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Analysis of Table Driven and On-demand Routing Protocols for Mobile Adhoc Networks

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ABSTRACT : Wireless communication technology is emerging as the most effective tool in the field of communication and networking technologies. A wireless ad hoc network is a decentralized wireless network. Software Simulator is an effective tool to be used to analyze complex network architectures, routing protocols and network topologies. Global Mobile Information Systems simulator is chosen to perform the simulation results from various types of network simulators available in this work. It is a scalable simulation tool for large wireless and wireline communication systems. In mobile adhoc networks each node of the network acts as router and packet forwarder. Therefore, bandwidth and power constraints are major issues in wireless multihop networks. In the last decade, on-demand protocols, which built routes have been proposed. In this work, a performance comparison of different table driven and on-demand routing protocols have been done. The performance analysis of DBF, a table driven protocol is compared with the on demand DSR routing protocol. The quantitative measure and the performance comparison of DBF and DSR analysis using simulation in common environment using GLOMOSIM is taken up in this work.

This work intends to analyze the different network parameters like control overhead, data throughput, end to end delay using simulation techniques. The simulation parameters were analyzed using the different parameters of the network viz. network nodes equal to 30, separated at a distance of 25m × 25m having transmission radius of 10 m with Random Movement of network nodes, Static Time of 10 sec, Channel capacity of 1.5 M bits/sec and MAC protocol IEEE 802.11 Distributed Coordination function. The simulation results show that the Dynamic Source Routing based on On-demand routing protocol techniques, outperforms the Distributed Bellman Ford model based on table driven routing protocol technique.

I. INTRODUCTION

The changing era of technology in this century has changed the way of living, thinking and executing our ideas during the different phases of our life cycle. The engineering sector has contributed to this modern way of living, with quality infrastructure like buildings, transportation, communication facilities and many more. But at the same time this development poses a challenge in the likes of implementation, market size, pros and cons of technological innovations on the human life. Telecommunication industry is the one which is changing the human lifestyle in many ways and helped the whole world look like a global village where we can easily interact with each other through different mediums of communication. In this work, the role of wireless infrastructure in making the world a global village is being explored [5]. The challenges of implementation, security, routing techniques etc are considered.

A wireless ad hoc network is a decentralized wireless network. The network is ad hoc because each node is willing to forward data to other nodes, and so the determination of nodes to forward data is made dynamically based on the network connectivity. This is in contrast to wired networks in which routers perform the task of routing [6]. It is also in contrast to managed wireless networks, in which a special node known as an access point manages communication among other nodes.

A mobile ad hoc network (MANET) is a collection of mobile nodes without any infrastructure. A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The different sets of applications for MANETs are diverse, ranging from small, static networks that are constrained by power sources, to large-scale mobile and highly dynamic networks [8]. MANETs need efficient distributed algorithms to determine network organization, link scheduling, and routing. Mobile nodes act as hosts (running applications) and routers (forwarding for others). The typical applications of mobile ad hoc networks include applications in military for security, mobile computing, public access in urban areas, intercommunication between various mobile devices, environmental monitoring, home networks where devices can communicate directly to exchange information, such as audio/video, alarms, and configuration updates [10].

A. Adhoc routing protocols

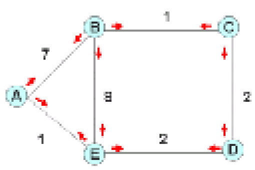
An Ad hoc routing protocol is a convention or standard that controls how nodes come to agree which way to route packets between computing devices in a mobile ad-hoc network (MANET). In ad hoc networks, nodes do not have a prior knowledge of topology of network around them, they have to discover it. The basic idea is that a new node optionally announces its presence and listens to broadcast announcements from its neighbors. The node learns about new near nodes and ways to reach them, and may announce that it can also reach those nodes. As time goes on, each node knows about all other nodes and one or more ways how to reach them. The ad-hoc network routing protocols Table-driven, a Pro-active Routing protocol and On-demand Reactive Routing are taken up in this work..

