Performance Evaluation in Wireless Network

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Abstract: An ad hoc network is a self –configuring network of wireless links connecting mobile nodes. These nodes may be routers and/or hosts. Each node or mobile device is equipped with a transmitter and receiver. They are said to be purpose-specific, autonomous and dynamic. Ad hoc networking is a concept in computer communications, which means that users wanting to communicate with each other from a temporary network, without any form of central administration. Term ad hoc means a network, which can take different forms in terms of topologies and in term of devices used. Ad hoc devices can be mobile, standalone or networked. A Mobile Ad hoc Network (MANET) is an autonomous system of mobile hosts, which are free to move around randomly and organize themselves arbitrarily. MANET is viewed as suitable systems which can support some specific applications as virtual classrooms, military communications, emergency search and rescue operations, data acquisition in hostile environments, communications set up in exhibitions, conferences and meetings, in battle field among soldiers to coordinate defense or attack, at airport terminals for workers to share files etc. In ad hoc networks nodes can change position quite frequently. The nodes in an ad-hoc network can be laptops, PDA (Personal Digital Assistant) or palm tops etc. These are often limited in resources such as CPU capacity, storage capacity, battery power, and bandwidth. Each node participating in the network acts both as a router and as a host and must therefore be willing to transfer packets to other nodes. For this purpose routing protocol is needed and the new protocol should try to minimize control traffic. An ad hoc network has certain characteristics, which impose new demands on routing protocols. The most important characteristic is dynamic topology, which is a consequence of node mobility. It should be reactive i.e. calculates routes only upon receiving a specific request.

I. INTRODUCTION

Wireless and mobile environments bring different challenges to users and service providers when compared to fixed, wired networks. Physical constraints become much more important, such as device weight, battery power, screen size, portability, quality of radio transmission, error rates. Mobility brings additional uncertainties, as well as opportunities to provide new services and supplementary information to users in the locations where they find themselves. If a user, application or company wishes to make data portable, mobile and accessible then wireless network is the answer. A wireless networking system would rid of the downtime normally have in a wired network due to cable problems. It will also save time and money due to the fact that it would square the expenses of installing a lot of cables. Wireless networking can prove to be very useful in public places, libraries, guesthouses, and hotels where one might find wireless access to Internet. In general, most application software, operating systems and network infrastructures are intended for more conventional environments, and so the mobile wireless user has great difficulty exploiting the computational infrastructure as fully as he or she might. There is an emerging consensus among researchers that a new architecture and dynamic infrastructure is inappropriate way to address this problem.

As the Internet becomes ever more pervasive, and wireless access to it becomes more common, there will be a growing need for middleware that can mediate among several parties involved. Infrastructure providers can provide location-based information to the subscribers and service-providers; they can also exploit aggregate and individual location information to better manage their own communication infrastructure. Mobile ISPs can provide value added services that enhance the user's awareness of services in the environment, and provide means of interacting with those services. Users perceive a rich, adaptive electronic infrastructure that presents the entire Internet to them in a convenient, controllable, dynamic way.

A *Objective*

The objective of this M.Tech(IT) thesis is to differentiate between various Ad hoc routing protocols by comparing all protocols with the help of simulator. To compare some factors like number of packets delivered, numbers of packets sent, pause time, congestion, efficiency, total number of nodes in network, number of connections between nodes, size of packets etc.

B. *Research Method Used*

In this thesis empirical research method is followed to compare the different Ad hoc routing algorithms. It is part of the scientific method, but is often mistakenly assumed to be synonymous with the experimental method. In this research the following steps have been tried to follow. Though step order may vary depending on the subject matter and researcher, the following steps are usually part of most formal research, both basic and applied:

- Formation of the topic
- Hypothesis
- Conceptual definitions
- Operational definitions
- Gathering of data
- Analysis of data
- Test, revising of hypothesis
- Conclusion

11. LITERATURE REVIEW

A. ***Mobile Ad-hoc Network (MANET)***

An Ad hoc wireless network is a collection of two or more devices equipped with wireless communications and networking capability. Such devices can communicate with another node that is immediately within their range or one that is outside their radio range. For the latter scenario, an intermediate node is used to rely or forward the packet from the source to destination. An ad hoc wireless network is self-organizing and adaptive. This means that a formed network can be de formed on the fly without the need of system administration. The term Ad hoc tends to imply "can take different forms" and "can be mobile, stand alone, or networked." Ad hoc nodes or devices should be able to detect the presence of other such devices and to perform the necessary handshaking to allow the sharing of information and services.

