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A Comparitive Study on Location based Multicast Routing Protocols of WSN:HGMR,HRPM,GMR

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Abstract- Wireless sensor network comprises of a set of sensor nodes that communicate among each other using wireless links and work in an open and distributed manner due to which wireless sensor networks are highly prone to attacks. This is difficult to determine the position of the sensor nodes; therefore the sensor network protocols must inculcate self-organizing competence. Location awareness is one of the important concern in WSN because for a network mostly data collection is grounded on location, so this is imperative for all the nodes to know their position whenever it is required and it is also helpful in calculating the distance between two particular nodes to deal with energy consumption issues. This paper focuses on the three location based routing multicast protocols: HGMR, HRMP, GMR and their comparison is done on the basis of different metrics like latency, PDP, encoding overhead etc.

Keywords: wsn(wireless sensor network);loaction based multicast routing protocols; hgmr(hierarchical geographic multicast routing); gmr(geographic multicast routing); hrpm(hierarchical rendezvous point multicast); pdp(average packet delivery ratio); normalized encoding overhead(neo); avergae delivery latency.

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I. Introduction

WSN offers an umpteen number [4] of applications in areas such as traffic monitoring, habitat monitoring, pollution monitoring robotic exploration, and many more. The sensor nodes need to be inexpensive, small, limited computation and communication, less energy resources. Sensors know their position using GPS or other virtual position systems moreover sensors share their information with their neighbors and then messages are delivered to the nodes which are located out of their radio range and sometimes single sensors need to send data to multiple destinations and to run these applications the use of multicast communication is required. Multicasting is a technique used in order to deliver messages efficiently from a source to a set of destinations to carry activities such as task assignments, code update and targeted queries, therefore multicasting is salutary to maintain as the energy is limited available in WSN networks. Multicasting protocols focus on minimizing the consumption of network resources by taking the advantage of the fact that some parts of the paths from the source to destinations can be shared by multiple destinations. WSN is characterized by its topological changes due to node failure or duty cycle operations and these characteristics make localized routing algorithms more appropriate for sensor networks. Localized algorithms do not need to know the entire topology in order to take routing decisions as comparative to that of centralized ones in which too much overhead is introduced.

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II. Routing Protocols in WSN

[4] Routing in wireless sensor networks differ from traditional wireless communication network (MANET) as the number of sensor nodes in wireless sensor networks can be several orders of magnitude which is higher than that in MANET, sensor node do not have any unique ID, [17]sensor nodes are cheaper than nodes in MANET,[16] power resources of sensor nodes should be very limited, sensor nodes are more limited in their computation and communication capabilities than MANETs, moreover sensor nodes are prone to failures. Therefore there is no infrastructure, sensor nodes may fail, wireless links are unreliable, and routing protocols have to meet strict energy saving requirements [17] so, it is imperative to study routing protocols for wireless sensor networks. The routing protocols proposed for WSN are classified into four main categories as,

- Data centric protocols. [12] These are those protocols which are query based and to reduce the repeated transmission, these protocols depend on the naming of data of interest.
- Hierarchical protocols. These are those protocols in which the sensors in the network are divided into different clusters [7]. It is an efficient way to reduce energy consumption within a cluster by introducing data aggregation and fusion to decrease the number of transmitted messages to the base station.
- Location based protocols. These protocols utilize the position information of nodes to relay data to the destinations. On the basis of the incoming signal strength the distance between the neighboring nodes is estimated [5]. Here the region which is to be sensed is known in advance using the location of

sensors and therefore the query generated will be diffused only to that particular region which will significantly estimate the number of transmissions.

- Energy efficient protocols. These protocols are to balance the energy consumption in the network as they are energy efficient as they utilize the power in an effective manner and consume less energy [17].

a) Unicast and multicast routing protocols

Earlier we have unicast routing protocols which were not that much efficient in terms of energy consumption, encoding overhead and many more.[4] The overhead in a WSN is to be kept low due to limited battery, storage capacity, bandwidth and processing power of sensor nodes so an efficient multicast mechanism is required to attenuate the overall consumption of resources in the network and to obtain this efficiently we need to send as limited copies as possible of each datagram to reach all the destinations. Multicasting is used with those sensors which are required to deliver the same data to the number of sinks whose position is known in advance; moreover from one sink we can multicast the same packets to other sinks with the help of sensors from the network.

