase the flows and all used the single channel the throughput is down because the collision are more due to computation among the flows, and also the back off occurs among the flows. three flows rate 0.01, BW 1Mb, to see BW achieved by each about 220Kb, aggregated 800Kb.Here we see the fluctuation between 3 flows because some time one reserve the channel and other will back off for some time and sometime other reserve the first will back off it means there is more competition for reserving the channel in such situation fluctuation will be occurs which will cause the drops. The

MAC layer and Routing header are also included. In last we also show the aggregated throughputs of the three flows which is 800 Kb.

6.5 Throughput gain by three flows on a Three Sub Channel along with their aggregated throughput

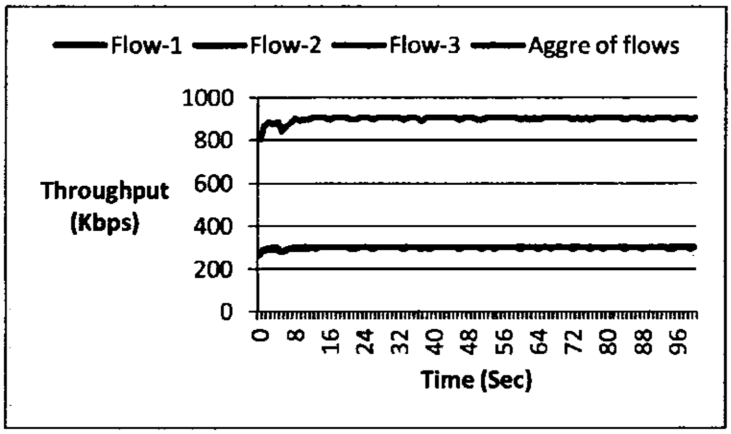

Figure 6.5: Throughput gain by three flows on a Three Sub Channel along with their aggregated throughput.

Throughput gain by three flows on a Three Sub Channel along with their aggregated throughput. Here we divided the 1 Mb link into 3 sub channel each get .33 Mb we see the throughput graph which is in uniform mode no fluctuations will occurs because there are no computation among the flows. Multi Channel, three flows rate 0.01, BW 0.33Mb, to see BW achieved by each, all flows used separate channel and we achieve the maximum throughputs because no competition among flows. The throughput graph will not reach to 1000 because the MAC layer and routing header packet are also included.

6.6 Throughput gain by three flows on a Three Sub Channel along with their aggregated throughput (Two flows are communicating on same sub-channel)

Throughput gain by three flows on a Three Sub Channel along with their aggregated throughput (Two flows are communicating on same sub-channel) this is the situation which is the drawback of our proposed technique when same channel will assigns to two neighboring nodes here the two neighboring nodes 0 and 4 are communicating on the same channel so we see the graph that collision will occurs and fluctuation occurs but the node 2 is communicating on the separate channel so his throughput graph is 350 Kb and the same channel graph is 200 Kb and if we see the aggregated graph which is 600 Kb so in such situation the collision chance are more. Multi Channel, three flows rate 0.01, BW 0.33Mb, to see BW achieved by each, two 0 & 4 are colliding, one 2 flow separate, aggregated 600Kb and the MAC layer and Routing header packet are also included.

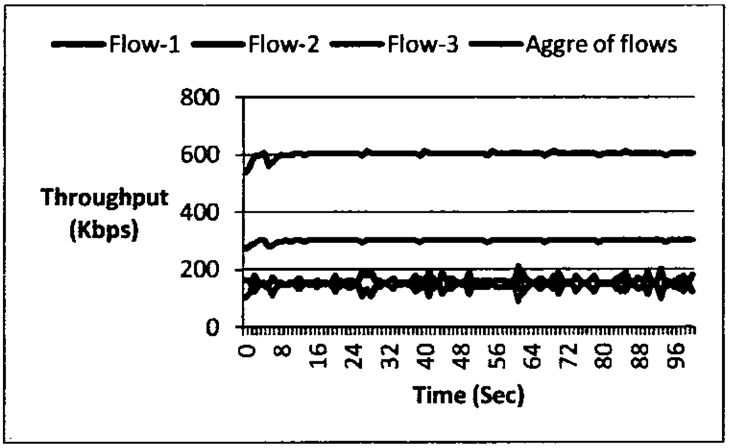

Figure 6.6: Throughput gain by three flows on a Three Sub Channel along with their aggregated throughput (Two flows are communicating on same sub-channel).