B. ***Applications***

A mobile Ad hoc network includes several advantages over traditional wireless networks, including: ease of deployment, speed of deployment, and decreased dependence on a fixed infrastructure. MANET is attractive because it provides an instant network formation without the presence of fixed base stations and system administrations. MANET is being viewed as suitable systems for some specific applications including:

- Personal communications like cell phones, laptops.
- Group communication such as communication set up in exhibitions, conference, presentation, meeting, and lectures.
- Military, emergency, discovery and civil communication.

C. ***Characteristics of Manet***

A MANET consists of mobile platforms (e.g. a router with multiple hosts and wireless communication devices), herein simply referred to as "nodes", which are free to move about arbitrarily. The nodes may be located in or on airplanes, ships, trucks, cars, perhaps, even on people or very small devices, and there may be multiple hosts per router. A MANET is an autonomous system of mobile nodes. The system may operate in isolation, or may have gateways to and interface with a fixed network. In the latter operational mode, it is typically envisioned to operate as a stub network connecting to a fixed network. Stub networks carry traffic originating at and/or destined for internal nodes, but do not permit exogenous traffic to transit through the stub network.

MANET nodes are equipped with wireless transmitter and receivers using antennas, which may be Omni directional (broadcast), highly directional (point to point), possibly steer able, or some combination thereof. At a given point in time, depending on node position and their transmitter and receiver coverage pattern, transmission power levels and co-channel interfaces levels, a wireless connectivity in the form of random, multi hop graph or ad-hoc network exists between the nodes. This Ad hoc topology may changes with time as nodes move or adjusts their transmission and reception parameters.

MANETs have several salient characteristics that have to be taken into account when considering their design and deployment.

1. Dynamic Topologies: Nodes are free to move arbitrarily: thus, the network topology, which is typically multihop, may change randomly and rapidly at unpredictable times, and may consist of both bi-directional and unidirectional links.
2. Bandwidth-constrained, variable capacity links: wireless links will continue to face 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. 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 multimedia computing and collaborative network 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.
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 network to reduce security threats. As a benefit, the additional robustness against the single points of failure of more centralized approaches.

111. ROUTING APPROACHES

A. ***Classification of routing protocols***

Routing is the process of selecting paths in a network along which to send network traffic. Routing is performed for many kinds of networks, including the telephone network, electronic data networks (such as the Internet), and transportation (transport) networks. Different Routing approaches are as following:

Proactive (Table Driven) Protocols

These protocols are based on distance vector/ link state algorithms. These algorithms attempt to monitor the current status of network topology by maintaining routing tables. The information in tables may be updated periodically at regular time intervals. Alternatively, the information in table may be updated when an event occur independent of traffic demand. An event may be a predefined distance traveled by a node, or a predefined number of links formed or broken by the movement of a node.

The advantage of such protocols is that route information for each destination is available whenever required. On the other hand these protocols waste network capacity to keep routing information current, even though most of information becomes stale even before it is used, due to node mobility. The communication overhead involved in maintaining global information about the networks is not acceptable for networks whose bandwidth and battery power are severely limited. These protocols work well for small size of networks with low mobility rate of nodes.