B. Distributed Bellman-Ford Algorithm

The DBF algorithm was developed to support routing in the ARPANET. A version of it is known as Routing Internet Protocol (RIP) and is still being used today to support routing in some Internet domains. It is a table-driven routing protocol, that is, each router constantly maintains an up-to-date routing table with information on how to reach all possible destinations in the network. For each entry the next router to reach the destination and a metric to the destination are recorded. The metric can be hop distance, total delay, or cost of sending the message. Each node in the network begins by informing its neighbors about its distance to all other nodes.

The receiving nodes extract this information and modify their routing table if any route measure has changed. For instance, a different route may have been chosen as the best route or the metric to the destination may have been altered. The node uses the following formula to calculate the best route [2]:

$$D(i, j) = \min_{k} [d(i, k) + D(k, j)]$$



Info at node	Distance to node A	B	C	D	E
A	0	7	~	~	1
B	7	0	1	~	8
C	~	1	0	2	~
D	~	~	2	0	2
E	1	8	~	2	0

Fig. 1. Network matrix to discover routes in DBF.

where $D(i, j)$ is the metric on the "shortest" path from node i to node j, $d(i, k)$ is the cost of traversing directly from node to node k, and k is one of the neighbors of node i. After recomputing the metrics, nodes pass their own distance information to their neighbor nodes again. After a while, all nodes/routers in the network have a consistent routing table to all other nodes. This protocol does not scale well to large networks due to a number of reasons. One is the so-called count-to-infinity problem. In unfavorable circumstances, it takes up to N iterations to detect the fact that a node is disconnected, where N is the number of nodes in the network. Another problem is the increase of route update overhead with mobility. RIP uses time- triggered and event-triggered routing updates. Mobility can be expressed as rate of link changes and/or router failures. In a mobile network environment, event-triggered routing updates tend to outnumber time-triggered ones, leading to excessive overhead and inefficient usage of the limited wireless bandwidth.

C. Dynamic source routing Protocol (DSR)

This is one of most useful on demand protocol. It is self-organizing and self-configuring. Dynamic source routing protocol is based on the concept of source based routing in which a source node determines the complete sequence of nodes threw which to forward the data packet rather than table based. A node seeding a packet to a destination node explicitly list the route to the destination [7].

In the of the packet. The list identify each "next hop" node that should be taken in order to get from the the source to the destination each node in the network maintain a route cache that contains source route that the route aware of. The route cache is continually updated with the old unused routes being purged and new routes inserted as a node learns about them

DSR has to important part: route discovery and route maintenance. When a node requires a route to destination its first action is to consult its route cache to determine if it already contains a route to the destination. If an unexpired route id found, the route is used for the data transmission. However, if there is no route in the nodes cache, it initiates a route discovery process by generating and broadcasting a route request (RREQ) packet across the network. The RREQ packet contain s the IP address of the source and destination nodes a unique route request ID and a route record which will contain the address of the sequence of nodes for the route. To limit the number of route request traversing the network, each nodes only processes a route request once the source node address and the unique route request ID are temporarily cached and if the node receive an other request with the same details it silently drops the packet.

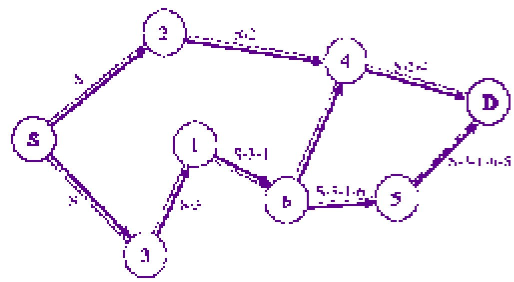


Fig. 2. Flooding of the route request to discover route record in DSR.

