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Performance and Comparison of Multi-Hop Ad-Hoc Routing Protocols – Quantitative Study

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Abstract

Wireless ad-hoc network is emerging network and form temporary networks. Due to its spontaneous nature the topology is frequently changes. Protocols selection and set up routing between any pair of nodes are the primary goal design for any wireless network. Several protocols are proposed in Mobile Ad-hoc Network (MANET) and selected protocol must provide best capability of data delivery and data integrity. In this paper, we are study and analysis the performance and characteristic of Ad-hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV) protocols using NS2 simulator. We are comparing the above said protocols based on the delay, throughput, control overhead and packet delivery ratio.

Keywords: *MANET, AODV, DSR, DSDV, OLSR.*

1. Introduction

MANET consists of mobile nodes. Each node is act as routers and is interconnected without a fixed infrastructure and can be arranged dynamically. The significant work has been done in the development of routing protocols in different types of ad hoc networks like MANETs, WMNs, WSNs, and VANETS etc [1]. Radio links are not reliable in wireless networks thus it integrated with physical, MAC and network layer. During the design of protocols we could concentrate on various limitations and capabilities such as power consumption, radio cell, packet loss, etc… [2]. In MANET a mobile node should have to communicate with other mobile node if it is not lie in radio range of transmission. Hence we can concentrate on protocol design based on minimal control overhead, minimal processing overhead, multi hop routing capability, dynamic topology maintenance and loop prevention [3].The figure 1 and 2 shows MANET and Multi-tier hybrid mobile ad hoc network architecture.

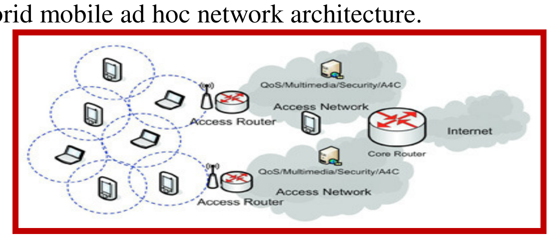

Figure 1: Mobile Ad Hoc Networks

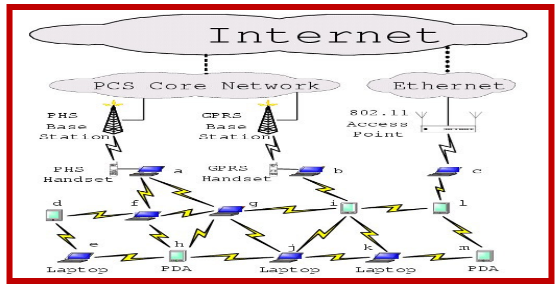

Figure 2: Multi-tier hybrid **mobile ad hoc network** architecture

2. Routing Protocols

MANET routing protocols are used to create a communication path between multiple nodes. The routing protocols are classified in different categories based on routing approach wise or network structure wise. According to routing approach the routing protocols can be categorized as table-driven or proactive and source-initiated or reactive or on-demand routing. The figure shows different categories of routing mechanism (Fig. 1). Different categories of protocols can behave differently on different wireless conditions. Hence the performance analysis of these protocols is a must task to know its behavior and work in that environment. Several factors will affect the overall performance of any protocol operating in an ad hoc network. For example, node mobility may cause link failures, which negatively impact on routing and quality of service (QoS) support. Network size, control overhead, and traffic intensity will have a considerable impact on network scalability along with inherent characteristics of ad hoc networks may result in unpredictable variations in the overall network performance.

Proactive (Table-Driven) routing protocol: -

In proactive routing protocol perform reliable and up-to-date routing information to all the nodes is maintained at each node.

Reactive (On-Demand) routing protocol: -

This type of protocols find route on demand by flooding the network with Route Request packets.

Hybrid routing protocol: -

This type of protocols operation is a combination of Proactive and Reactive routing mechanisms.

