Multicasting in MANET for near Real Time Systems

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AHMEDABAD-382481

May 2012

Multicasting in MANET for near Real Time Systems

Major Project

Submitted in partial fulfillment of the requirements

For the degree of

Master of Technology in Computer Science and Engineering

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May 2012

Declaration

I,**Vikas N.Tulshyan,10MCEC20,** give undertaking that the Major Project entitled "**Multicasting in MANET for near Real Time Systems"** submitted by me,towards the partial fulfillment of the requirements for the degree of Master of Technology in Institute of Technology of Nirma University,Ahmedabad,is the original work carried out by me and I give asssurance that no attempt of plagiarism has been made.I undertsand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere,it will result in severe disciplinary action.

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This is to certify that the Major Project entitled "Multicasting in MANET for near Real Time Systems" submitted by Vikas Tulshyan (10MCEC20), towards the partial fulfillment of the requirements for the degree of Master of Technology in Computer Science and Engineering of Nirma University of Science and Technology, Ahmedabad is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Acknowledgements

I am deeply indebted to my thesis guide **Prof. Zunnun Narmawala** for his constant guidance and motivation. He has devoted significant amount of his valuable time to plan and discuss the thesis work. Without his experience and insights, it would have been very difficult to do quality work.I would like to extend my gratitude to Prof. Zunnun Narmawala for his continuous encouragement.

I would also like to extend my gratitude to **Dr.S.N.Pradhan**,Professor and PG-Coordinator of Department of Computer Engineering,Institute of Technology,Nirma University,Ahmedabad for an exceptional support and continual encouragement throughout the Project.

I am also thankful to members of my class for their delightful company which kept me in good humor throughout the year. Last, but not the least, no words are enough to acknowledge constant support and sacrifices of my family members because of whom this becomes possible.

- Vikas N. Tulshyan

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Abstract

A mobile ad-hoc network (MANET) is composed of mobile nodes. MANET is not having any infrastructure. Mobile nodes self-organize to form a network over radio links. The goal of MANETs is to extend mobility into the realm of autonomous, mobile and wireless domains, where a set of nodes form the network routing infrastructure in an ad-hoc fashion. Many Applications of MANET are in areas where rapid deployment and dynamic reconfiguration are necessary and even wired network is not available. These includes Real Time Systems like military battlefields, emergency search, rescue sites, classrooms and conventions,where participants share information dynamically using their mobile devices. These applications lend themselves well to multicast operations.

Multicasting can improve the efficiency of the wireless link when sending multiple copies of messages by exploiting the inherent broadcast property of wireless transmission. Hence, reliable multicast routing plays a significant role in MANETs. There is a comparative study of various multicasting routing protocols. On Demand Multicast Routing Protocol(ODMRP) is well suited for near Real Time Systems. Concept of Network Coding is introduced in existing ODMRP multicast protocol. The performance measures to be evaluated are the Packet Delivery Ratio, Throughput and Delay. ODMRP with Network Coding improves Packet Delivery Ratio, Throughput and Delay.

Keywords: Mobile ad-hoc network(MANET), Multicast Routing Protocol, Network Coding.

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Chapter 1

Introduction

1.1 Multicasting

1.1.1 Definition

Multicasting is the transmission of packets to a group of zero or more hosts identified by a single destination address. Multicasting is intended for group-oriented computing, where the membership of a host group is typically dynamic that is,hosts may join and leave groups at any time. There is no restriction on the location or number of members in a host group. A host may be a member of more than one group at a time. Also, a host does not have to be a member of a group to send packets to the members in the group.

1.1.2 Two Multicast Schemes in Wired Network

- Shortest Path Multicast Tree
- Core Based Tree

Shortest Path Multicast Tree

The shortest path multicast tree method guarantees the shortest path to each destination, but each source has to build a tree. Therefore, too many trees exist in the network.

Core Based Tree

The core-based tree method cannot guarantee the shortest path from a source to a destination, but only one tree is required to be constructed for each group. Therefore, the number of trees is greatly reduced.

1.2 MANET

1.2.1 Definition

A MANET includes a number of geographically distributed, potentially mobile nodes connected by wireless links. Compared with other types of networks, such as cellular networks or satellite networks, the most distinctive feature of MANETs is the lack of any fixed infrastructure. The network is formed of mobile nodes, and is created on the fly as the nodes communicate with each other.The network does not depend on a particular node, and it dynamically adjusts as some nodes join or others leave the network.

The communication network, formed by a union of the links between these nodes,is called a MANET. A MANET can either be a standalone entity or an extension of a wired network.[2]

MANET nodes are equipped with wireless transmitters and receivers using antennas which may be omnidirectional (broadcast), highly-directional (point-to-point), possibly steerable, or some combination thereof. At a given point in time, depending on the nodes' positions and their transmitter and receiver coverage patterns, transmission power levels and co-channel interference levels, a wireless connectivity in the form of a random, multihop graph or "ad hoc" network exists between the nodes. This ad hoc topology may change with time as the nodes move or adjust their transmission and reception parameters.

