A Survey: Analysis of GPSR Routing Protocol in WSN

[1]Khandhar Riya, [2]Prof. Bharat V. Buddhadev
[1]M.E. Student, [2]Professor
Information Technology Department
Shantilal Shah Engineering College, Bhavnagar, India

Abstract - **In current era, Wireless Sensor Network (WSN) is more beneficial in real-time applications like monitoring the environmental parameters such as temperature, humidity and motion. For collecting the data and information from distinct destination transmission range WSN uses tiny sensor node. WSN is most useful where traditional wired or wireless network is tough to set up. There are some challenging issues like energy, bandwidth consumption and installation cost. WSN requires energy efficient routing algorithms for reducing the energy waste and rise the life span of network because sensor nodes have small batteries with limited power capabilities. As compared to wired or wireless networks, routing is more complex in WSN. In WSN, geographic routing means routing uses geographical position's information and routing should be energy efficient. The main purpose of geographical routing is to use location information to invent an efficient path investigation toward the sink node. Geographic routing provides the energy ability, localization and scalability. A Greedy forwarding method is used whereby each node forwards a data packet to the neighboring node that is "closest" to the sink node as next hop node. If source node does not find any neighbor node which is close to destination node then greedy algorithm generates "hole or local optimization" problem. To solve routing hole problem it needs an energy efficient routing algorithm i.e., Greedy Perimeter Stateless Routing (GPSR) protocol. This paper gives an overview of the different techniques, which is used in GPSR and gives a brief working of GPSR routing protocol in WSN. We have also compared different literature reviews about GPSR. The study concludes with the recommendation to the future direction in the energy efficiency routing for the sensor networks.**

Keywords – **Wireless sensor network, GPSR, greedy forwarding, location based technique, perimeter forwarding**

I. INTRODUCTION

"WSN is a network consisting of individual nodes that are spatially distributed devices using sensors to cooperatively monitor physical or environmental condition at different locations." [1] In other words, "WSN is a bridge between real physical and virtual world." In WSN, large amount of sensors are set up in network to achieve collaboration for specific goal. WSN is used in various categories of applications like tracking and monitoring. In these functions, nodes need to retrieve information of their location, so it succeeds of gathering and dealing with that data. Location information of node can be obtained by GPS (Global Positioning System) or a various location based algorithms.

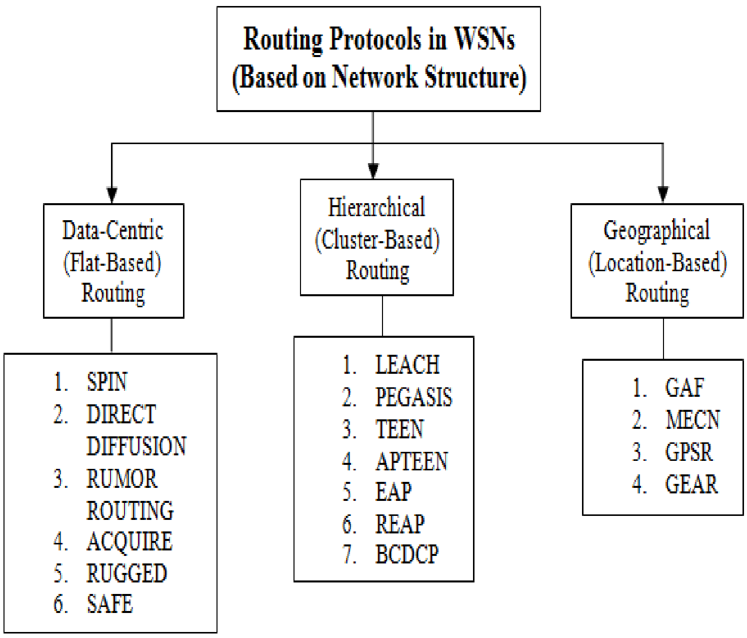

Fig. 1 Classification of Routing Protocols in WSNs

- **Geographic Routing Approach (Location-Based Routing)** [2]

