Mobility Aware MANET Routing Protocol Using Cross Layer Design Approach

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Mobility Aware MANET Routing Protocol Using Cross Layer Design Approach

Major Project

Submitted in partial fulfillment of the requirements

For the degree of

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By

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Guided By

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Declaration

I, **Dhwani Bhavsar**, **10MCEC02**, give undertaking that the Major Project entitled **"Mobility Aware MANET Routing Protocol Using Cross Layer Design Approach"** 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 assurance that no attempt of plagiarism has been made. I understand 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.

Dhwani Bhavsar

Certificate

This is to certify that the Major Project entitled ”Mobility aware MANET routing protocol using Cross Layer Design approach” submitted by Dhwani Bhavsar (10MCEC02), towards the fulfillment of the requirements for the degree of Master of Technology in Computer Science and Engineering of Nirma University, Ahmedabad is the record of work carried out by her 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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Abstract

Mobile Adhoc Network (MANET) is a dynamic network with time varying topology and time varying network resources. Due to the error-prone wireless channel and high mobility, traditional protocols of wired networks cannot be successfully applied to MANETs. The popularity of mobile and hand held devices equipped with wireless interface is creating a new challenge for Quality of Service. The wired network has also not been able to fulfill end-to-end guarantees. Due to the nature of MANETs, achieving the same end-to-end guarantees is very difficult. The mobility rate makes the task difficult. The aim is to fight against the losses caused due to mobility. This work attempts to build stable paths so as to counter the effects of mobility induced route failures.It attempts to implement a proactive protocol which uses Cross Layer Approach by using communication between Physical layer and Network layer. And the results will be compared with other protocols like AODV, DSDV in terms of throughput and packet delivery ratio.

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Abbreviations

AODV	Ad-hoc On-demand Distance Vector
CLD	Cross Layer Design
DBF	Distributed Bellman-Ford
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
FRTD	Full Routing Table Dump
IRU	Incremental Routing Update
MANET	Mobile Ad-hoc NETwork
MPR	Multi Point Relay
OLSR	Optimized Link State Routing

Chapter 1

Introduction

1.1 MANET Introduction

MANET is an autonomous collection of mobile users communicating over a relatively bandwidth constrained wireless link with limited battery power in highly dynamic environments.

Because of high mobility of nodes, each node is supposed to function as a transmitter, host and a router.

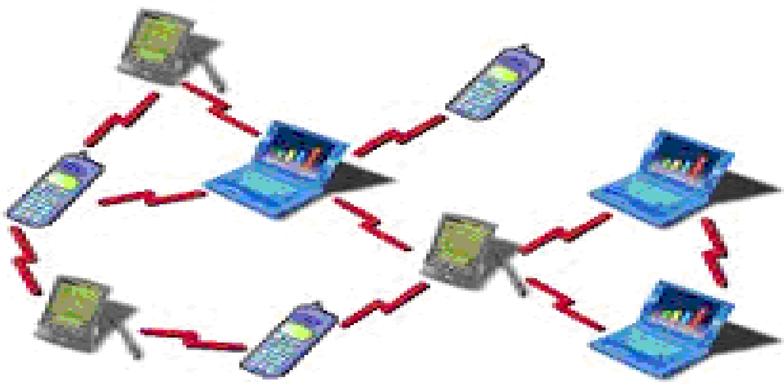

Figure 1.1: MANET infrastructure.

In MANET, the topology of the network may change rapidly and unpredictably over the time (fig-1.2). The network in MANET is decentralized.

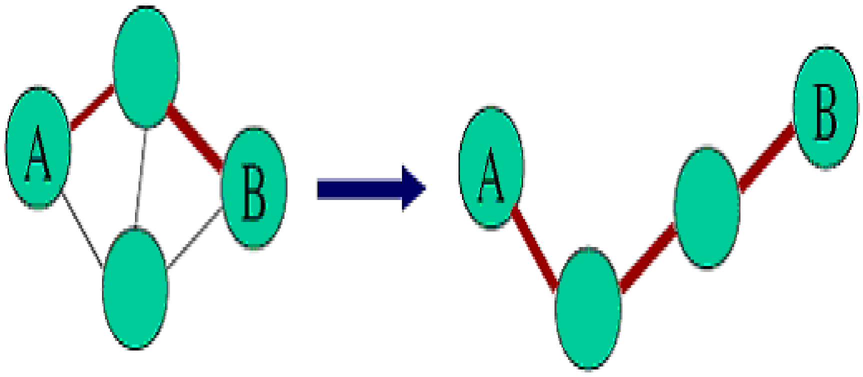

Figure 1.2: Frequent topology changes in MANET

1.2 Applications of MANET

- MANET is mainly used in battlefield and disaster recovery networks.
- Some applications of MANET technology include Industrial and commercial applications involving cooperative mobile data exchange.
- In addition, mesh-based mobile networks can be operated as robust, inexpensive enhancement to cell-based mobile network infrastructures.
- There are also existing and future military networking requirements for robust data services within mobile wireless communication networks.
- Also developing technologies of "wearable" computing and communications may provide applications for MANET technology.
- When properly combined with satellite-based information delivery, MANET technology can provide an extremely flexible method for establishing communication for fire/safety/rescue operations.

1.3 Characteristics of MANET

a. Dynamic topologies: Nodes are free to move arbitrarily; thus, the network topology which is typically multi-hop may change randomly and rapidly at unpredictable times, and may consist of both bidirectional and unidirectional links.

b. 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, noise, and interference conditions, etc. is often much less than a radio's maximum transmission rate.