Reactive (On Demand) Protocols

These protocols discover the routes when they are required. These algorithms minimize the communication overheads and are adaptive to sleep period operation since inactive nodes do not participate at the time when route is established. On-demand protocols typically have the following components:

- Route discovery (destination search): When the source node S needs to send a message to destination D, it issues a destination search request if route to destination D is not available.
  Flooding a short message performs the destination search, so that each node in the network is reached. Path to destination is memorized in the process.
- Route reply: When the destination node D receives the first short search message, D will send a route reply message to the source through the path obtained by reversing the path followed by the route request received by D. The route reply message may contain exact location, time, speed, etc of destination.
- Routing data message: After receiving route reply, the source node S then sends a data message ('long' message) towards the exact location of destination through the route obtained from the route reply message. The efficiency of destination search depends on the corresponding location update scheme.
- Route maintenance: The routes discovered are stored in the route table temporarily while it is in use or for some limited time to avoid frequent route discovery. A source restarts a route discovery procedure whenever it detects that a previously discovered route is obsolete.
- Route erasure: Obsolete route information or non-active routes are removed from routing tables to check the table size.

These protocols reduce redundant routing information in the network, do not waste network capacity on updates, and allow nodes to save power by going into sleep modes. On the other side, these protocols may suffer from high route latency. Also, the routes discovered using flooding, may cause large overheads, nullify the savings on updates.

C. Routing protocols for ad hoc Network

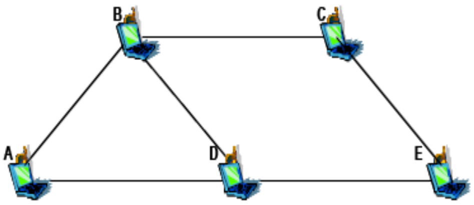
A number of routing algorithms have been developed to operate efficiently in mobile networking context. These algorithms can be classified into different categories based on the following qualitative and quantitative properties.

- Demand based routing
- Distributed Routing
- Position based Routing.
- Flat Routing
- Hierarchical Routing

B. Ad hoc Wireless Network

Operating Principles

To illustrate the general operating principles of a mobile ad hoc network, consider figure 3.1, which depicts the peer-level, multi-hop representation of a sample ad hoc network. Here, mobile node A communicates directly (single-hop) with another such node B whenever a radio channel with adequate propagation characteristics is available between them. Otherwise, multi-hop communication is necessary where one or more intermediate nodes must act as a relay (router) between the communicating nodes. For example, there is no direct radio channel (shown by the lines) between A and C or between A and E as shown in figure 3.1. Nodes B and D must serve as intermediate routers for communication between A and C, and between A and E, respectively. Thus, a distinguishing feature of ad hoc networks is that all nodes must be able to function as routers on demand along with acting as source and destination for packets. To prevent packets from traversing infinitely long paths, an obvious essential requirement for choosing a path is



that it must be loop-free. And this loop- free path between a pair of nodes is called a route.

Figure: Ad hoc Networks

An ad hoc network begins with at least two nodes, broadcasting their presence (beaconing) with their respective address information. If node A is able to establish direct communication with node B as in figure 3.1, verified by exchanging suitable control messages between them, they both update their routing tables. When a third node C joins the network with its beacon signal, two scenarios are possible. The first is where both A and B determine that single-hop communication with C is feasible. The second is where only one of the nodes, say B, recognizes the beacon signal from C and establishes direct communication with C. The distinct topology updates, consisting of both address and route updates, are made available in all three nodes immediately afterwards. In the first case, all routes are direct. For the other, the route update first happens between B and C, then between B and A, and then again between B and C, confirming the mutual reach ability between A and C via B. As the node moves, it may cause the reach ability relations to change in time, requiring route updates. Assume that, for some reason, the link between B and C is no longer available as shown in figure 3.2 Nodes A and C are still reachable from each other, although this time only via nodes D and E. Equivalently, the original loop- free route A□B□C is now replaced by the new loop- free route A□D□E□C. All five nodes in the network are required to update their routing tables appropriately to reflect this topology change, which will be first detected by nodes B and C, then communicated to A, E, and D.