2.1 Ad-hoc On Demand Vector Protocol (AODV)

AODV combines some property of both DSR, DSDV routing protocols. It uses route discovery process to cope with routes on demand basis. When a node wants to know a specific route for destination, it creates a route request (RREQ). RREQ message is broadcasted to neighbor node.The message floods through the network until the desired destination or a node knowing fresh route is reached. Sequence numbers are used to guarantee loop freedom. RREQ message cause bypassed node to allocate route table entries for reverse route. The destination node uncast a Route Reply (RREP) back to the source node. Node transmitting a RREP message creates routing table entries for forward route. This route created from each node from source to destination is a hop-by-hop state and not the entire route as in source routing [7].

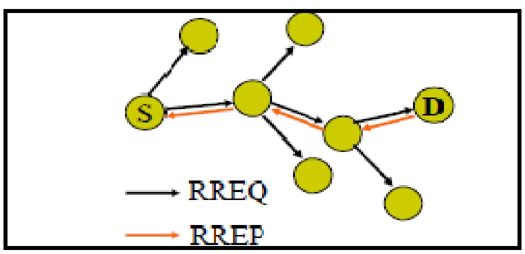

Fig 3: AODV routing protocol with RREQ. And RERR message

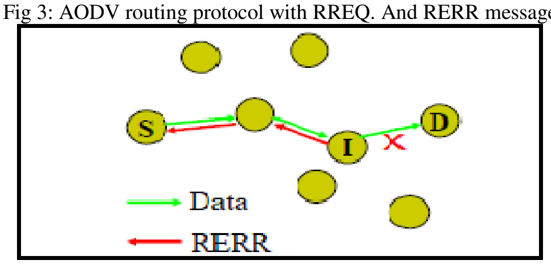

Fig. 4: AODV routing protocol with RREQ. And RERR message

2.2 Destination Sequenced Distance Vector (DSDV)

DSDV is a hop-by-hop distance vector routing protocol requiring each node to periodically broadcast routing updates based on the idea of classical Bellman-Ford Routing algorithm [8]. Each node maintains a routing table listing the “next hop” for each reachable destination, number of hops to reach destination and the sequence number assigned by destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid loop formation. 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.

2.3 Dynamic Source Routing (DSR)

The Dynamic Source Routing Protocol (DSR) is a reactive routing protocol .By the means of this protocol each node can discover dynamically a source route to any destination in the network over multiple hops. It is trivially loop free owing to the fact that a complete, ordered list of the nodes through which the packet must pass is included in each packet header. The two main mechanisms of DSR are Route Discovery and Route Maintenance, which work together to discover and maintain source routes to arbitrary destinations in the network [12, 13]. The following figure shows the route discovery method.

2.3.1 Salvaging

An intermediate node can use an alternate route from its own cache, when a data packet meets a failed link on its source rout e.

2.3.2 Gratuitous route repair

A source node receiving a RERR packet piggybacks the RERR in the following RREQ. This helps clean up the caches of other nodes in the network that may have the failed link in one of the cached source routes. Promiscuous listening: When a node overhears a packet not addressed to it, it checks if the packet could be routed via itself to gain a shorter route. If so the node sends a gratuitous RREP to the source of the route with this new, better route. Aside from this, promiscuous listening helps a node to learn different routes without directly participating in the routing process [14].