Chapter 7

Experiments and Results

Experiments and Results

7.1 Simulation Architecture

We evaluated the performance of MANTEs proposed MAC Protocols scheme in NS-2.33. The whole simulation architecture is about Ad hoc environment and the simulation nature is wireless simulation where the numbers of nodes are 100, with varying mobility from 1m/s to 20m/s with different pause time and traffic loads. The Simulation architecture also consists of: the channel type is wireless channel, propagation model is two Ray ground, network interface type is Wireless Phy.MAC type 802.11 and the link layer type is LL. We used the ns2 simulator for the whole simulation. For Ad hoc scenarios we used default setting of NS-2 for bandwidth, nodes range, battery model and other component. The whole study consists of 100 nodes which are moving in rectangular area 1000x1000 m^2.According to the Random Waypoint model all the nodes moves every node randomly select a destination point and then move to point with a certain randomly selected speed. Once the node reach at the distinction point then it stops there for a certain pause time and then again arbitrarily select a new distinction point and move toward it with a new speed. The speed is chosen from a uniform distribution between a minimum speed of 1m/s (walking speed) and the maximum speed of 20 m/s (car speed within city).In simulation FTP default traffic generator was used at application layer and CBR (constant bit rate) traffic generator was used at application with varying packets sizes. The simulation time for all these simulation (experiment) was set to 100 seconds. To get more across the broad result during the simulation we take the various parameters for various simulations.

7.2 Performance Metrics

To check the performance of the protocol w.r.t various parameters. The different parameters are given below.

- **Throughput**
- **Delay**
- **Energy consumption**
- **Packet delivery ratio (PDR)**
- **Control overhead Ratio also referred to Normalized Routing Load (NRL)**

7.2.1.Throughput: The throughput can be defined as that how much information can be delivered from one location to another in given amount of time if we achieve the higher throughput the better because it implies that the protocol is delivering more information in given time.

The throughput of a node can be defined as if the node sends the x number of bits in t amount of time then the throughput of this node may be defined as:

$$Thr=x/t.$$

If it take the smaller amount of time and delivered more bits then the network achieve the maximum throughput.

The maximum throughput is the ultimate objective of every network.

7.2.2. Success rate: The success rate means that how many packets successfully received by the destination node.

7.2.3. No. of Packets Delivered: It means that how many packets are delivered to the target node throughout the simulation. This parameter is useful in CBR traffic because CBR generates the packets with a fixed rate. The CBR ensure that the generation of packets remains same for all the protocol. Packets Delivery metrics gives a suggestion about the capability of the underlying protocol to transport the packets.

7.2.4. Delay: The Delay can be defined as how long take a time when the packet is sent from one location to another. If this value is minimum it means protocol is efficient and more desirable.

Delay (m sec): Average (Received Time - Sent Time)

7.2.5. Energy consumption: The energy consumption means that how many energy used by the node in the network. The protocol is a desirable if the energy consumption values is less.

Energy per user data: The total energy consumed means the energy used in transport data and the energy consumed by the control packets involved in sending data. This value minimum if the less number of control packets involved and the data will pass through fewer hopes. This metric is also called as energy expenditure.

7.2.6. Packet delivery ratio (PDR): It is the ratio of the number of packets successfully received by the application layer of a destination node to the number of packets originated at the application layer of each node for that destination. The higher the PDR, the better, as it means that the protocol has less number of collisions.

Packet delivery ratio means the number of packets received at the destination throughout the simulation. CBR generates the packets with a fixed rate so this metric is useful in CBR traffic. Thus the number of generated packets for the same simulation time remains the same for all protocols. This metric gives a direct idea about the ability of the underlying protocol to deliver the packets.

7.2.7. Normalized Routing Load (NRL): when the sender sends some data the NRL show ratio of the number of overhead (control packets) to the total number of data packets delivered. The NRL value is minimum the protocol is better.