1.4 MANET routing protocols

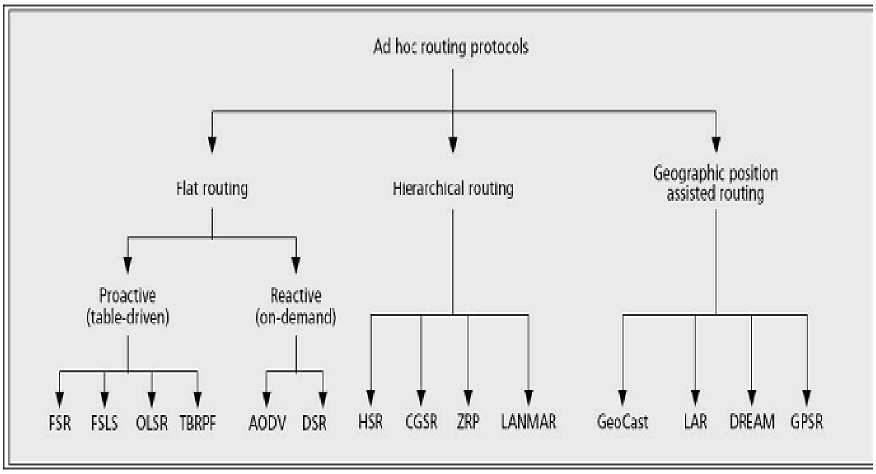

Figure 1.3: Classification of Routing Protocols In Mobile Ad-hoc Networks.

1.4.1 Table-Driven routing protocols(Proactive)

These protocols are also called as proactive protocols since they maintain the routing information even before it is needed. Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. Many of these routing protocols come from the link-state routing. There exist some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols maintain different number of tables.The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth.

- **Optimized Link State Routing (OLSR):**
  Optimized Link State Routing(OLSR) is a table driven routing protocol for MANET. In OLSR, each node exchanges its link state information to all other nodes in the network and transmits its neighbor list regularly so nodes can know their two hops neighbors. Each node selects its Multi Point relay (MPR) and the MPR nodes announce this information periodically using Topology control messages. When a node broadcasts a message, its neighbors will receive the message. The protocol uses MPRs to facilitate flooding of control messages and only the MPRs that have not seen the message before, rebroadcast the message in the network periodically. MPRs are used as intermediate nodes to route packets. Then, each node floods the link state information of its MPRs through the network and it obtains network topology information and constructs its routing table through link state messages.

- **Destination Sequenced Distance Vector (DSDV):**
  The DSDV algorithm is a Distance Vector (DV) based routing algorithm designed for use in MANETs, each node periodically advertises its knowledge of the network with the other nodes in the network. It makes modifications to the basic Bellman-Ford routing algorithms, thereby doing away with the count- to- infinity problem. Each routing table entry contains the destination

address, the number of hops to reach the destination, the next hop along the path to the destination, and the sequence number of the latest information received regarding the destination. Routing table entries with newer (higher) sequence numbers replaces entries with older sequence numbers. When faced with a choice between two routing table entries with the same sequence number, the entry with the lower value of the metric is chosen. Every destination stamps sequence numbers with consecutive even numbers. Every receiver in turn broadcasts this information to its neighbors, incrementing the value of the metric.

1.4.2 On Demand routing protocols(Reactive)

These protocols are also called reactive protocols since they don't maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery usually occurs by flooding the route request packets throughout the network.

- **Ad-hoc On-demand Distance Vector (AODV):**
  Ad Hoc On-demand Distance Vector Routing (AODV) protocol is a reactive routing protocol. As a reactive routing protocol, it maintains only routing information about the active paths. Every node uses hello messages to notify its existence to its neighbors and maintains routing information in their routing tables to keep a next-hop routing table that contains the destinations to which it has a route. In AODV, when a source node wants to send packets to the destination but no route is available, it initiates a route discovery operation. In the route discovery operation, the source broadcasts route request (RREQ) packets. A RREQ includes addresses of the source and the destination, the broadcast ID, the last seen sequence number of the destination as well as

the source node's sequence number. OLSR uses sequences numbers to ensure loop-free and up-to-date routes. Each RREQ has Time-to-Live (TTL) and nodes maintain a cache to keep track of RREQs it has received and discards any RREQ has seen before. When intermediate or destination node receives RREQ, it checks destination sequence numbers to what it knows. Then, the node creates a route reply (RREP) packet and forwards back to the source node only if the destination sequence number is equal to or greater than the one specified in RREQ. The RREP follows the reverse path of the respective RREP and intermediate nodes update their next hop table entries with respect to the destination node. When a node discovers a link disconnection, it broadcasts a route error (RERR) packet to its neighbors, which in turn propagates the RERR packet towards nodes whose routes may be affected by the disconnected link. Then, the affected source can re-initiate a route discovery operation if the route is still needed.

- **Dynamic Source Routing (DSR):**
  Dynamic Source Routing (DSR) stands as one of the common representatives of reactive routing protocols like all On-Demand routing algorithms, AODV, Dynamic MANET On-demand (DYMO). DSR applies source routing rather than hop-by-hop routing, in which each packet to be routed carrying in its header the full ordered list of nodes through which the packet should pass. The key benefits of source routing is that intermediate nodes do not need to maintain up-to-date routing information in order to route the packets they forward, since the packets themselves already contain all the routing decisions. This fact, coupled with the on-demand nature of the protocol, eliminates the need for the periodic route advertisement and neighbor detection packets present in other protocols. In DSR source node generates a route request packet when it has a new route to a destination. The route request is flooded through the network until it reaches some nodes with a route to that destination. Each route

request packet holds the information of the route it has propagated. When the route request packet arrives at the destination or an intermediate node with a route to the destination, a route reply packet will be generated. This reply packet is then sent back to the source node following the reverse route contained in the route request packet. While transmitting the data traffic, the complete path is added to each data packet according to the routing table of the source node. The intermediate nodes forward packets according to the path provided in the packet. More clearly, in DSR routing protocol to send route reply packet, when current route breaks, destination seeks a new route.

1.4.3 MANET routing protocol problems

- Asymmetric links: Unlike wired networks, where links are always stable, in MANET, nodes are continuously changing their positions in the network. Thus if node B sends a signal to node A, but this does not tell anything about the quality of the connection in the reverse direction.

- Routing Overhead: In wireless adhoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.