1.2.2 Characteristics of MANET

1) Dynamic topologies: Nodes are free to move arbitrarily and thus the network topology which is typically multihop may change randomly and rapidly at unpredictable times, and may consist of both bidirectional and unidirectional links.[3]

2) Bandwidth-constrained, variable capacity links: Wireless links will continue to have significantly lower capacity than their hardwired counterparts. In addition, the realized throughput of wireless communications after accounting for the effects of multiple access, fading, and interference conditions, is often much less than a radio's maximum transmission rate.[3]

One effect of the relatively low to moderate link capacities is that congestion is typically the norm rather than the exception, i.e. aggregate application demand will likely approach or exceed network capacity frequently. As the mobile network is often simply an extension of the fixed network infrastructure, mobile ad hoc users will demand similar services. These demands will continue to increase as multimedia computing and collaborative networking applications rise.

3) Energy-constrained operation: Some or all of the nodes in a MANET may rely on batteries or other exhaustible means for their energy. For these nodes, the most important system design criteria for optimization may be energy conservation.[3]

4) Limited physical security: Mobile wireless networks are generally more prone to physical security threats than are fixed cable nets.The increased possibility of eavesdropping, spoofing, and denial-of-service attacks should be carefully considered.Existing link security techniques are often applied within wireless networks to reduce security threats. As a benefit, the decentralized nature of network control in MANETs provides additional robustness against the single points of failure of more centralized approaches.[3]

1.2.3 Applications of MANET

- In a hostile environment where a fixed communication infrastructure is unreliable or unavailable, such as in a battlefield.

- Support for search and rescue missions in areas with little or no wireless infrastructure support.

- Replacement for the destroyed infrastructure in disaster relief operations.

- Provide support for people and applications to exchange data in the field or in a classroom without using any network structure except that which they create by simply turning on their computers or PDAs.

Chapter 2

Literature Survey

2.1 Multicast Routing Protocols

Routing protocols typically fall under two classifications;first one is unicast Routing Protocol, second one is multicast Routing Protocol. Different routing protocols try to solve the problem of routing in mobile ad hoc network in one way or the other.Both Unicast and Multicast routing protocols are divided into proactive,reactive and hybrid routing protocols.

2.2 Three Categories of Multicast Routing Protocol

- Proactive Multicast Routing Protocols
- Reactive Multicast Routing Protocols
- Hybrid Multicast Routing Protocols

2.2.1 Proactive Multicast Routing Protocols

Proactive routing means route available immediately. Conventional routing protocols such as Ad-hoc Multicast Routing (AMRoute), Core-Assisted Mesh Protocol(CAMP) and Ad-hoc Multicast Routing Protocol Utilizing Increasing id-numbers (AMRIS) are proactive multicast routing protocols. Periodic broadcast of network topology updates are needed to compute the shortest path from the source to every destination, which consumes a lot of bandwidth.

1. Ad-hoc Multicast Routing (AMRoute)

Ad-hoc Multicast Routing (AMRoute) [6] is a tree based multicast routing protocol for mobile ad hoc networks.AMRoute creates a multicast shared-tree over mesh.AMRoute relies on the existence of an underlying unicast routing protocol. AMRoute has two key phases: mesh creation and tree creation. This protocol can be used for networks in which only a set of nodes supports AMRouterouting function. It is only one logical core in the multicast tree, which is responsible for group member maintenance and multicast tree creation. In this routing protocol builds a user- multicast tree, in which only the group members are included; because non-members are not included in the tree, the links in the tree are virtual links.

AMRoute creates an efficient and robust shared tree for each group. It helps keep the multicast delivery tree unchanged with changes of network topology, as long as paths between tree members and core nodes exist via mesh links. When mobility is present, AMRoute suffers from loop formation, creates nonoptimal trees, and requires higher overhead to assign a new core. Also, AMRoute suffers from a single point of failure of the core node [2].

2. Ad hoc Multicast Routing Protocol Utilizing Increasing id-numbers (AMRIS) AMRIS [2] is a proactive shared tree based multicast routing protocol, which is independent of the fundamental unicast routing protocol. In AMRIS, the tree maintenance procedure operates continuously and locally to ensure a nodes connection to the multicast session delivery tree. AMRIS is an ondemand protocol that constructs a shared delivery tree to support multiple senders and receivers within a multicast session.

AMRIS dynamically assigns every node (ondemand) in a multicast session with an ID number known as msm-id. The msm-id provides a heuristic height to a node and the ranking order of msm-id numbers directs the flow of datagram in the multicast delivery tree. Every node calculates its msm-id during the initialization phase, which is initiated by a special node called S-id. Normally, the S-id is the source node if there is only one source for the session. Otherwise, the S-id is the source node that has the minimum msm-id. The S-id broadcasts a NEW-SESSION message to its neighbors. When a node wants to join the multicast session, it chooses one of its neighbors which has the smaller msm-id as its parent and send it a JOIN-REQ message.

If the neighbor is in the tree (if the tree has been built), it answers with a JOIN-ACK message, which means the joining is successful; otherwise (when it is the first time to build the tree), the neighbor forwards JOIN-REQ to its own neighbors and waits for the reply, which is repeated until the JOIN-REQ arrives at an on-tree node or the source. As a result, a delivery tree rooted from the source is formed to include all the group members and some relay non-members. AMRIS repairs the broken links by performing local route repair without the need for any central controlling node, thereby reducing the control overhead[2].