When an intermediate node receives a route request that it can process, its first action is to determine if its address is in packet's route record. If the route record already contains the nodes address a routing loop has occurred and the packet is dropped. If there is no routing loop the intermediate nodes inspects its route cache for an unexpired route to the destination it generate and sends a route reply (RREP) packet to the source node if such a route is found. If route is not found in the route cache, the intermediate node adds itd own address to yhe route record in PREQ and Broadcasts it to its neighbors. The route request packet is thus flooded in the network until either an intermediate node or the destination node itself replies to it. The process is shown in Figure 2. Note that the replying node, given a choice between two routes, chooses the route with least hop count. The route reply packet is routed back to the source node by reversing the order of the next hops in the route record of the original route request packet. The route reply packet that is sent back to the source node with the route record included. This can be seen in Fig. 3.

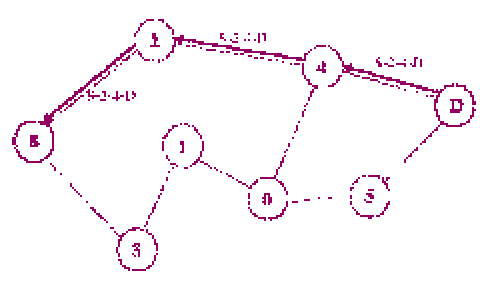


Fig. 3. Propagation of Route Reply in DSR.

The route maintenance procedure of the protocol monitors the operation of a route and is responsible for making the source node aware of any errors. If an intermediate node detects a failure to transmit a data packet to a downstream node, the node in the route error is removed from the nodes cache and all routes containing that node are truncated at that point. Link errors are detected by means of link layer feedback and/or data acknowledgments.

Table 1: Comparision of DBF and DSR.

Protocols	*DBF*	*DSR*
Route Establishment	Pro-active	On-demand
Routing Metric	Shortest Path	Shortest Path
Periodic Message	Route Tables	None
Loop Free	No	Yes

II. PROBLEM FORMULATION

In mobile adhoc networks each node of the network acts as router and packet forwarder. Therefore, bandwidth and power constraints are major issues in wireless multihop networks. While selecting the best routing protocol, bandwidth and power are the major concerns. In the last decade, on-demand protocols, which built routes have been proposed. In this thesis work, a performance comparison of different table driven and on-demand routing protocols have been done. The performance analysis of DBF, a table driven protocol is compared with the on demand DSR routing protocol. The quantitative measure and the performance of DBF and DSR analysis using simulation in common environment using GLOMOSIM is done.

A. Distributed Bellman-Ford

Nowadays routing is the vital problem while forwarding information from one node to another node in networks. Routing algorithm can be classified as distance vector and link state. Among distance vector and link state routing, distance vector routing algorithm forwards the information to each and every node from and to its neighbors. The distributed Bellman-Ford algorithm is a well known example of distance-vector algorithm (RIP) which calculates the shortest path.

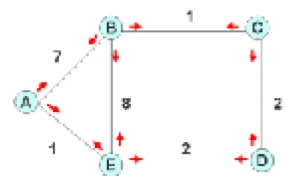
The Distributed Bellman-Ford protocol is a proactive table-driven protocol on basis of the Bellman-Ford Algorithm. That means that every node maintains a routing table. There are three different steps for catching every needed entry [1,2].

Start Conditions: Each router starts with a vector of distances to all directly attached networks. Each node maintains a routing table of destination, distance and successor.

Send step: Every node sends path vector tuples (destination, distance) to all immediate neighbors (no broadcast). These updates are sent periodically every second or minute. This depends on the size and the dynamic of the network. Triggered or immediate updates are sent out whenever destination vectors, entries in the routing table change.

Receiving step: For every network *Y*, router finds shortest distance to *X* considering current distance to *X* and it takes into account the distance to *X* from its neighbors. Router updates its cost to *X*. After doing this for all *X* destination routers (nodes), the router goes to send step.

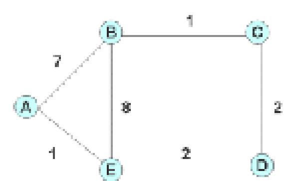
Fig. 4 shows the adjacent matrix from our proposed network after the start procedure has been designed. The numbers appearing on the links between two routers are called link costs. The costs of links can signify the hop count, bandwidth or even the really cost if there are two different operators connected on one link [1].