b) Location based multicast routing protocols

Earlier Position based multicast routing protocols were used because of their application potential in networks with demanding requirements. These protocols route decisions with the use of location information. Among all the position based protocols the geographic approach is the one which seize the attention mostly due to umpteen advantages. [13]The geographic routing is one of the debonair ways to forward packets from source to destination in a demanding environment without having wastage of network resources or creating any hindrance in the network design, so it is used in high number of applications including number of areas such as industry, home ,health, environment, military and commerce .The location based routing protocols are based on dealing with location information to guide routing discovery and maintenance as well as data forwarding, permitting directional transmission of the information and evading information flooding in the whole network. It mainly focuses on calculating the distance between the two particular nodes so that energy consumption can be estimated. There are number of location based approaches which deal with the location information in order to send the data packets from one node to another so that the data reaches in an efficient way in many terms or metrics. Nowadays the use of wireless networks is mushroomed drastically and the main concern is the deteriorated non rechargeable battery power of sensor nodes so it is salutary to have energy saving optimization in WSN. [15]There are two protocols which were earlier proposed to optimize two orthogonal aspects of location based multicast protocols: [12] GMR which ameliorates the forwarding efficiency of packets by elevating the multicast advantages. HRPM deteriorates the encoding overhead by constructing a hierarchy at virtually no maintenance cost via the use of geographic hashing. The HGMR assimilates the key design of GMR and HRPM and optimizes them for WSN by providing both forwarding efficiency as well as scalability to large scale networks.

These protocols are analyzed as,

i. *Geographic multicast routing protocol*

[3] Geographic multicast routing protocol was proposed by Juan A.Sanchez, Pedro M.Ruiz and Ivan Stojmenovic. [11] It is fully distributed and operates in a localized manner in tree formation. This is a Geocasting based protocol. Here each packet carries the ID's of multicast destinations and then forward it to each of the destination independently in a greedy manner. Those destinations which share the same next hop will go along the same way in the hop-by-hop forwarding in GMR. Path sharing will help to reduce total tree cost for reaching different destinations. Each packet is forwarded in a hop-by-hop manner until it reaches its intended or desired destination.

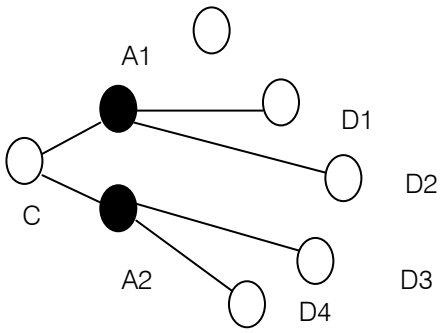


Figure 1: Fowarding Node Selection In Gmr [15] [18]

As earlier centralized membership management is done at the multicast root, but in GMR it is done along the multicast tree to send a data packet down the multiple branch of the multicast tree using one broadcast transmission.

Advantages [14]:

- Bandwidth utilization is provided to minimize the total number of transmissions for accomplishing a multicast task.
- GMR protocol is an energy inefficient protocol and it exhibits high delay during communication.

Disadvantages [15] [18][22]:

- Scalability issues are there for large scale networks.
- Too much encoding overhead.
- Energy consumption is limited to the nodes on the routing paths as for every data delivery same paths are created.
- In GMR there are more destinations so more complex is the evaluation, as the cost and the

progress need to evaluate for every subset of destinations at every hop.

ii. *Hierarchical Rendezvous Point Multicast*

[19] Hierarchical Rendezvous Point Multicast was introduced by Saumitra M.Das, Himabindu Pucha and Y.Charlie. [13] It reduces encoding overhead of location based multicast protocols by constructing a hierarchy by dividing the network into multicast groups and then into subgroups, then further each subgroup is restrained by its coordinator which is known as access point (AP).. This protocol uses the concept of mobile geographic hashing to reduce the maintenance of AP (access point) and RP (rendezvous point) nodes at virtually no maintenance cost. The need for this protocol is to construct and maintain hierarchy to have low encoding overhead. HRPM is designed to work for multicast communication and for HRPM there is no need to take care of cost factors like in GMR protocol.