3. **Core-Assisted Mesh protocol (CAMP)** Core-Assisted Mesh protocol (CAMP) is a proactive multicast routing protocol based on shared meshes. The mesh structure provides at least one path from each source to each receiver in the multicast group. CAMP relies on an underlying unicast protocol which can provide correct distances to all destinations within finite

time. Every node maintains a Routing Table (RT) that is created by the underlying unicast routing protocol.

CAMP modifies this table when a multicast group joins or leaves the network. A Multicast Routing Table (MRT) is based on the Routing Table that contains the set of known groups. Moreover, all member nodes maintain a set of caches that contain previously seen data packet information and unacknowledged membership requests. The creation and maintenance of meshes are main parts of CAMP[2].

2.2.2 Reactive Multicast Routing Protocols

Reactive routing means discovers the route when needed. Traditional routing protocols such as On-Demand Multicast Routing Protocol (ODMRP) and Multicast Adhoc on-demand Distance Vector (MAODV) are Reactive multicast routing protocols. Reactive routing protocols are well suited for a large-scale, narrow-band MANET with moderate or low mobility.

1.On-Demand Multicast Routing Protocol (ODMRP)

On-Demand Multicast Routing Protocol (ODMRP) [2] is a reactive mesh based multicast routing protocol. ODMRP is not only a multicast routing protocol, but also provides unicast routing capability.The source establishes and maintains group membership and multicast mesh on demand if it needs to send data packets to the multicast group, which is somewhat similar to MAODV. A set of nodes, which is called forwarding group, participate in forwarding data packets among group members. All the states in ODMRP are soft states, which are refreshed by the control messages mentioned above or data packets, which achieves higher robustness.

ODMRP uses a forwarding group concept for multicast packet transmission, in which each multicast group G is associated with a forwarding group (FG). Nodes in FG are in charge of forwarding multicast packets of group G. In a multicast group of ODMRP, the source manages the group membership, establishes and updates the multicast routes on demand. Like reactive unicast routing protocols, ODMPR comprises two main phases: the request phase and the reply phase.

When a multicast source has a packet to send but it has no routing and group membership information, it floods a Join Request packet to the entire network. Join Request packets are member-advertising packets with piggybacked data payload. When a node receives a non-duplicate JOIN Request, it stores the upstream node ID in its routing table and rebroadcasts the packet. When the JOIN Request packet reaches a multicast receiver, the receiver refreshes or creates an entry for the source in Member Table and broadcasts JOIN TABLE packets periodically to its neighbors. When a node receives a JOIN TABLE packet, it checks each entry of the table to find out if there is an entry in the table whose next node ID field matches its ID.

If there is a match, the node recognizes that it is on the path to the source, thus it is part of the forwarding group. Then it sets the FG-FLAG and broadcasts its own JOIN TABLE built upon matched entries. Consequently, each member of a forwarding group propagates the JOIN TABLE packets until the multicast source is reached via the shortest path. This process constructs (or updates) the routes from sources to receivers and builds a mesh of nodes, the forwarding group.

2. Multicast Ad-hoc On-demand Distance Vector (MAODV)

Multicast operation of Ad-hoc On-demand Distance Vector (MAODV) [2] is a reactive tree-based multicast routing protocol. MAODV is an extension of the unicast routin protocol Ad-hoc On-demand Distance Vector (AODV). Using MAODV, all nodes in the network maintain local connectivity by broadcasting Hello messages with TTL set to one. Every node maintains three tables, a Routing Table (RT), a Multicast Routing Table (MRT) and a Request Table. RT stores routing information and has the same function as in AODV. In unicast routing operations, every destination has a unique sequence number. Likewise, every multicast group also has a sequence number to indicate the freshness of the multicast routing information.

Thus, one and only one group leader is elected to broadcast periodical GROUP HELLO messages throughout the MANET to maintain the sequence number. The group leader is by default the first node joining the group, but could also be another node when the first node leaves the group.

The main drawbacks of MAODV are long delays and high overheads associated with fixing broken links in conditions of high mobility and traffic load. Also, it has a low packet delivery ratio in scenarios with high mobility, large numbers of members, or a high traffic load. Because of its dependence on AODV, MAODV is not flexible. Finally, it suffers from a single point of failure, which is the multicast group leader.[2]

2.2.3 Hybrid Multicast Routing Protocols

Hybrid routing means combination of both, such as proactive for neighborhood,reactive for far away. Traditional routing protocol such as Optimized Polymorphic Hybrid Multicast Routing Protocol (OPHMR) is the Hybrid multicast routing protocol.

1. Optimized Polymorphic Hybrid Multicast Routing Protocol (OPHMR)

This protocol [2] is invested with different operational modes that are either proactive or reactive based on a MNs power remainder, mobility level, and vicinity density level. It attempts to address the issues of power efficiency, latency, and protocol overhead in an adaptive manner. OPHMRs reactive behaviour is based on the On-Demand Multicast Routing Protocol (ODMRP). Its relatively simplistic. It generates on-demand route paths for multicast message requests.