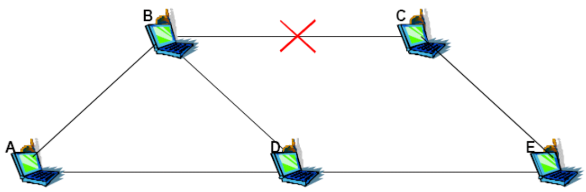


Figure: Changing Topology

This reach ability relation among the nodes may also change for various reasons. For example, a node may wander too far out of range, its battery may be depleted, or it may just suffer from software or hardware failure. As more nodes join the network, or some of the existing nodes leave, the topology updates become more numerous, complex, and usually, more frequent, thus diminishing the network resources available for exchanging user information (i.e., data). Finding a loop-free path between a source-destination pair may therefore become impossible if the changes in network topology occur too frequently. Too frequently here means that there may not be enough time to propagate to all the pertinent nodes the changes arising from the last change in network topology. Thus the ability to communicate degrades with increasing mobility and as a result the knowledge of the network topology becomes increasingly inconsistent. A network is combinatorial stable if, and only if, the topology changes occur slowly enough to allow successful propagation of all topology updates as necessary or if the routing algorithm is efficient enough to propagate the changes in the network before the next change occurs. Clearly, combinatorial stability is determined not only by the connectivity properties of the networks, but also by the efficiency of the routing protocol in use and the instantaneous computational capacity of the nodes, among others. Combinatorial stability thus forms an essential consideration for attaining efficient routing objectives in an ad hoc network.

1V. ROUTING PROTOCOLS

A. *Mobile Routing Protocols*

The Mobile Routing Protocols can be of two types.
Table Driven Routing Protocols (Proactive Protocols)
On Demand Routing Protocols (Reactive Protocols)

B. *Table Driven Routing Protocols in Ad hoc Networks*

In table driven routing protocols, consistent and up-to-date routing information to all nodes is maintained at each node. Following are the mainly used Table Driven Routing Protocols in ad hoc Networks: -

- DBF
- GSR
- DSDV
- WRP
- STAR

On Demand Routing Protocols

In On-Demand routing protocols, the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. Following are the mainly use On Demand Routing Protocols:-

- DDR
- DSR
- AODV
- RDMAR
- TORA

Bellman Ford Algorithm (DBF)

Shortest path routing algorithm based on distributed technique. According to DBF, a routing node knows the length of the shortest path from each neighbor to every network destination and this information is used to compute the shortest path successor in the path to each destination. It is table driven protocol, supports a flat architecture. Performance of this algorithm is as follows:

(a) Shortest path routing
(b) Simple in use
(c) Better computation efficiency due to distributed characteristic.
(d) It is available for both wire line and wireless networks.

Distance Sequenced Distance Vector Routing (DSDV)

Distance Sequenced Distance Vector (DSDV) routing protocol is a variant of distance vector routing method by which mobile nodes cooperate among themselves to form an ad hoc network. DSDV is based on RIP (Routing Information Protocol), which is used for Intra-Domain routing in Internet. DSDV requires each node in the network to maintain complete list of distance information to reach each node in the ad hoc network. In DSDV, each node uses a Sequence Number, which is a counter that can be incremented only by that node. Each node increments the Sequence Number every time it sends an update message and this Sequence Number uniquely identifies the update messages sent from a particular node. Routing information is propagated using broadcast or multicasting the messages periodically or triggered upon a change in the topology. DSDV uses only bi-directional links for routing as it is based on Distance Vector Routing. So in DSDV, each node does not insert information into its Routing table received from other neighbors unless the node is sure that the other node can listen to its advertisements.

Wireless Routing Protocol (WRP)

WRP is another protocol based on distributed Bellman-Ford algorithm (DBF). It substantially reduces the number of cases in which routing loops (count-to-infinity problem) can occur. It utilizes information regarding the length and second to last hop (predecessor) of the shortest path to each destination. Each node maintains a distance table, a routing table, a link-cost table and a message retransmission list. The distance table of a node contains tuples <destination, next hop, distance, predecessor (as reported by next hop)> for each destination and each neighbor. The routing table of a node contains tuples <destination, next hop, distance, predecessor, and marker> for each known destination where marker specifies whether the entry corresponds to a simple path, a loop or a destination that has not been marked. The link-cost table contains the cost of the link to each neighbor and the number of periodic update periods elapsed since the node received any error-free message from it. The message transmission list (MRL) contains sequence number of update message, retransmission counter, and acknowledgement required flag vector with one entry per neighbor, and a list of updates sent in the update message. It records which updates of an update message have to be transmitted and which neighbors should be requested to acknowledge such retransmission.

