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I. Introduction

Wireless networking is an emerging technology that allow user to access information and services electronically. Regardless of their geographic position. Wireless network can be classified in two types-Infrastructure network and Infrastructure Less networks or Ad-hoc Network [1].

a) Infrastructure Networks

Infrastructure mode wireless networking brides a wireless network to a wired Ethernet network. Infrastructure mode wireless also supports central connection points for WLAN clients. Infrastructure network consist of fixed and wired gateways. A mobile host communicates with a bridge in the network within in communicating radius. The mobile unit can move geographically while it is communicating. When it goes out of rage of one base station, it connects with new base station and start communicating through it. This is called handoff. In this approach the base station are fixed [2].

b) Infrastructure Less (ad-hoc) Networks

An Infrastructureless Networks is a collection of mobile nodes that are dynamically and arbitrarily located in such a manner that the interconnections between nodes are capable of changing on a continual basis. The primary goal of such an infrastructure less networks is correct and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner.

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Multicasting is to send single copy of a packet to all of those of clients that requested it, and not to send multiple copies of a packet over the same portion of the network, nor to send packets to clients who don't want it. Ad-hoc network are basically peer-to-peer self-organizing and self-configuring multi-hop mobile wireless network where the structure of the network changes dynamically [3]. This is mainly due to the mobility of nodes. Nodes in this network utilize the same random access wireless Channel, cooperating in friendly manner to engaging themselves in multi-hop Forwarding. The nodes in the network not only act as hosts but also as routers that route data to/from other nodes in the network [3]. Ad-hoc network flat routing protocols may classify as:

i. *Proactive routing (Table-driven) protocols*

Proactive routing or table-driven routing protocols attempt to maintain consistent, up-to date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to change in network topology by propagating route update throughout the network to Maintain consistent network view.

ii. *Reactive (On-demand) routing protocols*

In reactive or on demand routing protocols, the routes are created as when required. When a source wants to send to a destination, it invokes the route discovery mechanism to find the path to the destination. This process is completed when once a source is found or all possible route permutation has been examined. Once a route has been discovered and established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path from the source or route is no longer desired.

The following point shows the importance of ad hoc networks.

a. *Instant Infrastructure*

Unplanned meetings, spontaneous inter-personal communications etc., cannot rely on any infrastructure, it needs planning and administration. It would take too long to set up this kind of infrastructure; therefore ad-hoc connectivity has to setup.

b. *Disaster Relief*

Infrastructure typically breakdown in disaster areas. Hurricanes cut phone and power lines, floods destroy Base stations, fires burn servers. No forward planning can be done, and the set-up must be externally fast and reliable. The same applies to many military activities, which are, to be honest, one of the major driving forces behind mobile ad-hoc networking research.

c. *Effectiveness*

Service provided by existing infrastructure might be too expensive for certain applications. If, for example only connection oriented cellular network exist, but an application sends only small status information every other minute, cheaper ad-hoc packet-oriented network might be a better solution. Registration procedure might take too long and communication overheads might be too high with existing networks. Tailored ad- hoc networks can offer a better solution [4].

d. *Remote Areas*

Even if infrastructure could be planned ahead, it is sometimes too expensive to set up an infrastructure in sparsely populated areas. Depending on the communication pattern, so ad-hoc networks or satellite infrastructure can be a solution.

