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ANALYSIS OF DESTINATION-SEQUENCED DISTANCE VECTOR (DSDV) AND AD-HOC ON-DEMAND DISTANCE VECTOR (AODV) PROTOCOLS

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ABSTRACT

Routing protocols is very beneficial for mobile ad hoc network in terms of both performance and reliability. Mobile Ad-hoe Network (MANET) is decentralized network which needs a robust dynamic routine protocol. We have studied the following protocols: Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector (AODV), and Destination-Sequenced Distance Vector (DSDV) routing protocol. Nodes of these networks functions as routers which discovers and maintains the routes to other nodes in the network. Due to mobility, connections in the network can change dynamically and nodes can be added and remove at any time.

We have compared Mobile Ad-Hoc network routing protocols DSDV, AODV using network simulator NS2.34. Compared the performance of two protocols together and individually. The performance matrix includes PDR (Packet Delivery Ratio), Average End to End Delay, Routing Overhead. We are comparing the performance of routing protocols in two scenarios. In the first one we have calculated PDR, Average End to End Delay, Routing Overhead in an area of $50*50m^2$ taking number of nodes 20 & 50, varying the mobility of node as 0, 1m/s, 5 m/s and 10 m/s for a simulation time of 50 seconds to 150 seconds. In the other scenario we measured the performance of PDR of AODV and DSDV in an area of $500*500m^2$ for 50 nodes changing the data rate as 1 mbps, 5 mbps, 10 mbps for a simulation time varying from 5 minutes to 30 minutes.

KEYWORDS: MANET, AODV, DSDV, Infrastructure Network

INTRODUCTION

Wireless networks is an upcoming new technology that will permit users to access information and services electronically regardless of their geographic position. Wireless networks can be classified into two types: Infrastructure network and infrastructure less (ad hoc) networks. Infrastructure network (Conventional networks) consists of a network with fixed and wired gateways. A mobile host communicates with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed.

In contrast to infrastructure based networks, in ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Ad hoc networks are very useful in emergency search-and-rescue operations, meetings or conventions in which persons wish to quickly share information, and data acquisition operations in inhospitable terrain. An ad hoc network composes of a set of nodes, each mobile host can be a node. Each edge is formed by two nodes within the service range, it can be unidirectional or bi-directional. Edges changes with time as the mobile nodes in the ad hoc network moves freely. The topology of the ad hoc changes with time to time. With change of the topology of an ad hoc network, the nodes in the network have to update their routing information automatically and instantly. Routing protocols in packet-switched networks use either distance-vector or link-state routing algorithm. Both of them allow a host to find the next hop to reach the destination via the "shortest path". The metric of the shortest path might be number of hops, time delay, total number of packets queued along the path. Such shortest path protocols have been successfully used in many dynamic packet switched networks.

ROUTING PROTOCOLS

Link State Routing Protocol

It is one of the two main classes of routing protocols used in packet switching networks for computer communications. Examples of link-state routing protocols include open shortest path first (OSPF) and intermediate system to intermediate system (IS-IS). The link-state protocol is performed by every switching node in the network (i.e. nodes that are prepared to forward packets; in the Internet, these are called routers). The basic concept of link-state routing is that every node constructs a map of the connectivity to the network, in the form of a graph, showing which nodes are connected to which other nodes. Each node then independently calculates the next best logical path from it to every possible destination in the network. The collection of best paths will then form the node's routing table which is built up finding the shortest path of link cost. The information of link cost is transmitted periodically by all nodes using flooding technique. Each node updates its routing table using new link cost information gathered. Link cost information may be inconsistent because of dynamic behavior of topology or wireless medium, such as instantaneously incorrect long propagation delay etc. This may result in short-lived long routing loops, which disappear on link updates.

Distance Vector Routing Protocol

Distance: It is the cost of reaching a destination usually based on the number of hosts the path passes through or the total of all the administrative metrics assigned to the links in the path.

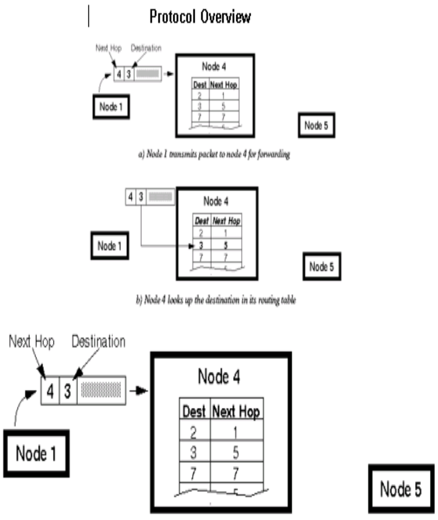
Vector: It is the interface traffic, it will be forwarded out in order to reach a given destination network along a route or path selected by the routing protocol as the best path to the destination network.