GLOBAL STATE ROUTING (GSR) PROTOCOL

This protocol is based on Link State routing, which has the advantage of routing accuracy, and dissemination method used in DBF, to avoid inefficient flooding in LS routing. Each node maintains a neighbor list, a topology table, a next hop table and a distance table. The neighbor list contains the list of nodes adjacent to the node. The topology table contains the link state information reported by a destination and a timestamp indicating the time at which this is generated. The next hop table and the distance table contain the next hop and the distance of the shortest path for each destination respectively. Initially, each node learns about its neighbors and the distance of the link to it (generally hop count equals one) by examining each packet in its inbound queue and broadcasts this information to its neighbors. Upon receiving the link state message from its neighbors, each node updates the link state information corresponding to that neighbor in the topology table to the most up to date information using timestamps. Then, the node rebuilds the routing table based on newly computed topology table and broadcasts it to its neighbors. The routing table information is exchanged periodically with the neighbors only.

Fisheye State Routing (FSR) Protocol

FSR protocol is an extension of GSR protocol. It attempts to reduce the size of update messages in GSR without seriously affecting the routing accuracy. The reduction in routing size is obtained by using different exchange periods for different entries in the routing table. Entries corresponding to nodes within the smaller scope are propagated to the neighbors with the highest frequency.

Temporally Ordered Routing Algorithm (TORA)

TORA is designed to work below Internet Protocol (IP). It does not have properties of link state or distance-vector algorithms, but link-reversal. The protocol is adaptive, and highly scalable. It is designed to minimize reaction to topological changes. TORA control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, nodes maintain routing information about adjacent nodes. TORA quickly discovers multiple routes on demand. Route does not have to be optimal, but it guarantees that all routes are loop-free. TORA only does the routing job, and heavily depends on Internet MANET Encapsulation Protocol (IMEP). A good analogy would be water flowing down the hill through pipes. Hilltop is the source, pipes are links, and pipe connections are nodes. TORA assigns level numbers to each node down the hill. When two intermediate nodes cannot communicate, the last node raises its level higher than any of its neighbors, so that water, which is data, flows back out of it.

Dynamic Source Routing (DSR)

Dynamic source routing is a Source routed On-Demand routing protocol in ad hoc networks. It uses Source Routing, which is a technique in which the sender of a packet determines the complete sequence of nodes through which the node has travel. The sender of the packet explicitly mentions the list of all nodes in the packet's header, identifying each forwarding 'hop' by the address of the next node to which to transmit the packet on its way to destination host. In this protocol the nodes don't need to exchange the Routing table information periodically and thus reduces the bandwidth overhead in the network. Each Mobile node participating in the protocol maintains a 'routing cache', which contains the list of routes that the node has learnt. Whenever the node finds a new route it adds the new route in its 'routing cache'. Each mobile node also maintains a sequence counter 'request id' to uniquely identify the requests generated by a mobile host. The pair < source address, request id > uniquely identifies any request in the ad hoc network. The protocol does not need transmissions between hosts to work in bi-direction. The main phases in the protocol are Route Discovery process and Route Maintenance process.

Ad hoc On-Demand Distance Vector (AODV)

The ad hoc On Demand Distance Vector (AODV) routing protocol is intended for use by the mobile nodes for routing data in Ad Hoc networks. AODV is an extension of Distance Sequenced Distance Vector (DSDV) routing protocol, a Table Driven routing protocol for Ad hoc networks that is discussed in the previous section. AODV is designed to improve upon the performance characteristics of DSDV in the creation and maintenance of routes.

