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A SURVEY ON MULTICAST ROUTING PROTOCOLS FOR PERFORMANCE EVALUATION IN WIRELESS SENSOR NETWORK

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Abstract
Multicast is a process used to transfer same message to multiple receivers at the same time. This paper presents the simulation and analysis of the performance of six different multicast routing protocols for Wireless Sensor Network (WSN). They are On Demand Multicast Routing Protocol (ODMRP), Protocol for Unified Multicasting through Announcement (PUMA), Multicast Adhoc On demand Distance Vector Protocol (MAODV), Overlay Boruvka-based Adhoc Multicast Protocol (OBAMP), Application Layer Multicast Algorithm (ALMA) and enhanced version of ALMA (ALMA-H) for WSN. Among them, ODMRP, MAODV and PUMA are reactive protocols while OBAMP, ALMA and ALMA-H are proactive protocols. This paper compares the performance of these protocols with common parameters such as Throughput, Reliability, End-to-End delay and Packet Delivery Ratio (PDR) with increasing the numbers of nodes and increasing the speed of the nodes. The main objective of this work is to select the efficient multicast routing protocol for WSN among six multicast routing protocol based on relative strength and weakness of each protocol. The summary of above six multicast routing protocols is presented with a table of different performance characteristics. Experimental result shows that ODMRP attains higher throughput, reliability and higher packet delivery ratio than other multicast routing protocol, while incurring far less end-to-end delay.

Keywords:
Wireless Sensor Network, Multicast Routing, ODMRP, MAODV, PUMA, OBAMP, ALMA, ALMA-H

1. INTRODUCTION

A Wireless Sensor Network (WSN) is a wireless network consisting of relatively large number of sensor nodes to monitor physical or environmental conditions [1]. WSN are currently receiving significant attention due to their wide range of applications such as environment monitoring, traffic surveillance, building structures monitoring, military sensing and information gathering, habitat monitoring, wildfire detection, pollution monitoring, etc [1], [2], [3]. Multicast is the transfer of same message to multiple receivers at the same time within the transmission range of the sender. Multicast is an essential component in many Wireless Network applications. Multicasting is a more efficient method of supporting group communication than unicasting or broadcasting. Applications of multicasting are conference meetings, military control operations to multicast tactical information [4], [5].

The multicast routing protocol is mainly classified into three categories i.e., reactive, proactive and hybrid. The reactive routing protocol is [6] called as on-demand routing protocol. It creates routes only when desired by the source node. When the source node has data packets to send to the destination node, a route discovery mechanism is initiated by the source node within the network. Once a route has been established, it is maintained until the route is no longer desired or the destination is not reachable. The benefit of these protocols is that overhead messaging is reduced. One of the disadvantages of these protocols is the delay in discovering a new route. Example for reactive multicast routing protocol is: ODMRP [7], MAODV [8] and PUMA [9]. The proactive routing protocol is called as table-driven routing protocol [6] in which, the route for all the nodes is maintained in routing table. Multicast Messages are transferred from source to destination through predefined route specified in the routing table. One of the advantages of these protocols is minimal delay. Because route is immediately obtained from routing table, whenever a route is needed [10]. OBAMP [11], ALMA [12] and ALMA-H [12] are proactive multicast routing protocols. The hybrid routing protocol is the combination of both reactive and proactive [13] protocols and takes advantages of these two protocols, also multicast routing protocols can be classified as according to their delivering the multicast packets to the receivers as tree based and mesh based [9]. In the tree based multicasting, tree structure can be highly not fixed in multicast ad-hoc routing protocols, as it needs frequent reconfiguration in dynamic networks [14], example for these type is MAODV, ALMA, ALMA-H and OBAMP. More than one path may exist between a source and receiver pair in the mesh based multicasting [14]. Two well-known examples of mesh based multicast routing protocols are ODMRP and PUMA.

1.1 MOTIVATION AND JUSTIFICATION

A multicast routing protocol for WSN is to support the distribution of information from a sender to all the receivers of a multicast group using available bandwidth efficiently in the presence of frequent topology changes. The need for one-to-many multicast data dissemination is quite frequent in critical situations such as disaster recovery or battlefield scenarios [15]. Though the selected multicast routing protocols were primarily designed for Mobile Adhoc Network (MANET), they can be used for WSN. But, it still has a lot of challenges like limited energy, limited bandwidth, short memory, limited processing ability, scalability and robustness [1], [2], [5], [16]. These considerable techniques are required to design the multicast routing protocols efficiently that would be increase the life time of a WSN. Such limitations become confronts for analyse the performance of six multicast routing protocols for WSN.

Sung-Ju Lee et al [7] evaluated the scalability and performance of ODMRP for adhoc wireless networks. In 2004, R. Vaishampayan [9] compared the mesh based and tree based multicast routing in MANET with varying the parameters of mobility, group members, number of senders, traffic nodes and the number of multicast groups and concluded that PUMA attains higher packet delivery ratios than ODMRP and MAODV. In 2007, Andrea Detti et al [11] proved that OBAMP has a low-latency and a high delivery ratio, even when the group size increases by analyze the performance of OBAMP and compared it with two state-of-the-art protocols, namely ODMRP and ALMA. In 2011, Pandi Selvam et al [17] compared the performance of two on-demand multicast routing protocols, namely MAODV and ODMRP in MANET. In 2012, Sejal Butani et al [18] chosen PUMA for multicast ad hoc network based on comparison of various multicasting protocols and concluded that PUMA provides less routing overhead, high throughput and better packet delivery ratio as compared to MAODV and ODMRP in MANET.