This protocol operates by having each node maintains a table, which contains a set of distance or cost. Node treats the neighbor as the next hop for a data packet destined for node. The routing table gives the best distance to each destination and which route to get there. To keep the distance set in the table up to date, each router exchanges information with all its neighbors periodically. If, as a result, a minimum distance to any neighbor of a node changes, this process will be repeated until all the nodes have updated the routing information. However, distance vector routing algorithm can cause both short-lived and long-lived loops due to updating the routing table with stale information. Though the looping problem can be eliminated using inter-nodal coordination method, which requires the routers to coordinate themselves mutually by confirmation messages in relatively stable environment. However, ad hoc networks are rapidly changing mobile environments. This inter-nodal coordination mechanism is difficult to be used in the ad hoc networks.

DSDV Protocol

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing protocol used for ad hoc mobile networks based on the Bellman–Ford algorithm. The main focus of the algorithm was to solve the loop problem. Each entry in the routing table contains a sequence number, using the newly added sequence number, the mobile nodes can distinguish stale route information from the new and thus prevent the formation of routing loops. The sequence numbers are generally even if a link is present; else, an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number. The data broadcast by each mobile computer will contain its new sequence number and the following information for each of route.

- The destination address.
- The number of hops required to reach the destination.
- The sequence no. of the information received regarding that destination.



a) Node 1 transmits packet to node 4 for forwarding

Figure 1

Routing Table Management

In DSDV, each mobile node of an ad hoc network maintains a routing table, which lists all available destinations, the metric and next hop to each destination and a sequence number generated by the destination node. Using such routing table stored in each mobile node, the packets are transmitted between the nodes of an ad hoc network Every time the network topology changes, the routing table in every node needs to be updated. To facilitate routing table maintenance, several additional pieces of information are stored in the routing tables. In addition to the destination address and next hop address, routing tables maintain the route metric and the route sequence number. Periodically when network topology changes are detected, each node will broadcast a routing table update packet. The update packet starts out with a metric of one. This signifies to each receiving neighbor they are one hop away from the node. The neighbors will increment this metric (in this case, to two) and then retransmit the update packet. It is different from that of the conventional routing algorithms. After receiving the update packet, the neighbors update their routing table with incrementing the metric by one and retransmit the update packet to the corresponding neighbors of each of them.

The process will be repeated until all the nodes in the ad hoc network have received a copy of the update packet with a corresponding metric. The update data is also kept for a while to wait for the arrival of the best route for each particular destination node in each node before updating its routing table and retransmitting the update packet. If a node receives multiple update packets for a same destination during the waiting time period, the routes with more recent sequence numbers are always preferred as the basis for packet forwarding decisions, but the routing information is not necessarily advertised immediately, if only the sequence numbers have been changed. If the update packets have the same sequence number with the same node, the update packet with the smallest metric will be used and the existing route will be discarded or stored as a less preferable route This process repeats itself until every node in the network has received a copy of the update packet with a corresponding metric..

To distinguish stale update packets from valid ones, each update packet is tagged by the original node with a sequence number. The sequence number is a monotonically increasing number which uniquely identifies each update packet from a given node. Consequently, if a node receives an update packet from another node, the sequence number must be equal to or greater than the sequence number already in the routing table; otherwise the update packet is stale and ignored. If the sequence number matches the sequence number in the routing table, then the metric is compared and updated as previously discussed. Each time an update packet is forwarded, the packet not only contains the address of the eventual destination, but it also contains the address of the transmitting node. The address of the transmitting node is entered into the routing table as the next hop (unless the packet is ignored, of course). To reach this consistency, the routing information advertisement must be frequent or quick enough to ensure that each mobile node can almost always locate all the other mobile nodes in the dynamic ad hoc network. Upon the updated routing information, each node has to relay data packet to other nodes upon request in the dynamically created ad hoc network.