- Interference: One transmission might interfere with another transmission. Also a node might overhear transmissions of other nodes. Thus, it can corrupt the transmission.

- Dynamic topology: Topology is not fixed in MANET. The mobile node might move or medium characteristics might change. In ad-hoc networks, routing tables must somehow reflect these changes in topology and routing algorithms have to be adapted.

1.5 Objective of the work

To design a proactive routing protocol for MANET which uses cross layer design and which is aware of high mobility of nodes.This protocol must decrease losses due to mobility and should also reduce overhead of extra packet exchanges due to route failure.In order to reduce effects introduced due to mobility, forward packets to more stable routes by using cross layer approach.

1.6 Thesis Organization

The rest of the thesis is organized as follows.

Chapter 2, *Literature survey of existing MANET routing protocols and their trade-offs justifies choice of proactive protocol. Also effects of mobility on protocol stack is described. Previously implemented different cross layer approaches are studied and described in this chapter.*

Chapter 3, *This chapter explains Cross Layer Design approach in detail and also it shows its benefits over traditional protocol stack.*

Chapter 4, *Problem identified after literature survey is described in this chapter. Also proposed algorithm for that problem is explained in the chapter. The algorithm uses Cross Layer Design (CLD) approach to solve the problem.*

Chapter 5, *This chapter describes NS2 simulator in brief. It also describes Cross Layer Implementation in NS2 simulator. Implementaion of proposed algorithm is also explained in this chapter.*

Chapter 6, *Results obtained after the implementation of proposed algorithm and analysis of the results is described in this chapter.*

Chapter 7, *Concluding remarks of the work done and future scopes for further optimization of the proposed algorithm.*

Chapter 2

Literature Survey

- According to Yaser Khamayseh, Omar M. Darwish and Sana A. Wedian et.al [1], a new protocol named MA-AODV with some variations in existing AODV protocol for MANET is proposed. This new protocol considers high mobility of MANET and try to establish more stables paths between source and destination. Simmulation results of this new protocol in Glomosom simulator shows better performance in terms of overhead and packet delivery ratio in compare to traditional AODV protocol.
  The paper suggests two approaches :

  a. Per Hop Mobility Aware AODV (PH-MA-AODV) : In PH-MA-AODV, each node computes its own mobility periodically. Then, while initiating the Route Discovery process, each node decides to whether participate in the discovery process and thus relay the RREQ further or not. Therefore, the overall selected route is stable and more reliable.

  b. Aggregate Mobility Aware AODV (Agg-AODV) : In Agg- AODV, upon receiving the RREQ packet, if the recipient node is not the intended destination, it adds its own mobility to the RREQ packet and forwards it further towards the destination. The destination node is responsible to store the aggregated value of mobility along the path from itself to the source, and to compare this value with future aggregated values that are obtained from other available paths towards the same source. If there are more than one active path between the source and the destination, the destination chooses the path whose aggregated mobility value is the least among all paths.

- According to Ching-Wen Chen, Chuan-Chi Weng and Yu-Chen Kuon et.al [2], received signal variation is used to predict the transmission bandwidth and the lifetime of a link. Accordingly, the possible amount of data that can be transmitted and the remaining power of nodes in the path after data transmission can be predicted. By predicting the possible amount of data that can be transmitted and the remaining power of nodes after data transmission.
  To determine the distance of two nodes to compute the transmission bandwidth, the received signal strength is detected and the dB-to-bandwidth table is used to determine the transmission bandwidth. In addition, to predict the possible amount of data that can be transmitted via a link, they proposed using the received signal strength variations to compute the link lifetime and the possible amount of data that can be transmitted. Accordingly, the remaining power of the nodes after data transmission can be determined and be used to design proposed bandwidth-based power-aware routing protocol.

- According to Fuad Alnajjar et.al [3], a Cross Layer Design(CLD) approach is used to design a reliable routing protocol for MANET. In proposed protocol, CLD shares information between physical layer and network layer. The protocol allows network layer to adjust its routing protocol dynamically based on Signal to Noise Ratio(SNR) and Received Power(RP) along the end-to-end routing path for each transmission link to improve end-to-end routing performance.The protocol is simmulated in OPNET simulator and its results are compared with traditional AODV,DSR and OLSR protocols in terms of packet delivery rate, average end-to-end delay and overhead.The best value of SNR or

RP of the weakest link along the route from destination to source to eliminate the routes with bad links that has very low SNR and to improve QoS.

- According to B.Ramachandran and S.Shanmugavel et.al [4], a mobility adaptive CLD is proposed to enhance the performance of AODV routing protocol by establishing stable routes. A receiving node measures signal strength and passes it from physical layer to routing layer. The received signal strength is used to calculate the distance between the transmitting and receiving nodes. The protocol is simulated in Glomosim simulator. Results show that the proposed protocol reduces the number of route failures and routing overheads.

- According to Boumedjout Amel, Mekkakia Maaza Zoulikha et.al [5], proposes a cross layer design among physical layer and routing layer by using Received Signal Strength (RSS) as cross layer interaction parameter. The protocol is tested with NS2 simulator in free space and shadowing model and guarantees an enhanced connectivity and reliable route in MANET. In this protocol, the received signal strength information is used to compute path loss incurred to choose reliable links by monitoring the signal quality to judge which route is chosen in the route discovery process.

Till now, only reactive protocols are implemented with cross layer approach. These reactive protocols are not that good in high mobile scenarios. To get reliable routes in high mobile scenario, proactive protocols can give better performance than reactive protocols. Also using cross layer approach we can design more efficient protocol.This work for the project is for the same purpose.

Chapter 3

Cross Layer Design approach

In wireless networks, small-scale channel variations due to fading, scattering and multi-path can change the channel state from "good" to "bad" within a few milliseconds, while large-scale channel variations are usually slow and depends on user location and interference levels from the surroundings. This is the reason why designing Mobile Adhoc NETworks (MANET) or cellular networks supporting data and real-time traffic using a packet switched approach is very difficult.

