QoS Performance of Proactive, Reactive, Hybrid Routing Protocols over Fading Channels in Wireless Sensor Network

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Abstract

The advancement in communication technology and the need for large-scale communication infrastructures has triggered the era of Wireless Sensor Networks (WSNs). In this Project we are analyzing the performance of Proactive, Reactive and Hybrid routing protocols on robust conditions to check the Quality of Service (QoS) metrics like Packet Delivery Ratio, Throughput, end to end delay and Jitter in the Wireless Sensor Networks. Multipath fading heavily contributes to the unreliability of wireless links; the impact of fading on wireless sensor networks is considerable. In this paper focus is given on studying the performance evaluation of various routing protocols using Qualnet simulator 7.1.4. The performance of the proactive, reactive and hybrid protocols are analyzed with different nodes over gaussian fading channel. The metrics used for the performance evaluation include jitter, throughput, packet delivery ratio and average end to end delay.

Keywords
Proactive, Reactive, Hybrid, Fading, Gaussian Fading Channel Performance Evaluation, Qualnet, Quality of Service, End-to-end Delay, Throughput, Jitter, Packet’s delivery ratio.

1. Introduction

In recent years, the applications of Wireless Sensor Networks are widely used over the many fields. Wireless Sensor Networks (WSNs) can be defined as the self-configured and infrastructure- less wireless networks. The WSNs are self-configured devices in which nodes are free to move anywhere with no centralized infrastructure and security. The WSNs had a broad range of applications that are spread around the fields of medical services, Science, Transportation, Civil infrastructure and Security. Sensor nodes in a wireless network are usually in an unfriendly environment. Those applications of those Sensor nodes are deployed in such fields that they need to be work for a long time with better efficiency. There will be some applications where it is impossible to replace those wireless networks.

A Fading channel is a communication channel that experiences the effect of fading. Fading in wireless communication is the variation of the attenuation of a signal with various parameters like time, geographical position and radio frequency. Fading in communication channel occurs when there is a significant variation in the received signals amplitude and phase over time.

The key factor that determines, how efficiently a multi-hop wireless network reacts to topology changes and node mobility is the routing protocol that provides routes for every node in the network. Routing protocol is the process of selection of the path for the data to transmit from source to destination. During this process of selection of the path a network encounters several difficulties while selecting the route which usually depends upon the type of network, channel characteristics and the performance metrics this article is concerned primarily with routing in Wireless Sensor Networks. In routing protocols, the data is transmitted in the form of packets. Those data packets are transmitted from the source to destination through the intermediate nodes. The routing protocol transmits the data packets on the basis of route mechanism of the protocol . Most routing algorithms use only one path at a time, but multipath routing techniques enable the use of multiple alternative paths. In this we analyze the two protocols from the each of the proactive, reactive and hybrid protocols.

In this work performance evaluation of various routing protocols like Open Shortest Path First (OSPFv2) and Intra Zone routing protocol (IARP) from proactive routing protocol and Ad-hoc On Demand distance vector (AODV) and Location Aided routing protocol (LAR1) from reactive routing protocol and Zone Routing Protocol and Landmark Routing Protocol (LANMAR) from hybrid routing protocol are studied using Qualnet 7.1.2 networks emulator for 40, 80, 120, 160, and 200 nodes. The rest of this paper is organized as follows: in section 2 brief introductions to various routing techniques is discussed. In section 3 reviews of literature and comments on related work is presented. Simulation platform and parameters used in the work is discussed in section 4. In section 5 the comparison results of the performance evaluation are thoroughly discussed. Conclusion is given in section 6.

2. Routing Techniques

Routing in Wireless Sensor Networks (WSNs) plays a important role in the field of monitoring of real time communication networks etc. Routing is the process of selection of the route for the data packets to be transmitted from the source to destination.

Routing protocols plays a very significant role to produce a interruption less and efficient communication between the source and the destination through the intermediate nodes. In WSN those networks have various application among the areas like military, medical and sensor application. In each type of areas, it is required to have a specific requirement of routing protocol. In WSN, based upon the routing mechanism the protocols are categorized into different categories among them one that is categorized on the basis of the route table mechanism is Route discovery-based routing protocol. Among the Route discovery-based routing protocols again they are classified by their process of discovering the route.

Routing protocols are divided into two categories namely, proactive, reactive and hybrid routing protocol.