For more and more traffic coming into the network, it becomes harder for the network to manage all these traffic so it is called network load.

This high network load or additional traffic on the network affects the MANET routing packets, which in result slows down the delivery of packets for reaching to the destination.

7.3 Simulation Parameters

To compare these entire multi channel MAC protocol scheme (IEEE 802.11 and multichannel scheme 3_Sub_Channel and 5_Sub_Channel) with each other, a testing environment had to be created in which the starting position and conditions are the same for all protocols. Creating a simulation environment in ns2 all this could be done. The below table show various parameters taken for the simulation study.

1) **Varying no. of flows:**
2) **Varying no. of Packet Size:**

Now we show all the details of parameters in table below.

Table 7.1: Simulation Parameters

Simulation No	*Nodes*	*Traffic Type*	*Flows*	*PKT Size*
1	100	CBR	15	64
2	100	CBR	15	128
3	100	CBR	15	256
4	100	CBR	15	512
5	100	CBR	15	1024

6	100	CBR	5	512
7	100	CBR	10	512
8	100	CBR	15	512
9	100	CBR	20	512
10	100	CBR	25	512
10	100	CBR	30	512

Table 2: Various Parameters for whole Simulation.

7.3 Various Parameters for Simulating Scenarios:

All of these experiments were performed with 100 no. of nodes, in 1000 X 1000 m^2 simulating area, for 100 sec time. All flows are peer to peer. Figure shows sample topology used in Ad hoc environment simulations. In the below topology 5 flows are used and the channel assigned to the node according to our formula.

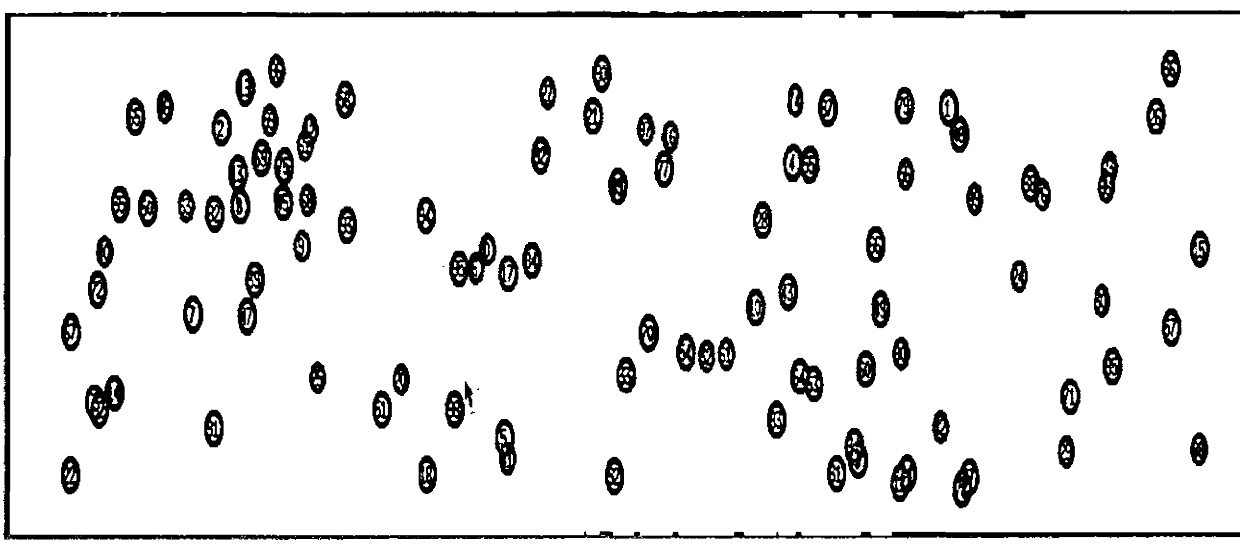

Figure 7.1: Ad hoc network simulations showing 100 nodes randomly distributed in 1000 x 1000 m2 area take Sample Topology Snapshot from NAM.

Now we take the various Scenarios for experiments and then test the performance of IEEE 802.11and proposed multichannel Scheme 3_Sub_Channel and 5_Sub_Channel in MANETs.