OPHMRs proactive behaviour is based on the Multicast Zone Routing

(MZR) protocol. It builds a zone around each Mobile Node (in hops) and periodically sends updates within each defined zone. For added efficiency, OPHMR utilizes an optimizing scheme adapted from the Optimized Link State Routing (OLSR) protocol. It used to decrease the amount of control overhead that is produced. OPHMR is, after a very lengthy period of time, able to extend battery life and enhance the survivability of the mobile ad hoc nodes. As a result, it decreases the end-to-end delay and increases the packet delivery ratio.

2.3 Summary

Table 2.1: Comparison of Multicast Routing Protocols
(taken from [2])

	AMROUTE	**AMRIS**	**CAMP**	**ODMRP**	**MAODV**
Structure of Multicast delivery	Tree	Tree	Mesh	Mesh	Tree
Loop Free	No	Yes	Yes	Yes	Yes
Scalability	Fair	Fair	Good	Fair	Fair
Dependency of Unicast Protocol	Yes	No	Yes	–	–
Periodic Message Requirement	Yes	Yes	Yes	Yes	No

2.4 Network Coding

Network coding is a method of optimizing the flow of digital data in a network by transmitting digital evidence about messages. The ”digital evidence” is, itself, a composite of two or more messages. When the bits of digital evidence arrive at the destination, the transmitted message is deduced rather than directly reassembled.

The core concept of Network Coding is to allow encoding of data packets at intermediate nodes and a receiver decodes original data when it gets enough encoded packets.Ahlswede et al.[4] who showed that the multicast capacity can be achieved by Network Coding mixing information from different flows. In Network coding, instead of forwarding packets as it is, nodes may recombine two or more input packets into one or more output packets. Li et al. in [5] showed that linear coding with finite field size suffices to achieve max-flow from the source to each destination.

In [3], Christina Fragouli. proved that linear coding obtains the multicast capacity bound,in addition, Ho et al. showed that random coefficients over a sufficiently large finite field can be adopted to reach the capacity bound.The random coefficients are determined in a distributed manner by random linear coding.

2.4.1 Random Linear Network Coding

We assume that each packet contains L bits. If packets to be combined are not of the same size, smaller packets are padded with trailing zeros. s consecutive bits of a packet can be interpreted as a symbol over the field F_{2^s} . i.e., each packet consists of a vector of L/s symbols. Outgoing packet at each node is linear combination of incoming packets or generated packets at that node where addition and multiplication operations are performed over the field F_{2^s} . The encoded packet also contains L bits. So an encoded packet contains information about all original packets and multiple such packets can be generated. In effect, information of an original packet is spread into number of encoded packets.

Chapter 3

Study of Network Simulator: NS-2

3.1 NS-2

NS-2 is an open source system that is developed using C++ and Tool Control Language TCL. Researchers can freely add new components to the system to serve their own purposes. It provides support for IP protocols suite and many standard routing protocols for wire and wireless networks. There are unicast and multicast routing protocols for wire network and DSR, DSDV, AODV,MAODV,ODMRP for wireless networks.

The network simulator (NS), which is a discrete event simulator for networks, is a simulated program developed by VINT (Virtual InterNetwork Testbed) project group (A Collaboration among USC/ISI, Xerox PARC, LBNL, and UCB). It supports simulations of TCP and UDP, some of MAC layer protocols, various routing and multicast protocols over both wired and wireless network etc. The basic structure of NS-2 is as shown in figure.

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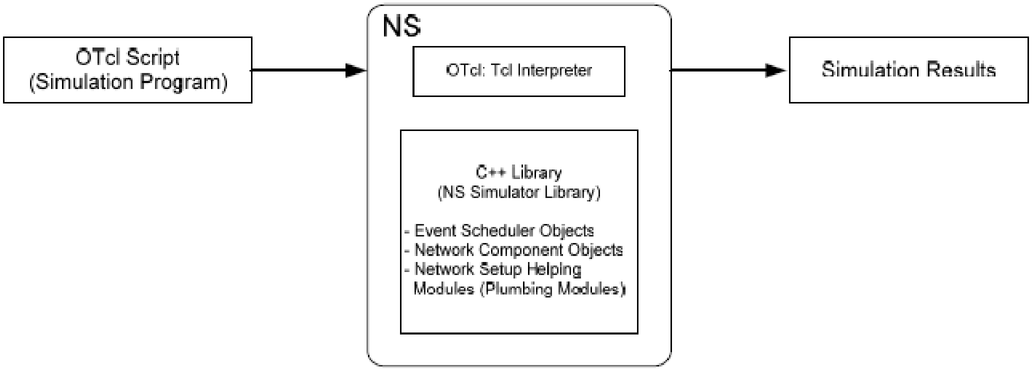

Figure 3.1: Basic Structure Of Ns-2[7]

layer protocols, various routing and multicast protocols over both wired and wireless network etc. The basic structure of NS-2 is as shown in figure 7.1.