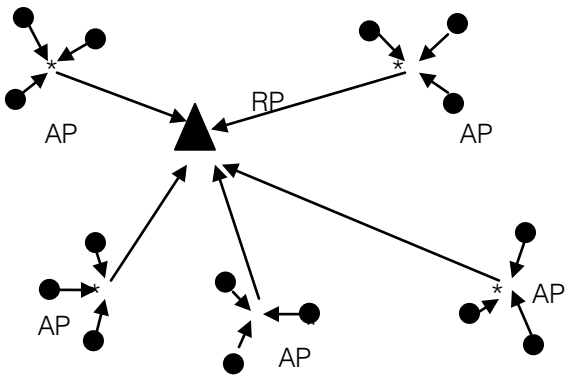


Figure 2 : Group Management In Hrpm [2]

Advantages [13] [19]:

- Reduced encoding overhead and delay is less.
- Scalable protocol and its performance do not decrease due to any change in network size or node density.

Disadvantages [19][2]:

- Consumes a lot of energy and therefore inefficient in terms of packet transmission as at each node along the source→APs (access point) or the AP→Member tree.
- Packet unicast to more than one neighbor node which consumes bandwidth.

iii. *Hierarchical Geographic Multicast Routing (HGMR)*

Hierarchical Geographic Multicast Routing Protocol was proposed by Dimitrios Koutson, Sumitra Das, Charlie Hu. and Ivan Stojmenovic [19]. HGMR put together the GMR and HRPM protocol [3]. It includes hierarchical decomposition of a multicast group into subgroups of manageable size which results in reduced encoding overhead using HRPM concept of mobile geographic hashing and within each subgroup it uses GMR concept. [7] Here the source builds an overlay tree, the source→to→AP tree and another overlay tree as AP→to →member tree. To transmit data packets from source the unicast based forwarding strategy of HRPM is used to propagate data packets to each AP along the source→to→AP overlay tree and in case of constructing an AP→to →member overlay tree in each cell. [8] Here local multicast scheme is used to forward a data packet along multiple branches of the multicast tree in one transmission. Hence it combines the high forward efficiency of GMR with low encoding overhead of HRPM.

[13] The need is to design such a protocol which provides scalability as well as forwarding efficiency.

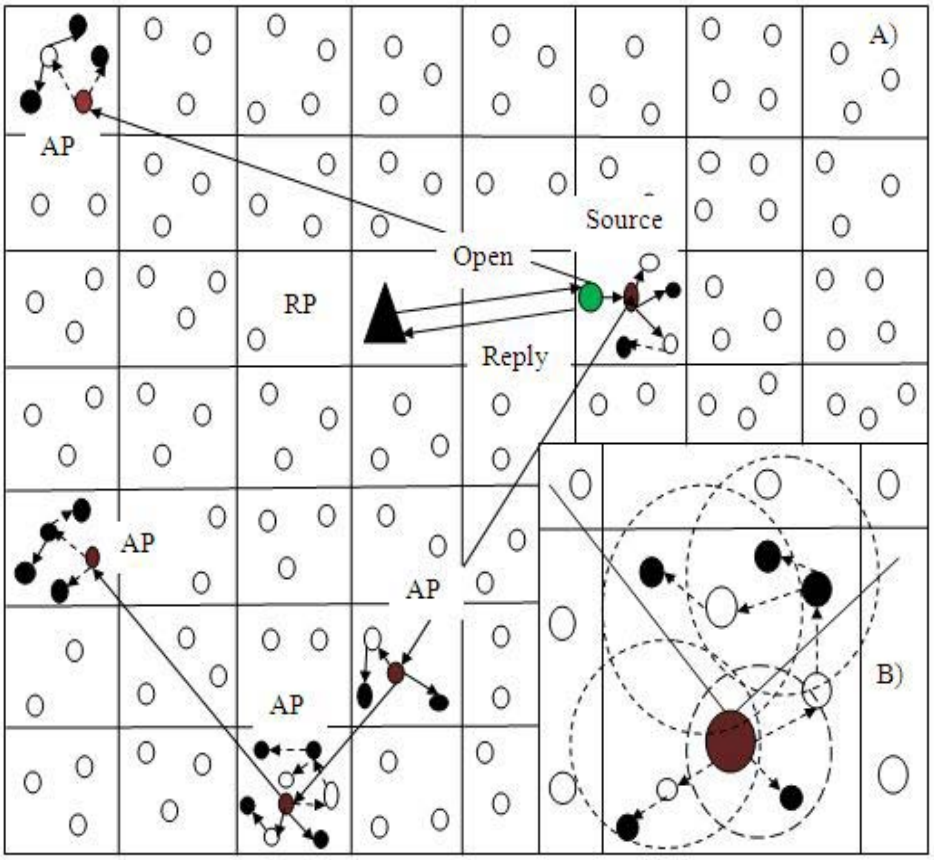
Advantages [7] [19]:

- Energy efficient and encoding efficient protocol as it provides higher forwarding efficiency which utilizes multicast advantages as concept of GMR is used in HGMR.
- Scalability is improved as it has low overhead hierarchical decomposition which is the concept of HRPM.
- Less delay as compared to GMR and HRPM.