Cross Layer Design(CLD) is a new approach of ad-hoc network design. It reduces inter-layer communication time, adapts to network changes rapidly, makes good use of resources and reduces overhead.

To fully optimize wireless broadband networks, both the challenges from the physical medium and the QoS-demands from the applications have to be taken into account. Rate, power and coding at the physical layer can be adapted to meet the requirements of the applications given the current channel and network conditions. Knowledge has to be shared between (all) layers to obtain the highest possible adaptivity.

As shown in Figure 3.1, the CLD approach to network architecture is located where the three communities intersect.

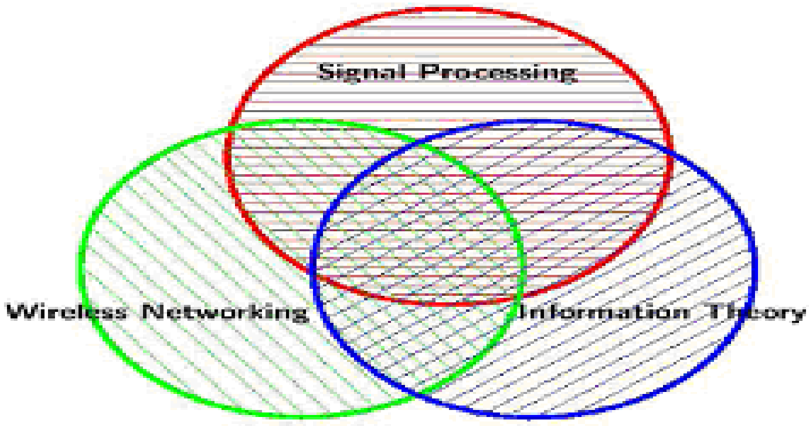

Figure 3.1: Collaboration across borders

Listed below are some of the fields the different research communities traditionally have focused on solving:

Wireless networking:

- Architecture: connection versus connectionless
- Energy efficient analysis of MANETs.
- Scaling laws of large scale networks
- Traffic theory
- Protocols

signal processing:

- Increasing spectral efficiency (bits/s/Hz)
- Reducing Bit Error Rate (BER)
- Reducing the transmission energy

- Detection and estimation algorithms for multi-access.

Information theory:

- Developing capacity limits
- Designing efficient source coding and channel coding algorithms.

3.1 Applications of CLD

At present ad-hoc networks' cross-layer design is at the beginning.There is no mature research method and there are different kinds of ideas and research issues in the literatures.MAC layer , routing layer and TCP layer attract more attention.We may classify CLD into following four categories:

- Cross-layer design between routing layer and physical layer.
- Cross-layer design between routing layer and MAC layer.
- Cross-layer design between routing layer and TCP layer.
- Cross-layer design between routing layer and application layer.

3.2 Benefits of CLD

These protocols are also called proactive protocols since they maintain the routing information even before it is needed. Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. Many of these routing protocols come from the link-state routing. There exist some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols maintain different number of tables.The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth.

- Event actication: Usually event is the message notified to the other layers, such as link break, routing failure and so on.Once an event occurs, this information should be detected at once and then be sent to the other protocol layers immediately to activate the corresponding processing procedure.
  Detection may be based on power. If the signal power reduces to some fixed value source proxy will be notified at once and looks for a new routing. Once a new routing is found, routing proxy will change to the new one.
  Event activation is the most familiar way of cross-layer design. When detecting whether the event has occurred, what is to be transmitted and which protocol layer to transmit to should be considered carefully.

- Inter-layer Mapping: Inter-layer mapping is a cross-layer design method supplying Qos priority. In primary layered design layers have no connection with each other, which may lead to priority in the upper layer lost in the lower layer. Mapping is the good solution to this problem.
  Inter-layer mapping is especially fit for designs supplying needed Qos. It usually covers multiple layers and need them to work coordinately. Mapping between layers ensures consistent priority in different layers.

- Interaction of Inter-layer Control Messages: Interaction of inter-layer control message reinforces cross-layer design. More interaction and inter-layer control makes communication more convenient and efficient.

- Aiming at a special Issue and Optimizing the Whole Performance from each layer: Mobile Ad hoc network is a complex system. Its performance is affected by many factors and its parameters may be determined by multiple layers. In order to obtain satisfied performance it should be optimized from each layer.

Chapter 4

Problem definition and Proposed algorithm

4.1 Problem definition

MANET is an infrastructure-less architecture where nodes keep moving rapidly. Existing routing protocols do not consider mobility of nodes as a different issue. Packet loss due to mobility of nodes is very high and this reduces throughput also.

Problem with both reactive and proactive protocols is the degradation of performance when mobility of nodes is high. In case of reactive protocol, the problem is breakage of link immediately after the discovery of the route. In this scenario, once route is discovered, the packet will travel on that discovered path without any knowledge of the broken link resulting in a route failure and rediscovery of the path. This will lead to extra routing overhead as well as increasing latency.

4.2 Suggested approach

In proactive protocol, routing of a packet is carried out with the help of routing table which is maintained and updated periodically. Also in case of any change in topology, triggered updates are executed and routing tables get updated to reflect that change in the topology. This approach requires more storage space than reactive kind of protocol. Also overhead of maintaining routing table is more. On the other hand it gives better performance in the case of link breakage, since breaking of a link is immediately reported to other nodes through triggered update. So at the time of routing, chances of route failure get reduced.

One possible approach to reduce this packet loss due to mobility is suggested here. The approach uses Cross layer Design (CLD). The suggested approach uses DSDV as a basic protocol and DSDV is modified to use CLD and also routing and forwarding module of traditional DSDV is modified to implement the suggested approach.

In order to design a proactive protocol using cross layer design, each node will maintain a table with the values of the transmission power(P_t) power of the signal received from its neighbour nodes along with all other information.Also it will calculate received power(P_r) and other parameters from the transmission power with the help of the propagation model that is been used for the radio transmission.