7.4 Effect of Varying Packet size

In the first Scenario we take the various PKT sizes which we show in table above then we see if we increase the PKT size what will be the affects of protocols in various performance such as PDR, Throughput, Energy used, Delay, and NRL.

When we take the various PKT size then we run the NS-2 simulation to examine protocols behavior. It is obvious that transmit larger packets size will have little longer airtime hence longer Delay, but at the same time protocols are delivering more bits on the same control overhead and same simulation time. Due to this it will cause an increase in throughput and finally increase in energy expenditure. These Simulations are performed with packet size of 64,128,256,512and 1024 Bits respectively. Figure shows the comparative results of various metrics w.r.t to varying packet size.

7.4.1 Packet Delivery Ratio (PDR)

With various packet sizes we see the behavior of the IEEE 802.11, 3_Sub Channel and 5_Sub channel what will they performed. Packets Delivery Ratio (PDR) graphs show the comparative results for all channels. When the packet size is small the PDR of 3_Sub Channel and 5_Sub channel multi channel MAC protocols scheme is about 98-99% as from figure when we increase the packet size the PDR of single, 3_Sub_Channel and 5_Sub_Channel are affected. But from graph we know that the single channel is more affected because the larger packet longer airtime and collision is also more if we see the results on 512 and 1024 the graph is 35-40% because collision are more because of longer time But the results of 3_Sub_Channel and 5_Sub_Channel are best because the nodes are communicating on the different channels due to which little collision occurs. But in IEEE802.11 all nodes are communicating on the same channel. So collision chances are more. It means if we use the multi channel for communication it will best instead of the IEEE802.11.

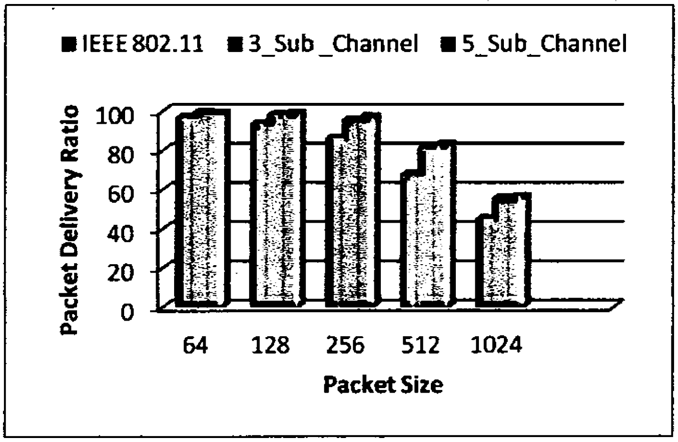

Figure 7.2: Results of Packet Delivery Ratio w.r.t varying PKT Size based on simulation.

7.4.2 Normalized Routing Load (NRL)

With various packet sizes we see the behavior of the IEEE802.11, 3_sub channel and 5_sub channel what will they performed. With various PKT size what will be the affect of overhead. When we send the small packet size the NRL is not affected because the collision chance is less but when we increase the packets size the NRL ratio increase because the collision occurs more because the larger packets have a longer time, due to collision the link fail and new routes will discovered for transmission. As from figure the NRL of multi channel, 3_sub channel and 5_subchannel scheme is less the NRL are unaffected with increase in packet size because the nodes are communicating on the different channel so collision chance is less. But on 512 and 1024 there is a lot of transmission which untimely increase the normalized routing load and energy consumption.

Increase in collision cause increase NRL. Because then again and again routing packets are send to discover the new rout route for transmission.

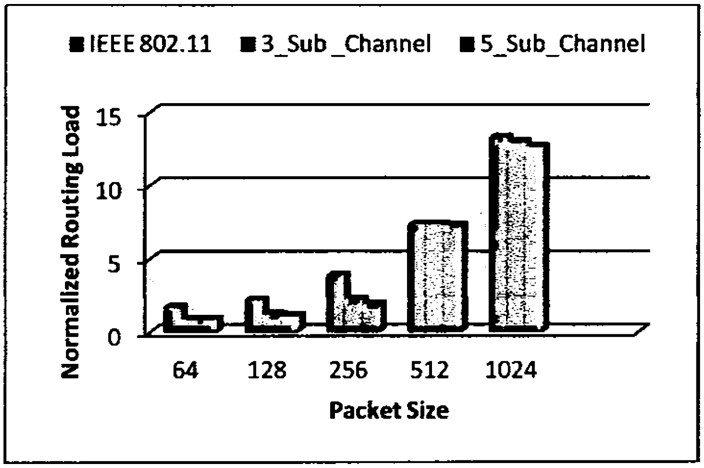

Figure 7.3: Results of Normalized Routing Load Ratio w.r.t varying PKT Size based on simulation.