II. Overview of the Protocol

a) *Ad hoc On Demand Distance Vector (AODV)*

Ad hoc On Demand Distance Vector Routing Protocol (AODV) is a reactive routing protocol designed for Ad hoc wireless network and it is capable of both unicast as well as multicast routing [5]. The Route Discovery process in this protocol is performed using control messages Route Request (RREQ) and Route Reply (RREP) whenever a node wishes to send packet to destination. Traditional routing tables is used, one entry per destination [6]. During a route discovery process, the source node broadcasts a Route Request packet to its neighbors. This control packet includes the last known sequence number for that destination. If any of the neighbors has a route to the destination, it replies to the query with Route Reply packet; otherwise, the neighbors rebroadcast the Route Request packet. Finally, some of these query control packets reach the destination, or nodes that have a route to the destination. At this point, a reply packet is generated and transmitted tracing back the route traversed by the query control packet. In the event when a valid route is not found or the query or reply packets are lost, the source node rebroadcasts the query packet if no reply is received by the source after a time-out. In order to maintain freshness node list, AODV normally requires that each node periodically transmit a HELLO message, with a default rate of one per second [13]. When a node fails to receive three consecutive HELLO messages from its neighbor, the node takes is as an indication that the link to its neighbor is down. If the destination with this neighbor as the next hop is believed not to be far away (from the invalid routing entry), local repair mechanism may be launched to rebuild the route towards the destination; otherwise, a Route Error (RERR) packet is sent to the neighbors in the precursor list associated with the routing entry to inform them of the link failure [14].

b) *Fisheye State Routing (FSR)*

Fisheye State Routing (FSR) [9] protocol is a proactive (table driven) ad hoc routing protocol and its mechanisms are based on the Link State Routing protocol used in wired networks. FSR is an implicit hierarchical routing protocol. It reduces the routing update overhead in large networks by using a fisheye technique. Fisheye has the ability to see objects the better when they are nearer to its focal point that means each node maintains accurate information about near nodes and not so accurate about far-away nodes. The scope of fisheye is defined as the set of nodes that can be reached within a given number of hops. The number of levels and the radius of each scope will depend on the size of the network. Entries corresponding to nodes within the smaller scope are propagated to the neighbors with the highest frequency and the exchanges in smaller scopes are more frequent than in larger. That makes the topology information about near nodes more precise than the information about far away nodes. FSR minimized the consumed bandwidth as the link state update packets that are exchanged only among neighboring nodes and it manages to reduce the message size of the topology information due to removal of topology information concerned far-away nodes. Even if a node doesn't have accurate information about far away nodes, the packets will be routed correctly because the route information becomes more and more accurate as the packet gets closer to the destination. This means that FSR scales well to large mobile ad hoc networks as the overhead is controlled and supports high rates of mobility.

III. Simulation Methodology

Simulation based study using Network Simulator NS-2 [10] has been used to compare two protocols viz. AODV and FSR under varying node density and varying pause time, assuming that the size of network, maximum speed of nodes and transmission rate are fixed. Tables 1 and 2 summarize the parameters used in the communication and movement models for simulation.

a) *Communication Model*

The simulator assumes constant bit rate (CBR) traffic with a transmission rate of 8 packets per second. The number of nodes varies from 25 to 100 in the denomination of 25, 50, 75 and 100. Given on the last line.

Parameter	Value
Traffic type	CBR
Number of nodes	25, 50, 75, 100
Transmission rate	8 packets/second

Table 1 : Parameters of Communication Model

b) Movement Model

In line with the realistic mobility pattern of the mobile nodes, the simulation assumes a Random Waypoint Model [7], where a node is allowed to move in any direction arbitrarily. The nodes select any random destination in the 500 X 500 space and moves to that destination at a speed distributed uniformly between 1 and nodes maximum speed (assumed to be 20 meter per second). Upon reaching the destination, the node pauses for fixed time, selects another destination, and proceeds there as discussed above. After testing all possible connection for a specific scenario, pause time changes to test the next scenario. This behavior repeats throughout the duration of the simulation (500 seconds). Meanwhile, number of nodes and pause time has been varied to compare the performance of the protocols for low as well as high density environment and for low mobility of the nodes to high mobility. Table 2 lists the movement parameters of the simulations.

Parameter	Value
Simulator	NS-2
Simulation time	500 seconds
Area of the network	500 m x 500 m
Number of nodes	25, 50, 100, 200
Pause time	10 seconds
Maximum speed of nodes	20 meters per second
Mobility Model	Random waypoint

Table 2 : Parameters of movement model

c) Performance Metrics

Three performance metrics has been measured for the protocols.

d) Throughput

Throughput is the number of packet that is passing through the channel in a particular unit of time [8]. This performance metric shows the total number of packets that have been successfully delivered from source node to destination node. Factors that affect throughput include frequent topology changes, unreliable communication, limited bandwidth and limited energy.

