A Review of Cross Layer Design for Routing Protocols in MANET

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Abstract — **Mobile Ad hoc 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 are 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. When a wireless node plays the role of intermediate node, it serves as a router that can receive and forward data packets to its neighbour closer to the destination node. Due to the nature of an ad-hoc network, wireless nodes tend to keep moving rather than stay still. Therefore the network topology changes from time to time. 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.**

Keywords: - **Cross layer Design, MANET, Routing Protocol**

I. 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. In MANET, the topology of the network may change rapidly and unpredictably over the time The network in MANET is decentralized. In MANET, a wireless node can be the source, the destination, or an intermediate node of data transmission. When a wireless node plays the role of intermediate node, it serves as a router that can receive and forward data packets to its neighbor closer to the destination node.

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.

Mobile Ad hoc networks (MANET) could be defined as spontaneous networks: a collection of terminals organizes itself to exchange packets with each other via wireless communications. A source is not always a neighbor of the destination, so a route must be provided. Moreover, neither wired nor wireless router exists to manage the network. Thus, some terminals must collaborate to forward the data packets from the source to the destination. Ad hoc networks do not distinguish the routers and the clients: a terminal plays both roles. In a MANET, all terminals are independent and can move freely. MANET could be interconnected to the Internet via special gateways: the Access Points (AP). Such networks are often called Hybrid Networks or Multi hops Wireless Access Networks.

[5] 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 tries to establish more stables paths between source and destination. [1] 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 trans-mission can be predicted.

[2] The Cross layer design 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. [6] 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.

[7] They are categorized as proactive and reactive protocols. Proactive protocols such as DSDV periodically send routing control packets to neighbors for updating routing tables. Reactive routing protocols such as AODV and DSR send control packets only when route discovery or route maintenance is done. Usually mobile devices have limited energy and computing resources.[8] An ad-hoc network is the cooperative engagement of a collection of Mobile Hosts without the required intervention of any centralized Access Point. The basic idea of the design is to operate each Mobile Host as a specialized router, which periodically advertises its view of the interconnection topology with other Mobile Hosts within the network. [9] DSDV is a modification of the conventional Bellman-Ford routing algorithm. It addresses the drawbacks related to the poor looping properties of RIP in the face of broken links. The modification adapted in DSDV makes it a more suitable routing protocol for ad hoc networks.

II. LITERATURE REVIEW

According to Yaser Khamayseh, Omar M. Darwish and Sana A. Wedian et.al [5], 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 :

1. 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.
2. 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.

The decision is either made by the destination to send a reply back through the stable route, as the case of Agg-AODV, or by the intermediate nodes through the route discovery process, as in PH-MA-AODV. The MA-AODV approaches can be enhanced further by embedding their idea in the Route Maintenance process. That is, when a node detects its mobility as high, it should inform its neighbors by its critical status.

According to Ching-Wen Chen, Chuan-Chi Weng et.al [1], 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 trans-mission 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. We compared our proposed routing protocol with signal based routing protocol, SSA and ABR, and a power –aware routing protocol.

According to Fuad Alnajjar et.al [2], 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.

In MANET the entire network is mobile where nodes move freely and topology is changing rapidly because of weather, terrain, highly variable delay links and error rate links. Nodes may not be able to communicate directly and have to rely on each other in order to deliver packets. The contacts between nodes in the network do not occur very frequently that makes routing difficult because the network graph is episodically connected.

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. The challenge was to find a routing design that can deal with dynamic environment causing networks to split and merge, considering nodes mobility, fading, and Doppler Effect. In this paper we will next implement in future is to complete the research and implement SNR/RP aware routing design on GRP and TORA.

we will implement Delay/Disruption Tolerant Network (DTN) in our Model in OPNET simulator to study and analyze the impact of the physical layer parameters on the performance of DTN routing protocols.