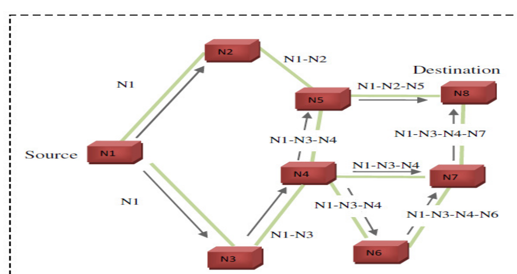

Fig.5: Creation of the route record in DSR

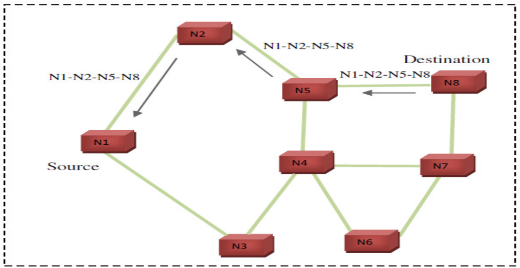

Fig. 6: Building of the route record during route discovery

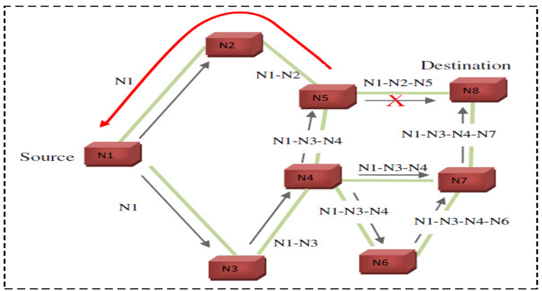

Fig. 7: Building of the route record during route discovery

2.4 Optimized Link State Routing (OLSR)

OLSR is a proactive routing protocol for mobile ad hoc networks. The protocol inherits the stability of the link state algorithm and has the advantage of having routes immediately available when needed due to its proactive nature. OLSR minimizes the overhead caused by flooding of control traffic by using only selected nodes, called Multi-Point Relays (MPR), to retransmit control messages. This technique significantly reduces the number of retransmissions required to flood a message to all nodes in the network. Upon receiving an update message, the node determines the routes (sequence of hops) toward its known nodes. Each node selects its MPRs from the set of its neighbors saved in the Neighbor list. The set covers nodes with a distance of two hops. The idea is that whenever the node broadcasts the message, only the nodes included in its MPR set are responsible for broadcasting the message [15] [16]. OLSR uses HELLO and TC messages. The Topology Control (TC) messages for continuous maintain of the routes to all destinations in the network, the protocol is very efficient for traffic patterns where a large subset of nodes is communicating with another large subset of nodes, and where the [source, destination] pairs change over time. The HELLO messages are exchanged periodically among neighbor nodes, to detect the identity of neighbors and to signal MPR selection. The protocol is particularly suited for large and dense networks, as the optimization is done by using MPRs which work well in this context. The larger and more dense a network, the more optimization can be achieved as compared to the classic link state algorithm. OLSR uses hop-by-hop Routing, i.e., each node uses its local information to route packets [15].

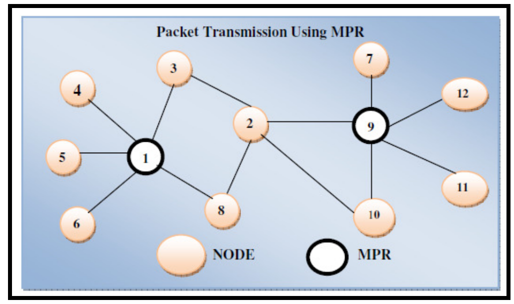

Fig.8: Packet Transmission Using MPR

3. Result Analysis

In this paper we are carried out performance and analysis of four protocols (AODV, DSR, OLSR and DSDV) based on number of nodes or pause time or network area while keeping other parameters constant. The three above performance factors are known as Network Load analysis, Mobility analysis and Network Size analysis.

3.1 Network Load Analysis

In this analysis the number of nodes varied from 10 to 50 with an increment of 10 nodes whereas the pause time, network size and simulation duration are fixed at 30s, 600X600 sqm, and 150s respectively. The DSR protocol has less control overhead in comparison with AODV, OLSR and DSDV in terms of control overhead Fig 9. The OLSR has highest control overhead up to 25 nodes and after that it is almost similar to the AODV. If the number of nodes increases then the control overhead of all protocols increases whereas the control overhead of DSR has a very slow rate of change in comparison to other protocols considered in this work.

