PERFORMANCE EVALUATION OF ROUTING PROTOCOLS IN DIFFERENT WIRELESS HEALTHCARE SCENARIOS

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ABSTRACT

In this paper evaluation on the performance of broadcasting based routing protocols for two popular wireless networks in the literature viz. Mobile Ad-Hoc Network (MANET) and Wireless Sensor Network (WSN) has been done in different test conditions for different healthcare scenarios. The healthcare scenarios discussed here are of an area where patients send their vitals over MANET and in other scenario a typical hospital is depicted where patients send their health information over WSN. As healthcare data is critical it requires a particular Quality of service (QoS) which can be maintained by finding proper route for sending the data to reduce delays, jitter and improve overall throughput. Thus, for routing purpose , routing protocols from each category of Reactive, Proactive and Hybrid are chosen and performance comparison of four broadcast based routing protocols i.e. Ad-hoc On Demand Vector Routing (AODV), Location Aided Routing1 (LAR1), Optimized Link State Routing (OLSR) & Zone Routing Protocol (ZRP) is been done by carrying simulations and study based upon the performance metrics such as average End to End delay, average Throughput, average jitter, Packet delivery ratio, total packet received. The purpose is to test their efficiency under two test conditions of (a) by varying traffic load in terms of changing the no. of nodes (b) by varying mobility.

KEYWORDS: *MANET, WSN, AODV, LAR1, OLSR, ZRP, Blood Pressure, ECG, EEG, Qualnet version 6.1*

I. INTRODUCTION

Wireless Network is the type of computer network that is not connected by cables of any kind. Each wireless technology is defined by a standard that describes unique functions at both the physical and Data link layers of the OSI model. In this work two different wireless networks have been considered-MANET [1] and WSN [12] .The Routing Protocols are widely divided in three categories: - Proactive, reactive and hybrid. All the on-demand MANET routing protocols employ a simple form of broadcasting called flooding to discover the routes. We define broadcasting as being the process of delivering one packet, originated at one node, to (ideally) all other nodes in the MANET. Routing becomes an important task of the process because of contention developed in channel access and using the network resources [17]. Many routing protocols [20] have been proposed in this field. A typical healthcare data include Blood Pressure reading, Electrocardiogram (ECG), Electroencephalogram (EEG), X-Ray images, and Ultrasound images and live video interaction between patient and Doctor. Typical data rate requirements for the devices capturing these various class of data is summarized in table 1 [15] below. Data rate used for simulation here in this paper is that of low bit rate physiological data such as blood pressure information, temperature, heart rate and ECG etc. which are acquired through sensors placed on human body.

Table 1.1 Data rate requirements for different devices used in healthcare monitoring

Devices	Data Rates	
	Good	**Excellent**
ECG	2 kbps	12 kbps
Doppler Instrument	40 kbps	160 kbps
Blood Pressure Monitor	1 kbps	1 kbps
Ultrasound Machine	100 kbps	400 kbps
Camera	100 kbps	2,000 kbps
Stethoscope	40 kbps	160 kbps
Microphone	40 kbps	160 kbps

The aim of this paper is to perform comparative analysis of performance of four broadcast based routing protocols: Ad-hoc On AODV, LAR1, OLSR and ZRP in two different experimental conditions; one of constant mobility (pause time) with varying number of nodes and the other of constant number of nodes with varying mobility (pause time) for two discussed wireless standards. Section 1 describes introduction along with the wireless standards discussed in detail. Section 2 provides insight into routing protocols used. Section 3 gives detailed description of simulation and parameters along with discussions on results. Section 4 concludes the findings of previous section. Future work has been proposed in section 5.

1.1 Mobile Ad-Hoc Network (MANET)

MANET [1] is collection of wireless mobile nodes dynamically forming a temporary network without the use of any existing network infrastructure (or) centralized administration. They are self-organizing & self-controlled infrastructure less network and Mobile nodes are free to move randomly (organize free to move randomly),Thus the network's wireless topology may change rapidly and unpredictably, however since there is no stationary infrastructure so mobile hosts need to operate as router in order to maintain the information about network connectivity [19] [22]. Mobile users will want to communicate in situations in which no fixed wired infrastructure is available. For example, a group of researchers en route to a conference may meet at the airport and need to connect to the wide area network, students may need to interact during a lecture, or firefighters need to connect to an ambulance en route to an emergency scene. In such situations, a collection of mobile hosts with wireless network interfaces may form a temporary network without the aid of any established infrastructure or centralized administration.

Applications of Ad Hoc Wireless Networks-

The following are the applications of ad hoc wireless networks:

- Community network
- Enterprise network
- Home network
- Emergency response network
- Vehicle network
- Sensor network

Characteristics of Mobile Ad-hoc Networks are:

- No expensive infrastructure must be installed
- Use of unlicensed frequency spectrum
- Quick distribution of information around sender
- Use of ad-hoc networks can increase mobility and flexibility, as ad-hoc networks can be brought up and torn down in a very short time.
- Because of multi-hop support in ad-hoc networks, communication beyond the Line of Sight (LOS) is possible at high frequencies.
- Multi-hop ad-hoc networks can reduce the power consumption of wireless devices. More transmission power is required for sending a signal over any distance in one long hop than in

multiple shorter hops. It can easily be proved that the gain in transmission power consumption is proportional to the number of hops made.