According to B.Ramachandran and S.Shanmugavel et.al [6], 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 pro-posed protocol reduces the number of route failures and routing overheads.

Multi-hop routing, random movement of the nodes and other features unique to ad-hoc networks results in lots of control signal overhead for route discovery and maintenance. This is highly unacceptable in bandwidth-constrained ad-hoc networks. Usually the mobile devices have limited computing resources and severe energy constraints.

Cross layer interaction schemes that can support adaptability and optimization of the routing protocols can discover and maintain the routes based on current link status traffic congestion, signal strength etc. Usually routing layer is not concerned with signal strength related information handling. Lower layer takes care of signal strength related issues. signal strength threshold and minimum route life-time enforcement is serious in lightly densed networks and hence, a detailed study on impact of node density on our cross layer proposal will be the future work.

According to Sharada valiveti and Shital Patel et.al [7], The Cross Layer Design (CLD) approach in which we use the Physical layer Characteristics at Network layer. We have proposed a techinique, which would use the concept of Doppler Effect in Routing and eliminates the noisy signals received at physical layer by comparing the Signal to Interference Noise Ratio (SINR) with the Threshold Signal to Interference Noise Ratio (SINRT).

The Mobility Model is designed to describe the movement pattern of mobile users, and how their location, velocity and acceleration change over time. Since mobility patterns may play a significant role in determining the protocol performance, it is desirable for mobility models to emulate the movement pattern of targeted real life applications in a reasonable way.

Routing in Ad hoc network is very challenging as nodes are moving, topology of the network changes dynamically. So a good route will be unavailable after a short time. Hence there is a need to design a 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.

Multiple MANET Routing protocols are found to meet the challenges. They are categorized as proactive and reactive protocols. Proactive protocols such as DSDV periodically send routing control packets to neighbors for updating routing tables. Reactive routing protocols such as AODV and DSR send control packets only when route discovery or route maintenance is done. Usually mobile devices have limited energy and computing resources. Due to these characteristics, there is lot of research work happening in the performance optimization of ad hoc networks.

Mobility Models: The Mobility Model is designed to describe the movement pattern of mobile users, and how their location, velocity and acceleration change over time.

1. **Random Walk Mobility Model**
   The Random Walk Mobility Model is the simplest mobility model, generating completely random movement patterns. It was designed for simulations in which the movement patterns of mobile nodes are completely unpredictable.
2. **Random Way point Mobility Model**
   This model introduces specific pause times between movements i.e changes in direction and speed. The random way point model is the most popular mobility model employed in contemporary research, and can be considered as a foundation for building other mobility models. Mobile node (MN) starts its journey by staying in one location for a certain period of time (i.e. a pause time).
3. **The Random Direction Model**
   The Random Direction Mobility Model was created in order to overcome a flaw discovered in the Random Way point Mobility Model. In this model, Mobile nodes chooses a random direction in which to travel instead of a random destination. The Best value of RSS and SINR is chosen by applying the above proposed algorithm to find route which is more stable and noise free than all other routes in the whole network. In future work, we will implement the above approach in NS2 and also wants to implement route maintenance process of routing protocol .

According to PERKINS C. E. BHAGWAT P et.al [8] An ad-hoc network is the cooperative engagement of a collection of Mobile Hosts without the required intervention of any centralized Access Point. In this paper we present an innovative design for the operation of such ad-hoc networks. The basic idea of the design is to operate each Mobile Host as a specialized router, which periodically advertises its view of the interconnection topology with other Mobile Hosts within the network.

This amounts to a new sort of routing protocol. We have investigated modifications to the basic Bellman Ford routing mechanisms, as specified by RIP , to make it suitable for a dynamic and self-starting network mechanism as is required by users wishing to utilize ad hoc networks.