Disadvantages [19]:

- Packets may be corrupted due to noise or the receiver may be unable to decode them due to low SNR and it increases with the packet size.
- Simple network partition may not achieve the optimal routing path from the root node to multicast group members.
- Here the routing data efficiency can be low because the data packets are always sent from the upper APs to lower APs without considering that lower APs may be closer to the source than upper APs.

Figure 3 : Data delivery in HGMR



III. Comparison on Different Metrics

There are four main measurable metrics [4] to evaluate the effectiveness of these three protocols for data forwarding.

1. **Packet Delivery Ratio (PDR).** It is the ratio of number of data packets delivered to a multicast group member divided by the number of data packet transmitted by the [1] source which is averaged over all multicast group members. It is of the amenities because in the realistic environment there is packet loss.
2. **Average Delivery Latency (Delay).** delivery ratio is calculated over all multicast packets delivered to all receivers. It inculcates all possible delays which are [8] caused by queuing at the interface queues, propagation, transfer time and back off at MAC layer when the channel is busy.
3. Data transmission of packets. The total number of packets delivered [1] from the source to the destination is the measure of the efficiency of the multicast path selected.
4. **Network encoding overhead.** Total number of encoding bytes transmitted at every hop to the total number of data bytes transmitted at every hop. Here the encoding bytes are the bytes used in each data packet to encode the information required by each protocol.
5. **Forwarding cost**. The total number of data packet transmissions divided by the total number of packets received by all the multicast members. It gives the average number of transmissions required per delivered packet. In an ideal environment, the number of data received (denominator) is same for all protocols, and hence this metric degenerates to be the same as the total number of transmissions. In a realistic environment, the PDR is different for each protocol, and hence this metric combined with the total number of transmissions gives a better picture of the forwarding efficiency of each protocol.

Earlier by Dimitrios Koutsonikolas et al. the simulation of these existing protocols is done using Glomosim simulator but here in this papers simulation is done using MATLAB and on the basis of the results the comparison table is drawn.

Table 1 : Comparison Of Location Based Multicast Protocols In Wsn[1]

S.No	Protocol / Metrics	GMR	HRPM	HGMR
1.	Data transmission	Very Less (200,000)	High (322,000)	Less or same as GMR (200,000)
2.	PDR	Low (60%)	(high) 82%	(very high) 83%
3.	latency	Highest (0.068 sec)	average (0.054 sec)	lowest (0.053 sec)
4.	FC	low (1.1)	high (1.5)	lowest (0.8)
6.	NEO	high (38%)	low (14%)	Average (16%)

Table 2 : Comparative Study Of Location Based Multicast Protocols In Wsn[14][1]

Protocol name	year	author	approach	advantages	Disadvantages
GMR	2006	Juan A.Sanchez,Pedro M.Ruiz and Ivan stojmen	Geocast based approach to optimize cost over progress ratio	Bandwidth utilization proper and forward efficiency is provided	Scalability issues for large scale network, too much encoding overhead
HRPM	2007	Saumitra M.Das,Himabindu Pucha,Y.charlie	reduces encoding overhead of location based multicast protocols by constructing a hierarchy	Reduced encoding overhead, scalable protocol, delay less than GMR	Inefficient in terms of packet transmission, consumes a lot of energy so inefficient
HGMR	2010	Dimitrios Koutsonikolas,Saumitra Das,Charlie Hu .and Ivan Stojmenovic	Combined together GMR and HGMR	Less delay than GMR and HGMR, efficient routing with the help of multicast groups	Load balancing problem, do not achieve optimal routing path, routing data efficiency can be low

Comparison of location based protocols is done on the basis of the four performance metrics. Among all the three location based protocols HGMR, HRPM and GMR, HGMR shows better performance, as it is combination of the GMR and HRPM protocols.

IV. Conclusion

Location based routing in sensor networks has captivated a lot of attraction in the recent years. In this paper we have summarized recent research results on three location based protocols HGMR, HRPM and GMR.As our study revels, that out of all these three routing protocols HGMR performs better. Although many routing protocols have been proposed for sensor networks, many issues still remain to be addressed.

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