Proactive routing protocols:

In proactive routing, it maintains information of all the routes throughout the network and even if they are not required for the formation of the path, so each node maintains a route table to all the other nodes in the network. In proactive routing protocols every intermediate node in the network contains one or more number of tables that contains the information of the other nodes that are neighbor to that node in the network. In this these protocols exchange the control information between the nodes on a regular basis, which keeps updated routes for each node in the network. As the number of nodes in the network increases the proactive routing protocol doesn’t suitable for those networks as they need to maintain each and every node entry in the routing table. This condition of proactive routing protocols caused the more overhead in the routing table leads to consumption of more bandwidth. Examples of such protocols from the proactive routing protocol are: Bellman ford protocol, Optimized link state protocol (OLSR), Intra-Zone routing protocol (IARP), Open Shortest Path First (OSPF v2) etc.

Open Shortest Path First (OSPFv2):

It is a proactive routing protocol where the routes are always available when there is needed. Open Shortest Path First (OSPFv2) is a routing protocol for the Internet Protocol (IP) networks. OSPFv2 is a link state routing protocol that employs a version of Dijkstra’s algorithm which is used to find the shortest path between the source and destination and it is a open standard. OSPFv2 is a typical routing protocol, which uses Dijkstra’s algorithm to calculate the best path for packet transmission. In this, Dijkstra’s algorithm is used by each router to generate the shortest path tree from source to destination in a network. OSPF area is interconnected via a backbone area, which is called area zero. OSPF route aggregation capabilities allow routing overhead to be reduced, if the IP addressing plan and topology are constructed accordingly, so that routes to multiple, specific addresses within an area can be correctly synchronized with routes to partial address matches at area boundaries and AS boundaries. If this cannot be achieved, LSU (Link Status Update) message in OSPF routing overhead can increase very quickly. OSPFv2 requires that IP datagram exchange between areas must traverse the zero area.

Intra-Zone Routing Protocol (IARP):

The Intra Zone Routing Protocol (IARP) is a limited scope proactive routing protocol which is used to improve the performance of a primary global routing protocol. The Scope of the IARP is defined by the zone radius of the network. This IARP is implemented as a modified distance vector scheme. In this IARP, each node communicates with the interior nodes of its zone and they are responsible for maintaining routes within the zone radius. Every node in IARP network maintains their own routing zone. IARP is one of the protocols that is used for the finding of the shortest path from the source to the destination. IARP network can work more efficiently for the global search used to guide route queries. In IARP the local route discovery is efficient due its proactive in nature as these networks removes the redundant routes and shortening of routes for local route optimization.

Reactive protocols (On-demand):

Reactive routing is also known as on-demand routing protocol since they do not maintain routing information or routing table at the network nodes if there is no communication. Reactive protocols form the route table only if the path is available from the source to destination. In the reactive routing protocols mainly consists of four control packets they are Hello, route request (RREQ), route reply (RREP) and route error (RERR).By using of these four control packets the route table from the source to destination is established in the Reactive Protocols. Examples of reactive routing protocols are the Ad-hoc On-demand Distance Vector routing (AODV), Location Aided Routing (LAR), Dynamic Source Routing (DSR) and Temporally Ordered Routing Algorithm (TORA) .

Ad Hoc On-demand Distance Vector (AODV):

In Ad Hoc On-Demand Distance, to start a communication source node sends hello message to every node in the network and then sends a route request message. If the neighboring node receives the hello message it also includes the data about the node. The source node broadcasts the RREQ packets to its neighbor in case if the route to destination is not available. Every intermediate node similarly sends the RREQ packets to their neighbor nodes until the destination node is reached. If the destination node is available, it retransmits the route reply (RREP) packets in the backward direction to the previous node as per the data in its routing table. When RREP reaches the source node, forward path is established from the source to the destination. If the destination node is not available it sends a route error (RRER) packets in reverse path to the previous node as per data in routing table once the RRER message received by the source it deletes that transmission path from routing table. The source node will again have to transmit RREQ packets to start a communication considering that the transmission path to the desired destination node has broken. Thus, the communication in AODV is established.

Location Aided Routing (LAR):

Location aided routing, is an advanced routing protocol to flooding algorithms to reduce flooding overhead. Most of the protocols in the on-demand routing, including DSR and AODV use flooding to obtain a route to the destination. LAR aims to minimize the process of overhead by reducing the overhead to send the route requests only into a specific area, which is likely to contain the destination.