Info at node	Distance to node A	B	C	D	E
A	0	7	–	–	1
B	7	0	1	–	8
C	–	1	0	2	–
D	–	–	2	0	2
E	1	8	–	2	0

Fig. 4. Network matrix for the proposed work.

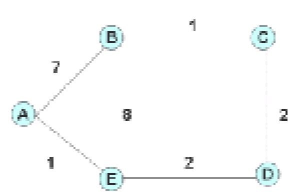
Fig. 5 shows the network matrix after the first update from router *D* to neighbor *E*.



Info at node	Distance to node A	B	C	D	E
A	0	7	–	–	1
B	7	0	1	–	8
C	–	1	0	2	–
D	–	–	2	0	2
E	1	8	4	2	0

Fig. 5. Network matrix after first update of the route.

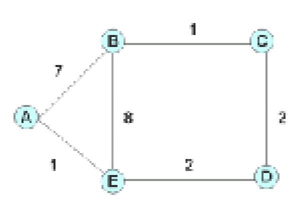
Fig. 6 shows the network matrix after the update from router *B* to neighbor *A*. *E* knows router *C* since the update from router *D*. But as we can see router *A* don't takes the shortest path to *C* because he still doesn't know the router *D*, so the path over *E*, *D* to *C* with lower costs.



Info at node	Distance to node A	B	C	D	E
A	0	7	8	–	1
B	7	0	1	–	8
C	–	1	0	2	–
D	–	–	2	0	2
E	1	8	4	2	0

Fig. 6. Network matrix after second update of the route.

Fig. 7 shows the network matrix after last updates of the route has been performed. All red marked costs mean now all costs show the shortest way to every other destination in the network.

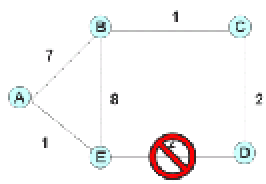


Info at node	Distance to node A	B	C	D	E
A	0	6	5	3	1
B	6	0	1	3	5
C	5	1	0	2	4
D	3	3	2	0	2
E	1	5	4	2	0

Fig. 7. Network matrix after last update of the route.

Fig. 8 shows a broken link in the route (link between router *E* and *D*). In this case a triggered update has to be sent out, and after the whole network is updated we can see red marked link costs have changed because of the broken link (*E*, *D*).

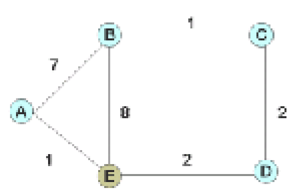
Router *A* is now no more able to reach router *C* by taking the shortest path over router *E*, *D*. Now *A* must actualize his routing table for the vector to *C* by using the longer but available path over router *B*.



Info at node	Distance to node A	B	C	D	E
A	0	7	8	10	1
B	7	0	1	3	8
C	8	1	0	2	9
D	10	3	2	0	11
E	1	8	9	11	0

Fig. 8. Network matrix for a broken link of the route.

Fig. 9 shows the routing table existing in Router *E*. Vertically on the left we can see all available destinations of the network and with a given next hop the cost to each other node. On the other hand the red marked costs are the shortest paths to other nodes. For example is it possible to reach router *A* taking router *B* as next hop, naturally the costs are much more higher (7 + 8 = 15) then taking the path directly to router *A*(1).



E's routing table

dest	Next hop A	B	D
A	1	14	5
B	7	8	5
C	6	9	4
D	4	11	2

Fig. 9. Network matrix showing table for routee E of the route.

There exist some problems in routing and can be attributed as count-to-infinity and looping

Bellman-Ford algorithm

Bellman-Ford algorithm is used to solve the single-source shortest-path problem in the general case in which edges of a given digraph can have negative weight as long as G contains no negative cycles. it uses d[u] as an upper bound on the distance d[u, *v*] from u to *v*. The algorithm progressively decreases an estimate d[v] on the weight of the shortest path from the source vertex s to each vertex v in V until it achieve the actual shortest-path. The algorithm returns Boolean TRUE if the given digraph contains no negative cycles that are reachable from source vertex s otherwise it returns Boolean FALSE [2].

