

Performance evaluation of reactive routing protocols for IEEE 802.11

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Abstract

The progress of communication technology has made wireless devices smaller, less expensive and more powerful. This has initiated everyone to use various wireless network technologies such as 3G, 4G of cellular network, Ad-Hoc, IEEE 802.11 based Wireless Local Area Network (WLAN) and Bluetooth. The performance of the routing protocols AODV, DSR and LAR are compared using Qualnet 5.0.2.Network Simulator with the metrics like average jitter, throughput, end-to-end delay, total number of bytes received and packet delivery ratio successfully routed to their destination.

Keywords: Proactive, Reactive, AODV, DSR, LAR, Qualnet, Routing

INTRODUCTION

The widespread use of laptops, cell phones, PDAs, GPS receivers, intelligent electronics devices represents a gigantic step towards an increasing miniaturization and ubiquity of modern embedded systems. With it, computing devices have become cheaper, more mobile, more distributed, and more pervasive in everyday life, creating an eagerness for monitoring and controlling everything, everywhere [1]. These advancements in information and communication technology (namely on memories, batteries, energy scavenging techniques and hardware design) and the necessity of large-scale communication infrastructures, triggered the birth of the Wireless Sensor Network (WSN) paradigm.

In recent years, the progress of communication technology has made wireless devices smaller, less expensive and more powerful. Such rapid technology advance has provoked great growth in mobile devices connected to the Internet. So everyone are using various wireless network technologies such as 3G, 4G of cellular network, Ad-Hoc, IEEE 802.11 based Wireless Local Area Network (WLAN) and Bluetooth. IEEE 802.15.4 is a very important technology of ubiquitous Wireless sensor network.

Many routing protocols for ad-hoc wireless networks, promise rapid network convergence, multi-hop routing capabilities and soft real-time performance. With the use of IEEE 802.11 as the underlying Mac layer, a totally distributed wireless infrastructure can self-organize and form a multihop wireless network. Some of the applications of ad-hoc networks can be in law enforcement, in emergency response in case of catastrophic events [1], various military applications, in construction sites, industries, in airports, railway stations, convention centers etc. The key factor that determines how efficiently a multihop wireless network reacts to topology changes

and node mobility is the routing protocol that provides routes for every node in the network.

In this work an attempt is made to study the performance evaluation of the routing protocols: Ad-hoc On-demand Distance Vector routing (AODV), Dynamic Source Routing (DSR) and Location Aided Routing (LAR) using Qualnet 5.0.2. network simulator. The study includes the metrics like average jitter, throughput, end-to-end delay, data delivery ratio and number of packets successfully routed to their destination.

ROUTING PROTOCOLS

Routing protocols are divided into two categories: Proactive and Reactive. Proactive routing protocols are table-driven protocols that always maintain current up-to-date routing information by sending control messages periodically between the nodes which update their routing tables. The proactive routing protocols use link-state routing algorithms which frequently flood the link information about its neighbours [1]. Reactive or on-demand routing protocols create routes when it is demanded by the source. Such protocols use distance-vector routing algorithms [2].

Proactive (Table-Driven) Routing Protocols

In proactive routing, each node has one or more tables that contain the latest information of the routes to any other node in the network. Various table-driven protocols differ in the way how the information propagates through all nodes in the network when topology changes. The proactive routing protocols are not suitable for larger networks as they need to maintain each and every node entries in the routing table. This causes more overhead in the routing table leading to consumption of more bandwidth.

Examples of such schemes are the conventional routing schemes: Destination Sequenced Distance Vector (DSDV), Bellman ford protocol, Optimized Link State Protocol (OLSR) etc.

Reactive Protocols (On-Demand)

Reactive routing is also known as on-demand routing protocol since they do not maintain routing information or routing activity at the network nodes if there is no

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communication. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery occurs by flooding the route request packets throughout the network. Examples of reactive routing protocols are the Dynamic Source Routing (DSR), Adhoc On-demand Distance Vector routing (AODV) and Location Aided Routing (LAR).

1) Adhoc On-demand Distance Vector routing (AODV): This protocol performs route discovery using control messages route request (RREQ) and route reply (RREP) whenever a node wishes to send packets to destination. When source node receives the route error (RERR) message, it can reinitiate route. Neighbourhood information is obtained from broadcast Hello packet. It is a flat routing protocol which does not need any central administrative system to handle the routing process. AODV tends to reduce the control traffic messages overhead at the cost of increased latency in finding new routes. The AODV protocol is a loop free and uses sequence numbers to avoid the infinity counting problem which are typical to the classical distance vector routing protocols [3].