According to Guoyou He et.al [9] DSDV is a modification of the conventional Bellman-Ford routing algorithm. It addresses the drawbacks related to the poor looping properties of RIP in the face of broken links. The modification adapted in DSDV makes it a more suitable routing protocol for ad hoc networks. Compared to Bellman-Ford routing, QoS with DSDV routing has substantial improvement in the routing results, but it is expected that further researches including multi-path routing, QoS Multicasting in DSDV and ad hoc networks. Many improvements of DSDV have been developed.

Topology-Based Routing Protocols

These routing protocols use links' information that exists in the network to perform packet forwarding. They can further be divided into proactive (table-driven) and reactive (on-demand) routing.

- **Table-Driven Routing Protocols (Proactive) [3]:**
  In proactive routing protocols, every node maintains a list of destinations and updates its routes to them by analyzing periodic topology broadcasts from other nodes. When a packet arrives, the node checks its routing table and forwards the packet accordingly. Every node monitors its neighbouring links and every change in its neighbours results in a topology broadcast packet.
  That is flooded over the entire network. Other nodes update their routing tables accordingly upon receiving the update packet. In a well-connected network, the same topology broadcast packet could reach nodes multiple times and therefore enjoy a good packet reception probability.
  The advantage of these protocols is that a source node does not need route-discovery procedures to find a route to a destination node. On the other hand the drawback of these protocols is that maintaining a consistent and up-to-date routing table requires substantial messaging overhead, which consumes bandwidth and power, and decreases throughput,

especially in the case of a large number of high node mobility. There are various types of Table Driven Protocols: Destination Sequenced Distance Vector routing (DSDV), Wireless routing protocol (WRP).

III. MANET ROUTING PROTOCOL

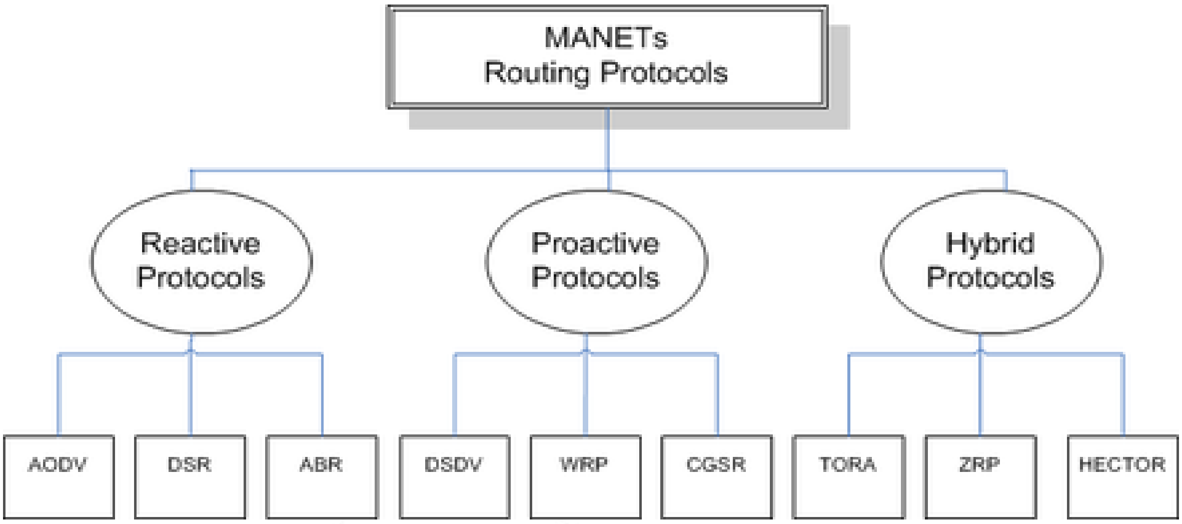

Figure 3.1 MANET Routing Protocol[14]

Optimized Link State Routing (OLSR) [10]

OLSR (Optimal Link State Routing) protocol provides a more organized and efficient way to manage traffic control packets between two nodes based on a shortest path strategy [11]. As a proactive protocol, OLSR periodically exchange information among nodes in order to acquaint itself the network status. Consequently the routing tables of network nodes are maintained constantly updated with link state messages. However, the protocol limits the number of nodes that are allowed to forward link state messages in order help to preserve high network through-put.