As we are supposed to design a proactive protocol, on the link breakage, the neighbour nodes will be informed about it and they will try to find alternate links and will keep updating the table. Unlike in traditional DSDV the metric on which routing decision is made will not be the hop count here in the proposed protocol.

From the table all links will be classified as a stable or unstable link. When a source initiates transmission it will route the information over stable links and will try to reach destination.

In this approach, we will not go for a shortest path but will try to find more reliable paths by considering mobility of nodes.

4.3 Traditional DSDV(Destination Sequenced Distance Vector) protocol

Every node i in the network maintains distances to every other node in the network in terms of intermediate hops.i.e.This distance is chosen from the shortest distance $d_{ix} = min(d_{ij} + d_{jx})$, where x is the destination node, and j is a neighbour of i. Each node keeps track of the distances between itself and every other node in the network, and periodically broadcasts its current estimate of the shortest distance to every other node in the network to all of its neighbours. This algorithm is known as the Distributed Bellman-Ford (DBF) algorithm [6].

However, Distance Vector algorithms such as the DBF algorithm suffer from the count-to-infinity problem [6]. This can be solved using the split-horizon and poisoned reverse mechanisms. However, these solutions are not entirely compatible with the essentially broadcast nature of radio communications.

4.3.1 Sequence Numbers

Each routing table entry contains the destination address, the number of hops to reach the destination, the next hop along the path to the destination, and the sequence number of the latest information received regarding the destination.

Routing table entries with newer (higher) sequence numbers supersede entries with older sequence numbers. When faced with a choice between two routing table entries with the same sequence number, the entry with the lower (better value) of the metric (number of hops) is chosen.

Every destination stamps sequence numbers with consecutive even numbers. Every receiver in turn broadcasts this information to its neighborus, incrementing the value of the metric. Odd sequence number is considered as an abnormal routing entry and route advertise with the odd sequence number will be discarded.

4.3.2 Broken Links

A broken link can be detected by either layer-2 protocol or it may be inferred if no broadcasts have been received for a while from a former neighbour.

A broken link is described by a metric of 8. Whenever a link between a destination and a neighbour breaks, the neighbour changes the link distance stored to to 8 and increments the sequence number by 1, i.e., the next highest odd number.

If any node receiving information of a link break (with a distance metric of 8) has a routing table entry with a later (even) sequence number, it broadcasts this information to all of its neighbours.

4.3.3 Full Routing Table Dump vs Incremental Routing Update

The DSDV algorithm defines two kinds of routing table updates. The first is called an Incremental Routing Update (IRU), where only those routing table entries that have changed since the last IRU was sent are transmitted. The second, called the Full Routing Table Dump (FRTD), transmits every routing table entry in the node's routing table.

The latter is done less frequently, and then only when there is not much node movement (i.e., no Incremental Routing Updates(IRU) have been sent in awhile). An IRU should ideally fit inside a single network layer packet, whereas a FRTD will most likely require multiple such packets, even in small networks.

Perkins and Bhagwat[7] also shows the need for a mechanism by which it is determined if a change in a routing table entry is significant enough for it to be included in an IRU message.

4.3.4 Preventing Routing Table Fluctuation

In order to prevent a continuous stream of routing updates from a given node, it is suggested that two different routing tables be used - one each for advertisement and forwarding respectively; with the former being updated less frequently than the latter [7].

4.3.5 Issues with the DSDV Algorithm

- Transmission of FRTDs when there is no change in the network would waste transmitter power, and can be done away with.

- Maintaining two distinct routing tables would be a waste of memory. A simpler approach would be to delay transmission of routing updates, in order to allow for the best routes to be available before IRUs are transmitted. Also, in order to prevent fluctuations caused by nodes that spasmodically appear to be neighbours.

4.3.6 Advantages of DSDV

- DSDV protocol guarantees loop free paths [8].

- Count to infinity problem is reduced in DSDV [8].

- We can avoid extra traffic with incremental updates instead of full dump updates.

- Path Selection: DSDV maintains only the best path instead of maintaining multiple paths to every destination. With this, the amount of space in routing table is reduced.

4.3.7 Limitations of DSDV

- Wastage of bandwidth due to unnecessary advertising of routing information even if there is no change in the network topology.
- DSDV doesn't support Multi path Routing.
- It is difficult to determine a time delay for the advertisement of routes [9].

4.3.8 Why DSDV over other proactive link state protocols

- Computationally more efficient.
- Easier to implement.
- Requires much less storage space in compared to link state protocols.

It is evident that within ad-hoc environment design tradeoffs and the constraints under which a routing method has to operate are quite different. The proposed DSDV approach offers a very attractive combination of desirable features. Its memory requirement is very moderate O(n). It guarantees loop-free paths at all instants, and it does so without requiring nodes to participate in any complex update coordination protocol.

The worst case convergence behavior of the DSDV protocol is certainly non-optimal but, in the average case, it is expected that convergence will be quite rapid.

Routing method	**Looping**	**Internodal Coordination**	**Space Complexity**
Bellman Ford	s/l	-	O(nd)
Link State	s	-	O(n^2)
Loop-free BF	s	-	O(nd)
RIP	s/l	-	O(n)
Merlin Segall	loopfree	Required	O(nd)
Jaffe Moss	loopfree	Required	O(nd)
DSDV	loopfree	-	O(n)

s - short term loop, 1- long term loop ,n - number of nodes, d - maximum degree of a node

Table 4.1: Comparison of various routing methods [7]

4.4 Proposed Algorithm

Here, we propose a mobility aware proactive protocol with the advantages of cross layer communication to enhance the performance of a Destination-Sequenced Distance-Vector Routing (DSDV).

The decision about route selection is made according to mobility of nodes with the help of routing tables to define stable routes. Stability of the route will be defined from the received signal strength information and speed of mobile nodes to build stable and optimum routes.

Later the protocol will be compared with existing routing protocols to show better performance in terms of packet delivery, effects of mobility, throughput etc. The simulation of the designed protocol will be carried out using NS-2 version 2.34 .