7.4.3 Throughput

Throughput of the both protocol IEEE802.11 and 3_Sub_Channel and 5_Sub_Channel scheme is increased due to increase in packet size. The main reason is when we increase the packet size it will carry the more bits.

The results of the 3_Sub_Channel and 5_Sub_Channel is efficient because the nodes are communicating on the sub channels at the same time so more data are delivered in less time. In the IEEE802.11the throughput is affected to longer transmission time because the larger packets take longer time in transmission. But the throughput graph increase in IEEE802.11 when we increase the packet size it will sure that larger packets take longer transmission but also the large packet carry more bits so the throughput increase because the more data is delivered to the destination. The below graph show the comparative results of the channels. The results of 3_Sub_Channel and 5_Sub_Channel are best when we increase the packets size. It means to achieve the maximum throughput we use multi channel for the communication because at the same time communication will done on multi channel and more data is delivered to the target position.

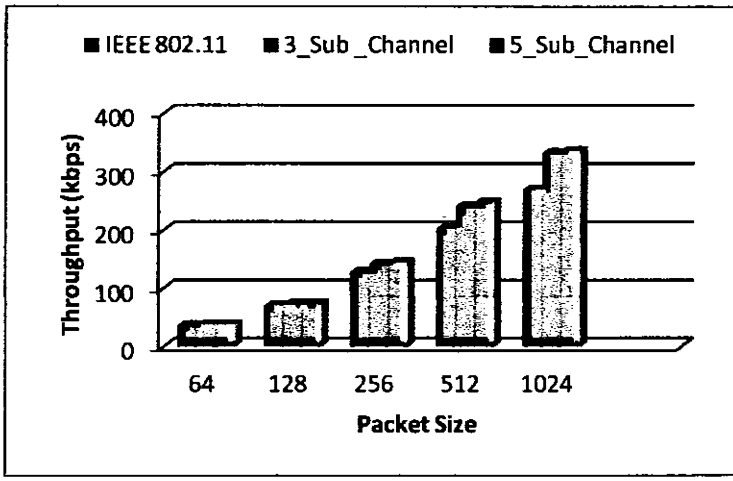

Figure 7.4: Results of Throughput Ratio w.r.t varying PKT Size based on simulation.

7.4.4 Delay

Average Delay of single MAC protocol is increased with the increased in packet size as from figure the reason of increased is because of the longer transmission time due to which collision occurs more because the network become congested. The delay also depends on link capacity if we used the IEEE802.11 for transmission the delay will occur and also we increase the packet size then delay chance is more and also the large packet take longer transmission time as compared to small packet. So when we increase the packet size delay increase but the performance of Multi channel MAC protocols scheme 3_sub channel and 5_sub channel is best as shown in the graph. Because here no longer transmission because the nodes are communicating at the different channel. But delay on packet size 512 and 1024 are more but the result is some better as compare to single channel the main reason is sub channels.

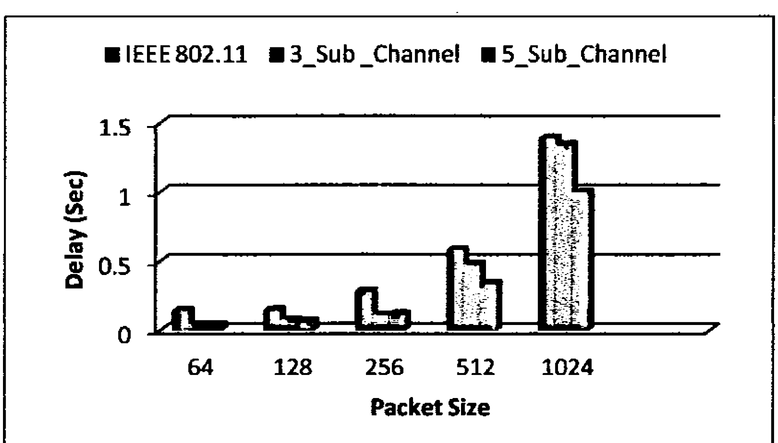

Figure 7.5: Results of Delay Ratio w.r.t varying PKT Size based on simulation.