Relative Distance Micro Discovery Ad hoc Routing Protocol (RDMAR)

RDMAR is a loop free routing protocol for ad hoc mobile networks. The protocol is highly adaptive, efficient and scaleable and is well suited in large mobile networks. The protocol is called Relative Distance Micro Discovery Ad hoc Routing Protocol (RDMAR). It uses the mechanism for route discovery, called Relative Distance Micro discovery (RDM). The concept is that query flood can be localized by knowing the relative distance between two terminals. RDMAR does not use a route cache. Each node has a routing table that lists all available destinations and number of hops to each. It is on demand routing with hybrid architecture.
Summary of the Routing Protocols:

DSDV was the only proactive protocol discussed. AODV is reactive, an on-demand version of DSDV. Authors of AODV, who were also authors of DSDV added multicast capability to AODV. Reactive approach of AODV is similar to DSR's. They both have a route discovery mode, which uses messaging to find new routes. DSR uses source routing; the route is in each packet. Thus, DSR learns more routes than AODV. DSR supports unidirectional links due to its vast knowledge on the topology. TORA runs on top of IMEP, and suffers for its internal instability and IMEP's too frequent HELLO messages generating too much control overhead in the network. DSDV and GSR are table-driven protocols that use destination sequence numbers to keep routes loop-free and up-to-date. HSR is a hierarchical routing protocol derived from FSR. FSR reduces the size of tables to be exchanged by maintaining less accurate information about nodes farther away. CGSR is a cluster-based routing protocol where nodes are grouped into clusters of transmission size ranges.

TABLE: Comparison of Major ad-hoc Routing Protocols

Protocol Property	DSDV	AODV	DSR	ZRP	TORA
Loop free	Yes	Yes	Yes	Yes	Yes
Multiple routes	No	No	Yes	No	Yes
Distributed	Yes	Yes	Yes	Yes	Yes
Reactive	No	Yes	Yes	Variable	Yes
Unidirectional	No	No	Yes	No	Yes

link support					
QoS support	No	No	No	No	No
Multicast	No	Yes	No	No	No
Security	No	No	No	No	Possible
Power efficiency	No	No	No	No	No
Periodic broadcasts	Yes	Yes	No	Yes	Yes

Comparison between On-Demand and Table Driven Protocols

These two types of protocols have their own working areas. At some places one type is suitable and in others the second category is used. Choice of protocol depends on the type of network in operation and working requirements.