Example

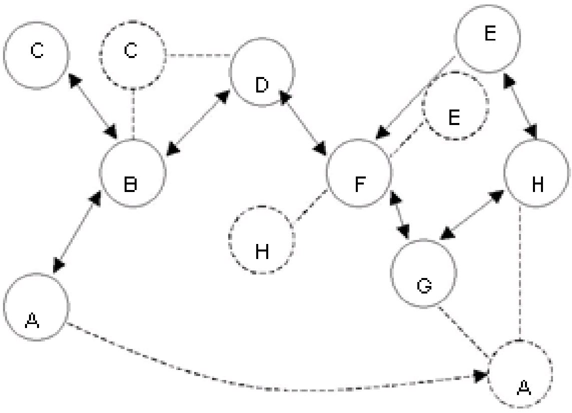


Figure 2: An Example of an Ad Hoc Network

Table 1: The Routing Table of Node F at One Instant

Dest	Next Hop	Metric	Seq.No.	Install
A	D	3	S406 A	T001 F
B	D	2	S128_B	T001_F
C	D	3	S564_C	T001_F
D	D	1	S710_D	T002_F
E	G	3	S392_E	T001_F
F	F	0	S076_F	T001_F
G	G	1	S128_G	T002_F
H	G	2	S050_H	T002_F

This shows the example of an ad hoc network before and after the movement of the mobile nodes. Table 1 is the routing table of the node F at the moment before the movement of the nodes. The Install time field in the routing table helps to determine when to delete stale routes.

Figure indicates that the node G advertises its routing information with broadcasting the update packet to its neighbors. When the node F receives the update packet, it will check the routing information of each item contained in both the update packet and the its routing table and update the routing table. The entries with higher sequence numbers are always entered into the routing table (e.g., the entry A has newer sequence number - S516A in the update packet in Figure a. This sequence number is entered into the updated routing table Figure c after the routing update.), regardless of whether each of them have a higher metric or not. If an entry has the same sequence number, the route with smaller metric is entered into the routing table (e.g., the entry E has the same sequence number – S502_E in both the update packet in Figure a and the current routing table in Figure b, but the entry E in the current routing table in Figure b has lower metric, so it enters the updated routing table in Figure c.). The items with old sequence numbers in the update packet are always ignored (e.g., B and H have old sequence number respectively in the update packet in Figure a, both of them are ignored in the updated routing table in Figure c).

Destination	Next Hop	Metric	Sequence Number
G	G	0	S238_G
A	A	1	S516_A
B	F	3	S228_B
C	D	4	S764_C
D	F	2	S820_B
E	H	2	S502_E
F	F	1	S204_F
H	G	1	S148_H

a) G advertised table (update packet)

+

Dest	Next Hop	Metric	Seq.No.	Install
A	D	3	S406_H1	T001_F
B	D	2	S238_H2	T001_F
C	D	2	S764_H3	T001_F
D	D	1	S820_H4	T002_F
E	E	1	S502_H5	T812_F
F	F	0	S204_H6	T001_F
G	G	1	S238_H7	T002_F
H	F	1	S160_H8	T811_F

b) F Routing Table

||

Dest	Next Hop	Metric	Seq.No.	Install
A	G	2	S516_A	T810_F
B	D	2	S238_B	T001_F
C	D	2	S764_C	T001_F
D	D	1	S820_D	T002_F
E	E	1	S502_E	T812_F
F	F	0	S204_F	T001_F
G	G	1	S238_G	T002_F
H	F	1	S160_H	T811_F

c) F Updated Routing Table

Figure 3: Example of Updating Routing Information

Problems of DSDV

The main purpose of DSDV is to address the looping problem of the conventional distance vector routing protocol and to make the distance vector routing more suitable for ad hoc networks routing. However, DSDV arises route fluctuation because of its criteria of route updates. At the same time, DSDV does not solve the common problem of all distance vector routing protocols, the unidirectional links problem.

Damping Fluctuation

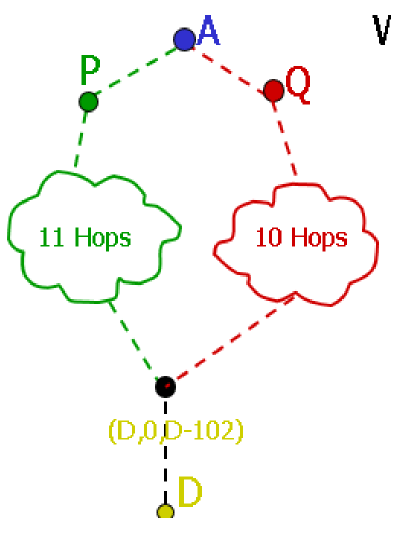


Figure 4

What are Fluctuations

- **Entry for D in A:** [D, Q, 14, D-100] D makes Broadcast with Seq. Nr. D-102 A receives from P Update (D, 15, D-102)
- **Entry for D in A:** [D, P, 15, D-102] A must propagate this route immediately A receives from Q Update (D, 14, D-102)
- **Entry for D in A:** [D, Q, 14, D-102] A must propagate this route immediately.