Performance comparison among ODMRP, MAODV, PUMA, OBAMP, ALMA and ALMA-H of MANET and Wireless Mesh Network (WMN) multicast routing protocols (Reactive, Proactive and Hybrid) is already done by the researchers [7], [9], [11], [19], [20] whereas A.M. Zungeru et.al [16] compared the different MANET routing protocols and presented a comprehensive survey in WSN, Abid ali minhas et.al [21] compared the MAODV, TEEN (Threshold-Sensitive Energy Efficient Sensor Network), SPEED (A Stateless Protocol for Real-Time Communication) [22], MMSPEED (Multi-path and Multi-SPEED) for WSN and also some simulation results have been published before. To the best of the author's knowledge no performance comparative study has been found yet representing the relative merits and demerits of six state-of-the-art multicast routing protocols considered in this paper for WSN. The main objective of this work is to select the efficient multicast routing protocol for WSN among six multicast routing protocol based on relative strength and weakness of each protocol. Therefore, evaluating the performance of these six multicast routing protocol in WSN is essential in order to analyze their behavior and effectiveness.

1.2 OUTLINE OF THE PAPER

The outline of the paper is depicted in the Fig.1.

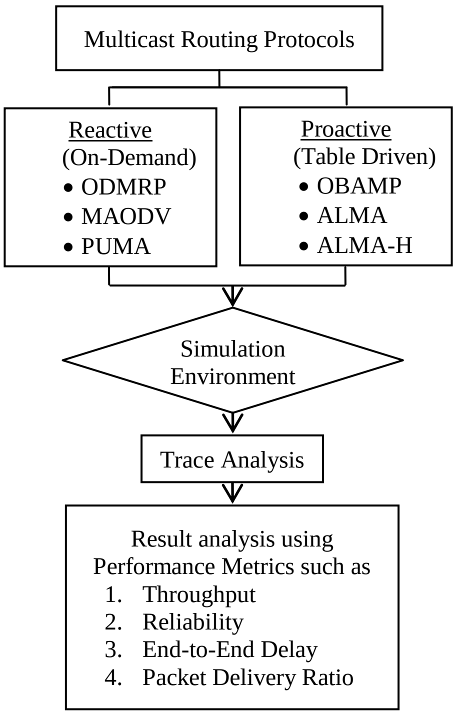


Fig.1. Outline of the paper

It presents a performance comparison of six well-known multicast routing protocols in WSN, based on the result analysis obtained by running simulations with different scenarios in Network Simulator (NS-2). The simulation was done based on the simulation environment as given in Table.2. To evaluate performance metric of throughput, reliability, end-to-end delay and packet delivery ratio, data can be extracted from the trace analysis file after simulation. Finally, the simulation results are plotted as graph using gnuplot tool of ns-2 for the above mentioned performance metrics.

1.3 ORGANIZATION OF THE PAPER

The rest of the paper is organized as follows: In section 2, the description of multicast routing protocol is given. Characteristics of multicast routing protocols are summarized as table and explanation is given in section 3. Section 4 describes the simulation environment, performance metrics, simulation parameters and simulation results. Finally, conclusion about the comparison is given.

2. MULTICAST ROUTING PROTOCOLS

In this section, basic operation procedures of six state-of-art multicast routing protocols (ODMRP, MAODV PUMA, OBAMP, ALMA and ALMA-H) are described.

2.1 ON DEMAND MULTICAST ROUTING PROTOCOL (ODMRP)

ODMRP is a state-of-art on-demand multicast routing protocol [4], [7], [8], [23], [24]. It is a mesh based and a source initiated protocol. It uses the forwarding group concept to establish a mesh. It follows "soft state" approach to maintain a mesh.

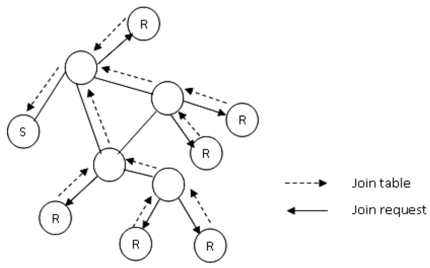
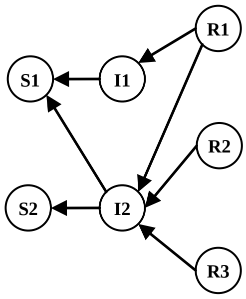


Fig.2. Multicast route and membership maintenance

The Fig.2 illustrates on-demand procedure for membership setup and maintenance of ODMRP. When a source node wants to send data packets to the multicast group, it broadcasts JOIN_QUERY packet to the network periodically and received by each intermediate node, it checks its received packet is a duplicate or not based on sequence number in the packet header. If not, the intermediate nodes store their upstream node identifier (ID) in its routing table and rebroadcast the packet. If the JOIN_QUERY reaches its receiver node of multicast group, the node creates a join table and it broadcasts a JOIN_REPLY packet with join table to its neighbor nodes. Join table forwarding process is shown in Fig.3. The join table has two fields: they are sender node and the next node. When a node receives a JOIN_REPLY message, it checks whether it is the last hop in any of the entries in the join table. If so, the source node realizes that the current node is on the path to the source node and update in its joining table thus becomes a part of the Forwarding Group (FG) of the source node by setting its forwarding group flag (FG_Flag). Now, the source node broadcasts its own JOIN_REPLY, which contains matched entries. IP address of the next hop can be obtained from the message cache. Thus the node updates the route from sources to receivers and builds the forwarding group. Route information and membership is updated by periodically by sending JOIN_QUERY message. A Source node can multicast the data packets after constructing a forwarding group.