LAR utilizes the GPS location for the geographical information of the node for improving the efficiency of routing by reducing the control overhead. In the location aided routing protocol, there are two zones expected zone and request zone are introduced. Expected Zone is the zone where the destination is expected to be present based on the past location and its mobility. If such information is not available, then the entire location is said to be the expected zone. And the request zone is location is said to be the expected zone. And the request zone is the zone in which the path finding control packets are permitted to be propagated. If the sender node or any intermediate node is not available in this zone then the additional area will be selected for propagation. But usually, the nodes outside the Request zone discard the control packets. A request zone that is framed includes the source node and the expected zone. When the source node is inside the expected zone, the size reduces to be the expected zone. RREQ packet is forwarded to every neighbor node and the packet will be discarded if the node is outside the request zone.

Hybrid Routing Protocol:

Hybrid routing protocol is the combination of the both the proactive and reactive protocols. Hybrid routing Protocol combines the merits from the both proactive and reactive protocols by neglecting the demerits of those protocols. Hybrid routing protocol is the network routing protocol that combines the distance vector routing protocols and link state routing protocols. Some of the hybrid routing protocols are Zone Routing Protocol (ZRP), Landmark Routing Protocol (LANMAR) and Routing Information Protocol (RIP) etc.

Zone Routing Protocol (ZRP):

Zone routing protocol is the hybrid routing protocol that uses both proactive and reactive routing protocols while sending the information over the network. In ZRP, it sends the information within the inter zone and the intra zone of the communication system. The proactive scope is reduced to zone in ZRP. The maintenance of routing information will be easier in the limited zone. In ZRP overlapping of nodes takes place because each node keeps its own routing zone. For those nodes present inside the zone the Intra Zone routing protocol (IARP) is responsible and for the nodes outside the zone the Inter Zone Routing Protocol (IERP). As there is a one-to-one correspondence between nodes and routing zones, unlike hierarchal clusters, do not provide to hide the details of local network topology. The IERP actually finds out routes between individual nodes, rather than searching or finding the system components of higher level.

Landmark Routing Protocol (LANMAR): LANMAR is a typical hierarchical routing protocol for scalable wireless ad hoc networks. The Lanmar is a proactive routing protocol that has the necessary routing information of the nodes within the scope. LANMAR is a cluster-based routing protocol. LANMAR protocol uses Fisheye State Routing protocol. Every logical subnet has one header node (LANDMARK header), which serves for that subnet. Such LANDMARK header has the information about all nodes in its subnet In LANMAR, if the data packet that is need to be transmitted to the destination and the destination is outside its scope then the node will direct the packet to the landmark corresponding to the group ID of such destination and if the destination to which data packet need to be transmitted is within its scope, then it is directly forwarded by fisheye state routing protocol. In this protocol, each node will maintain the accurate routing information about immediate neighbor and as well as to its header node. For routing inside the scope, each node periodically interchanges the routing information to its one hop neighbors. In each update, the node includes all the routing table entries and sent it to the members within the scope.

The QoS performance of OSPFv2 and IARP from proactive and AODV and LAR1 from reactive and ZRP and LANMAR from hybrid routing protocols are compared using Qualnet 7.1.2 network simulator with the metrics like Packet delivery ratio, throughput, end to end delay and jitter.

Gaussian Fading Channel:

A Gaussian Noisy channel adds white Gaussian noise to the signal that passes through it. It is the basic model for a digital communication channel and therefore used as a standard channel model. In this model, the transmitted signal gets disturbed by only a simple additive white Gaussian noise process. Thus, the received signal can be obtained by:

$$y(t) = s(t) + n(t)$$

Where s(t) denotes a sample function of the additive white Gaussian noise process with power spectral density of $\Phi_{nn}(f) = \frac{1}{2}N_o$ W/Hz. The white noise consists of a frequency spectrum which is in continuous and uniform over a specified frequency band. In Gaussian Noisy channel model, there is no random scattering and diffraction transmitted signals at the receiver. Unfortunately, most wireless channel links cannot be modeled as GN channels.