1.2 Wireless Sensor Network (WSN) –IEEE 802.15.4

A Wireless Sensor Network [12](WSN) consists of spatially distributed autonomous sensor so co-operatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance and are now used in many industrial and civilian application areas, including industrial process monitoring applications, home automation, and traffic control, machine health monitoring, environment and habitat monitoring, healthcare.

In addition to one or more sensors, each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and bandwidth.

A sensor network normally constitutes a wireless ad-hoc network, meaning that each sensor supports a multi-hop routing algorithm where nodes function as forwarders, relaying data packets to a base station. This way routers gain knowledge of the topology of the network.

Classification of Wireless Sensor Networks:

- Individually addressable nodes.
- Group or mixed addressable nodes.

Characteristics of WSN are:

- Limited power they can harvest or store.
- Ability to withstand harsh environmental conditions
- Ability to cope with node failures
- Mobility of nodes
- Dynamic network topology
- Communication failures Heterogeneity of nodes
- Unattended operation

II. ROUTING PROTOCOLS: CLASSIFICATION IN BRIEF

Routing is the process of finding a path from a source to destination among randomly distributed routers. The set of rules for specific routing needs, routing protocols, are classified as follows-

2.1 Proactive Protocols

Proactive protocol [23] routes to all reachable nodes in network available also they have lower latency due to maintenance of routes all the time .Due to this it can have much higher overhead due to frequent route updates. The advantage of proactive type protocol is they have minimal initial delay for application e.g., OLSR [5], DSDV [8]

2.2 Reactive Protocols

Reactive protocols have higher latency since the route have to be discovered when the source node initiate a route request. So this type of protocols has lower overhead since routes are maintained only on demand basis but there is a long delay for application when no route to the destination available. e.g., AODV [3], LAR1 [13], DYMO [9]

2.3 Hybrid protocol

Hybrid routing protocol, which incorporate the merit of proactive (table driven) &reactive (on-demand) routing protocol. It combines the advantage from proactive protocol to find node's neighborhoods as well as reactive protocol for routing between these neighborhoods. Example: ZRP [10], TORA [4]

A. AODV

AODV is an on-demand routing protocol in which each mobile host operates as a specialized router, and routes are obtained as needed (i.e., on demand with little or no reliance on periodic advertisements) [3]. AODV routing algorithm is quite suitable for a dynamic self-starting network as required by users wishing to utilize ad hoc networks [16]. AODV provides loop-free routes even while repairing broken links. Because the protocol does not require global periodic routing advertisements, the demand on the overall bandwidth available to the mobile nodes is substantially less than in those protocols that do necessitate such advertisements.

AODV uses symmetric links between neighboring nodes. It does not attempt to follow paths between nodes when one of the nodes cannot hear the other one. Nodes do not lie on active paths; they neither maintain any routing information nor participate in any periodic routing table exchanges. Further, a node does not have to discover and maintain a route to another node until the two need to communicate unless the former node is offering its services as an intermediate forwarding station to maintain connectivity between two other nodes. When the local connectivity of the mobile node is of interest, each mobile node can become aware of the other nodes in its neighborhood by the use of several techniques, including local (not system wide) broadcasts known as Hello messages. The routing tables of the nodes within the neighborhood are organized to optimize response time to local movements and provide quick response time for requests for establishment of new routes also route maintenance is the another phase of protocol .It is performed by the source node and can be subdivided into : 1.source node moves ,2.destination (intermediate) nodes move.

B. LAR

LAR[13] protocol is a reactive on demand, source routing protocol that uses the location information of nodes, means it utilizes location information via GPS(global positioning system) to limit the boundary of route request packet for destination in forwarding zone called request zone instead of in entire information on destination we determine the request zone .

Two concepts:

1. Expected Zone: Determined based on location and velocity if the destination and it is expected to contain the location of destination.
2. Request Zone: smallest rectangle which include the location of source and the expected zone.

In LAR, It has assumed that source has advanced knowledge of the destination location and velocity [16].

In LAR1

- RREQ messages are limited to request zone only and nodes within request zone forward these requests
- Those nodes not located in the request zone simply discard the packet
- Sender specifies the request zone in RREQ message explicitly
- If a route cannot be found using smaller request zone, the source initiates another route discovery with larger request zone after a timeout interval.
- Advantage of LAR1 type of protocols is that it reduces the route request flood to a limited area and reduces route discovery overhead as a result.

Disadvantages of LAR1 are as follows:

- A node needs to know its physical location
- GPS availability is not worldwide
- All mobile nodes may not necessarily equipped with GPS receivers (heterogeneity of devices)
- Error in positional information.
- Routing is solely based on location information.
- Prior and advance information about destination node may not be readily available at the source node.
- An existing route from intermediate node to destination node is not used.