$$Throughput = \frac{Received\_Packet\_Size}{Time\ to\ Send} \quad (1)$$

e) Average End-to-End Delay

A specific packet is transmitting from source to destination node and calculates the difference between send times and received times. This metric describes the packet delivery time. Delays due to route discovery, queuing, propagation and transfer time are included metric [13].

$$Avg\_End\_to\_End\_Delay = \frac{\sum_1^n (CBR\_Sent\_Time - CBR\_Recv\_Time)}{\sum_i^n CBR\_Recv} \quad (2)$$

f) Normalized Routing Load

Normalized Routing Load is the ratio of total number of routing packet received and total number of data packets received [12].

Normalized_Routing_Load=

$$\frac{Number\ \_of\ \_Routing\ \_Pkts\ \_Recvd}{Number\ \_of\ \_Data\ \_Pkts\ \_Recvd} \quad (3)$$

IV. Simulation Result and Analysis

Figures 1, 2 and 3 represent the performance analysis in terms of throughput, average end-to-end delay and normalized routing load respectively. In all the cases the node density varies from 25 to 100 and pause time varies from 5 to 20 second.

a) Throughput

Based on the result of simulation as indicated in Fig 1(a) it is evident that performance of AODV is better than FSR in a low node density environment but with a rise innode density FSR out performs AODV which is evident from Fig 1(b), 1(c) and 1(d).

Another characteristic that has come to the notice is that pause time does not have significant bearing on the throughput whereas the performance is dictated only by the density of the network. The possible reason for the same is due to proactive nature of FSR routing protocol, which causes less number of table update in a stable topology, thus producing better throughput.