2) Location Aided Routing (LAR): Location Aided Routing, as proposed by Ko and Vaidya [4], is an enhancement to flooding algorithms to reduce flooding overhead. Most on-demand methods, including DSR and AODV use flooding to obtain a route to the destination. This flooding results in significant overhead. LAR aims to reduce the overhead to send the route requests only into a specific area, which is likely to contain the destination.

For this purpose the notions of expected zone and request zone is introduced. The expected zone covers the area where the destination is expected. Since the expected zone need not contain the source node, a larger area must be covered by flooding. This expanded expected zone is called request zone and is used to restrict the flooding, i.e. only nodes that are part of the request zone forward a route request. On unsuccessful route discoveries, the request zone may need to be expanded further, possibly covering the whole network. Such subsequent route requests increase the initial latency for connections. This results in a tradeoff between reduced overhead and increased latency which needs to be balanced carefully.

3) Dynamic Source Routing (DSR): In dynamic source routing, source node floods a route request to all nodes which are in the wireless transmission range. The initiator (source node) and target (destination node) of the route discovery is identified by each route request packet. The source node also provides a unique request identification number in its route request packet. For the route request, the target node generally scans its own route cache for a route before sending the route reply toward the source. The route maintenance mechanism is used when the source node is unable to use its current route to the destination due to changes in the network topology. In such case, the source has to use any other route to the destination. However, it may invoke the route discovery mechanism again to discover a new route. A routing entry in DSR contains all the intermediate nodes of the route rather than just the next hop information. A source puts the entire routing path in the data packet, and the packet is sent through the intermediate nodes specified in the path. If the source does not have

a routing path to the destination, then it performs a route discovery by flooding the network with a route request (RREQ) packet. Any node that has a path to the destination in question can reply to the RREQ packet by sending a route reply (RREP) packet. The reply is sent using the route recorded in the RREQ packet [5].

RELATED WORK

A number of wireless routing protocols are already proposed to provide communication in wireless environment using open source simulators. Performance comparison among some set of routing protocols are already performed by the researchers such as among PAODV, AODV, CBRP, DSR, and DSDV [6], among DSDV, DSR, AODV, and TORA [7], among SPF, EXBF, DSDV, TORA, DSR, and AODV [8], among DSR and AODV [9], among STAR, AODV and DSR [10], among AMRoute, ODMRP, AMRIS and CAMP [11], among DSR, CBT and AODV [12], among DSDV, OLSR and AODV [13] and many more. These performance comparisons are carried out for ad-hoc networks. For this reason, evaluating the performance of wireless routing protocols in mobile WiMAX environment is still an active research area. In this paper an attempt is made to study and compare the performance of AODV, DSR, OLSR and ZRP routing protocols.

There are several other efforts related to the work under study. In the work of Perkins, Royer, Samir R. Das and Manesh [7], evaluation of DSR and AODV using nS-2 network simulator for 50 and 100 nodes in a rectangular space was studied. The traffic and mobility models they used are the ones incorporated into nS-2 include ZRP, neither they tried to find the impact of specific attributes of DSR or AODV in network performance. The mobility models were not different but instead they used a uniform distributed speed of nodes between 0-20 m/sec. in various mobility scenarios since the nodes move in a mean 10m/sec speed. Another relative work has been presented by Broch, Maltz, Johnson, Hu, and Jetcheva [8]. They evaluated four ad-hoc routing protocols including AODV and DSR. They also used nS-2 to simulate 50-node network models with mobility and traffic scenarios similar to the scenarios Perkins et al did. On the other hand in this paper an exponentially distributed packet size of 512 bytes are used which makes the comparison fair between DSR and LAR. The scenarios selected demonstrate the adynamic behaviour of the mobile ad-hoc networks. An effort is made to compare the performance evaluation of reactive routing protocols using Qualnet 5.0.2. Network simulator.

SIMULATION PLATFORM AND MODELS

In this work Qualnet 5.0.2 simulator has been used to evaluate the performance of Reactive routing protocols. The study uses the wireless module to enable mobility of the wireless nodes and support more accurate wireless models for propagation, path loss, multipath fading and reception on wireless networks. The simulations are carried out for network sizes of 25, 50 and 75 nodes respectively. The area considered for the above network sizes are 500m X 500m, for all the above specified network sizes. Simulations are configured with the parameters as show in the table1.