B. OLSR

OLSR is a proactive link state routing protocol which uses HELLO and TOPOLOGY CONTROL (TC) message to discover & then disseminate link state information throughout the MANET [5]. Due to proactive nature, it has an advantage of having routes immediately available when needed. In OLSR each node selects a set of its neighbor nodes as “multipoint relays” (MPR). In OLSR, only nodes, selected as such MPRs are responsible for forwarding control traffic, intended for diffusion into the entire network [18]. MPRs provide an efficient mechanism for flooding control traffic by reducing the number of transmissions required. Nodes, selected as MPRs, also have a special responsibility when declaring link state information in the network. Indeed, the only requirement for OLSR to provide shortest path routes to all destinations is that MPR nodes declare link state information for their MPR selectors. Additional available link state information may be utilized, for example for redundancy.

Nodes which have been selected as multipoint relays by some neighbor node(s) announce this information periodically in their control messages. Thereby, a node announces to the network that it has reach-ability to the nodes which have selected it as an MPR. In route calculation, the MPRs are used to form the route from a given node to any destination in the network. Furthermore, the protocol uses the MPRs to facilitate efficient flooding of control messages in the network.

OLSR is well suited to large and dense mobile networks, as the optimization achieved using the MPRs works 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, that is, each node uses its local information to route packets. OLSR is well suited for networks, where the traffic is random and sporadic between a larger set of nodes rather than being almost exclusively between a small specific set of nodes. As a proactive protocol, OLSR is also suitable for scenarios where the communicating pairs change over time: no additional control traffic is generated in this situation because routes are maintained for all known destinations at all times.

C. ZRP

ZRP is a hybrid variety of routing protocol, which incorporates the merit of proactive (table drive) & reactive (on-demand) routing protocol [10]. It combines the advantages from proactive protocol to find node’s neighborhood as well as reactive protocol for routing between these neighborhoods. ZRP divides its network in different zone centered itself (or) we can say that each node has a routing zone by specifying a zone radius in terms of hops. In ZRP, size of zone can affect the communication performance .Within the routing zone ,a table driven routing protocol is used, therefore each node has a route to all the other nodes within the zone & if the destination falls out of the routing zone of the source node ,an on-demand routing protocol is used.

ZRP consists of three sub-routing protocols-

1. Intra-zone Routing Protocol (IARP)Proactive
2. Inter-zone Routing Protocol (IERP) Reactive
3. Bordercast Resolution Protocol(BRP)

IARP operates within a zone and learns all the possible routes proactively. So all nodes within a zone knows about its zone topology as well IERP is a reactive & a source node finds a destination node which is not located within the same zone ,by sending RREQ(route request) message to all border nodes. This continues until destination is found.

III. SIMULATION AND PERFORMANCE EVALUATION

In this paper the characteristic comparison and performance analysis of AODV[3], LAR1[13], OLSR[5] and ZRP[10] on-demand routing protocol in two wireless standards IEEE 802.11 and IEEE 802.15.4 is presented. Simulations have been carried on Qualnet 6.1 simulator [6] [7]. This paper explores the performance with the parameters metrics data throughput, jitter, end-to-end delay and packet delivery ratio, energy consumption in transmit and receive mode in environments with varying traffic load in terms of two different experimental conditions;

i. One of constant mobility with varying nodes.
ii. The other of constant nodes with varying mobility.

3.1 Introduction to Performance Metric

In order to analyze and compare the performance of four routing protocols AODV [3], LAR1 [13], OLSR [5] and ZRP [10] simulation experiments were performed in mentioned wireless networks. The purpose of these experiments was to testify the efficiency of the routing protocols under different network conditions and network sizes.

The focus was concentrated on the following performance metrics:

1. Throughput

2. Average End-to-End Delay
3. Average Jitter(s)
4. Total packet received
5. Packet Deliver Ratio (PDR)
6. (a) Energy consumption in packet transmit mode (for WSN)
   (b) Energy consumption in packet receiving mode (for WSN)

Throughput

It is the average rate of successful message delivery over a communication channel. The throughput is usually measured in bits per second (bit/s), and sometimes in data packets per second.

Average End-to-End delay

A specific packet is transmitting from source to destination and calculates the difference between send times and received times. Delays due to route discovery, queuing, propagation and transfer time are included in the delay metric. End-to-End delay indicates the length of the time taken for a CBR (constant bit rate) source to the destination. It represents the average data delay an application or a user experiences when transmitting data.

Average Jitter(s)

Average Jitter is the variation time in the packet arrival. It is different from the delay and caused due to congestion, topology change etc. in network. It is expected to be low for better performance in ad-hoc networks. It becomes a matter of concern if it is more than the threshold value which is different for each type of transmission as data, voice or video.

Total Packets Received

Total packet received by any server per second it determines the efficiency of the network for delivering the packet without loss. More is the packet received per unit time more efficient is the network.

Packet Deliver Ratio (PDR)

The (PDR) is defined as the ratio between the amount of packets sent by the source and received by the destination.

Energy Consumption (for WSN)

The lifetime, scalability, response time and effective sampling frequency all parameters of the WSN depend upon the power. Power failure often causes breakage in network. Energy is required for maintaining the individual health of the nodes, during receiving the packets and transmitting the data as well.

3.2 Simulation Parameters for MANET

In first test , simulations were performed by varying the network size i.e., number of nodes while maintaining the constant maximum mobility and the second test was simulation by taking constant number of nodes for a given area but varying the maximum mobility. Simulation of each test was repeated 100 times and parameter were observed and analyzed.