The primary goal of an ad-hoc network routing protocol is to establish correct and efficient routes between nodes so that message passing takes place in a timely manner. This process of route establishment must be carried out with minimum overhead and minimum bandwidth.

MANET characteristics like random movements of nodes, multi-hop routing etc results in control signal overhead for route discovery and maintenance. Optimizing a particular layer might improve the performance of the particular layer locally but its possible that this optimization might produce side effects that will degrade overall performance.

Optimization across the layers is required through interaction among different OSI layers by sharing interlayer interaction metrics[10]. Cross layer interaction is helpful in designing an architecture that can exploit the interdependencies among link, medium access, networking and application protocols.

In OSI model, existing protocol leads to redundant processing and unnecessary packet exchange to get information that is easily available to other layers.This increases control signals overhead resulting in wastage of bandwidth and energy.To cope up with problems such as the poor performance of wireless links and mobile terminals including high error rate, power saving requirements and quality of service ,a protocol stack that considers cross layer interaction is required. This enables layers to exchange locally available information among themselves.

Cross layer communication enables nodes to discover and maintain routes based on the status of the link, traffic congestion, signal strength etc. In normal scenario routing protocols are not concerned with signal strength. Lower layers take care of it. If we use this information at routing layer, we can define a link as a stable or unstable link and depending on that we can choose a more reliable route.

4.4.1 Algorithm

In this proposed model of a protocol, receiving node measures signal strength and pass it from physical layer to routing layer. We made following assumptions while designing the protocol:

- Information about speed of the node is available
- no time synchronization between nodes.

Signal strength available from Physical layer is passed to routing layer. Speed of the node is also available. DSDV protocol's route discovery mechanism is modified to use these parameters in decision making on forwarding the packet.

The received signal strength is used to calculate the distance between the transmitting and receiving nodes. Here we consider **Two-ray Ground propagation** model.

4.4.2 Two-ray-ground propagation model

A single line-of-sight path between two mobile nodes is seldom the only means of propagation. The two-ray ground reflection model considers both the direct path and a ground reflection path. It is shown in that this model gives more accurate prediction at a long distance than the free space model[11]. The received power at distance is predicted by:

$$P_r(d) = \frac{P_t G_t G_r {h_t}^2 {h_r}^2}{d^4 L} \tag{4.1}$$

Where h_t and h_r are the heights of the transmit and receive antennas respectively. where P_t is the transmitted signal power.G_t and G_r are the antenna gains of the transmitter and the receiver respectively.$L(L \geq 1)$ is the system loss, and λ is the wavelength. It is common to select G_t=G_r=1 and L=1 in NS simulations. The original equation assumes L=1[11].

The above equation shows a faster power loss as distance increases. However, the two-ray model does not give a good result for a short distance due to the oscillation caused by the constructive and destructive combination of the two rays. Instead, the free space model is still used when d is small.

Therefore, a cross-over distance d_c is calculated in this model. When $d < d_c$, following equation is used:

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \tag{4.2}$$

When $d > d_c$, Eqn. (4.1) is used. At the cross-over distance, Eqns. (4.1) and (4.2) give the same result. So d_c can be calculated as :

$$d_c = \frac{4\pi h_t h_r}{\lambda} \tag{4.3}$$

Proposed Algorithm: The two-ray ground model considered here, assumes maximum transmission range d_{max} of nodes is 350 meters which corresponds to 10dBm(10mW) transmission power [4]. Hence the received signal strength can be expresses as eqn (4.2) , because in this case $d < d_c$. Also $G_t = G_r = 1$.
Therefore,

$$P_r(d) = P_t(\frac{\lambda}{4\pi d})^2 \tag{4.4}$$

Where,
P_t = Transmission Power
λ = Wavelength in meters
d = Distance between transmitting and receiving nodes.
Here, we consider unity gain omni-directional transmitting and receiving antennas.

For each link between the nodes, distance d can be calculated from eqn(4.4) as follows

$$d = (\frac{P_t}{P_r})^{\frac{1}{2}} * \frac{\lambda}{4\pi} \tag{4.5}$$

Also, the receiving node calculates its distance to the transmission range boundary(d_b) of the transmitting node using the known maximum transmission range(d_{max}) as,

$$d_b = d_{max} - d \tag{4.6}$$

The minimum time needed for a node to go out of the transmission range boundary of the transmitting node depends on its distance from the boundary and the speed as given below.

$$t_b = \frac{d_b}{Speed} \tag{4.7}$$

any intermediate node receiving that packet can calculate its safe distance(d_s) from transmission range boundary using its speed information as,

$$d_s = t_b * Speed \tag{4.8}$$

The routing table of traditional DSDV will contain some extra entries for our newly proposed protocol. These additional entries are : distance to transmission range boundary(d_b) , safe distance(d_s).

When a node receives an advertisement from its neighbours , and both can be selected as a next hop for a particular destination than the node with having db>ds will be chosen as a next hop. Thus, instead of hop count as a metric unlike traditional DSDV protocol, we will use d_b and d_s as our metric.

If both the nodes have d_b>d_s then the node with minimum $|d_b - d_s|$ will be selected.This is nothing but a link with d_b<d_s is identified as stable link over another and will be considered as next hop for the routing.