This can happen every time D or any other node does its broadcast and lead to unnecessary route advertisements in the network, so called fluctuations.

How to Damp Fluctuations

Record last and avg. Settling Time of every Route in a separate table. (Stable Data). Settling Time = Time between arrival of first route and the best route with a given seq. nr. A still must update his routing table on the first arrival of a route with a newer seq. no. but he can wait to advertising it. Time to wait is proposed to be 2*(avg. Settling Time). Like this fluctuations in larger networks can be damped to avoid unnecessary advertisement, thus saving bandwidth

Other Drawbacks

It is difficult to determine the maximum setting time DSDV does not support multi-path routing. The destination central synchronization suffers from latency problem. It has excessive communication overhead due to periodic and triggered updates. Each node must have a complete routing table.

Evaluation of DSDV

Complexity

In DSDV, the time complexity and communication complexity (link addition/failure is very high

Performance

DSDV maintains two table at each node. The bulk of the complexity in DSDV is to generate and maintain these two tables. The updates are transmitted to neighbors periodically as when needed. As with the growth of mobility and number of nodes in the network, the size of the bandwidth and the routing tables required to update these tables grows simultaneously.

Therefore the overheads for maintaining and updating these tables will increase correspondingly. Heavy routing overhead will degrade the performance of the network.

QoS Routing with DSDV

- **Band Reservation:** Multimedia applications such as digital audio and video has more stringent QoS requirements than traditional application. For the network to deliver QoS guarantees it must reserve and control resources. The ad hoc network must allocate bandwidth at call setup time in order to support real time connections.
- **QoS Routing:** QoS supports real time traffic, when the mobile nodes know the minimum delay path to destination and also need to have the knowledge of the bandwidth available on that path. At call setup time, the bandwidth has to be available and reserved. Otherwise the call setup request will be rejected.
- **Congestion Control:** Our analysis indicates that: a probabilistic congestion control scheme based on local tuning

of protocol parameters is feasible; and such a mechanism can be effective in reducing the amount of traffic routed through a node which is temporarily congested. network congestion due to the dynamics of mobility and of traffic patterns has to be controlled via applying selective packet dropping and input rate control, etc.

- **Mobility:** A QoS routing simulation was done in a wireless network, which interconnected to ATM in this case, QoS routing information permits to extend the ATM virtual circuit service to the wireless network with renegotiation of QoS parameters at the gateway. In the simulation, a cluster TDMA architecture was used. Only bandwidth was considered for the quality of service due to bandwidth guarantee is the most critical requirement for real time application. The available bandwidth computation is carried out independently at each node and is piggybacked on the DSDV loop-free routing algorithm

Current Status

DSDV is a well-known routing algorithm proposed for ad hoc network routing, but it has many problems as discussed earlier. Currently, there are no standard specifications and commercial implementations available for DSDV, but one DSDV simulator has been implemented with C++.

Many improved protocols based on DSDV have been developed. These improvements of DSDV include Global State Routing (GSR) Fisheye

State Routing (FSR), Ad Hoc On-Demand Distance Vector Routing (AODV)

AODV Protocol

Reactive Protocol Ad Hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for MANETs and other wireless ad hoc networks. It is a reactive routing protocol, meaning that it seeks to set up routes on – demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. In contrast, the most common routing protocols of the Internet are proactive, meaning they find routing paths independently of the usage of the paths.

AODV is as the name indicates, a distance-vector routing protocol. AODV avoids the counting-to-infinity problem from the classical distance-vector protocols by using sequence numbers for every route. AODV is capable of both unicast and multicast routing. When a node wishes to transmit data to a host to which it has no route, it will generate a *route request* (RREQ) message that will be flooded in a limited way to other nodes.

This causes control traffic overhead to be dynamic and it will result in an initial delay when initiating such communication. A route is considered found when the RREQ message reaches either the destination itself or an intermediate node with a valid route entry for the destination. For as long as a route exists between two endpoints, AODV remains passive. When the route becomes invalid or lost, AODV will again issue a request.

Consider nodes A, B, C and D making up a MANET. A is not updated on the fact that its route to D via C is broken. This means that A has a registered route, with a metric of 2, to D. C has registered that the link to D is down, so once node B is updated on the link breakage between C and D, it will calculate the shortest path to D to be via A using a metric of 3.

C receives information that B can reach D in 3 hops and updates its metric to 4 hops. A then registers an update in hop-count for its route to D via C and updates the metric to 5. And so they continue to increment the metric in a loop.