The animated simulation view is shown in fig.. The IEEE 802.11 for wireless LANs is used as the MAC layer protocol. In the scenario UDP (User Datagram Protocol) connection is used and over it data traffic of Constant bit rate (CBR) is applied between source and destination. In the first test 25, 50, 75, 100, 125, 150, 175 and 200 nodes respectively were taken in MANET scenario.

In the second test 250 nodes are placed uniformly over the region of 1500m x1500m.The mobility model uses the random waypoint model in a rectangular field. The two CBR applications are applied over two different source nodes and two destinations nodes. The data traffic load is constant i.e. 1 packet per sec to analyze the performance of AODV, LAR1, OLSR and ZRP routing protocols. Simulation parameters are listed in table 2.

Table 3.2.1 Simulation parameters for IEEE 802.11

Parameters	**Values**
Simulator	QualNet
Protocols studied	AODV, LAR1,OLSR & ZRP

Number of nodes	Test parameter data
Simulation Time	101 s
Simulation Area	1500 *1500 m^2
Node movement model	Random waypoint mobility
Traffic types	2 CBR sources
Mobility of nodes	Min speed= 1m/s , Max speed =10 m/s
Rate of packet generation	4 packets/sec
Size of packets	512 bytes

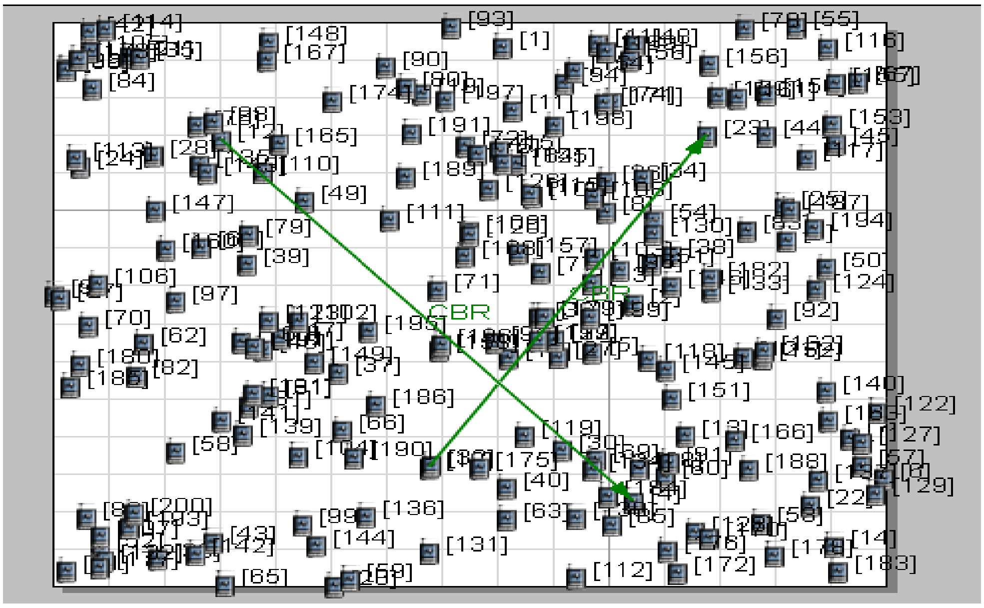

Fig. 3.2.1 Simulation scenario

3.2.1 Results and Discussion

Based on Number of Nodes:

For different number of nodes results are as follows

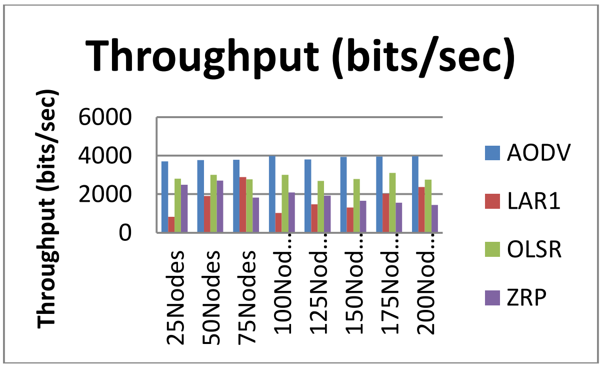

Fig.3.2.1.1

It is observed that AODV performs better than LAR1 OLSR and ZRP. And LAR1 performs worst among them in case of throughput with varying nodes.

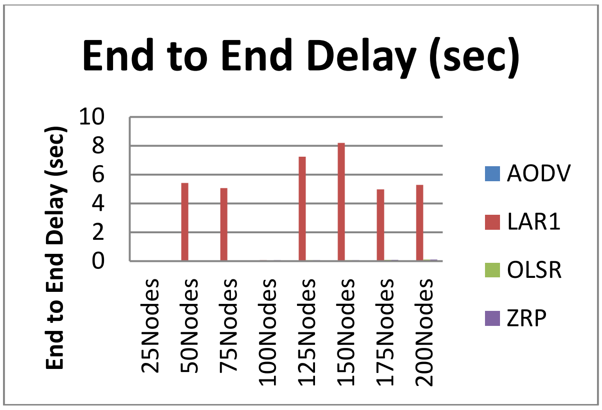

Fig.3.2.1.2

The average end to end delay is very high in LAR1 when no. of nodes increases. The AODV has least end to end delay.