Basic structure of NS: To setup and run a simulation, a user writes an OTcl script, which is a simulation program to initiate an event scheduler, set up the network topology using the network objects and plumbing functions in the library, and to tell traffic sources when to start and stop transmitting packets through the event scheduler. When NS-2 which works as OTcl interpreter receives the OTcl script, it will set environment parameters following the received script. If a user wants to make a new network object, it will be easy to make a compound object from the object library, and plumb the data path through the object rather than write a new one. When the simulation is finished, the simulation results are produced in one or more text-based output files that contain detailed simulation data, which can be used to analyze directly.

3.2 Model of Wireless Mobile Node

3.2.1 Basic wireless mobile node

Figure shows the model of a basic wireless model in ns. Each mobile node makes use of a routing agent for the purpose of calculating routes to other nodes in the ad hoc network. Packets are sent from the application and are received by the routing agent.The agent decides a path that the packet must travel to reach its destination. It then sends the packet down to the link layer.The link layer uses an Adress resolution protocol (ARP)to decide the hardware addresses of neighbouring nodes and map IP addresses to their correct interfaces.

When this information is known, the packet is sent down to the interface queue and awaits a signal from the MAC layer. When the MAC layer decides it is ok to send it onto the channel,it fetches the packet from the queue and hands it over to the network interface which in turn sends the packet onto the radio channel. this packet is copied and delivered to all the network interfaces at the time at which the first bit of the packet would begin arriving at the interface in a physical system. Each network interface stamps the packet with the recieving interface properties and the invokes the propagation model. The propagation model uses the transmit and recieves stamps to determine the power with which the interface will recieve the packet. The recieving interface then uses the packets properties to determine if it successfully received the packet, and sends it to the MAC layer if appropriate. If the MAC layer receives the packet error free and collision free, it passes the packet to the mobile nodes entry point.

From there it reaches a demultiplexer, that decides if the packet should be forwarded again, or if it has reached its destination node. If the destination node is reached, the packet is sent to a port demultiplexer which decides the application to which the packet should be delivered.If the packet should be forwarded again, the routing agent will be called and the procedure will be repeated.

3.2.2 ODMRP Agent

Figure shows the modification we made to the basic wireless mobile node structure to support ODMRP. We make the ODMRP agent the entry point of the node.This enables the agent to overhear all the packets on the chan-

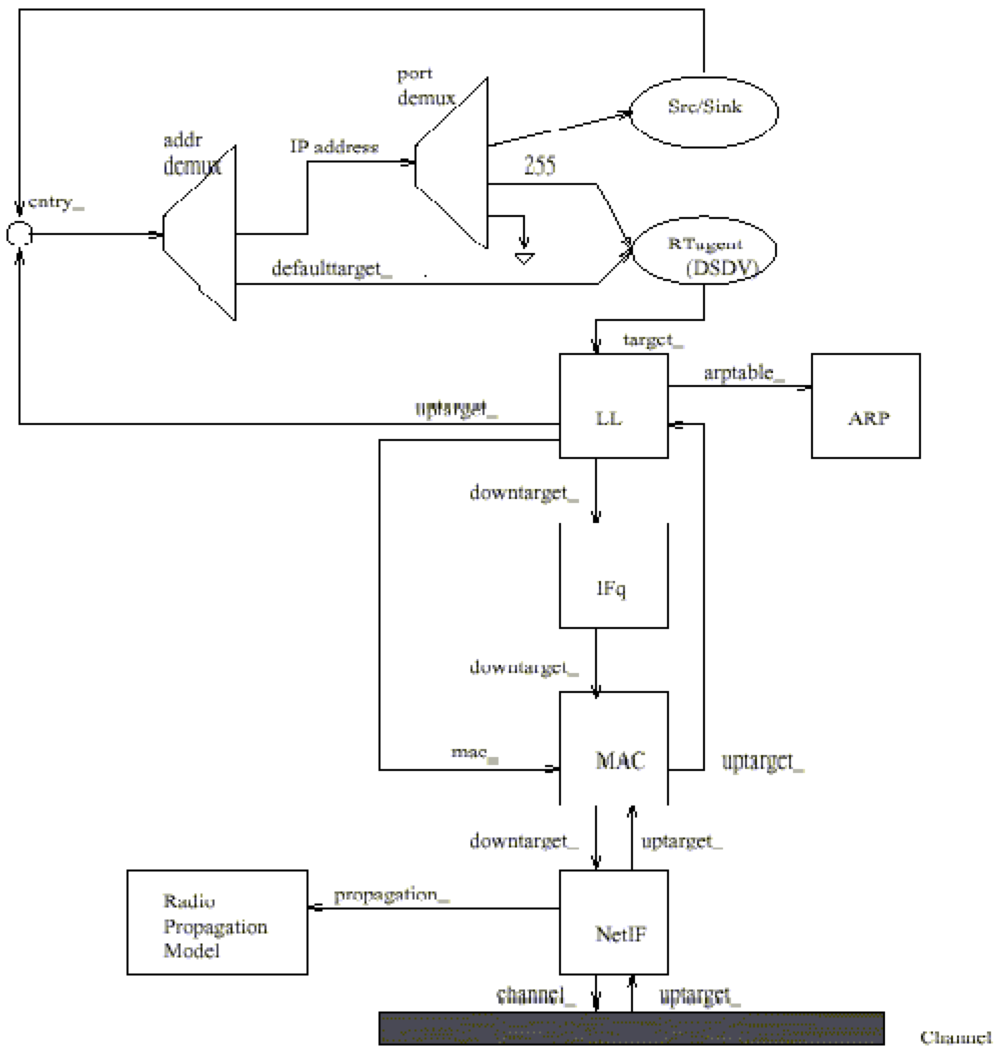

Figure 3.2: Model of Basic Wireless mobile node[7]

nel by tapping into the MAC layer. This is needed to support the pasive acknowledgement feature of ODMRP which enables the reliable delivery of JOIN REPLY messages.