Pseudo-code for above Algorithm is shown below:

```
for each routing table received
{
if (received.seqno == current.seqno for that destination){
       if(received.db>received.ds && current.db<current.ds){
                current.next hop=received.address; current.db=received.db;
                current.ds=received.ds;  schedule triggered update;
             }
        else if(|received.db-received.ds|<|current.db-current.ds|){
                current.next hop=received.address;  current.db=received.db;
                current.ds=received.ds;  schedule triggered update
             }
          }
  else if(received.seqno >current.seqno for that destination){
                   if(received.db>received.ds && current.db<current.ds){
                current.next hop=received.address;  current.db=received.db;
                current.ds=received.ds; current.seqno=received.seqno
                schedule triggered update
             }
else if(|received.db-received.ds|<|current.db-current.ds|){
                current.next hop=received.address;  current.db=received.db;
                current.ds=received.ds;  current.seqno=received.seqno
                schedule triggered update
             }
     }
}
```

Destination	**Next**	**Metric Hop**	**Sequence number**	**Distance from transmission Range boundary(d_b)**	**Safe Distance(d_s)**
A	A	0	564_A	0.0m	0.0m
B	B	1	589_B	54.24m	23.21m
C	B	2	523_B	54.24m	23.21m
D	B	2	593_B	54.24m	23.21m

Table 4.2: New routing table structure for node A

Also The routing table structure for proposed algorithm is shown above. As shown in above table, d_b and d_s are two additional entries in routing table and are calculated as shown in previous chapter.

Chapter 5

Simulation and implementation details

The proposed protocol will be simulated and tested in NS-2 version 2.34 simulator. The Simulation will be carried for different scenarios and results will be compared with traditional DSDV protocol and AODV protocol. The comparison will be in terms of packet delivery, packet latency , effects of mobility etc.

5.1 Network Simulator-2

NS is a discrete event simulator targeted at networking research. NS provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks. NS-2 is written in C++ and an Object oriented version of Tcl called OTcl. NS is not a polished and finished product, but the result of an on-going effort of research and development. In particular, bugs in the software are still being discovered and corrected.

5.1.1 Resource requirements for NS-2

To build NS we need a computer and a C++ compiler. NS-2 is designed to run from on most UNIX based operating systems. It is possible to run NS-2 on Windows machines using Cygwin. If you don't have a UNIX install, you can also use a virtual linux machine and run that under Windows. Simple scenarios should run on any reasonable machine, but very large scenarios benefit from large amounts of memory. NS is fairly large. The allinone package requires about 320MB of disk space to build. Building NS from pieces can save some disk space.

5.1.2 NS-2 Components

Ns-allinone is a package which contains required components and some optional components used in running NS. The package contains an "install" script to automatically configure, compile and install these components. After downloading, run the install script.
Currently the package contains:

- Tcl release 8.5.10 (required component)
- Tk release 8.5.10 (required component)
- Otcl release 1.14 (required component)
- TclCL release 1.20 (required component)
- Ns release 2.35 (required component)
- Nam release 1.15 (optional component)
- Xgraph version 12 (optional component)
- CWeb version 3.4g (optional component)
- SGB version 1.0 (optional component, builds sgblib for all UNIX type platforms)

- Gt-itm gt-itm and sgb2ns 1.1 (optional component)
- Zlib version 1.2.3 (optional, but required should Nam be used).

5.1.3 NS-2 installation

NS-2 version 2.34 is available on the following link:
$http://nsnam.isi.edu/nsnam/index.php/Downloading\_and\_installing\_ns-2$
Installation guidelines are also available there.

5.2 Proposed Protocol implementation

5.2.1 Cross layer Interaction

For the proposed protocol, it is needed to implement interaction between physical layer and routing layer. This will enable routing layer to use and manipulate physical layer parameters.

Accessing Physical layer from Routing layer: The following steps demonstrate how Physical layer information from the routing protocol is accessed . Here Routing protocol is DSDV.

a. In dsdv.h header file, mobilenode.h header file is included :
   #include $< mobilenode.h >$
   With this change, now nodes can be defined in the network as mobile nodes and also accordingly parameters of a mobile node can be set.

b. As proposed protocol is for wireless networks, declared a WirelessPhy object within the DSDV_Agent class.
   $WirelessPhy * netif\_;$
   This is possible because wireless-phy.h(which includes WirelessPhy class) file is included in the mobilenode.h file.

c. Then following code was added in the command() function in dsdv.cc file:

```
int
DSDV_Agent:: command (int argc, const char * const * argv) {
. . .
. . .
else if (argc == 3) {
...
...
else if (strcmp (argv [1], "access-phy") == 0) {
netif_ = (WirelessPhy *) TclObject:: lookup (argv[2]);
if (netif_ == 0) {
fprintf (stderr, "Agent: %s lookup %s failed. \n", argv[1], argv[2]);
return TCL_ERROR;
} else {
double x, y, z;
((MobileNode*) netif_->node())->getLoc(&x, &y, &z);
printf ("This node's location: %f %f \n", x, y);
return TCL_OK;
}
}
}
. . .
. . .
}
```

d. Then while running the sample tcl script I added following in the script at the time of node initialization:

```
# get the routing protocol
```

```
set rt [$node_ agent 255]
# get the network interface
$rt access-phy [$node_ set netif_(0)]
```

5.2.2 Protocol implementation

Now, to implement the algorithm protocol, changes are made in following files:
-ns-allinone-2.34/ns-2.34/dsdv/dsdv.h,
-ns-allinone-2.34/ns-2.34/dsdv/dsdv.cc,
-ns-allinone-2.34/ns-2.34/dsdv/trable.h,
-ns-allinone-2.34/ns-2.34/dsdv/rtable.cc
In dsdv.c file, major changes are made in following functions:
updateRoute(), processUpdate() and makeUpdate()and forwardPacket().
After implementing proposed algorithm in NS-2, its results were compared with existing DSDV.The comparision is shown in next chapter.

Chapter 6

Results and analysis of results

The proposed approach has been implemented, simulated and tested in NS-2.34 simulator. Simulation results are shown in Figure 6.1, 6.2, 6.3 and 6.4. The simulation was carried out to test the protocol in terms of packet delivery ratio and throughput. Because of mobility of nodes, route failures result in low packet delivery ratio. But as shown in Figure 6.1 and 6.2 the proposed approach increases packet delivery ratio in comparision to traditional DSDV. Also throughput increases as shown in Figure 6.3 and 6.4.