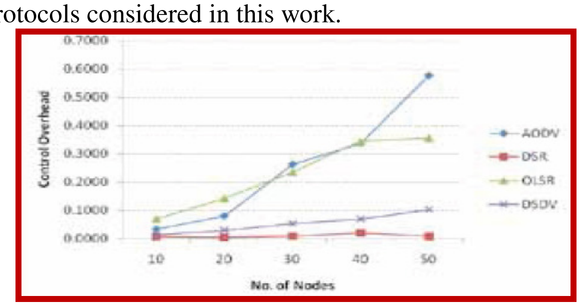

Fig 9: Variation for Control Overhead

The DSR outperforms the OLSR and DSDV whereas it is very closer with AODV in terms of PDR by increasing the nodes (Fig 10).

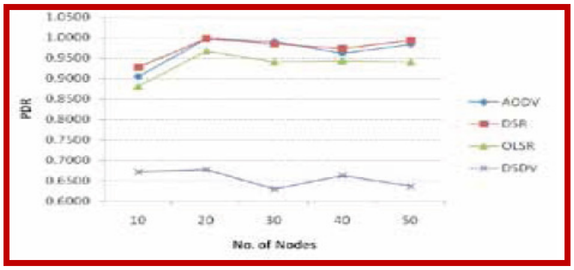

Fig 10: Variation of PDR

Similarly the DSR gives an average result in terms of delay and the variation is very low as compared to DSDV and AODV for different nodes which are shown in Fig 11.

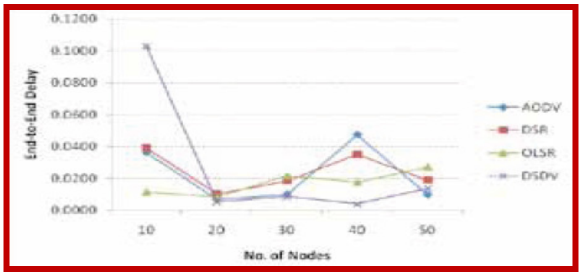

Fig 11: Variation of End-to-End Delay

The throughput of DSR is closer to OLSR but lower than the DSDV as shown in Fig 12. The AODV has lowest throughput in comparison with all the other three protocols considered.

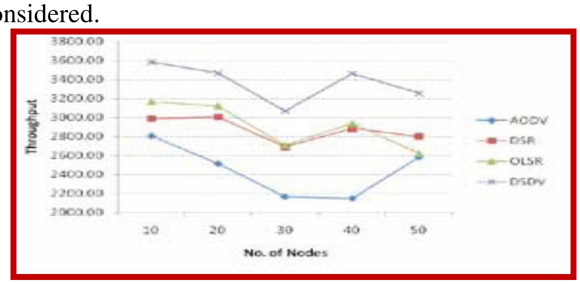

Fig 12: Variation of Throughput

3.2 Mobility Analysis:

In this analysis we assumed that each node has different velocity and direction. We considered "Random Waypoint Mobility" model of NS2 simulator to generate different mobility scenario. In simulation we considered the following pause times: 0s, 30s, 90s, 120s and 150s. I.e. the mobile condition (0s pause time) to static condition (150s pause time; same as total simulation duration). The maximum speed which is an important factor is fixed at around 10 m/s and the total number of nodes is fixed at 30 for each scenario of different pause time keeping all other parameters fixed. OLSR has the highest and DSR has the lowest overhead in terms of control overhead (Fig 13). Hence DSR is the best in terms of control overhead with different pause time.

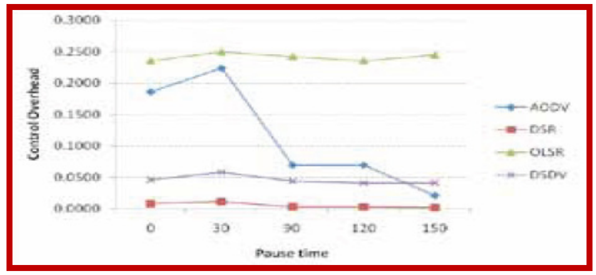

Fig 13: variation for control overhead

Similarly the DSR has highest PDR in different pause time which is reported in Fig 14.