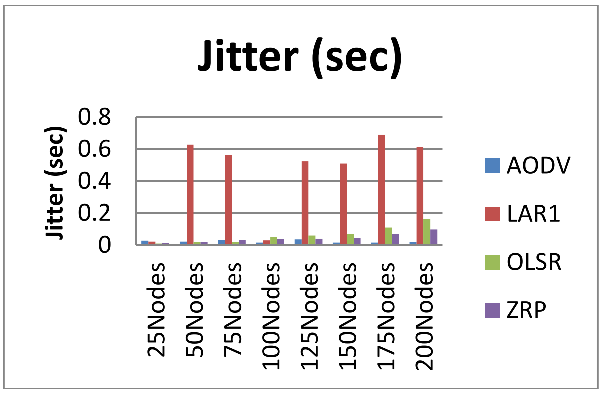

Fig.3.2.1.3

In this analysis with varying number of nodes, it can be observed that LAR1 has largest Jitter. Whereas AODV has least jitter among all of them.

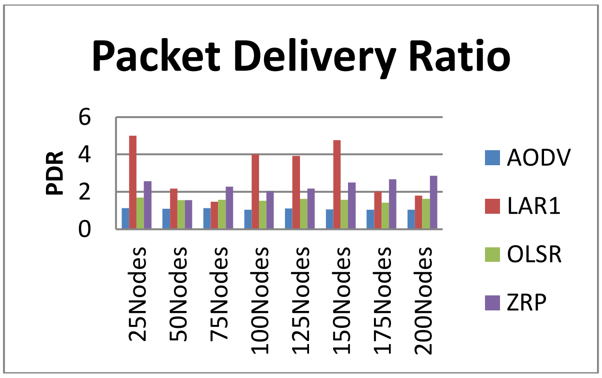

Fig. 3.2.1.4

From the above result it is observed that, AODV performs better than other when no. of nodes increases. And LAR1 performs better to all when total traffic is less than its peak size .

Based on different Pause Time:
For different pause times results are as follows-

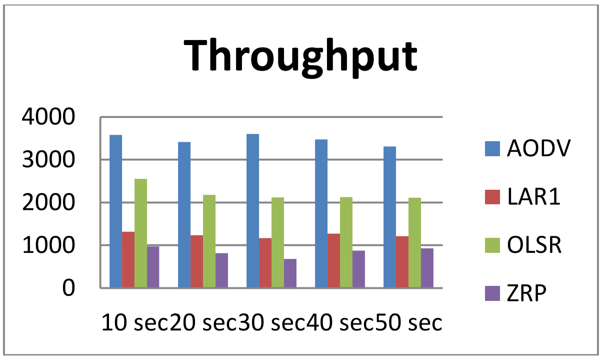

Fig. 3.2.1.5

With the constant nodes and varying mobility the throughput is analyzed & It is observed that AODV performs better than LAR1, OLSR and ZRP. Here the performance of ZRP protocol is weak in case of throughput as mobility is varying.

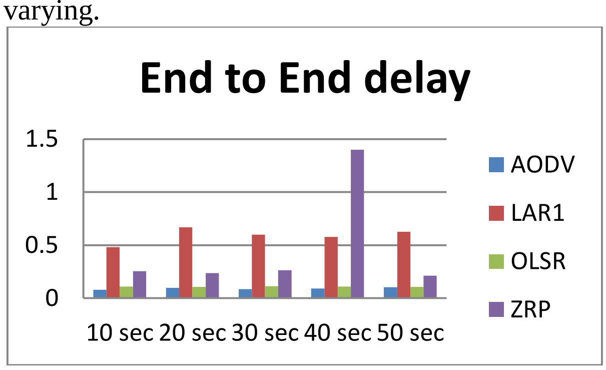

Fig. 3.2.1.6

In this analysis it is observed as expected the delays are increasing as the mobility is increasing. The average end to end delay very high in LAR1. The AODV has least end to end delay, or we can say almost constant end to end delay with varying mobility.

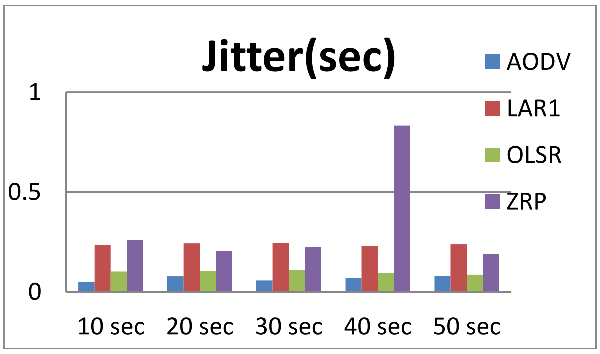

Fig. 3.2.1.7

In this analysis with varying mobility It is observed LAR1 has largest Jitter.& AODV has a minimum.