Sensor Node	Next Node
S1	I1
S2	I2

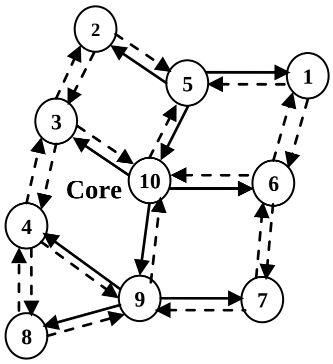
Sensor Node	Next Node
S1	S1

Fig.3. Join table forwarding

When a source node wants to join or leave the group, it does not require any control packets. If a source node does not have any data packet to send, it just stops sending any packets to the multicast group [25]. Three types of tables in ODMRP architecture, they are: Member node table, routing table and Forwarding Group table. The Member node table is used for storing the source information. Each entry in the table is designated by source ID and time of last JOIN_QUERY received pair. If JOIN_QUERY is not received by a member node within a refresh period, that entry is removed. The Routing table is created on demand and is maintained by each node. When a non-duplicate JOIN_QUERY is received by member node, the routing table is updated. Forwarding nodes performs forwarding the packets and maintains the group information in the forwarding group table [26].

2.2 PROTOCOL FOR UNIFIED MULTICASTING THROUGH ANNOUNCEMENT (PUMA)

PUMA is distributed; receiver initiated and mesh based protocol [9], [18]. PUMA does not depend on any unicast protocol and all transmissions are broadcast. A multicast group has a special node called core node. Each receiver connects to elected core along the shortest path and forming a mesh structure. The first receiver node acts as a Rendezvous Point (RP). If many receivers join into the multicast group at same time, then one receiver with highest ID become the RP. Due to this, the sender can send a data packet to multicast group along any of the shortest path between core node and sender node. It uses a control message called announcement message. Fig.4(a) illustrates the propagation multicast announcement message. Connectivity list is formed at every node as the control message and it passes through the multicast group, this connectivity list is used to form a mesh topology and route multicast data packets from senders to receivers. When the core fails one of the other group members becomes the core. Fig.4(b) shows building the connectivity list at node 4.



Connectivity List at node 4

Neighbour	Multicast Announcement	
	Distance to Core	Parent
9	1	10
3	1	10
8	2	9

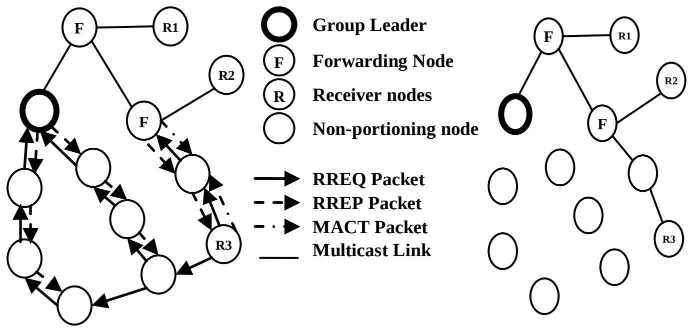
(a) (b)

Fig.4. Propagation of multicast announcement message and connectivity list: (a). Dissemination of multicast announcement, (b). Connectivity list at node 4

The announcement message gives the details about sequence number, core ID, group ID, distance to the core and parent node details. Parent indicates that the preferred neighbor to reach the core node. The core node broadcasts its multicast announcements periodically. When a node wants to join into a multicast group, first it verifies that whether it has received a multicast announcement message for that group or not. If the multicast announcement message is already received then the core node is specified in that announcement is taken as its core [27]. If not, it considers itself as a core node for the multicast group and starts to broadcast a new announcement message to its neighbor nodes. After forming a connectivity list at every node, the sender node can flood the multicast data packets to the receivers using announcement message of the core.

2.3 MULTICAST ADHOC ON DEMAND DISTANCE VECTOR PROTOCOL (MAODV)

MAODV is the multicast extension of AODV [8], [21], [28] it is a hard state reactive tree based routing and it discovers multicast routes on demand using a broadcast route-discovery mechanism.



(a) (b)

Fig.5(a). MAODV Joining Process, (b). MAODV multicast tree at the end of joining process

MAODV is an on-demand routing protocol, therefore, it follows conventional scheme for maintaining routing table i.e. each destination has only one entry in the routing table. Fig.5 illustrates the joining process of MAODV. New entries are added to this table by the reception of a MACT (Multicast Activation message) from the source node that previously asked for a route for multicast group. Each entry has two data field, the first field is it will update its destination with next hop and the second field is it will update its sequence number. This entry keeps the record of all active neighbour nodes which passes the destination information. A new node initiates and broadcast a route request message (RREQ), when it wants to join into the multicast group. The first node of a multicast group becomes the leader of that group. The group leader is responsible for maintaining its multicast group sequence number and broadcasting this number to the multicast group. The group leader initiates and responds with a route reply message (RREP). If a source node receives many reply messages for its route request, route is decided based on the current sequence number. Then, it unicasts the MACT to this selected next hop. If this node is not in a member list, it forwards the MACT to the best next hop from which it received a RREP and enables the corresponding entry in its multicast route table. This process continues until reaching a tree member that already generated a RREP.