Bellman-Ford (G, *w*, *s*)

1. INITIALIZE-SINGLE-SOURCE (G, *s*)
2. for each vertex *i*= 1 to V [G] - 1 do
3. for each edge (u, *v*) in E[G] do
4. RELAX (u, *v*, *w*)
5. for each edge (u, *v*) in E [G] do
6. if d[u] + *w* (u, *v*) < d[*v*] then
7. return FALSE
8. return TRUE

B. Dynamic Source Routing protocol (DSR)

The Dynamic Source Routing protocol (DSR) is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration.

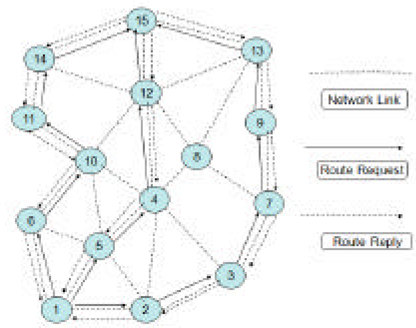


Fig. 10. Route establishment in DSR.

DSR has been implemented by numerous groups, and deployed on several testbeds. Networks using the DSR protocol have been connected to the Internet. DSR can interoperate with Mobile IP, and nodes using Mobile IP and DSR have seamlessly migrated between WLANs, cellular data services, and DSR mobile ad hoc networks.

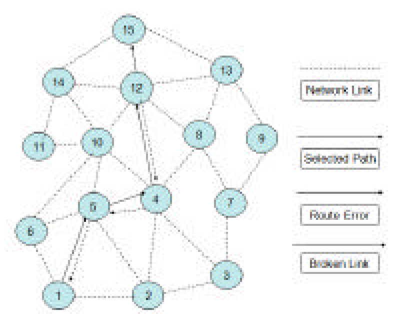


Fig. 11. Route Maintenance in DSR.

The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. All aspects of the protocol operate entirely on-demand, allowing the routing packet overhead of DSR to scale automatically to only that needed to react to changes in the routes currently in use.

The protocol allows multiple routes to any destination and allows each sender to select and control the routes used in routing its packets, for example for use in load balancing or for increased robustness. Other advantages of the DSR protocol include easily guaranteed loop-free routing, support for use in networks containing unidirectional links, use of only "soft state" in routing, and very rapid recovery when routes in the network change. The DSR protocol is designed mainly for mobile ad hoc networks of up to about two hundred nodes, and is designed to work well with even very high rates of mobility [1].

III. SIMULATIONS AND RESULTS

Simulation is another name of a dynamic process of a model to achieve knowledge, which one can carry over to reality. Simulations present a wide variety of alternatives to be analyzed under different environments.

Global Mobile Information Systems simulator is chosen to perform the simulation results out of various types of network simulators available for this work. The particular reason for the selection of Glomosim is that it is a scalable simulation tool for large wireless and wireline communication systems. Glomosim simulates network upto thousand nodes linked by heterogeneous communication capability that includes multicast, asymmetric communication using adhoc networking and traditional internet protocols.

A. Simulation Model

The simulation model for analyzing the performance is implemented in Glomosim. In this model, power of a signal attenuation as 1/d2 when d is the distance between nodes. Response of Simulation of Indoor Radio Channel Impluse Response models (SIRCM), which explores fading, barriers, foliages, interference etc. have also been simulated.

Source nodes and destination nodes were chosen randomly with uniform possibility. Multiple simulations have been performed.

A Table-driven routing protocol, Distributed Bellman Ford (DBF), used in traditional wired networks is compared with the on demand routing protocol, Dynamic Source Routing (DSR) in this thesis work. The different network parameters like control overhead, data throughput, end to end delay are measured using simulation techniques [6].