Routing protocols	AODV, DSR & LAR
Radio type	802.11b
No. Of Channels	One
Channel frequency	2.4 GHz
Mobility	None
Mobility speeds	None
Path loss model	Two ray
Energy model	Mica Motes
Shadowing model	Constant
Simulation time	100 second
Battery Model	Linear model
Simulation Area	500m X 500m
Number of nodes	25, 50 and 75

Figure 1 shows the snapshot of Qualnet network simulator for AODV routing protocol. In this figure the route discovery mechanism is shown. The source node tries to find out the route to the destination by flooding the requests to all the neighbouring nodes.

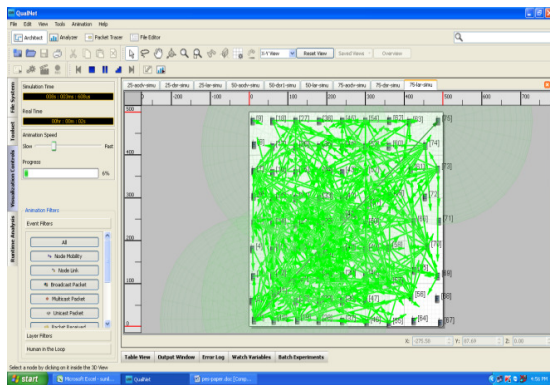


Fig 1. Snapshot of Qualnet network simulator showing Route discovery mechanism in AODV protocol for 50 nodes.

When the route is established source send the data to the destination. This is shown in figure 2.

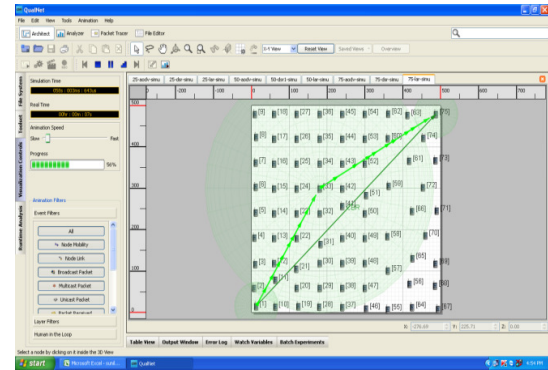


Fig 2. Snapshot of Qualnet network simulator showing Route maintenance mechanism in AODV protocol for 50 nodes.

RESULTS AND DISCUSSIONS

Effects of different parameter on performance of AODV, DSR and LAR routing protocols are discussed below.

Packet Delivery Ratio(PDR)

In Fig.3 the packets delivery ratio of the routing protocols is compared for different node density. The recorded values are shown in table 2. It is clear from the values that all the three reactive routing protocols exhibit almost the same PDR as the route discovery mechanism is reactive. However, it can be observed that AODV and LAR perform better in low density compared to DSR.

Table 2: packet delivery ratio for the protocols with change in node number

Nodes	Protocols		
	AODV	DSR	LAR
25	96	50	98
50	94	98	99
75	94	99	97

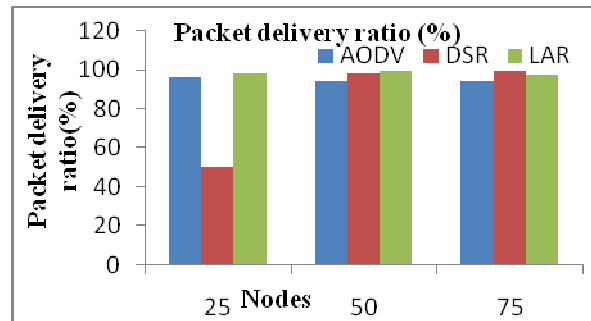


Fig 3. Packet Delivery Ratio (%) as a function of node density for all the routing protocols.

Average Jitter (second)

In Fig 4 Average Jitter (second) of the routing protocols is compared for different node density. The recorded values are shown in table 3. It is clear from the values that AODV and DSR show very

low jitter compared to LAR. LAR shows large jitter compared to AODV or DSR, since it is a location based routing whose operation is based on the range of the expected zone. For low density scenarios AODV has least jitter and hence is suitable in those applications.