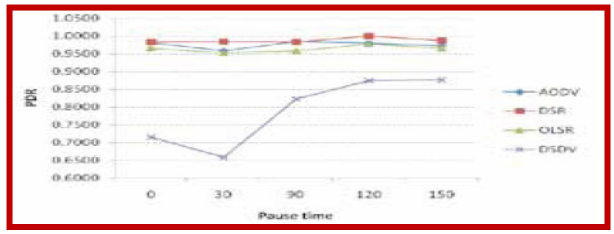

Fig 14: Variation of PDR

The DSR performs highest End-to-End delay up to 90 pause times and at 120 pause time all the protocols have almost same end-to-end delay; in fact this is the lowest end-to-end delay and after 120 pause times, DSR protocol has the lowest end-to-end delay (Fig 15).

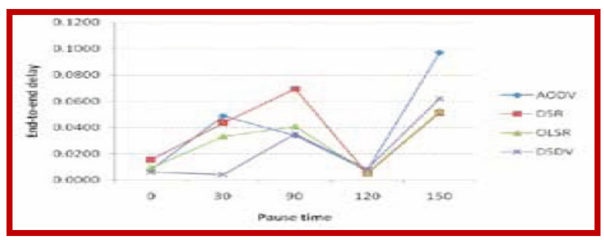

Fig 15: Variation of End-to-End Delay

DSR has the moderate throughput which is in between AODV and DSDV but closer to OLSR whereas after 120 pause time the throughput of all the protocols have almost equal throughput (Fig 16).

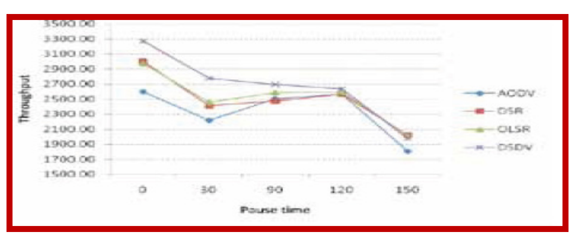

Fig 16: Variation of Throughput

3.3 Network Size Analysis:

In network size analysis the geographic network area is varied as 200x200 sqm, 400x400 sqm, 600x600 sqm, 800x800 sqm, and 1000x1000sqm keeping the number of nodes fixed at 30 under highly mobile condition. DSR performs better in terms of control overhead as it is very low in compared to other protocols i.e. AODV, DSDV and OLSR protocols (Fig 17).

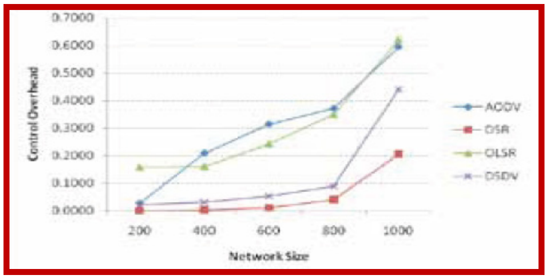

Fig 17 Variation for control overhead

The PDR of AODV and DSR is almost same as shown in Fig 18. Again the PDR performance of OLSR is better than DSDV but poor than other two protocols after 400x400sqm, network size.

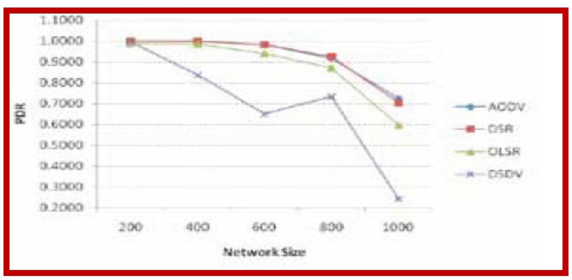

Fig 18: variation of PDR

From Fig 19 it is observed that the end-to-end delay gradually increases for all protocols as network size is increased. It is maximum for DSR and minimum for DSDV protocol after 400X400 sqm, network size.