3. RELATED WORK:

A number of wireless routing protocols are proposed for the communication in the Wireless Sensor Networks. And also, some set of performance comparison of routing protocols is also performed by the researchers in the beginning. Some of the performance comparisons made by the researchers are AODV and DSR, DYMO & TORA, AODV & EEAODV, ZRP&AODV&DSR, AODV&TORA,

STAR & AODV& OSLR. In this paper an attempt is made to study the different types routing protocols and to compare the QoS performance analysis of different routing protocols over Gaussian fading Channel.

In this paper we select the any two protocols from the proactive, reactive and hybrid routing protocols and compare their QoS performance analysis. In this paper packet size of 512bytes are used, which makes the comparison of OSPFv2 & IARP and AODV & LAR1 and ZRP & LANMAR and the nodes are used in the interval of 40 by sending the 100 unicast messages at the source. An effort is made to compare the internal performance evaluation comparison of proactive (OSPFv2, IARP), reactive (AODV, LAR1) and hybrid (ZRP, LANMAR) are compared and also the final comparison that is made from the best protocols obtained among each routing technique by using Qualnet 7.1.2 network simulator.

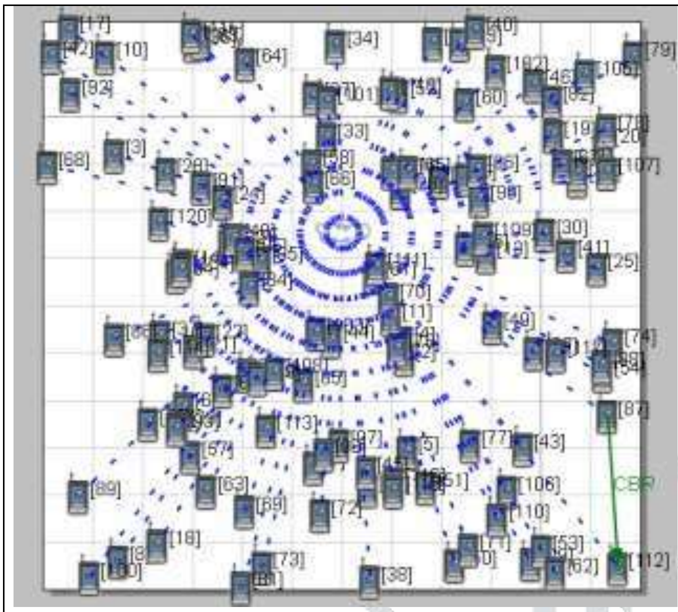
Simulation Platform:

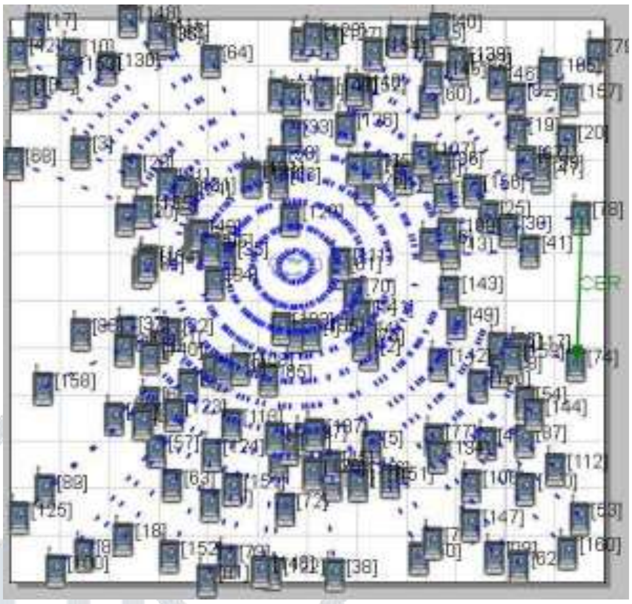
In this work Qualnet 7.1.2 network simulator has been used to evaluate the performance of the proactive (OSPFv2, IARP), reactive (AODV, LAR1) and hybrid (ZRP, LANMAR) routing protocols of wireless sensor networks over gaussian fading channel. The physical medium used is 802.11b radio is used. The MAC protocol used is 802.11 MAC protocol, configured for the wireless sensor networks. In this work wireless module of IEEE 802.11b is used to enable the mobility of the wireless nodes. In this work the gaussian fading channel is used. The simulations are carried out for network densities of 40, 80,120,160 and 200 nodes respectively. The area considered for the above network densities are 1200mX1200m for all the interval of nodes. The total number of unicast messages sent at source was 100. The ideal parameters were used for all the interval of nodes. The simulation time used for the all routing protocols at every interval of time was 360sec. Simulations configured for the performance evaluation of different routing protocols with the QoS metrics like packet delivery ratio, end to end delay, throughput and jitter. The simulation parameters that are ideally used for all the routing protocols mentioned in the paper are as given in the below table.