2.4 OVERLAY BORUVKA-BASED ADHOC MULTICAST PROTOCOL (OBAMP)

OBAMP is a mesh-first overlay multicast protocol [11] with Boruvka algorithm. It is sending the information to other nodes through the transport layer tunnels. Boruvka algorithm is used to find the minimum spanning tree. The main aim of this protocol is to reduce the network traffic in order to get the maximum delivery ratio and low delay. Initially, it builds an overlay network spanning of all members (i.e., a mesh), then it builds the distribution tree by selecting a subset of non-cyclic overlay links belonging to the mesh. Fig.6 reports an example of mesh creation and corresponding distribution tree. In the mesh network, it can quickly select a recovery overlay link using mesh-first approach.

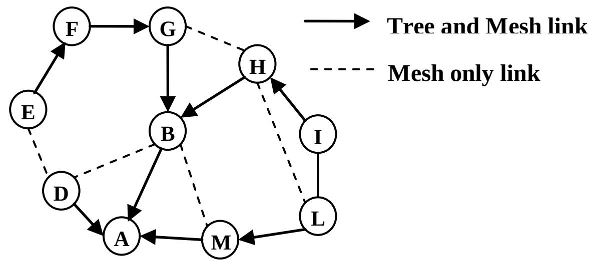


Fig.6. Mesh creation in OBAMP

Three operations are performed to create and maintain the mesh structure. The hello and fast-hello sub operation are used to find the neighbors of each member node and to estimate their hop distance. Neighbour nodes are connected by a mesh link. The mesh link is established periodically by using the above two operations. The third operation is link-pruning, which is used to manage the removal of a mesh link. The status of the mesh links connected to the member node is maintained by each member using a neighbour's list structure [27]. To limit signalling and improve the system scalability, OBAMP nodes do not build a full mesh among them, but create only the necessary links to keep the OBAMP overlay network connected.

2.5 APPLICATION LAYER MULTICAST ALGORITHM (ALMA)

ALMA is a receiver-driven, flexible and a highly adaptive overlay multicast protocol [12]. It constructs an overlay multicast tree of logical links between the multicast group members in dynamic, decentralized and incremental way. Here, receiver-driven means that the member nodes of multicast group find their neighbours according to their needs. ALMA is flexible means that it can satisfy the needs of a wide range of applications and its performance goals. It is highly adaptive means that it reconfigures the multicast tree in response to mobility or congestion. The advantages of ALMA are independence from lower layer protocols, simplicity of deployment, reliability, congestion control and security that may be provided by the lower layers.

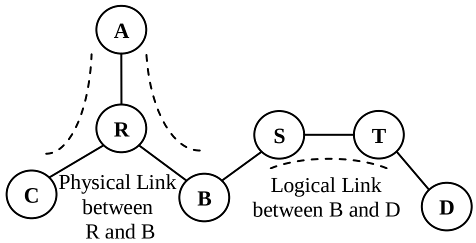


Fig.7. Logical Links versus physical links

ALMA creates a logical multicast tree between the multicast members of the network [12]. Each edge of the multicast tree represents logical link, which corresponds to multicast path at the network layer. As an example in Fig.7, there is a single logical link between nodes B and D, this logical link contains four underlying physical links, from B to S, from S to T and from T to D. When a node wants to join into a multicast group, it finds its parent node. Parent node is considered as a first node of the logical link path to its root node along the multicast tree. When a node receives a data packet from the source node, it makes multiples copies of the packet and forwards a copy of packet to its child nodes. Member nodes are responsible for maintaining their connections with their parent node in the multicast tree [29]. If any problem in its performance, the member node reconfigures the multicast tree locally, either by switching their parent node or by releasing its child node.

2.6 APPLICATION LAYER MULTICAST ALGORITHM-HIERARCHICAL (ALMA-H)

ALMA-H is an enhanced version of ALMA in terms of tree efficiency. It is also a receiver-driven, flexible and a highly adaptive overlay multicast protocol [12]. It forms a unique shared tree that is not dependent source node of the group but it depends only on member of the group. In ALMA, the metric used for parent selection is round trip time, but in ALMA-H the metric is number of hops for parent selection.

3. CHARACTERISTICS OF MULTICAST ROUTING PROTOCOLS

Table.1 summarizes the characteristics of multicast routing protocols of studied in this paper. It discusses their characteristics: Multicast topology, routing initiation (source based or receiver based), packet control overhead, dependency, maintenance, periodic control message and routing approach [18], [28].