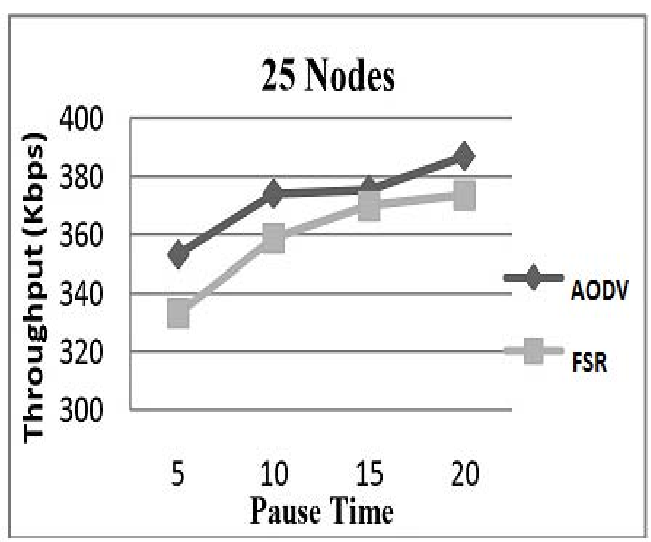

Figure 1(a) : Throughput for 25 nodes

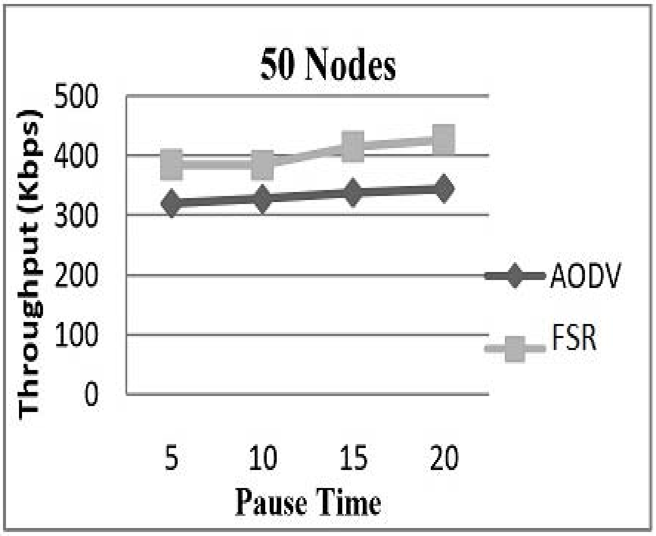

Figure 1(b) : Throughput for 50 Nodes

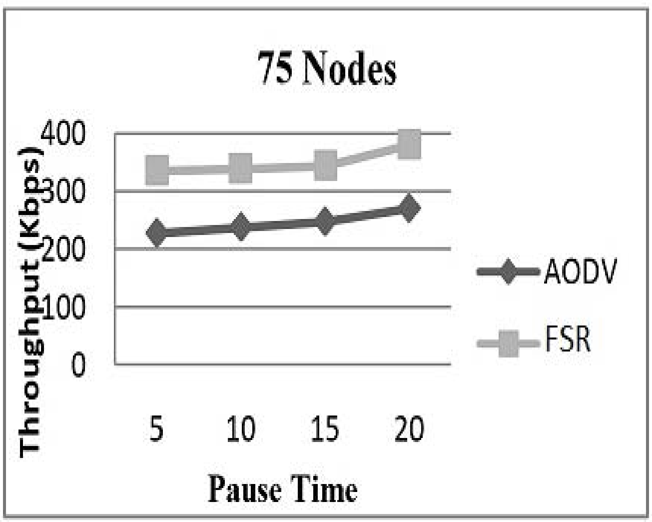

Figure 1(c) : Throughput for 75 Nodes

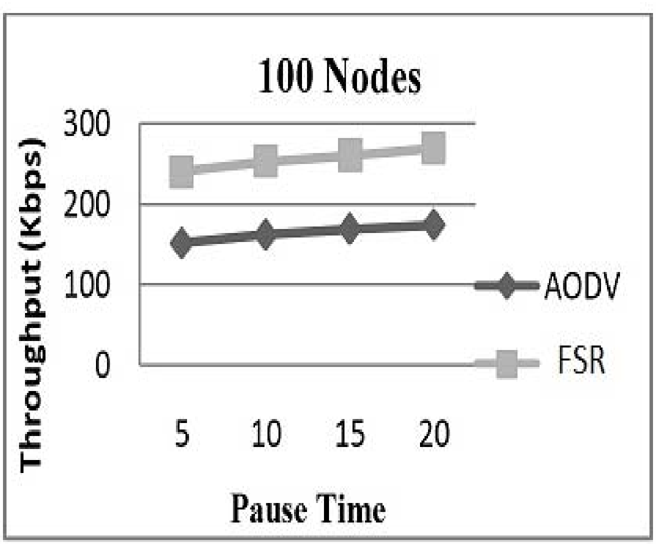

Figure 1(d) : Throughput for 100 Nodes

b) Average End-to-End Delay

The simulation result as indicated in Fig 2(a) and 2 (b) shows that in case of low node density, the average end-to-end delay of AODV is higher than FSR whereas Fig 2(c) and 2(d) indicates that with an increase in node density, AODV outperforms FSR.

It also has been observed that with an increase in pause time there is a decline in the average end-to-end for both the protocols under low node density environment (Fig 2a and 2b). However, this is not true when there is a rise in the network density. The possible reason for such behavior is the presence of more number of nodes between source and destination which effects in increase of hop count thus resulting in increased average end-to-end delay.