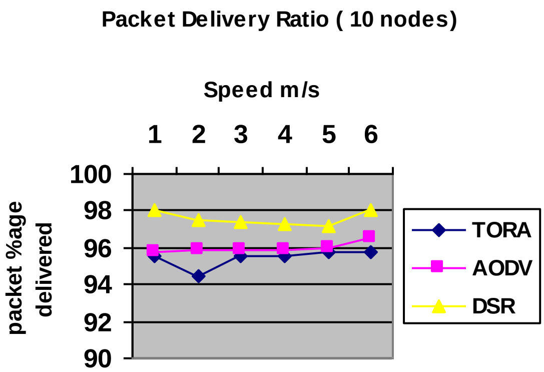
V. RESULTS AND DISCUSSION

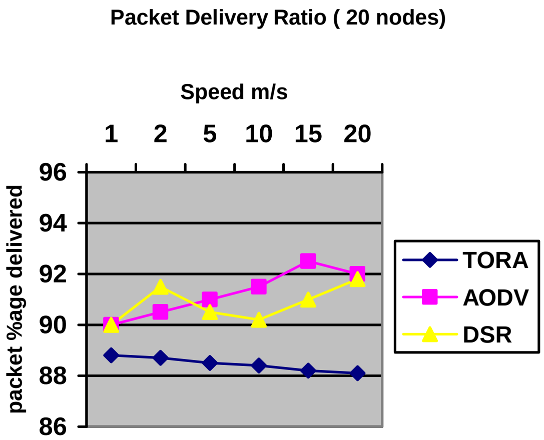
Successful Packet Delivery

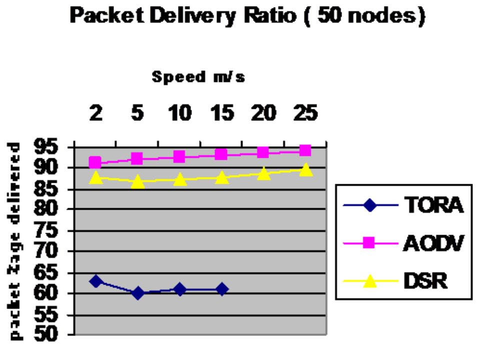
The fraction of successfully received packets, which survive while finding their destination is called packet delivery ratio. This performance measure also determines the completeness and correctness of the routing protocol. Successful packet delivery is calculated such that, all data packets with unique identifier leaving the source MAC are counted and defined as originating packets. Received packet IDs are compared to collected transmission database and each unique packet are counted once to ensure prevention of counting excess receptions

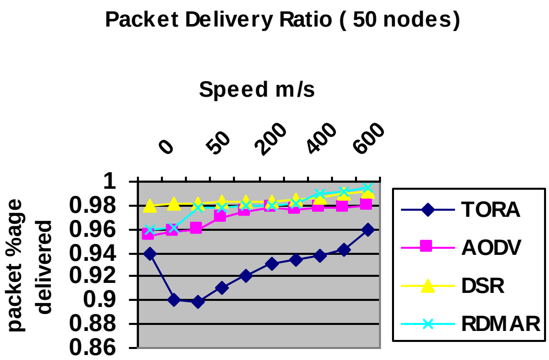
Simulation Results

Parameters chosen for all protocols have been same, sending 4 packets per second of size 512 bytes and using 15-20 connections with 50 nodes. Protocols have been evaluated in 750*750 meters environment for 700 seconds of simulated time at a speed of 10 meter per second. Pause time used is 0, 25, 50, 100, 200, 300, 400, 500, 600 and 700. Pause time 0 means continuous motion while 700 corresponds to no motion. When each data packet is originated, simulator calculates the shortest path between packet's sender and its destination. Traffic type used has been CBR (Constant Bit Rate) using both TCP and UDP packets. It has been observed that simulations were more stable with TCP packets than UDP; in particular DSR has some problems dealing with UDP packets.









The Graphs show packet delivery ratio of 50 nodes at speed 10 meters per second. It shows that all the protocols deliver more than 98% of their packets at this speed. DSR and AODV deliver almost 97 to 100 % of packet in all cases. TORA does well. RDMAR behaves better than TORA and AODV. It was seen that if sources are increased DSR and AODV behave nicely but TORA has problems in initially, below 250ms. It may be because of increased congestion. It was seen that if sources are increased then DSR, AODV and RDMAR behaves same with only very slight changes but TORA drops in packet deliver ratio. It is because of increased congestion in case of TORA.

In order to explore the change in the behavior of the protocols with varying speed, we performed the experiments with speed change from 10 meter per second to 1 meter per second. Figure shows results at 1 meter per second speed sending 4 packets per second of size 512 bytes and using 20 sources.

It was observed that with change in speed, all protocols deliver above 98% of the packets with slight drops in case of TORA and RDMAR DSR and AODV were excellent in performances at all speeds. Overhead also have less effect for DSR and AODV. DSR caching is effective at faster speeds, but works much better at slower speeds also. Some simulation studies for protocols have been done earlier also, although those simulations used different parameters and sources with varying results. No study involving RDMAR comparisons have been published earlier. In this study, several existing routing protocols for ad hoc wireless networks have been described. Results based on the simulations have been analyzed and presented with the advantages and disadvantages of each protocol. It is not simple to determine which of the four protocols under comparison is the best for Ad hoc network environment. No Protocol is ideal for all scenarios. A good criterion to choose a protocol might be the size and expected traffic load in the target network. The simulations presented here clearly show that there is a need for routing protocols specifically tuned to the characteristics of ad-hoc networks. Overall, the proactive protocols (AODV and DSR) behaved similar in terms of delivery and throughput. On the basis of this study both should be considered suitable for mobile ad-hoc networks. However, a number of differences among the protocols do exist. The source routes used by DSR give increased byte over-head compared to AODV when routes have many hops and packet rates are high. DSR is, on the other hand, efficient in finding (learning) routes in terms of the number of control packets used, and does not use periodic control messages. Data packets in AODV carry the destination address only. Therefore, the byte overhead for AODV is the lowest of the examined protocols. The overhead is high in terms of packets since AODV broadcasts periodic Hello messages to its neighbors. DSR behaves better in this case.