7.4.5 Energy Consumption

The results in graph show the energy consumption comparison. When the packet size increase the 3_sub_channel and 5_sub_channel energy consumption is more because when the nodes are communicating at different channel at the same time. It means that more bits are delivered at the same time. A lot of transmission is done due to which energy consumption are more but the IEEE802.11 energy consumption is less because at the same time one channel are used for communication so less number of transmission is done as compare 3 and 5_Sub_Channel.

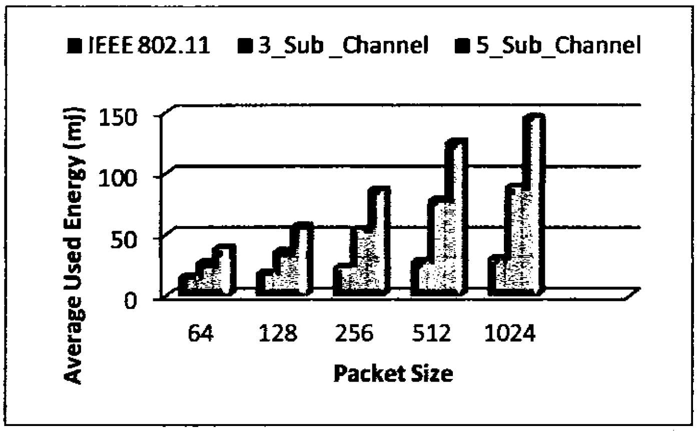

Figure 7.6: Results of Energy Consumption Ratio w.r.t varying PKT Size based on simulation.

7.5 Effect of Varying Flows

The purpose of these experiments was to test the performance of the both protocols to approve it to varying conditions is evaluated under varying stresses. This experiment helps us in thoughtful the maximum possible upper limit of these MAC protocols. Performance of the protocols is evaluated with flows5,10,15,20,25,30.Graph show the comparative results of the IEEE802.11and multi channel MAC Protocols scheme w.r.t to various number of flows to test their performance in congested situation.

7.5.1 Packet Delivery Ratio

The packet Delivery ratio result of multi channel Scheme 3_Sub_Channel and 5_Sub_Channel is well because the nodes are communicating on the different channels so congestion is less due to which collision chance as less as compare to IEEE 802.11. But the IEEE 802.11 result is best when we take the less number of flows but if we increase the number of flows then competition will occurs among the flows so congestion will occurs in network.

Due to which collision occurs more so the packets are drops. The relatively low PDR of single channel MAC protocol is because of its forceful reaction on link failure which results in failure of other established routes due to collision. In the more flows the IEEE802.11 PDR is more affected.

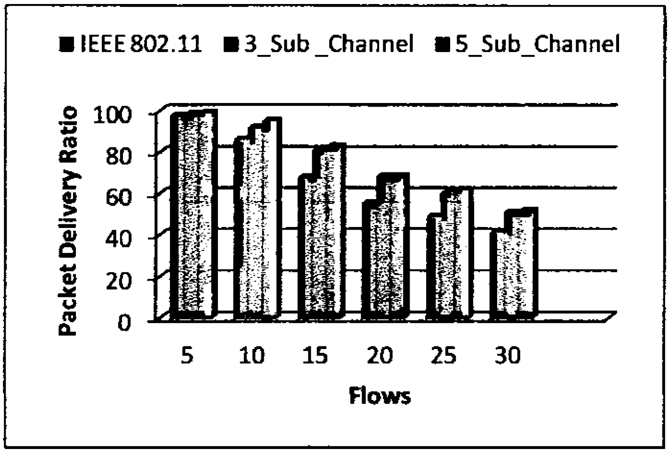

Figure 7.7: Results of Packet Delivery Ratio w.r.t varying no of Flows based on simulation.