Table 3: Average jitter (s) with change in node number

Nodes	Protocols		
	AODV	DSR	LAR
25	0.000806	0.005114	0.042522
50	0.001894	0.000662	0.021307
75	0.002012	0.0077	0.04524

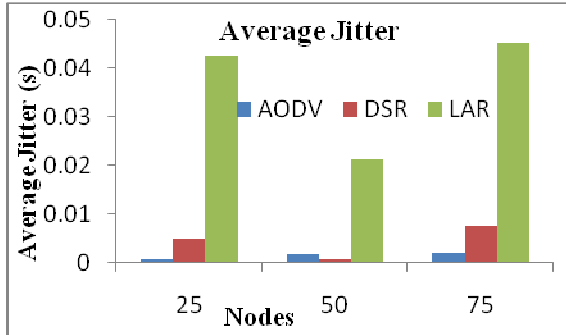


Fig 4. Average Jitter (Second) as a function of node density.

End to End Delay (second)

In Fig 5 End-to-End Delay (second) of the routing protocols is compared for different node density. The recorded values are shown in table 4. It is clear from the values that AODV show very small delay compared to DSR and LAR.

Table 4: End-to-End Delay (s) with change in node number

Nodes	Protocols		
	AODV	DSR	LAR
25	0.00758	0.01226	0.039472
50	0.008321	0.007364	0.039019
75	0.008351	0.013696	0.053849

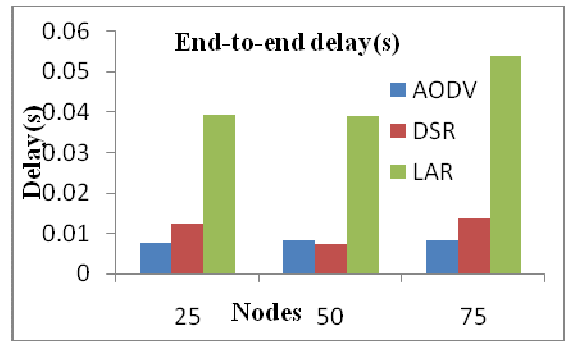


Fig 5. End-to-End Delay (Second) as a function of node density for all the routing protocols.

Throughput (Bits/second)

In Fig 6 Throughput (Bits/s) of the routing protocols is compared for different node number. The recorded values are shown in table 5. It is clear from the values that AODV show low throughput compared to DSR and LAR. LAR shows large throughput compared to AODV or DSR in medium node scenario(50nodes).

Table 5: Throughput with change in node number

Nodes	Protocols		
	AODV	DSR	LAR
25	4012	4193	4056
50	4011	4096	4182
75	3929	4102	4015

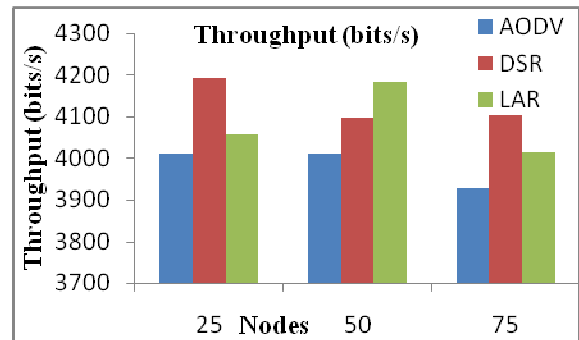


Fig 6. Throughput (bits/s) as a function of node density.

Total Bytes Received

In Fig 7 Total bytes received at the receiver of the routing protocols is compared for different node density. The recorded values are shown in table 6. It is clear from the values that all the protocols show almost same number of bytes received in low and high node densities.

Table 6: Total bytes with change in node number

Nodes	Protocols		
	AODV	DSR	LAR
25	49152	25600	50176
50	48128	50176	50688
75	48128	50688	49664

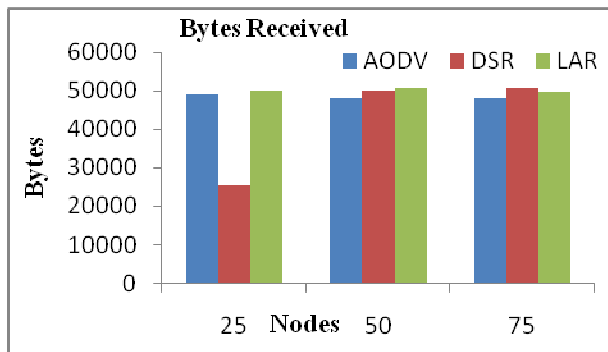


Fig 7. Total Bytes Received as a function of node density.

CONCLUSION

The reactive protocols for IEEE 802.11 wireless local area network AODV, DSR and LAR are evaluated for different node density scenarios. The observations show that AODV suits applications where End-to-End delay, Average Jitter and throughput are very critical.

Considering the overall performance of DSR it performs well in low (25 nodes) and high (75 nodes) node density scenarios when compared to LAR.

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