Destination Sequenced Distance Vector (DSDV) [8]

The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements. Every mobile station maintains a routing table that lists all available destinations, the number of hops to reach the destination and the sequence number assigned by the destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid the formation of loops. The stations periodically transmit their routing tables to their immediate neighbors. A station also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven.

The routing table updates can be sent in two ways: a “full dump” or an incremental update. A full dump sends the full routing table to the neighbors and could span many packets whereas in an incremental update only those entries from the routing table are sent that has a metric change since the last update and it must fit in a packet. If there is space in the incremental update packet then those entries may be included whose sequence number has changed. When the network is relatively stable, incremental updates are sent to avoid extra traffic and full dump are relatively infrequent.

DSDV [8] serves for networks not centralized to any server or base stations. The mobile hosts participating in the formation of a network can enter and leave any time without harming the integrity of the protocol. This particular nature makes it fit for ad-hoc networks. DSDV effectively removes the looping problem by assigning sequence numbers to each root. DSDV uses distance vector algorithm for finding the next hop in the network as compared to link-state method.

DSDV treats each mobile host participating in network as a specialized router which provides a mechanism for mobile computer to exchange data along the dynamically changing topology of network. The routing information is disseminated either by broad casting or multicasting the updates periodically or incrementally. This allows a new mobile host to enter and leave the network anytime without hampering the performance of network. The data packets are used for information sharing which follows the routing tables stored at each mobile host. DSDV requires each mobile host to maintain the routing tables and advertise them periodically and incrementally.

The routing table contains a list of all available destinations and number of hops to reach each of them, this hop count is termed as metric. Each route table entry is tagged with a sequence number generated by the destination. Each root has an associated metric and a sequence number. The selection of a new route depends on both of these parameters. The consistency of the routing tables is an important issue and DSDV removes it by periodically broadcasting or multicasting the routing information.

Each mobile host broadcast the route table changes as it finds the information to be significant enough to be disseminated. The mobile hosts involved in transfer of data with each other broadcast the necessary information periodically say once every few seconds. Upon the reception of new information, by a mobile host, it is compared with the routing table entries.

On Demand routing protocols(Reactive)

Reactive routing protocols can dramatically reduce routing overhead because they do not need to search and maintain routes on which there is no data traffic at the expense of increasing end-to-end delay. This property is very appealing in the resource-limited environment. Depending on how the routing method is implemented, reactive routing protocols can be divided in source routing protocols and hop-by-hop or point-to-point protocols.

- **Source Routing Protocols**
  In source routing protocols every data packet carries the whole path information in its header. Before a source node sends data packets, it must know the total path to the destination, that is, all addresses of nodes which compose the path from source to destination. There is no need that intermediate nodes update its routing tables, since they only forward data packets according to the header information. However it entails scalability problems since as the number of hops increases, the path information every data packet must carry become major and it may waste bandwidth. Moreover, the path is established from the source node so that a bad adaptation to quickly topology changes will be performed.

  DSR (Dynamic Source Routing):
  The Dynamic Source Routing Protocol is one of the on-demand routing protocols, and is based on the concept of source routing. In source routing, a sender node has in the packet header the complete list of the path that the packet must travel to the destination node. That is, every node in the path just forwards the packet to its next hop specified in the header without having to check its routing table as in table-driven routing protocols. Besides, the nodes don't have to periodically broadcast their routing tables to the neighboring nodes.