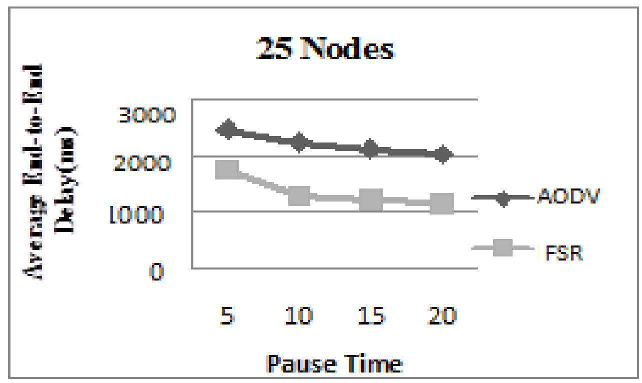

Figure 2(a) : Average End-to-End Delay for 25 Nodes

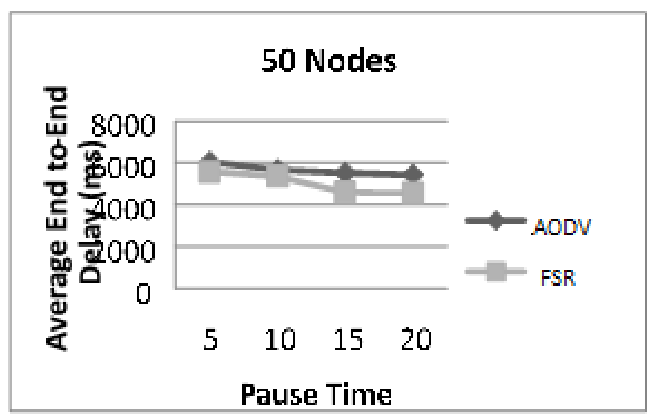

Figure 2(b) : Average End-to-End Delay for 50 Nodes

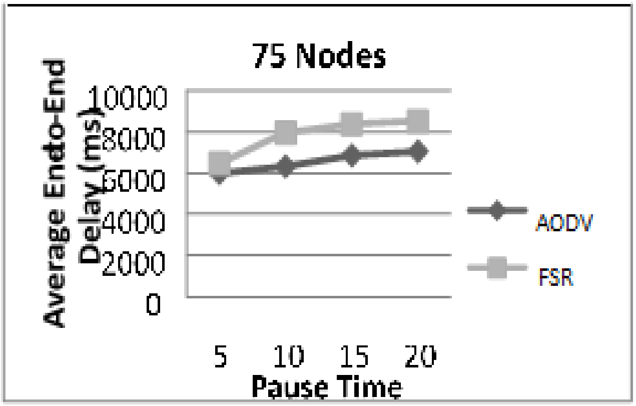

Figure 2(c) : Average End-to-End Delay for 75 Nodes

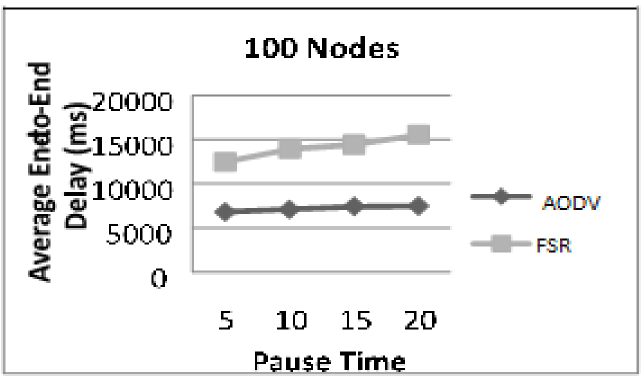

Figure 2(d) : Average End-to-End Delay for 100 Nodes

c) Normalized Routing Load

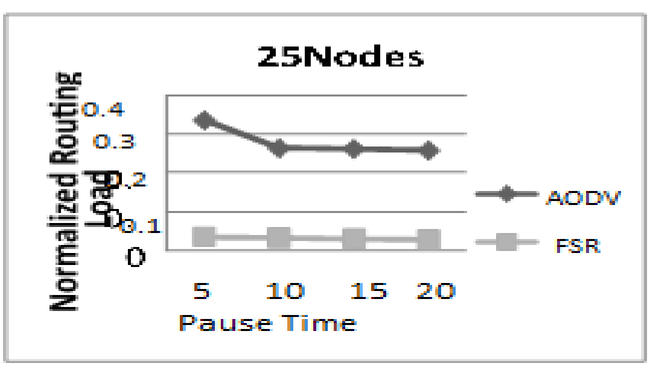

Figure 3(a) : Normalized Routing Load for 25 Nodes

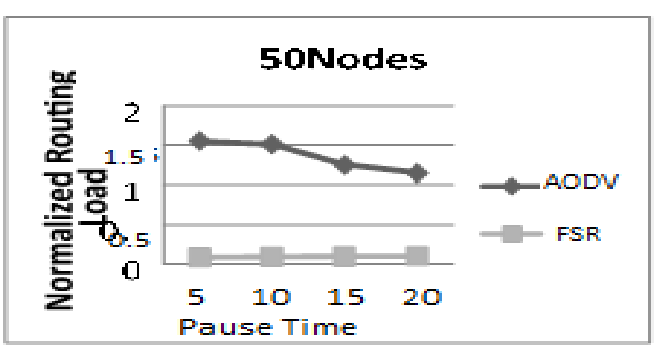

Figure 3(b): Normalized Routing Load for 50 Nodes

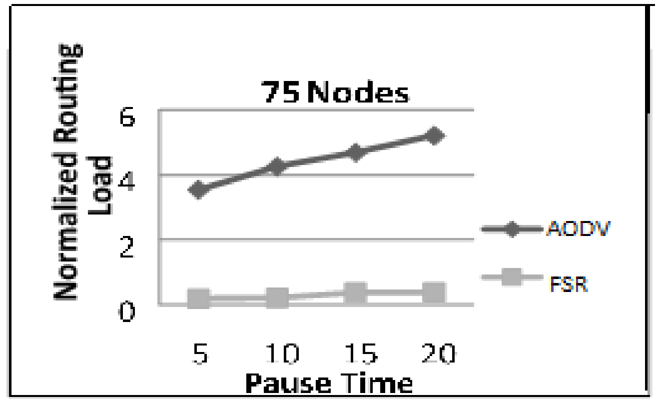

Figure 3(c) : Normalized Routing Load for 75 Nodes

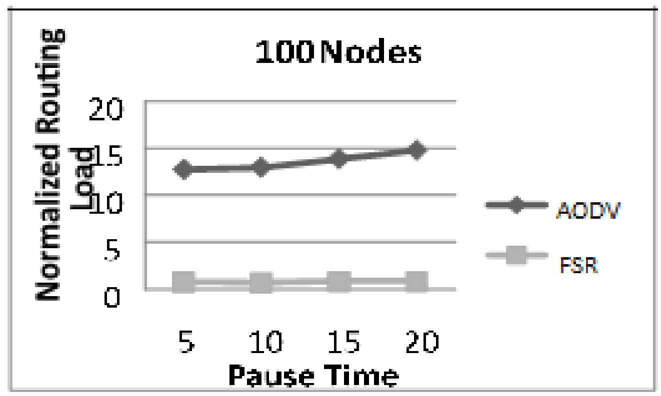

Figure 3(d): Normalized Routing Load for 100 Nodes

Fig 3(a), Fig 3(b), Fig 3(c) and Fig 3(d) indicates that normalized routing load of AODV is always higher than FSR under any scenario. The performance of FSR in terms of normalized routing load is not influenced in any way with respect to change in node density and pause time. The reactive nature of AODV routing protocol causes more number of control overhead than FSR. Therefore, normalized routing load for AODV will always be higher than FSR.

V. Conclusion

The performance evaluation of two routing protocols, AODV and FSR, has been done with respect to metrics viz. throughput, average end-to-end delay and normalized routing load under varying node density and varying pause time. From the result analysis, it has been observed that in high node density the performance of both protocols decreases significantly. The increase of node density in the network causes more number of control packets in the network for route establishment between a pair of source and destination nodes. This is the main reason of performance degradation of the routing protocols in high node density [15]. On other hand, increase of pause time indicates more stable network. Thus the performance of both routing protocols increases with the increment of pause time. It has been observed that in low node density the performance of AODV is better than FSR in terms of throughput, whereas the performance of DSDV is better in high node density (up to 100 nodes). Another observation has been found from the result that increment of pause time does not affect much in the performance of FSR where the performance of AODV varies significantly with the pause time. In Current work, only three performance metrics have been considered to analyze the performance of AODV and FSR. Inclusion of other performance metrics will provide in depth comparison of these two protocols which may provide an insight on the realistic behavior of the protocols under more challenging environment. The current work has been limited with fixed simulation area (500x500m) with CBR traffic and node density is up to 100 nodes. From previous work [15], it has been observed that in higher node density (200 nodes) AODV performs better than FSR. Varying simulation area and higher node density with different traffic will provide in depth performance analysis of these two protocols.

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