Parameter Name	Parameter Value
Routing Protocols	OSPFv2, IARP, AODV,LAR, ZRP, LANMAR
Number of nodes	40,80,120,160,200
Terrain Size	1200mX1200m
Simulation Time	360sec
Mobility Model	Random Waypoint
Connection Type	CBR
Fading Channel	Gaussian Channel
Physical layer	IEEE 802.11b
Network layer	IPv4
No. of Packets sent	100
Packet Size	512 bytes
Simulator	Qualnet 7.1.2 Network Simulator

4. Results And Discussions

In this work various performance of different types routing protocols are studied and also analyzed their QoS parameters over the gaussian fading channel. Figure 1 & 2 shows the snapshots of Qualnet 7.1.2 simulation scenario of 120 and 160 nodes for LANMAR routing protocol over fading channel.


Snapshot of simulation scenario of LANMAR with 120 nodes over fading channel


Snapshot of simulation scenario of LANMAR with 160 nodes over fading channel

Quality of Service (QoS) Metrics:

Quality of Service is generally defined as Quality of Service is generally defined as the collective effect of service performance which determines the degree of satisfaction of a user of the service. The ultimate goal of QoS is to achieve a more efficient and deterministic network behavior so that it can carry the information better and loss less. In WSN there are multiple Quality of Services which Throughput, Delay, End-to-End Delay, Packet Delivery Ratio, Packet Loss Ratio, Energy Consumption, Congestion Control etc. are the some of the QoS parameters and among them we analyze the packet delivery ratio, end to end delay, throughput and jitter.

Packet Delivery Ratio:

In the packet delivery ratio, we check the number of data packets received by the destination. The packet delivery ratio will be varying for the different protocols. There are many factors which are going to affect the data packets received by the destination. The variation of the packet delivery ration can be seen for increasing the number of nodes in the interval of 40, 80,120,160 and 200 nodes. In this analysis we ideally send the 100 data packets at the source node and we will check the number of data packets received by the destination node.

Throughput:

In WSN, throughput is not usually as significant as other parameters. Throughput can be defined as the how much data can be transferred from one location to another location in a give amount of time. A sensor node mostly sends the data in form of small packets but there are certain where it is required to send the large amount of data packets. Thus, there are some WSN applications that are required to maximize the throughput. The standard measurement of throughput is bits/seconds. The calculation of Throughput

$$I=r*t$$

Where I=Inventory, r=rate, t=time.

End-To-End Delay:

End-To-End refers to the time taken for a data packet to be transmitted from the source to the destination. The delay of any node is caused while transferring of information from the source to the destination. The End-To-End delay of a packet depends upon the route discovery latency. The delay of any network depends upon the no of nodes and the size of the data packets to be sent. The standard End-To-End delay measurement is in seconds. The End-to-end Delay is given by

$$N*L/R.$$

Where N= Number of link, L= packet length, R= transmission rate

Jitter:

Jitter can be defined as the difference between the arriving of data packets over the network. The jitter can negatively impact the information that is passed over the network. Jitter is most often caused network congestion and also sometimes by the route changes in the network. The longer the data packets take time to arrive the more jitter can affect the network. The standard Jitter measurement is in milliseconds. The jitter is given by Σ(N1-N2) Where N1 is the present data packet and N2 is the previous data packet.

Performance Comparison of Proactive Routing Protocols:

From the proactive routing protocols as we considered two protocols that are Open Shortest Path First (OSPFv2) routing protocol and Intra Zone Routing Protocol (IARP). In this work we analyze the QoS performance of these routing protocols over gaussian fading channel.