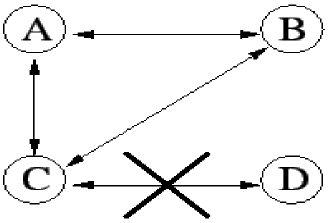


Figure 5: A Scenario that Can Lead to the “Counting to Infinity'' Problem

The way this is avoided in AODV, for the example described, is by B noticing that as route to D is old based on a sequence number. B will then discard the route and C will be the node with the most recent routing information by which B will update its routing table.

Route Request (RREQ) Message

When node S wants to send a message to node D, S searches its route table for a route to D.If there is no route, S initiates a RREQ message with the following components : The IP addresses of S and D.The current sequence number of S and the last known sequence number of D.A broadcast ID from S. This broadcast ID is incremented each time S sends a RREQ message.

Processing a RREQ message

- The <broadcast ID, IP address> pair of the source S forms a unique identifier for the RREQ.
- Suppose a node P receives the RREQ from S. P first checks whether it has received this RREQ before.
- Each node stores the <broadcast ID, IPaddress> pairs for all the recent RREQs it has received.

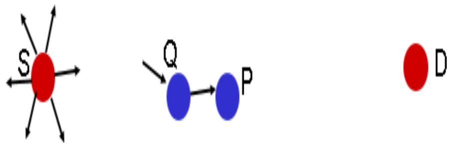


Figure 6

- If P has seen this RREQ from S already, P discards the RREQ. Otherwise, P processes the RREQ
- P sets up a reverse route entry in its route table for the source S.
- This entry contains the IP address and current sequence number of S, number of hops to S and the address of the neighbour from whom P got the RREQ.
- Lifetime is associated with the entry in the route table.This is important feature of AODV, if the root entry is not used within the specific lifetime, it is deleted. The route is maintained only when it is used. The route that is unused for a long time is assumed to be stale.

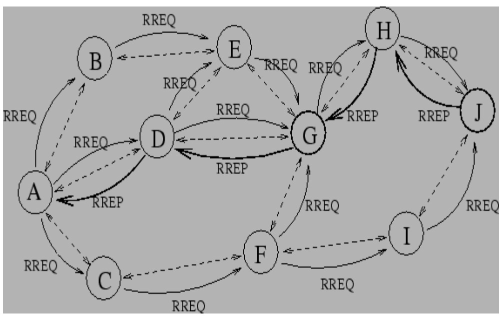


Figure 7

Route Reply (RREP) Message

A route reply message is unicasted back to the originator of a RREQ if the receiver is either the node using the requested address, or it has a valid route to the requested address. The reason one can unicast the message back, is that every route forwarding a RREQ caches a route back to the originator.

Route Error (RERR) Message

Nodes monitor the link status of next hops in active routes. When a link breakage in an active route is detected, a RERR message is used to notify other nodes of the loss of the link. In order to enable this reporting mechanism, each node keeps a ``precursor list", containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination.

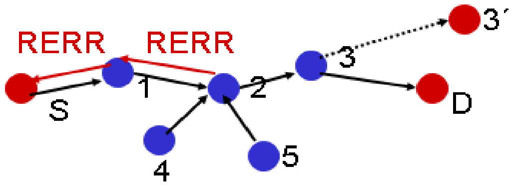


Figure 8

Performance of AODV

- AODV does not retransmit data packets that are lost and hence does not guarantee packet delivery.
- However, the packet delivery percentage is close to 100 with relatively small number of nodes.
- The packet delivery percentage drops with increased moility.
- The overhead packets in AODV are due to RREQ, RREP and RERR messages.
- AODV needs much less number of overheads packets compares to DSDV.
- The route discovery lattency in AODV is low compared to DSR and DSDV.
- Tha average path length for discovery routes is also qite low.

CONCLUSIONS AND FUTURE WORK

- The analysis shows that routing is very important Factor for estimating the system performance. In an adhoc network, the topology dynamically changes and traditional routing algorithms cannot satisfy its requirement hence a lot of research is needed to extented the existing routing algotithm and study its behaviour in different scenarios
- In this, we have compared the performance of routing protocols with respect to metrics: time, no. of nodes and mobility of nodes.The result indicate the performance of AODV is superior to DSDV.
- The graph for packet delivery ratio shows that receiving throughput for TCP packets that is almost constant (near about 98%) in the time range of 50 to 150 for AODV protocol is heigher than DSDV. With increasing number of nodes PDR for both the protocols is decreasing. As the simulation is run for a longer time the Packet Delivery Ratio of both the protocols starts to fall.
- AODV perform better under high mobility simulations than DSDV. High mobility results in frequent link failures and the overheads involved in updating all the nodes with the new routing information as in DSDV is much more than that involved AODV, where the routes are created as and when required.

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