Simulation is carried out in area of 350m*350m. To consider mobility of a node, number of connections are changed and accordingly packet delivery ratio and throughput is measured for 50 nodes and 100 nodes. Figure 6.1 and Figure 6.2 shows packet delivery ratio versus number of connections for 50 nodes and 100 nodes respectively. As we can see, the suggested algorithm gives better performance than DSDV. Figure 6.3 and Figure 6.4 shows throughput versus number of connections for 50 nodes and 100 nodes respectively. Throughput also increases when compared to traditional DSDV. Simulation parameters are shown in Table 6.1.

Simulation area:	350m*350m
Number of nodes:	50(Figure 6.1, 6.2) and 100 (Figure 6.3, 6.4)
Number of connections:	10,20....,100
Simulation parameters:	Packet Delivery Ratio (PDR) and Throughput

Table 6.1: Simulation parameters

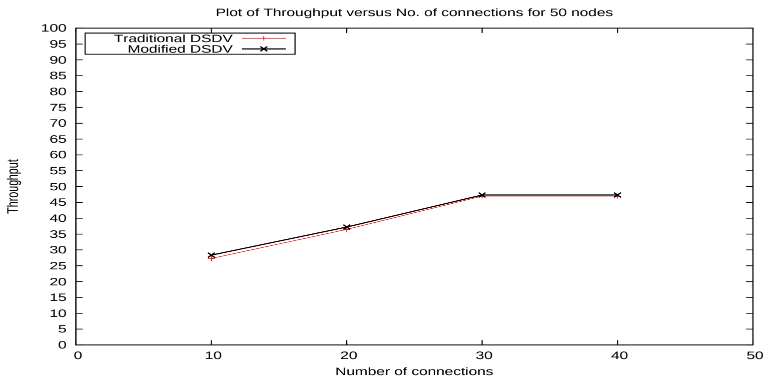

Figure 6.1: Plot of Throughput versus No. of connections for 50 nodes

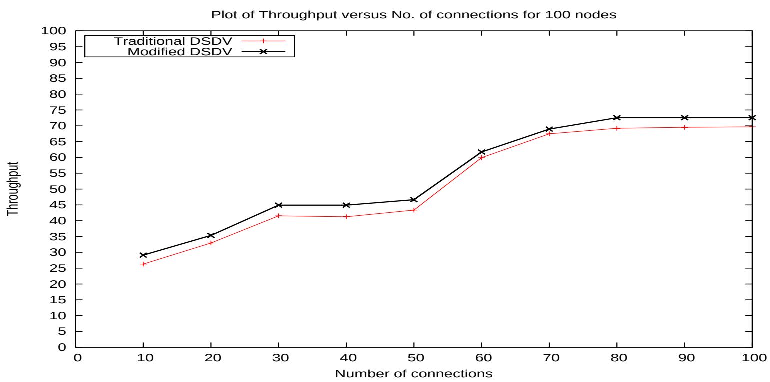

Figure 6.2: Plot of Throughput versus No. of connections for 100 nodes

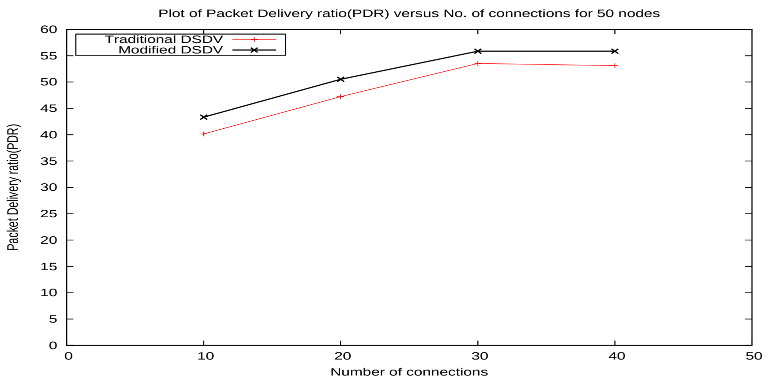

Figure 6.3: Plot of Packet Delivery Ratio versus No. of connections for 50 nodes

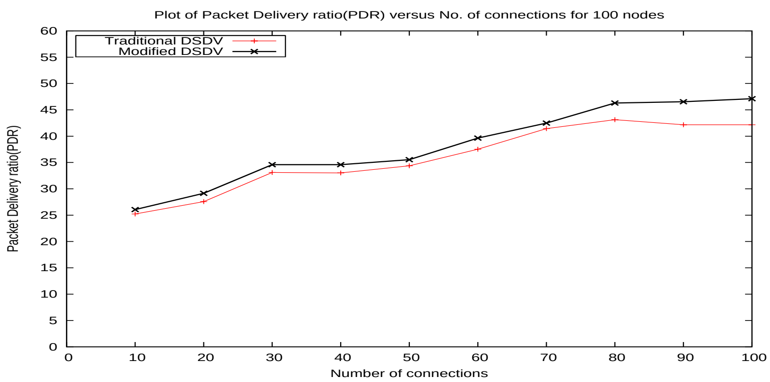

Figure 6.4: Plot of Packet Delivery Ratio versus No. of connections for 100 nodes

Chapter 7

Conclusion and Future Work

7.1 Conclusion

The proposed algorithm is when simulated in NS-2 simulator, gives better performance compared to original DSDV protocol. It can be concluded that:

- The suggested approach increases packet delivery ratio and throughput compared to traditional DSDV.
- It reduces number of route failures.
- The overhead of routing because of route failure is also decreased. But at the same time in sone scenarios it increases end to end delay. But that increase in end to end delay is negligible.

Thus, this approach is more suitable for scenarios where reliability is of more concern than delay.

7.2 Future Work

Further optimization of this approach is possible if we consider traditional DSDV metric (minimum hop count) along with these physical layer parameters. It includes development of new algorithm which may use some threshold values of both these metrics to take routing decision on the reliable as well as comparatively shorter path.

It is also possible that this approach can be further optimized by using other physical layer parameters or MAC layer parameters at routing layer. More benefits of Cross Layer Design approach are there which can be think of and can be implemented.

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