Table.1. Characteristics comparison of multicast routing protocols

Characteristics	Multicast Routing Protocol					
	Reactive			Proactive		
	ODMRP	**MAODV**	**PUMA**	**OBAMP**	**ALMA**	**ALMA-H**
Multicast Topology	Mesh	Tree	Mesh	Tree	Tree	Tree
Initiation	Source	Source	Receiver	Receiver	Receiver	Receiver
Control Overhead	Low	Low	Low	High	High	High
Dependency	Autonomous	Unicast based	Autonomous	Dependent	Dependent	Dependent
Maintenance	Soft	Hard	Soft	Soft	Soft	Soft
Periodic Control message	Yes	Yes	Yes	Yes	Yes	Yes
Routing Approach	Flat	Flat	Flat	Flat	Flat	Flat

So far in this paper, the protocols have been analyzed theoretically, the table compares the result from these theoretical analysis and shows that ODMRP, MAODV and PUMA are low control overhead protocols because reactive multicast routing protocols maintained limited on-demand routing table. Remaining three is high control overhead because proactive multicast routing protocols maintained many routing tables. Here, proactive multicast routing protocols are dependent, which means that depends on any unicast routing protocols. In reactive, ODMRP and PUMA are autonomous which means that does not depend on unicast routing protocol. MAODV is unicast-based which means that depends on a specific unicast (AODV) routing protocol. After comparison of above mentioned multicast routing protocols as shown in Table.1 in terms of its characteristics, this paper shows that reactive protocols are better than proactive protocols.

4. SIMULATION ENVIRONMENT AND PERFORMANCE EVALUATION

4.1 SIMULATION SETUP

In the simulation experiment, nodes were placed uniformly at random locations in an area of 500 m × 500 m. The multicast traffic is Constant Bit Rate (CBR) with 250 bytes data packet. The simulation scenarios are created by the setdest tool of ns-2. The simulation time is 200 seconds. Mobility model uses a random waypoint model in a rectangular field. Here, 1-to-many multicast concept has been taken, i.e., Sender is fixed as one and only the receivers are varied from 19 to 79. The minimum and maximum speed were set from zero to 20 m/s, respectively while pause time duration is 1 simulation seconds, which corresponds to constant motion and transmission rate is 128 Kbps, transmission range is 50 m for all nodes. The simulation parameters are summarized in Table.2.

Table.2. Simulation parameters

Sl. No.	Parameters	Particulars
1	Simulator	Network Simulator-2
2	Protocol	ODMRP,PUMA,MAODV, OBAMP, ALMA,ALMA-H
3	No. of nodes	20-80 nodes
4	Simulation time	200 secs
5	Simulation area	500 m × 500 m
6	Node movement	Random way point
7	Sender & Receiver	Sender-1 Recevier-19-79
8	Pause time	1 sec
9	Traffic	CBR
10	CBR Packet size	250 bytes
11	Transmission rate	128 Kbps
12	Mobility speed	0, 5, 10, 15, 20 m/s
13	Transmission range	50 m

4.2 PERFORMANCE METRICS

4.2.1 Throughput:

Throughput can be defined as the number of data packets generated by source node to the number of data packets received in the destination node.

$$\text{Throughput} = \frac{\text{Number of bytes received} \times 8}{\text{Simulation Time} \times 1000}\ \text{kbps} \tag{1}$$

4.2.2 Reliability:

Reliability is defined as the successful end-to-end data delivery ratio [30].

$$\text{Re}liability(r_0, r_1 \ldots r_{h-1}, r_h) = \exp\left(-\sum_{i=1}^{h} \frac{d^k_{ri-1ri}}{snr_{ri-1ri}}\right) \tag{2}$$

where, $(r_0, r_1 \ldots r_{h-1}, r_h)$ is route

d^k_{ri-1ri} is distance between the nodes

snr_{ri-1ri} is the transmitted signal-to-noise power

4.2.3 End-to-End Delay:

The end-to-end delay is defined as the interval that elapses between the time a packet is sent and the time at which the packet is successfully delivered [31].

$$Delay = \frac{1}{R}\sum_{j=1}^{n}(r_j - s_j) \tag{3}$$

where, R is the number of successfully received packets, j is unique packet identifier, r_j is time at which a packet with unique id_j is received, s_j is time at which a packet with unique id j is sent and Delay is measured in sec. It should be less for high performance.

4.2.4 Packet Delivery Ratio (PDR):

PDR is the ratio of the number of data packets delivered to the destination to the number of packets generated by the source node [32] as below:

$$\text{PDR} = \frac{\text{Total number of packets received at destination}}{\text{Total packets sent}} \quad (4)$$

where,

$$\begin{matrix}\text{Total number of packets} \\ \text{received at destination}\end{matrix} = \sum_{i=1}^{n} \begin{matrix}\text{No. of source nodes} \times \text{No. of} \\ \text{packets} \times \text{Received at} \\ \text{destination by each node}\end{matrix} \quad (5)$$

$$\text{Total packet sent} = \sum_{i=1}^{n} \begin{matrix}\text{No. of nodes} \times \text{No. of packets} \\ \text{sent by each node}\end{matrix} \quad (6)$$

4.3 SIMULATION RESULTS AND ANALYSIS

In this section, simulation results for the selected six multicast routing protocol for the performance metrics of throughput, reliability, end-to-end delay and packet delivery ratio for WSN are elaborated. Each protocol is simulated and analyzed by the following two scenarios: a) Varying the number of nodes and b) Varying the speed of the nodes.

4.3.1 Scenario-I - Varying the Number of Nodes:

In the first scenario, the performance of reactive and proactive multicast routing protocols are measured for the four performance metrics considered in this paper for WSN by increasing number of nodes from 20 to 80 nodes for fixed minimum speed of 0 m/s (static) in network coverage area. The following graphs shows that performance comparison between selected six multicast routing protocols separately after filtering the data from trace files generated after simulation.