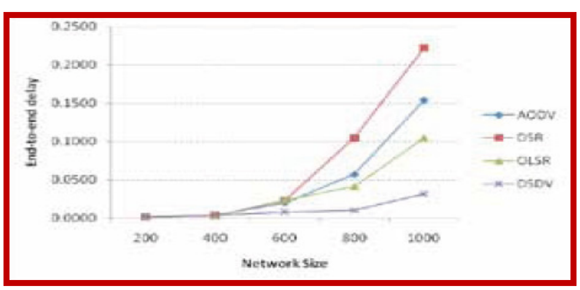

Fig 19: Variation of End-to-End delay

As delay is increased the throughput for all protocols are decreased gradually with increase in network size as shown in Fig 20. The DSDV protocol has the highest throughput, whereas DSR and OLSR have moderate throughput and are almost same for different network sizes up to 600X600sqm.

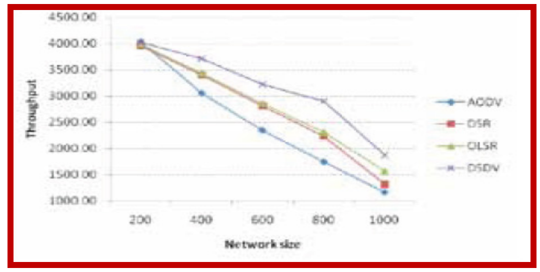

Fig 20: Variation of Throughput

3.4 Comparison Analysis

Table: 1Comparison between DSDV, DSR, AODV, OLSR

Protocol property	DSDV	DSR	AODV	OLSR
Multi-cast routes	NO	YES	NO	YES
Distributed	YES	YES	YES	YES
Unidirectional link	NO	YES	NO	YES
Multicast	NO	NO	YES	YES
Periodic broadcast	YES	NO	YES	YES
Qos support	NO	NO	NO	YES
Routes information maintained in	Route table	Route cache	Route table	Route table
Reactive	NO	YES	YES	NO
Provide loop free routers	YES	YES	YES	YES
Route optimization	YES	YES	YES	YES
Scalability	YES	YES	YES	YES
Route reconfiguration	Sequence number adopts	Erase route notify source	Erase route notify source	Link state announce ment
Pro active	YES	NO	NO	YES
Routing philosophy	FLAT	FLAT	FLAT	FLAT

3.5 Network load analysis

Property/ Protocol	AODV	DSR	DSDV	OLSR
Control Overhead	Moderate	Low	Moderate	High
Packet Delivery	Moderate	High	Moderate	Moderate
End-to-End delay	High	Average	High	Moderate
Throughput	Low	Average	High	Average

3.6 Mobility Analysis

Property/	AODV	DSR	DSDV	OLSR
Control Overhead	Moderate	High	Moderate	High
Packet Delivery	Moderate	High	Moderate	Moderate
End-to-End delay	High	Low	High	High
Throughput	Moderate	Moderate	Moderate	Moderate

3.7 Network size analysis

Property/Protocol	AODV	DSR	DSDV	OLSR
Control Overhead	Moderate	Low	Moderate	Moderate
Packet Delivery Ratio	High	High	Moderate	Low
End-to-End Delay	Moderate	High	Low	Moderate
Throughput	Low	Moderate	High	Moderate

4. Conclusions

In this paper we evaluated based on its metrics such as over head, PDR, End-to-End delay, Throughput. As a result the DSR routing protocol performs a best average PDR compare to other protocols in mobility conditions. DSR protocol performs better packet delivery ratio than other protocols making it suitable for highly mobile random networks. DSR protocol provide out performance in terms of network size with variations compare to other protocols. In high mobility conditions, OLSR protocol gives a better performance.

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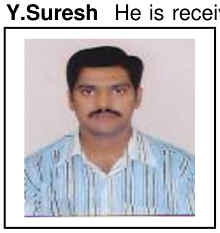

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