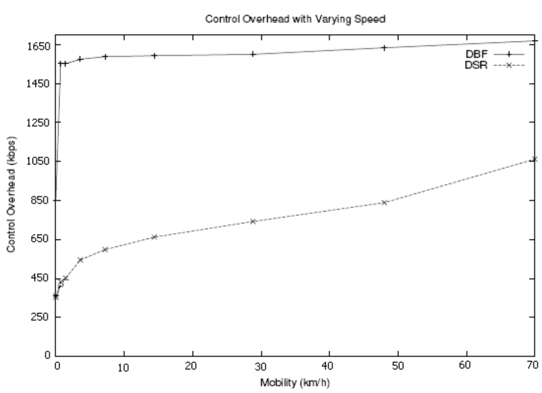


Figure 12. Control overhead for different mobility of nodes.

B. Control overhead

The control overhead for table drive routing protocol DBF is compared with on demand routing protocol DSR and is shown in figure 12. The route for sending the data is periodically updated in order to obey the respective routing table with the help of trigerring update and generate the control overhead. It has been noted that the control overhead for on demand routing technique DSR is considerably better as compared to table driven routing technique DBF.

C. Throughput

Throughput for table drive routing protocol DBF is compared with on demand routing protocol DSR as shown in figure 13. DBF protocol gives a poor response due to the route update control signals using the maximum value of the bandwidth. At the same time, it is found that route update control signals are not present in on-demand routing technique and hence saves the larger space for the productive usage. Routes are chosen in DSR techniques using the technique of shortest delay at a particular time during the design of the route.

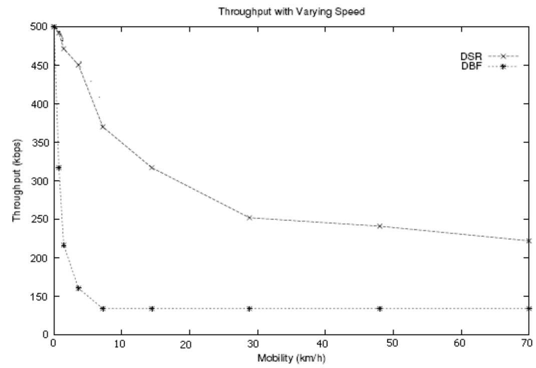


Fig. 13. Thoughput for different speed characteristics.

It is quite possible that the path so chosen gives the maximum optimization at that given instance but might not be able to give such type of consistency during another time period. But, when we compare both these protocols it is found that DSR is a technique that is best suited for the current scenario used in this thesis work.

D. End to end delay

Simulation results for End to end delay in data packets for both the network routing techniques table driven routing protocol DBF and on demand routing protocol DSR is given in figure 14. Simulation results show that there is a large amount of delay in case of table driven routing protocol DBF as compared with on demand routing protocol DSR. The difference between end to end delay becomes considerably large when the nodes are in moving situation in a network. It is also found that when the route loads are balanced, the factors like delay and congestion are considerably reduced. It is concluded from all the above factors that on demand routing protocols give much better performance as compared to table driven routing protocols.

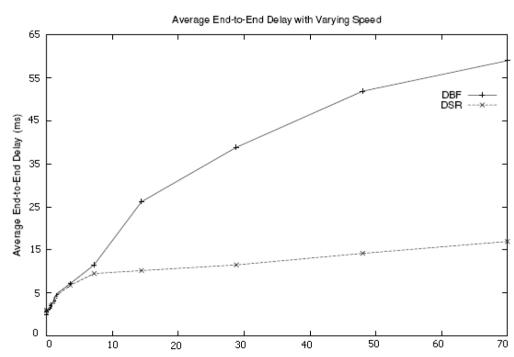


Fig. 14. End to end delay for different speed characteristics.

IV. CONCLUSION

It is inferred from the simulation results that the on demand routing protocol, Dynamic Source Routing (DSR) gives better performance when compared with Table-driven routing protocol, Distributed Bellman Ford (DBF). From the above conclusions, it is concluded that the On Demand routing protocols based Dynamic Source routing technique gives larger bandwidth, lesser delay and provides better control overhead than Distributed Bellman Ford (DBF) technique based table driven routing protocols.

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