In Fig.8 simulation results of throughput (Kbps) versus number of nodes are plotted.

From the Fig.8 it is observed that, on increasing the number of nodes, ODMRP provides higher throughput than other multicast routing protocol. ODMRP delivers data packets at higher rate due to their operations which is on-demand (reactive characteristic) in nature. MAODV has worst performance in throughput than other multicast routing protocols because most of the nodes are not participate in data transfer. Another reason is link breakage since MAODV cannot repair route of breakage path. ALMA-H and ALMA show better performance than PUMA, OBAMP and MAODV but less than ODMRP.

Figure 9 shows the reliability versus number of nodes with low load, where the number of senders is only one. So every protocol achieves high reliability. This is because under low load, collisions between messages are very rare. Nevertheless, ODMRP and PUMA achieve the highest reliability among the other multicast routing protocol. It is observed that, on increasing the number of nodes, ODMRP provides better reliability (received messages) than other multicast routing protocol. As the number of nodes increases and the network becomes strongly connected, so the reliability also improves. MAODV offers average reliability. Proactive multicast routing protocols (OBAMP, ALMA and ALMA-H) has less reliability, because it maintains many routing table and high control overhead.

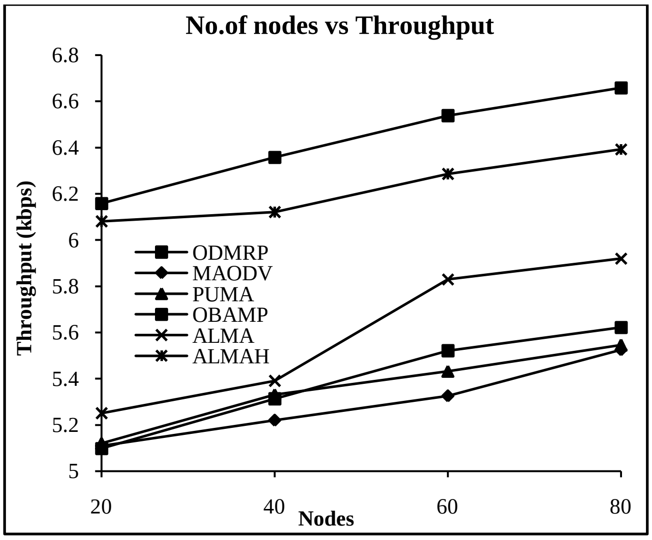


Fig.8. No. of nodes vs Throughput (Kbps)

The Fig.9 shows the reliability as a function of number of nodes.

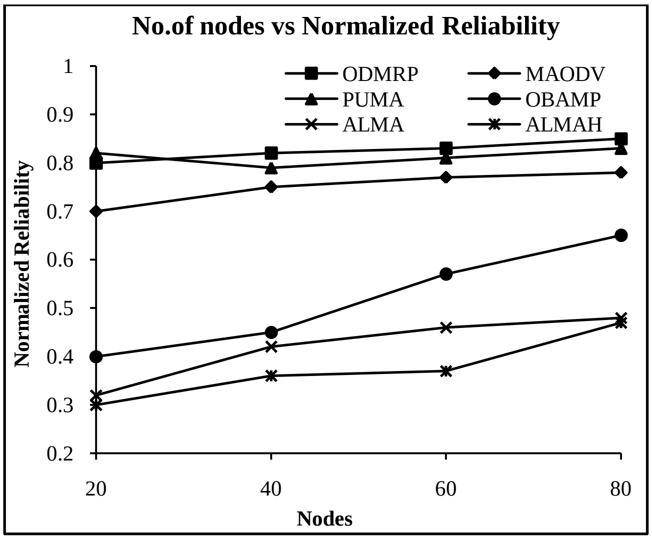


Fig.9. No. of nodes vs Reliabilty

Figure 10 shows the graphs for end-to-end delay (sec) versus number of nodes.

The Fig.10 shows the ODMRP exhibits lesser values of end-to-end delay, because its route discovery mechanism is fast, therefore ODMRP shows a better delay performance than the other multicast protocols at low pause time (high mobility), when increasing the number of nodes. The presence of routing information in advance leads to lower end-to-end delay.

Delay should be less for better performance. ALMA-H and ALMA shows average performance with respect to OBAMP and MAODV. MAODV shows worst performance in the case of end-to-end delay. MAODV needs more time in route discovery. Hence it leads to greater end-to-end delay. So as compared to other protocols end-to-end delay of ODMRP and PUMA offers better performance.

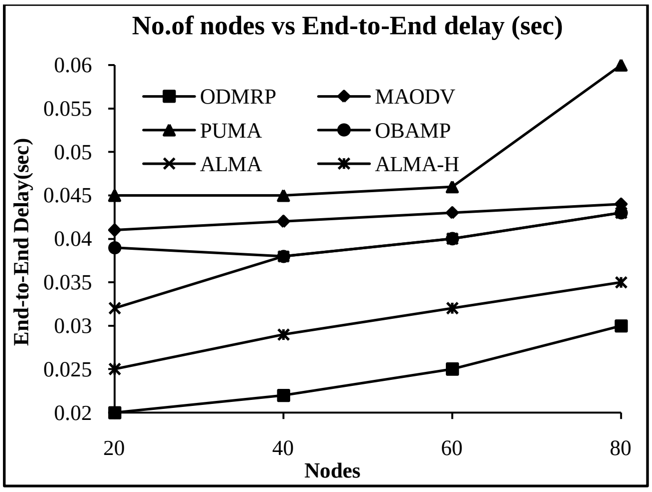


Fig.10. No. of nodes vs End-to-End delay (sec)

The Fig.11 shows packet delivery ratio(%) vs No. of nodes.