Each of the routing protocol generated different amount of overhead. DSR has the least overhead, TORA has maximum overhead. DSR, TORA and AODV are all on demand protocols and their overhead drops as mobility rate drops. It has been found from Graph that

(a) DSR performance is very good at all mobility rates and movement speeds with all the metrics of comparison.

(b) TORA is the worst performer in all the experiments the network was unable to handle all the routing traffic and lots of packets were dropped.

(c) AODV has performed as well as DSR and accomplishes its goal of eliminating source routing overhead and

(d) RDMAR has performed well.

V1. CONCLUSION AND FUTURE STUDY

The performance of the protocol has been evaluated with other common ad-hoc network routing protocols like DSR, AODV and TORA using a detailed packet level simulator NS. The traffic schemes assigned are TCP and UDP. Simulations have been carried out in an area as large as 1km x 1km with many sources connected to each other. More sources lead to more network load. Results have shown that quick management of route maintenance is an important factor that affects all the performance measures, especially the successful delivery rate at high workloads and increased speed.

It is found that the AODV has highest packet delivery ratio for all speeds and pause times. In other protocols, for very high-speed networks, AODV performs much better in successful packet delivery. The packet delivery rate of DSR, which is a source routing protocol, is directly related to the generation of control messages. Therefore it is related to the frequency of data packet transmissions. At very high speeds DSR cache transmission suffers and a loss in packet delivery occurs. TORA has the lowest throughput and generates a large amount of control messages to manage DAGs, and its control messages encapsulated in IP are dropped because of collisions, which lead to much more decrease in performance. AODV have used much less control messages, limited to the hosts involved in routing process, therefore they have the highest standard division. This means that they distribute the load over the network in least efficient way.

Results have been derived from a series of experiments conducted on simulated network. The following observations can be made:

- Best packet delivery ratio: AODV is the best in terms of packet transmission. More packets are transmitted than any of the studied protocols. This is true even in case of changing scenario and fast moving nodes. So it is able to achieve one of the most important objectives of ad-hoc networks as successful packet delivery.
- Simple: AODV can easily be implemented and executed. The simulation studies have been conducted on Pentium-IV with standard configurations. Though it is best performing under LINUX environment but can be easily implemented on Windows platform also. Efficiency is particularly important when the software implementing the routing algorithm must run on a computer with limited physical resources.
- Route Repair: The route phase of the protocol is unique as compared to other such protocols and outperform all in its category. It describes the maintenance process, which can be done as fast as possible. It describes the level of self-organization in the network. The protocol uses local route repair of routing process.

Future Work

Some of the objectives remained untouched due to the limited time available. On the other hand, outcome of the current research has exhibited the possibilities of further extensions. List of the work that can be carried out in future as an extension of current work is given below:

(a) There is limitation of Battery Life in an ad hoc environment. Battery is most commonly used; none of the protocols discussed the concept of Power as one of the deciding factor in route selection

(b) The existing strategies use fixed scenarios for carrying out simulations. It means before start of the simulation process, position of the nodes is known and also total sources used are fixed, but real life situations demand random scenes and varying sources.

(c) If a link breaks in the route process due to any reason, repair starts and it involves reconstruction of new path.

Reconstruction phase requires better approach in all protocols for fast selection of new routes.

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