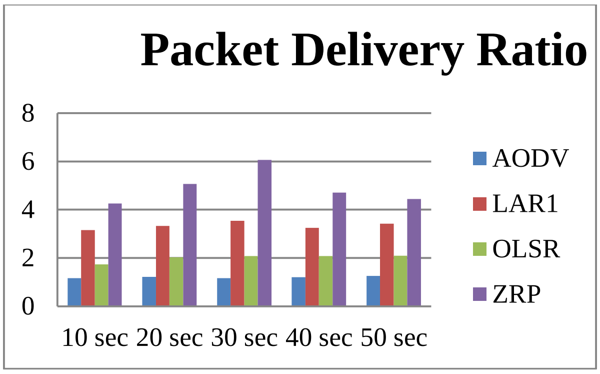

Fig. 3.2.1.8

After analyzing PDR, It is observed that ZRP routing protocol performs better in varying mobility conditions and next is LAR 1. AODV has least PDR.

3.3 Simulation Parameters for WSN

For its use in low data rate wireless communication system simulation area here has been chosen as 300*300 sq mts. Our scenario represents a typical hospital scenario which is located in some sub urban region with typical 50 bed capacity. Sensors have been placed on patients bodies which convey respective vitals viz. Blood Pressure (B.P), temperature, heart beat etc. to Hospital Information System (HIS) . Patients are provided mobility with wireless sensors placed on their body in this scenario. Their vitals can be well accessed any time with no need for physical measurement. This scenario can be extended in this way to cater mobility and seamless wireless connectivity to patients in a hospital premises. Two test conditions are:

i. At constant mobility with varying nodes (18, 36, 54, 72, 90, 108, 126 and 144).
ii. At constant node (50) with varying mobility (10s , 20s, 30s, 40s, 50s, 60 s)

Table 3.3.1 Simulation parameters for WSN

Parameters	Values
Simulator	QualNet
Protocols studied	AODV, LAR1,OLSR & ZRP
Number of nodes	Test parameter data
Simulation time	101 sec
Simulation area	300 *300 sq.m
Node movement model	Random waypoint mobility
Traffic types	4 CBR sources
Mobility of nodes	Min speed= 1m/s , Max speed =10 m/s
Rate of packet generation	10 packets/sec
Size of packets	50 bytes

3.3.1 Results and discussion

Based on different Number of Nodes:

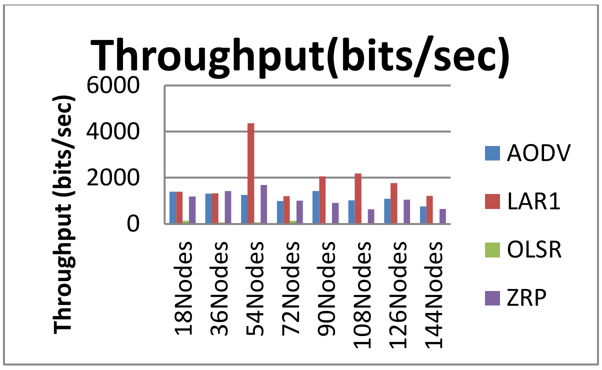

Fig: 3.3.1.1

Here in WSN LAR1 protocol has a best throughput among other three which is much better than AODV.

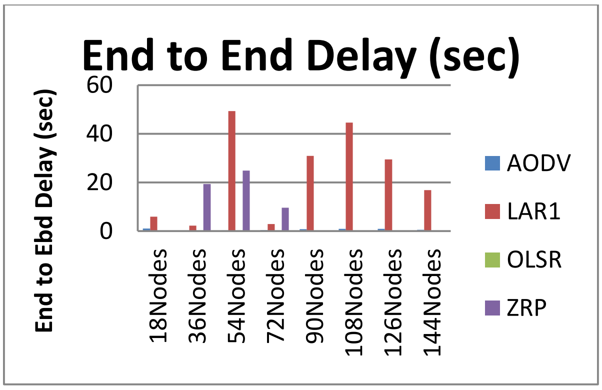

Fig: 3.3.1.2

Hybrid protocols are poor performer here with varying nodes while it is least for AODV.

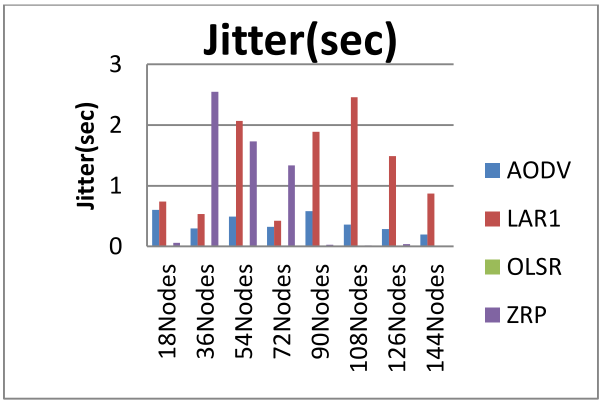

Fig: 3.3.1.3

It is observed that LAR1 has more jitter. As node density increases ZRP have least jitter compared to others while AODV has almost constant low jitter.