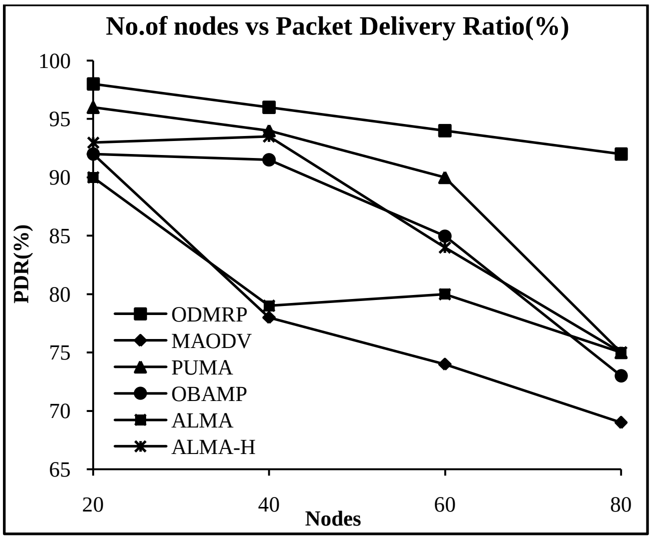


Fig.11. No. of nodes vs Packet Delivery Ratio (%)

Based on the simulation results shown in Fig.11, the packet delivery ratio of ODMRP is higher (98%) than other multicast routing protocol when the number of node is minimum (20 nodes) and packet delivery ratio is gradually decreases when increasing the number of nodes from 20 to 80 nodes. PUMA and MAODV are purely on-demand routing protocol, but ODMRP is dynamically on-demand multicast routing protocol that means ODMRP can be adjusted dynamically and send data better than other on-demand (reactive) multicast routing protocols, PUMA shows better (96%) packet delivery ratio than another on-demand (MAODV) multicast routing protocol. MAODV shows worst performance than ALMA, OBAMP and ALMA-H multicast routing protocols because it sends two times RREQ for getting destination route when link breakage and route error or route discovery failure also it cannot form a routing table proficiently with the dynamically changing network. During link breakage MAODV fails to resend data.

4.3.2 Scenario-II - Varying The Speed of the Nodes:

In the scenario-II, the performance of reactive and proactive multicast routing protocols are measured for the four performance metrics considered in this paper for WSN by increasing the speed of the nodes from zero to 20 m/s for the fixed 80 nodes in network coverage area. The following graphs shows that performance comparison between selected six multicast routing protocols separately after filtering the data from trace files generated after simulation.

In Fig.12 simulation results of throughput (Kbps) versus mobility speed (m/s) are plotted.

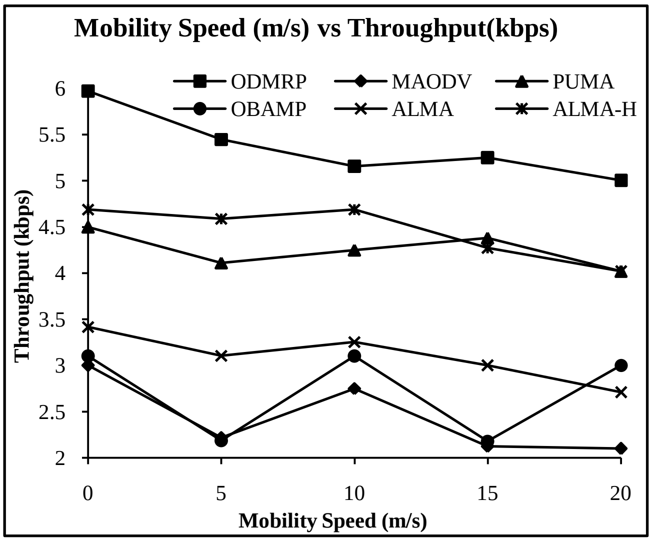


Fig.12. Mobility Speed vs Throughput

From the Fig.12, it is observed that, throughput of six multicast routing protocol is decreases as speed increases but ODMRP still provides better results than ALMA-H, PUMA, ALMA, OBAMP and MAODV multicast routing protocols. Since finding the route requires more and more routing traffic as speed increases. Therefore less and less of the channel will be used for data transfer, thus decreasing the overall throughput.

The Fig.13 shows the reliability versus mobility speed (m/s). It is observed that, on increasing the speed of nodes, ODMRP and ALMA-H provides better reliability than other multicast routing protocol because it has less delay for transmission of message and also each node moves within a speed of 0-20 m/s. The message load is low and the message size is 100KB. On the other hand, MAODV, OBAMP, ALMA has bad reliability, because it has higher delay where every message is delayed for further transmission.

The Fig.14 shows an end-to-end delay of six multicast routing protocols considered in this paper by varying the node speed. The increase of node speed induces topology change frequently and therefore the probability of broken links has also increased. These links may cause additional route recovery process and route discovery process. For this reason, as the node speed increases the average end-to-end delay of packet increase. It is observed that ODMRP exhibits lesser values of End-to-End delay than other multicast routing protocol, when increasing the speed of nodes because ODMRP maintains that latency due to its frequent state discovery and uses the shortest forwarding paths, MAODV shows highest end-to-end delay than OBAMP, PUMA, ALMA and ALMA-H due to its longer path and network load.