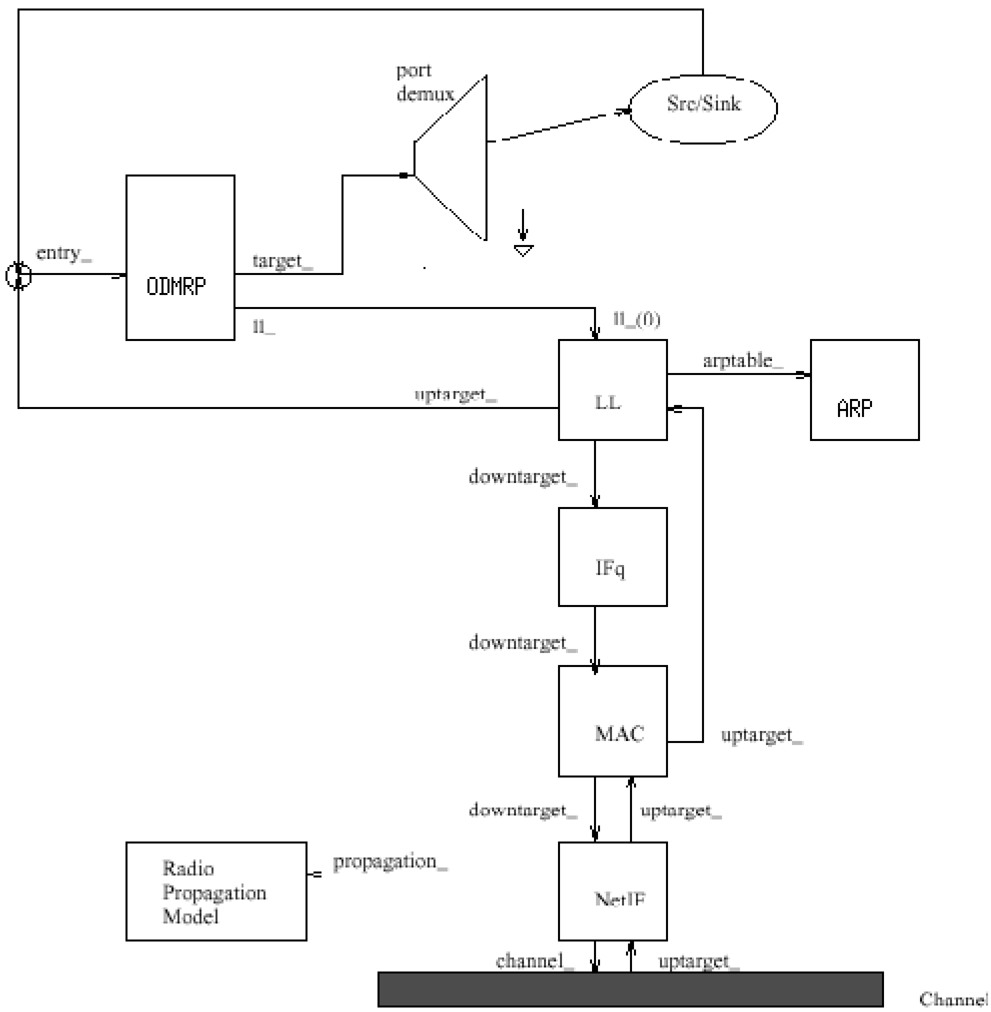

Figure 3.3: Model of an ODMRP Agent[7]

Chapter 4

Proposed Algorithm

4.1 Algorithm

In the existing protocol, ODMRP, after route construct process between source and destination, multicast source start to transmit packets. But the route from source to destination may be failed due to dynamic nature of the network. Thus the packet is lost and the routing process should start again to find a new route. This procedure causes PDR reduction. Now in order to increase the PDR, in the dynamic network we introduce the concept of network coding as shown in below figure.

The route discovery for the first time happens in a regular way. Once the route discovery happens, the source starts to transmit packet using network coding mechanism. The source encodes the packets by taking the dot product of randomly generated co-efficient and first byte of each packet.