7.5.2 Normalized Routing Load (NRL)

Normalized routing load increased when we increased the number of flows but the results of 3_Sub_channel and 5_Sub_channel are best from the IEEE802.11. Increasing the number of flows then congestion will occurs in IEEE802.11 MAC protocol so collision occurs due to which links fail then the protocol try to discover the new link for transmission. So the Routing packet ratio increased to discover the new link. On the flows 20, 25, 30 there is a lot of transmissions which ultimately increase NRL and energy consumption. It means when there is a lot transmission starts then the chance of collision are more when collision occurs more than NRL ratio increase and also energy expenditure are more.

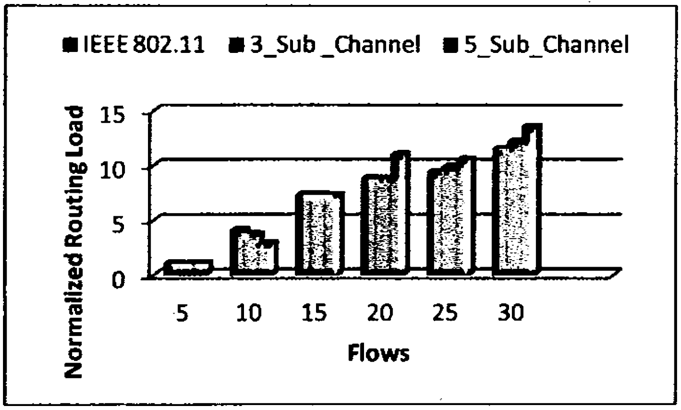

Figure 7.8: Results of Normalized Routing Load Ratio w.r.t varying no of Flows based on simulation.

7.5.3 Throughput

As for the graph the result of multi channel scheme such as 3_Sub_Channel and 5_Sub_Channel is best as compared to IEEE802.11 .When we increase the number of flows throughput of all flows increases as we are injecting more and more packets into network but the more bits are delivered the results of them is best because of reduced collisions as compare to the single flows if we see the graph as we increase the flows the throughput increase but the results of the IEEE802.11 is not well as compare to the 3 and 5 sub channel because in the IEEE802.11 collision chance are more. When flows increase congestion situation creates in IEEE802.11 due to which drops occurs but in 3_Sub_Channel and 5_Sub_Channel the congestion chance is less because the nodes are communicating on the sub channels.

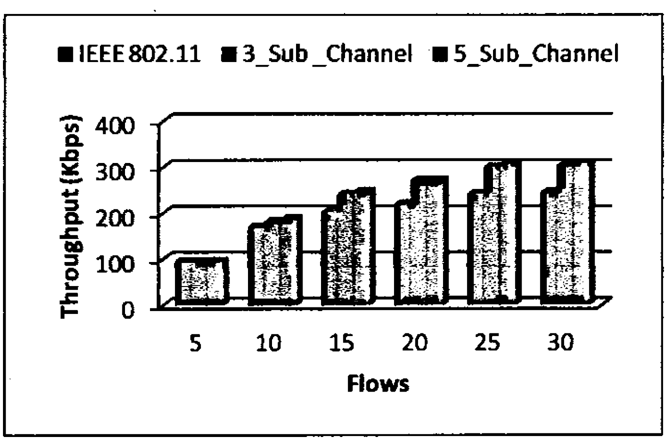

Figure 7.9: Results of Throughput Ratio w.r.t varying no of Flows based on simulation.

7.5.4 Delay

The Average Delay is increased when increased the number of flows as from the graph but the delay results of IEEE 802.11is best when we increase the numbers of flows it show us that with increase in no of channels delay is affected and increased. In other words more channels are not suitable when small delay is desirable.