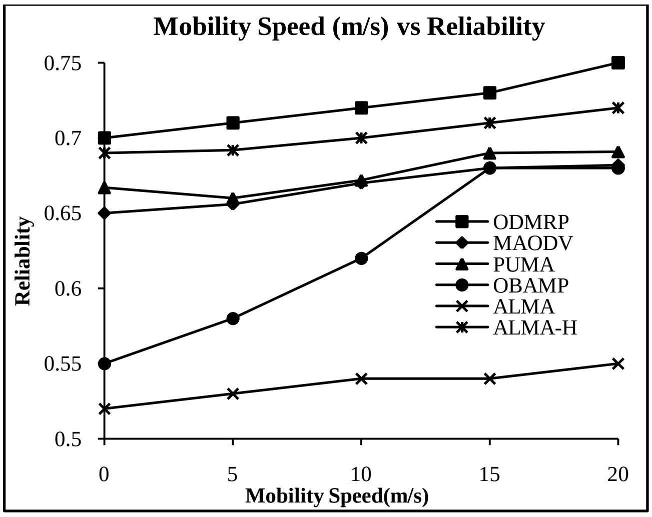


Fig.13. Mobility Speed (m/s) vs Reliability

The Fig.14 shows the graphs for end-to-end delay (sec) versus mobility speed (m/s).

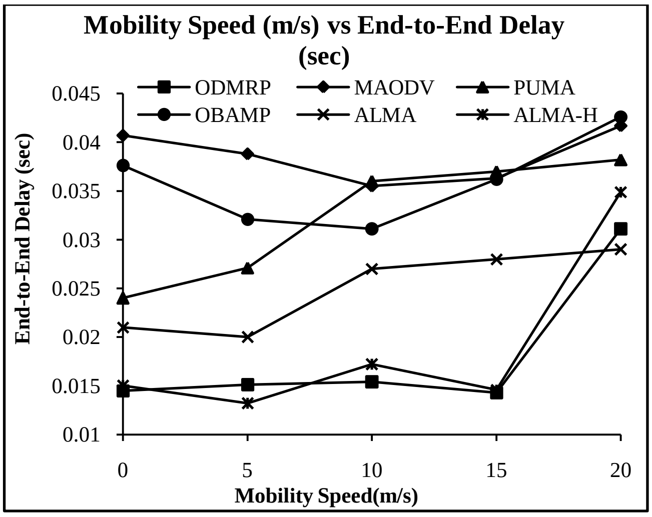


Fig.14. Mobility Speed vs End to End Delay

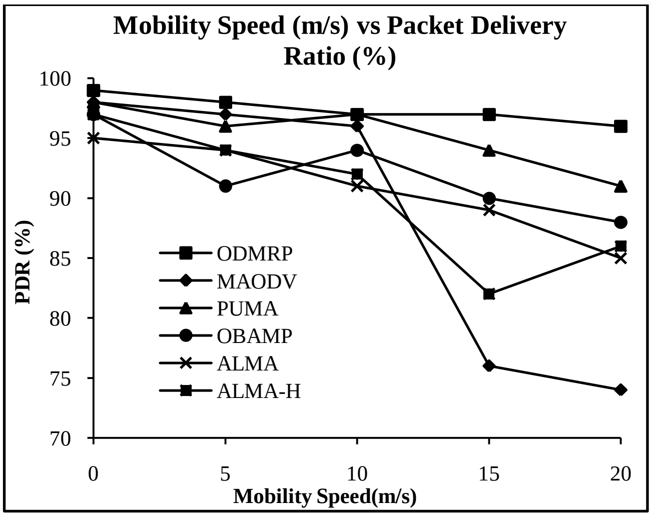


Fig.15. Mobility speed vs Packet Delivery Ratio

The Fig.15 shows packet delivery ratio (%) versus mobility speed (m/s) for the studied multicast routing protocols in this paper.

Based on the simulation results shown in Fig.15, the packet delivery ratio of six multicast routing protocol is decreases as speed increases but ODMRP still provides better results than other multicast routing protocol. It is observed that packet delivery ratio is very close to 95% for all multicast routing protocols at speed 0 m/s. However, as node speed increases, the packet delivery ratio is decreases dramatically.

5. CONCLUSION

In this paper, the performance evaluation of six state-of-art multicast routing protocols ODMRP, PUMA, MAODV, OBAMP, ALMA and ALMA-H for WSN is compared with respect to four performance metrics such as throughput, reliability, End-to-End delay and packet delivery ratio. Performance analyses were conducted under two conditions: i) increasing the number of nodes, ii) increasing the speed of the nodes. According to Simulation results, ODMRP provides better results than the remaining five multicast routing protocols in all scenarios and concluded that ODMRP is effective and efficient in highly dynamic situations and scalable to large number of multicast nodes in WSN. As future work, to face the key challenges (i.e. limited energy, limited bandwidth, short memory and limited processing ability) of sensor nodes, performance of ODMRP will be enhanced and increase the life time of a WSN by adding efficient techniques. On the other hand, security is the major challenge in WSN, this also will be considered for improving the performance of ODMRP in WSN.

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