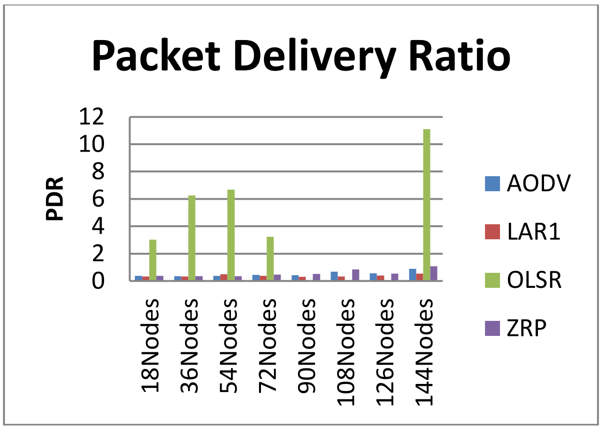

Fig: 3.3.1.4

PDR performance is analyzed it is observed that for low traffic OLSR has highest PDR with LAR 1 has least. AODV has almost consistent value.

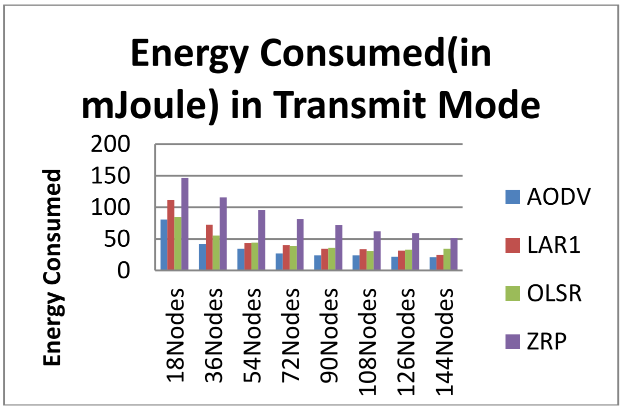

Fig: 3.3.1.5

It is observed that here consumption of energy is decreasing with the increases node density .Here ZRP have maximum energy consumption and AODV has minimum energy consumption

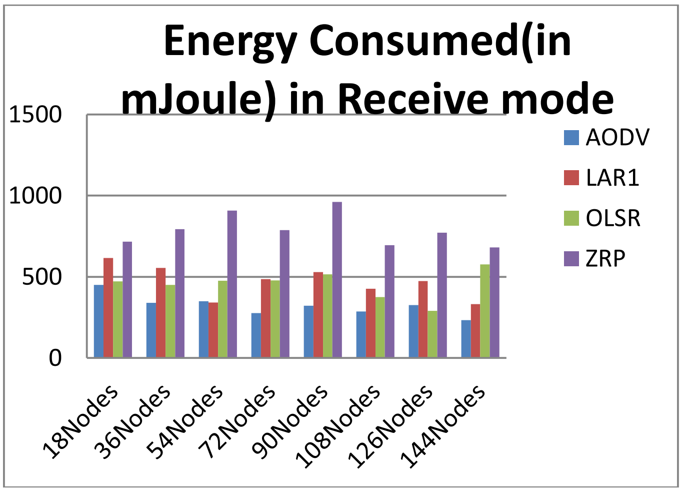

Fig: 3.3.1.6

Energy Consumed in Receive Mode normally constant but different variation for different routing protocol like in AODV its value is very least compare to other. ZRP have maximum energy consumption compared to all three protocols. It is observed that here consumption of energy is decreasing with the increase in node density.

Based on different Pause Time:

For different pause times results are as follows-

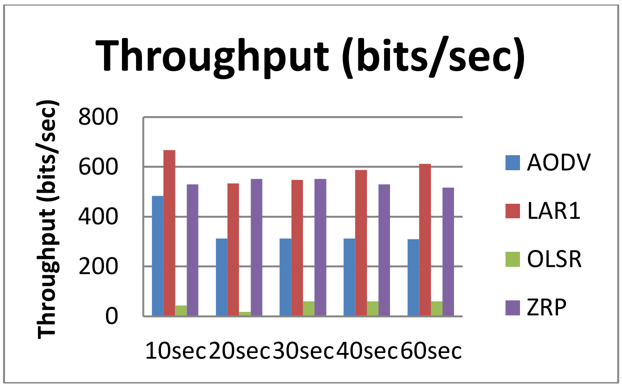

Fig: 3.3.1.7

Here with varying mobility LAR1 performing best. The performance of OLSR is inferior to all.

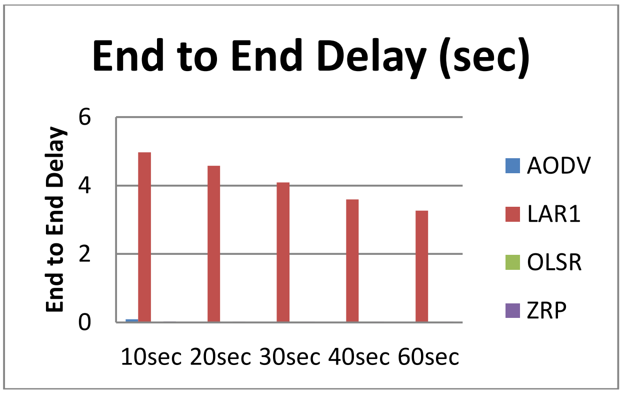

Fig: 3.3.1.8

It is analyzed that here because of hybrid characteristic of the LAR1 is the maximum even with varying mobility while is least for AODV and OLSR inferior between them.