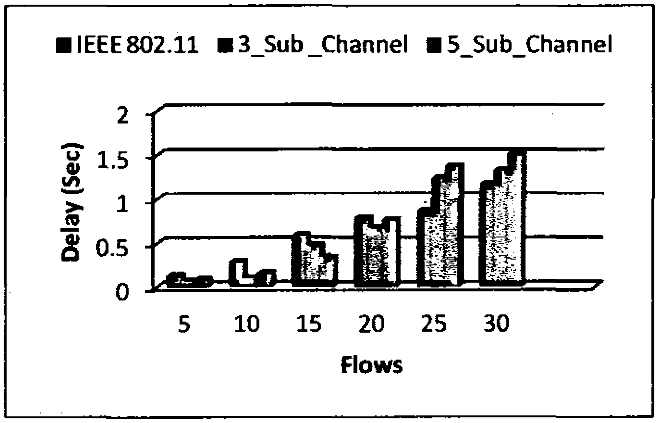

Figure 7.10: Results of Avg Delay Ratio w.r.t varying no of Flows based on simulation runs.

7.5.5 Energy Consumption

The results in graph show the energy consumption comparison. When the flows increase the 3_sub_channel and 5_sub_channel energy consumption is more because when the nodes are communicating at different channel at the same time a lot of transmissions are done at this time. It means that more bits are delivered at the same time. But the IEEE802.11 energy consumption is less because at the same time one channel are used for communication and the transmission ratio is less as compare to the 3 and 5_Sub_Channel.

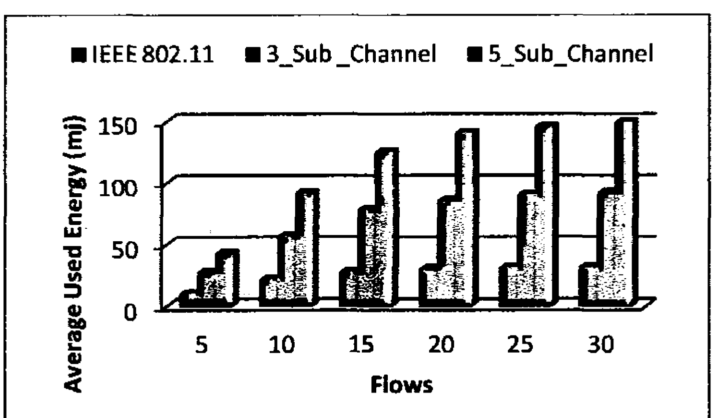

Figure 7.11: Results of Energy Consumption Ratio w.r.t varying no of Flows based on simulation.

We have discussed simulation setup very great detail. The purpose of this chapter to include in the dissertation is very critical. We have observed that student who are new in research have face while building healthy simulation for implementation and testing of the proposed solution. They have to spend a lot time to do this. By going through this chapter they can easily build a very healthy simulation setup as soon as possible.

In this chapter simulation in ns-2.33 has been shown. We have take the various performance parameters for comparison second also we check if we used the multi channel then how many channel will be suitable for network if we used the more channel what will effect on the network. Solution implemented in ns-2.33 has been dully run in NAM and EXAMS for taking results. Results meet our objectives. We see from the results if we use the more sub channel for communication we achieve the maximum throughput but the energy consumption are more.

Chapter 8
Conclusion and Future

Conclusion and Future

8.1 Conclusion

In this thesis Multi Channel Scheme has been planned for mobile Adhoc networks. The proposed scheme offers a simple and light weight mechanism for solving the problem of channel reservation in multi-channel MAC protocols. The key attribute of our technique is the Zero control overhead is involved, reduced collision and the channel utilization is best. The performance of the Single channel has been compared with that of the proposed Multi channel scheme under various parameters in the latest simulation environment NS-2. It is observed that the performance of proposed multi channel scheme outperform then Single Channel MAC protocol in the various. From all these experiments it is accomplished that proposed Multi Channel scheme provides the best solution for mobile ad hoc networks.

8.2 Future work

Perfection is elusive. We are looking forward to extend the current work in two directions. First, although our proposed scheme has improved the performance of traditional MAC protocol but, its real gain will be revealed when compared against some existing multi channel protocols. As ns-2 code of any multi channel protocol is not available, so we will implement some selected multi channel protocols for comprehensive analysis. Secondly, proposed scheme channel assignment is based on a simple formula that does not guarantee selection of a distinct channel for neighboring nodes. We need some how to modify the scheme to overcome its inherited problem.

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