Total number of unicast messages received by sending 100 data packets at the source

Throughput comparison of OSPFv2 vs IARP

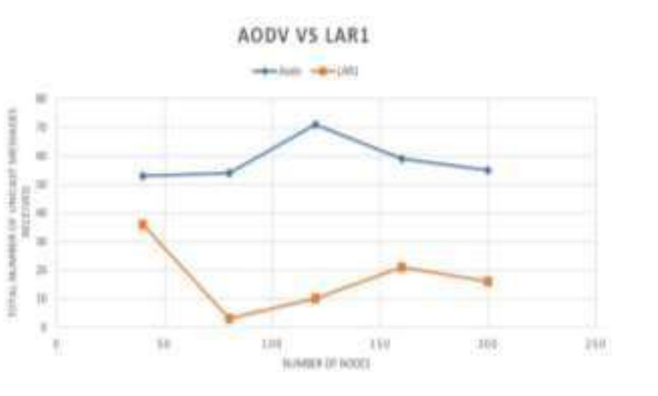
End-To-End delay comparison of OSPFv2 vs IARP

Jitter comparison of OSPFv2 vs IARP

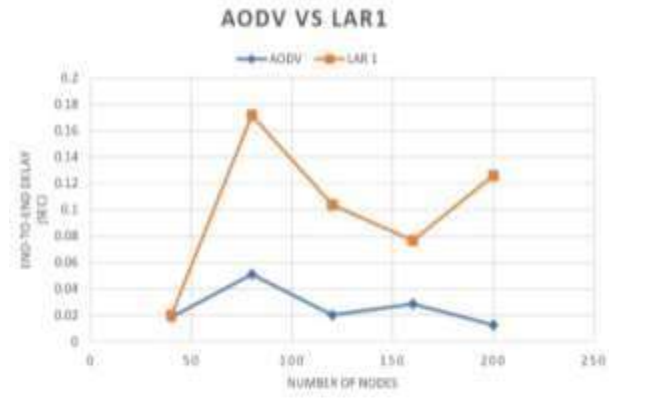
From the above comparison we can say that the IARP had the best QoS parameters among the proactive protocols (OSPFv2 & IARP)

Performance Comparison of Reactive Routing Protocols:

From the reactive routing protocols as we considered two protocols that are Ad Hoc On Demand distance vector (AODV) routing protocol and Location Aided routing protocol (LAR1). In this work we analyze the QoS performance of these protocols over the gaussian fading channel.



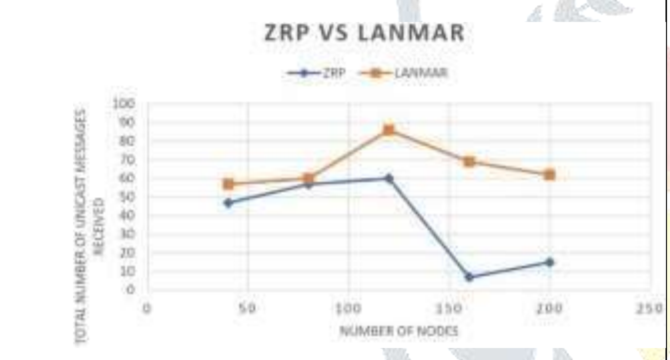
Total number of unicast messages received by sending 100 data packets at the source



End-To-End delay comparison of AODV vs LAR1

Performance Comparison of Hybrid Routing Protocols:

From the reactive routing protocols as we considered two protocols that are Zone Routing Protocol (ZRP) and Landmark routing protocol (LANMAR). In this work we analyze the QoS performance of these protocols over the gaussian fading channel.



Total number of unicast messages received by sending 100 data packets at the source

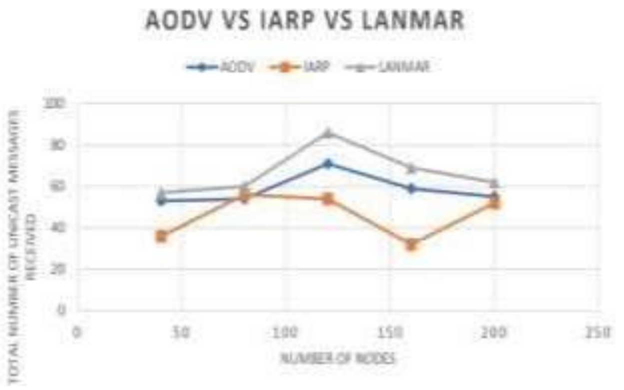
Throughput Comparison of ZRP vs LANMAR

From the above comparison, we can say that LANMAR has the best QoS performance among the reactive protocols (ZRP & LANMAR)