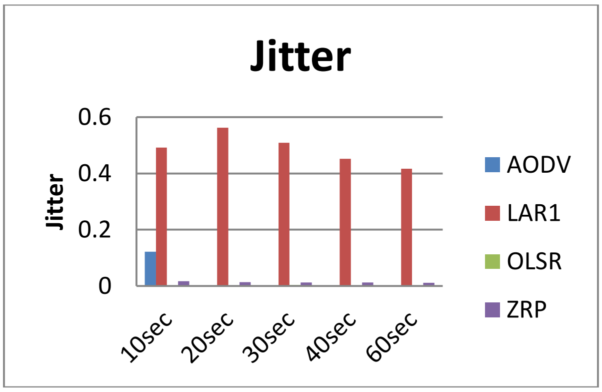

Fig: 3.3.1.9

Here it is observed jitter increases with mobility due to congestion problems with mobility. LAR1 have more jitter compared to other while it is least for AODV. OLSR performs inferior among them. As the mobility decreases packets are dropped severely using OLSR.

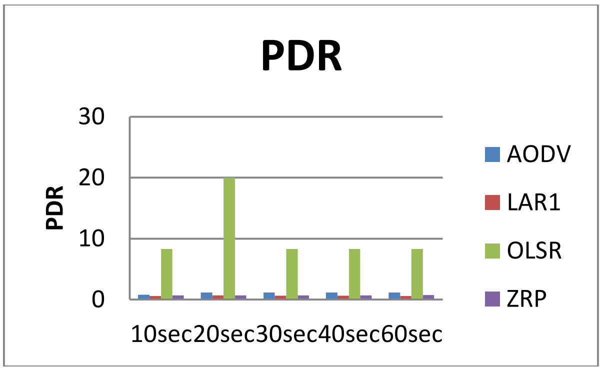

Fig: 3.3.1.10

It is observed that OLSR routing protocol performs better and LAR 1 performs inferior to all these protocols.

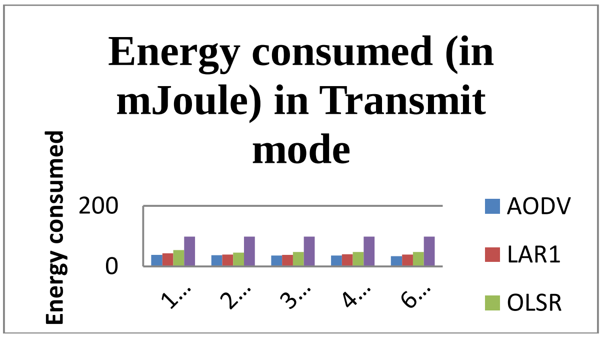

Fig: 3.3.1.11

It is observed ZRP have maximum energy consumption and AODV have minimum energy consumption in transmit mode.

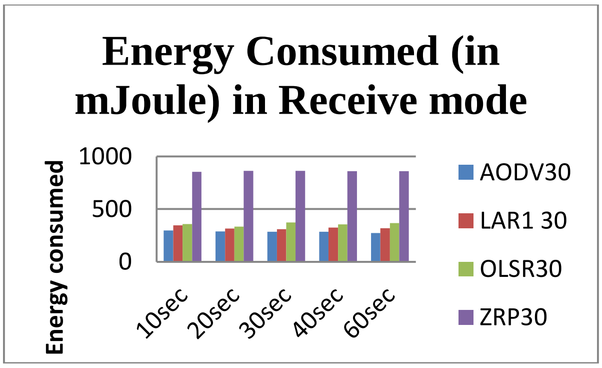

Fig: 3.3.1.12

Energy Consumed in Receive Mode normally constant but different variation for different routing protocol like in AODV its value is very least compare to other. ZRP have maximum energy consumption in receive mode.

IV. CONCLUSION

For MANET in terms of throughput, in both test conditions, AODV outperformed both ZRP and LAR1. End to End delay was least for AODV with highest for ZRP and LAR1 which means data transmission was faster with using AODV protocol which was further confirmed by least jitter value of AODV it means hybrid protocol works inferior than proactive & reactive type of protocols in terms of speed Packet delivery ratio is highest using ZRP and LAR1 which means that hybrid protocols ensure better representation of data at receiver by compromising on speed. It means that reduction in hops using hybrid protocols can bring better communication in MANET scenario.

In case of WSN, Throughput using LAR 1 was maximum but the End to End delay was also maximum for LAR 1 in both the test conditions whereas AODV performs best with least value, it means faster communication. As traffic increases ZRP gave least jitter while for low mobility scenarios AODV outperformed all. In terms of PDR, OLSR outperformed all and hence ensured better representation and information content. ZRP consumed most of the energy in transmit and receive mode and AODV consumed least. It means here in case of WSN hybrid protocols consumed more energy with high throughput put and least information flow. So, development of better hybrid protocols is needed for WSN.

V. FUTURE WORK

Present comparative analysis of performance evaluation can be extended to search for a better routing protocol in a given wireless standard for its use in addressing emergency scenarios such as medical assistance, battlefield, emergency assistance on ships and many other demanding scenarios. Performance in terms of described metrics may be further judged by introducing various realistic mobility models [21] for each scenario.

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