This encoded packet is then forwarded to intermediate node selected using ODMRP. The intermediate node upon receiving the encoded packet, re-encodes it with its own random co-efficient, and forwards to its intermediate neighbors, not only to those who are in the shortest path, but to all. A re-encoded packet is generated of the generation which has the maxi-

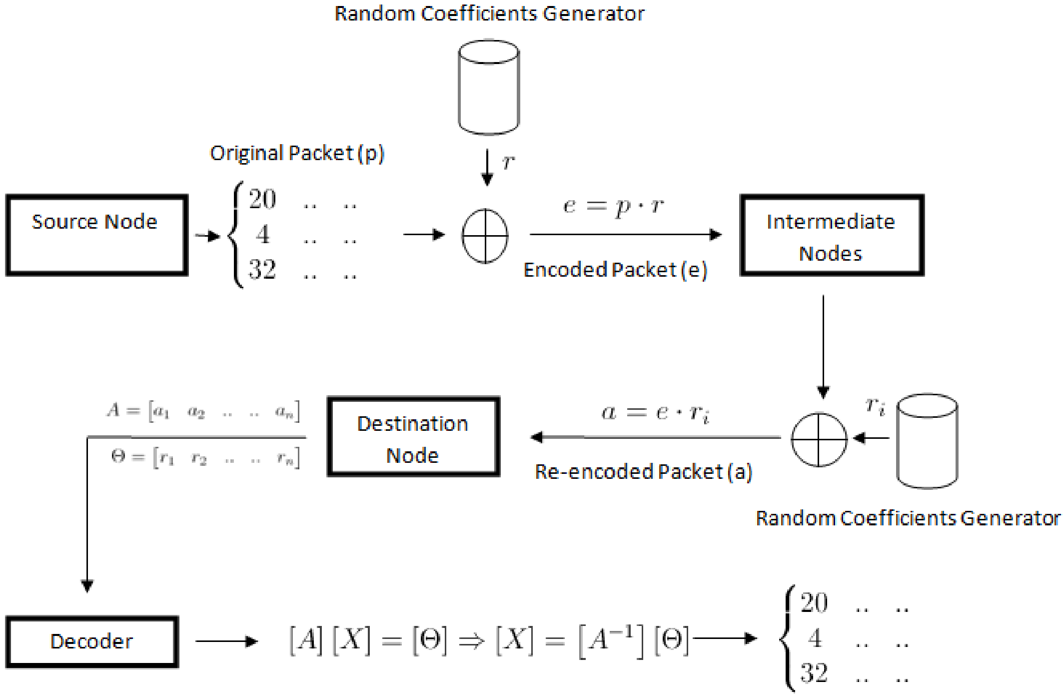

Figure 4.1: Block Diagram

mum number of encoded packets to be sent. The re-encoded packet is the mixture of all the independent packets stored at the node for the generation.

Hence using this concept, even in the dynamic nature of the network, the destination node can receive encoded packets from one or other nodes.

This increases the PDR, as the packets sent by the source are always present in the network. Also the packets are not redundant; hence the packets dont get dropped also.

The destination node upon receiving m linearly independent encoded vectors, decodes the system using the following mechanism.

Let the received the set be

$$\left(r^1, a^1\right), ..., (r^n, a^n)$$

. In order to retrieve the original packets, it needs to solve the system

$$X = A^{-1} \cdot \Theta.$$

This is a linear system with m equations and n unknowns. We need

$$m \geq n$$

to have a chance of recovering all data, i.e., the number of received packets needs to be at least as large as the number of original packets. Conversely, the condition

$$m \geq n$$

is not sufficient, as some of the combinations might be linearly dependent.

Chapter 5

Results

5.1 Simulation Environment

We have simulated the protocol in NS2 Simulator. A network contains 100 nodes which moves according to Random Way Point model.Simulation duration is 100 sec. The mobility model uses a random waypoint model with 50 nodes. Here each node starts its journey from a random location to a random destination with a randomly chosen speed from 20mps to 80 mps. Note that this is a fairly high speed for an ad-hoc network, comparable to traffic speeds inside a city. Once the destination is reached, another random destination is targeted after a pause. When the node reaches the simulation terrain boundary, it bounces back and continues to move.

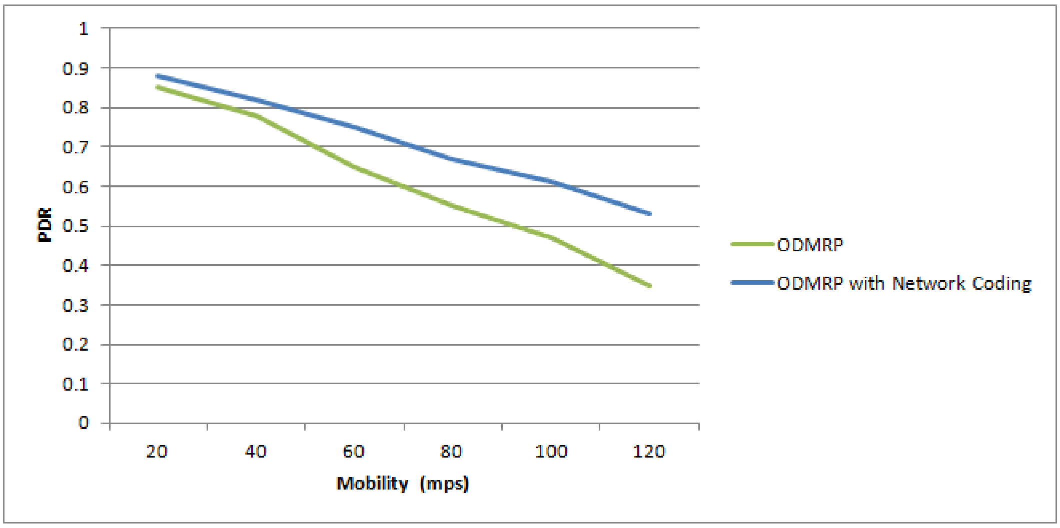

Figure 5.1: PDR vs Mobility

5.2 Simulation Results

When we have simulated the existing ODMRP protocol and compared it with the concept of Network Coding the results are as shown in the graph. From the results, it is clear that as mobility increases, the Packet delivery ratio improves. The performance of algorithm with Network coding is approximately 13 to 16% better than existing ODMRP Protocol at a mobile speed in the range of 70 to 100 m/s.