- **Hop-By-Hop Routing Protocols**
  Hop-by-hop routing protocols try to improve performance by keeping the routing information in each node. Every data packet does not include the whole path information any more. On the contrary they only include the address of the following node where data packet must be forwarded to get the destination as well as the destination address. Every intermediate node must look up its own routing table to forward the data packets to its destination, so that the route is calculated hop by hop. Hop-by-hop routing protocols save bandwidth and performs well in a large network since a data packet does not carry the whole path information. However, intermediate nodes must update their routing tables. The most representative hop-by-hop routing protocol is AODV.

  AODV (Ad hoc On-demand Distance Vector):
  Ad hoc On-demand Distance Vector (AODV) routing protocol was motivated by the limited bandwidth that is available in the media that are used for wireless communications. Unlike DSR routing protocol, AODV determines a route to a destination only when a node wants to send a packet to a destination [12].

Hybrid Routing Protocol

Hybrid routing protocols combine the proactive and reactive routing approaches. They divide the network into routing zones, so that it will be used proactive routing schemes for intra- zones routing issues and reactive routing schemes for inter-zones routing issues. The most representative hybrid routing protocol is ZRP (Zone Routing Protocol).

- **Geographic (Position-Based) Routing**
  In geographic (position-based) routing, the forwarding decision by a node is primarily made based on the position of a packet's destination and the position of the node's one-hop neighbors. The position of the destination is stored in the header of the packet by the source. The position of the node's one-hop neighbors is obtained by the beacons sent periodically with random jitter (to prevent collision). Nodes that are within a node's radio range will become neighbors of the node. Geographic routing assumes each node knows its location, and the sending node knows the receiving node's location by the increasing popularity of Global Position System (GPS) unit from an onboard Navigation System and the recent research on location services respectively [14].

  Since geographic routing protocols do not exchange link state information and do not maintain established routes like proactive and reactive topology-based routings do, they are more robust and promising to the highly dynamic environments like MANET. In other words, route is determined based on the geographic location of neighboring nodes as the packet is forwarded. There is no need of link state exchange nor route setup.

IV. CROSS LAYER DESIGN

Cross Layer Design Definition

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.

In the traditional way of designing a wireless manet or cellular network architecture, has been to identify each process or module and then assign them roles or requirements. Since each process or module has been treated separately, this approach has in many ways caused the research communities to split into different groups, where each group focus their resources on solving "their" problem the best possible way. What other research communities are doing, is not really important, as long as the job is done. This is of course a bit exaggregated, but none the less illustrates the problem in an efficient manner [4].

As shown in Figure 4.1, the CLD approach to network architecture is located where the three communities intersect. 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

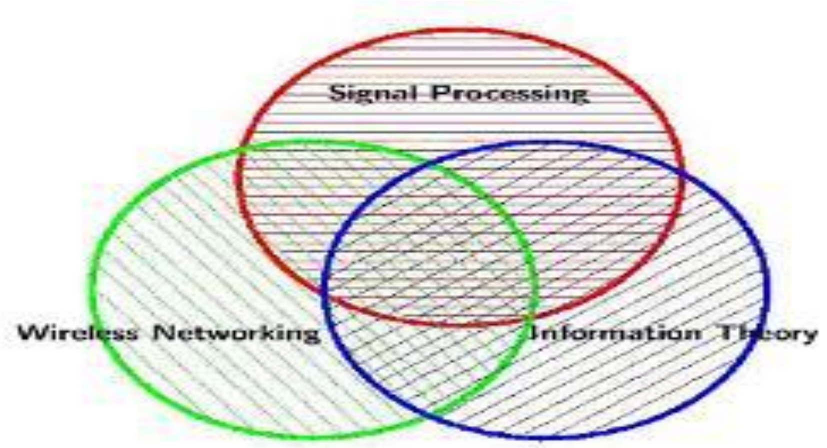

Figure 4.1: Collaboration across borders [4]

Information theory

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

The whole idea behind CLD is to combine the resources available in the different communities, and create a network which can be highly adoptive and QoS efficient by sharing state information between different processes or modules in the system [4].