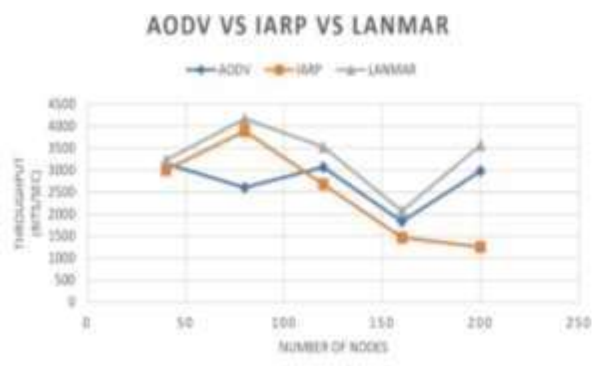
From the best protocols obtained from the comparison of the proactive, reactive and hybrid protocol. We compare the AODV and IARP and LANMAR routing protocols.

Final Comparison of AODV vs IARP vs LANMAR:

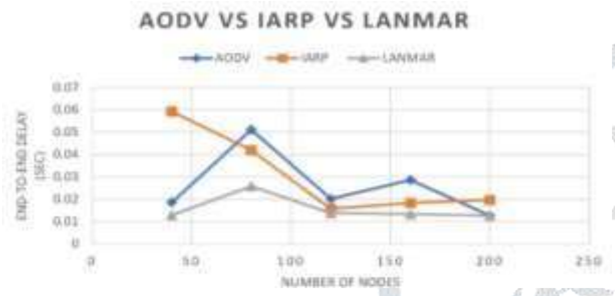
In this we compare the AODV vs IARP vs LANMAR routing protocols



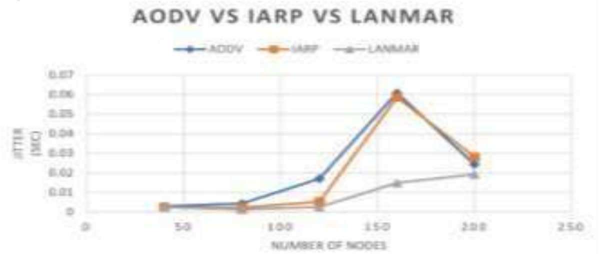
Total unicast messages received by sending 100 data packets at the source



Throughput comparison of AODV vs IARP vs LANMAR



End-To-End delay comparison of AODV vs IARP vs LANMAR



Jitter comparison of AODV vs IARP vs LANMAR

Table 2: QoS performance Analysis of AODV vs IARP vs LANMAR over gaussian fading channel

Number of nodes	tal unicast messages received			Throughput			End-To-End Delay			Jitter		
	AODV	IARP	LANMAR	AODV	IARP	LANMAR	AODV	IARP	LANMAR	AODV	IARP	LANMAR
40	53	36	57	3151	3010.3	3246	0.01857	0.05923	0.01280	0.00292	0.00242	0.00298
80	54	56	60	2608.1	3887.7	4170.3	0.05110	0.04188	0.02578	0.00431	0.00217	0.00126
120	71	54	86	3071.9	2684.8	3529.3	0.02012	0.01567	0.01369	0.01699	0.00520	0.00256
160	59	32	69	1833.8	1469.6	2073.6	0.02859	0.01829	0.01390	0.06091	0.05866	0.01486
200	55	52	62	2983.9	1252.8	3574.6	0.01262	0.01963	0.01260	0.02431	0.02812	0.01925

5. CONCLUSION:

The Quality of Service (QoS) performance evaluation of the reactive (AODV & LAR1), proactive (OSPFv2 & IARP) and hybrid (ZRP & LANMAR) routing protocols over the gaussian fading channel is studied by varying the node density (40, 80,120,160 and 200) using Qualnet 7.1.2 network simulator. From the results, it can be observed that in proactive routing protocols among OSPFv2 and IARP routing protocols, IARP is said to be efficient routing protocol in terms of QoS parameters over fading channel and from the reactive routing protocol among AODV and LAR1, AODV is said to be efficient routing protocol in terms of QoS parameters over fading channel and from the hybrid routing protocols among ZRP and LANMAR, LANMAR is said to be efficient routing protocol in terms of QoS parameters over fading channel. Thus, from all the above these best routing protocols LANDMARK routing protocol is said to be efficient routing protocol in terms of QoS metrics over gaussian fading channel.

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