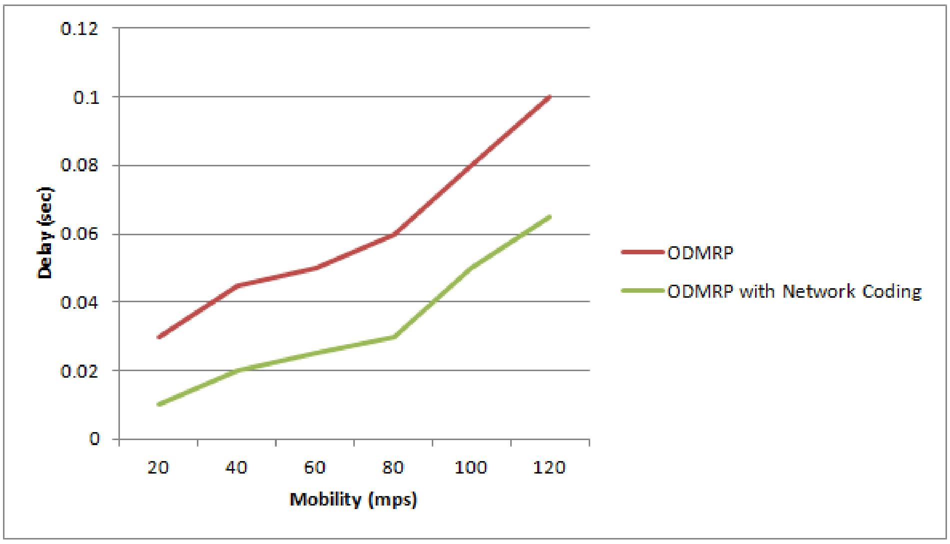

Figure 5.2: Delay vs Mobility

From the results shown in figure, when delay is measured against Mobility with existing ODMRP Protocol,there is 3ms to 10ms delay in the mobility of 20 to 80mps.When same is simulated with network Coding concept it is improved. .

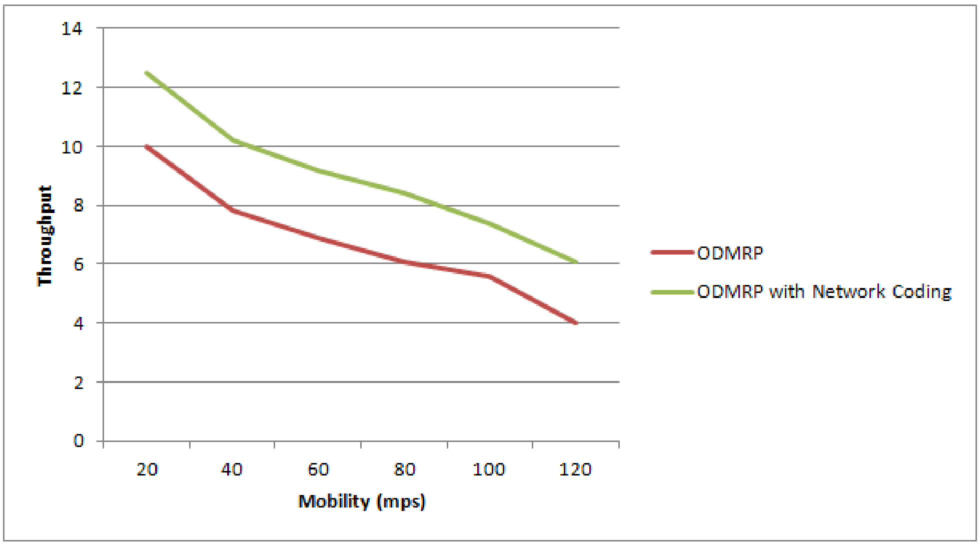

Figure 5.3: Throughput vs Mobility

As shown in graph throughput decreases with increase in mobility.As mobility increases the throuhgput goes from 10kb/s to 5 kb/s. When Network coding is implemented then it improves.

Chapter 6

Conclusion

6.1 Conclusion

ODMRP is on-demand and mesh based protocol that forwards data packets from source to destination with creating mesh. Three Performance Metrics Packet Delivery Ratio,Throughput and Delay were measured. By using Network Coding concept in existing ODMRP protocol improves all the three metrics.

6.2 Future Work

We intend to find the Optimal Generation Size as a function of packet delivery ratio,delay and throughput empirically. Also try to prevent excess amount of route discovery for dynamic network changes.

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