V. CONCLUSION

In MANET, the topology of the network may change rapidly and unpredictably over the time. The network in MANET is decentralized. MANET could be interconnected to the Internet via special gateways: the Access Points (AP). Such networks are often called Hybrid Networks or Multi hops Wireless Access Networks. A Cross Layer Design (CLD) approach is used to design a reliable routing protocol for MANET. A mobility adaptive CLD is proposed to enhance the performance of AODV routing protocol by establishing stable routes. Multiple MANET Routing protocols are found to meet the challenges. They are categorized as proactive and reactive protocols. Proactive protocols such as DSDV periodically send routing control packets to neighbors for updating routing tables. Reactive routing protocols such as AODV and DSR send control packets only when route discovery or route maintenance is done. FUTURE WORK is to implement the Cross layer Design Approach for routing protocol in NS2.

REFERENCES

Journal Papers:

[1] Ching-Wen Chen, Chuan-Chi Weng, Yu-Chen Kuo , "Signal strength based routing for power saving in mobile ad hoc networks",The Journal of Systems and Software 83 (2010) 1373-1386.

[2] Fuad Alnajjar, "SNR/RP Aware Routing Model for MANETs", City College and Graduate Center of City University of New York ,Multidisciplinary Journals in Science and Technology, Journal of Selected Areas in Telecommunications (JSAT), March Edition, 2011.

[3] Radha Rani Gupta , Mahendra ku. Mishra , Manish Shrivastava “Review Of Energy Efficient Routing Protocols In Mobile Ad Hoc Network” International Journal of Engineering Reserch & Technology (IJERT) Vol. 2 Issue 5, May -2013.

Thesis:

[4] Frank Aune, Cross-Layer Design Tutorial , Norwegian University of Science and Technology, Dept. of Electronics and Telecommunications, Trondheim, Norway. Published under Creative commons License. 26.11.2004.

Proceedings Papers:

[5] Yaser Khamayseh, Omar M. Darwish, Sana A. Wedian ,"MA-AODV: Mobility Aware Routing Protocols for Mobile Ad hoc Networks", Department of Computer Science Jordan University of Science and Technology Irbed, Jordan,2009 Fourth International Conference on Systems and Networks Communications.

[6] B.Ramachandran, S.Shanmugavel, "Mobility Adaptive Cross Layer Design for Reliable Route Discovery in Ad-hoc Networks", in third international conference on wireless communication and sensor networks,13- 15 dec'07 .

[7] Sharada valiveti and Shital Patel, “Mobility aware Routing strategy in MANET Using Cross Layer Design Approach,” in International conference on engineering, NUiCONE-2012, 06-08 december , 2012.

[8] PERKINS C. E.,BHAGWAT P.,"Highly Dynamic Destination-Sequenced Distance-Vector Routing(DSDV) for Mobile Computers.",ACM SIGCOMM Computer Communication Review (October 1994), 234244.

[9] Guoyou He.,"Destination-sequenced distance vector (DSDV) protocol". Technical report, Helsinki University of Technology, Finland.

[10] Jeferson Wilian de Godoy Stênico, Lee Luan Ling “Topology control for Ad- hoc Networks: A Comprehensive Review for Table Driven and On-Demand routing Protocols” Communications and Network, 2013, 5, 239-246.

[11] A. Huhtonen, “Comparing AODV and OLSR Routing Protocols,” Heleniski University of Technology, Espoo, 2004.

[12] S. Das, C. Perkins, E. Royer, "Ad hoc on demand distance vector (AODV) routing", Internet Draft, draft- ietf-manetaodv-13.txt, Mobile Ad Hoc Networking Working Group,2003.

[13] C. Perkins, Ad hoc on demand distance vector (AODV) routing, internet draft, draft-ietf-manet-aodv- 00.txt

[14] Krishna Gorantala “Routing Protocols in Mobile Ad-hoc Networks”.