In WSN to develop an efficient and scalable routing protocol is very challenging task, due to the restricted resources and dynamic topology of sensor network. Sensor nodes may not have the Internet Protocol (IP) address, so it cannot be used for the WSN. In location-based routing, the routing decisions are taken using the location information for finding the next hop; there is no need of complex computations as compare to other routing strategy. Location based protocols are very efficient in premises of routing data packet because it takes the advantage of real location information instead of the whole global topological information. Location-based routing protocol uses node's location information to provide scalability and higher efficiency. Location-based routing protocol requires three details: First, through GPS or by any other methods, each and every node in sensor network must be aware of its own location information. Second, each node must be aware of its own neighbour node's location that is one-hop away from it in sensor network. Third, the source node must be aware of the location of sink node. In WSN, finding an optimal path is one of the challenge because this type of network having vast number of sensor nodes. Finding shortest path is another challenging problem because sensor nodes having limited energy. Hence, this type of sensor network needs an effective routing algorithm. In conventional routing there are two issues: First, rate of change in topology and Second the number of routers in the routing domain. GPSR points out these two issues. Greedy algorithm is used by most of the location-based routing protocols to forward the packets to the sink node. These algorithms only vary the way they can handle the "void or hole" problem in communication process. To solve this void problem, GPSR uses a planar graph. Planar graph is derived from the original graph. To avoid the "hole" problem in network, packet follow the planarization technique of perimeter mode.

II. LITERATURE SURVEY

GPSR (Greedy Perimeter Stateless Routing) [3]

GPSR is a novel routing protocol in wireless datagram network that uses the location of routers and a packet's sink (destination) to take packet forwarding decisions. It also offers routing in WSN. GPSR is a reactive and energy inefficient routing protocol in WSN. GPSR uses two forwarding approaches: (i) Greedy Forwarding and (ii) Perimeter Forwarding. Greedy refers to that packets route are optimal for each hop. Perimeter refers to the travel strategy.

- **Greedy Forwarding** [6]

Greedy forwarding refers to that a node forwards packet within its transmission range to geographically closest to sink node with assuming that all packets in the sensor network topology are pointed by their originator and sink node location. Greedy forwarding will continue in greedy mode until the packet reaches successfully at the sink node location. GPSR uses the Relative Neighbourhood Graph (RNG) technique to find their immediate neighbours. After finding their immediate neighbours, every node constructing the graph to find shortest path in which beaconing mechanism or simply beacon message is necessary to find their neighbours. The beaconing mechanism sends the HELLO or BEACON packets to discover the neighbours. In the forwarding process, when the neighbour node forward packets to the next hop node which is also closed to sink node at that time forwarding node receives beacon that includes attribute like IP address and information of location coordinates and it will updates its information in the table. In certain amount of time interval, if forwarding node fails to gain beacon packet then it will delete that neighbour node from its own table. Also, the 802.11 MAC layer will send notification of retransmission failure to neighbour nodes. Now, Fig. 2 shows how GPSR Protocol works in Greedy Mode?

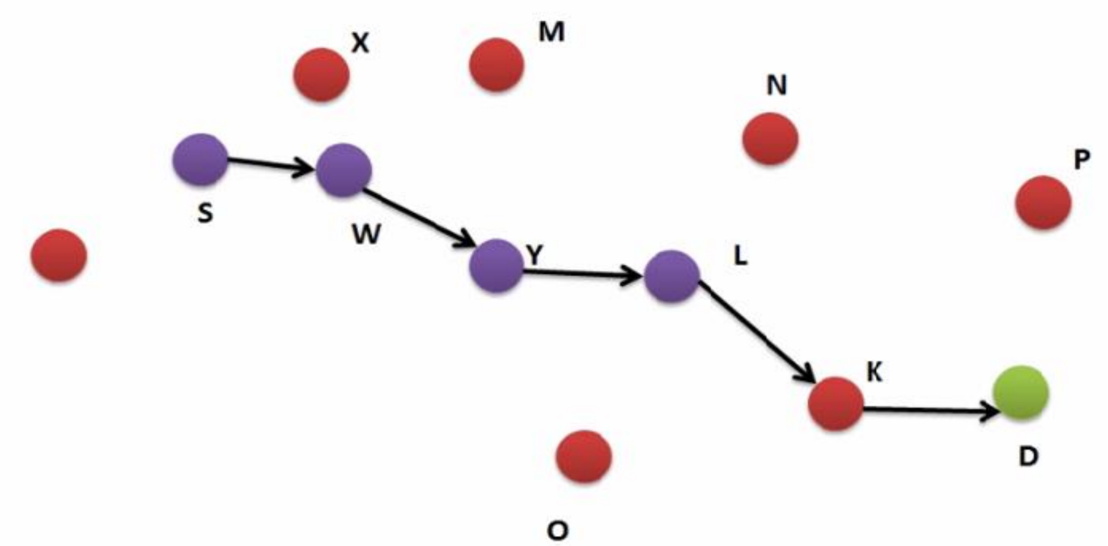

Fig. 2 Example of Greedy Forwarding

Suppose, node S wants to send data to node D. To find the location of neighbour node S will check its own table and then will check which neighbour is more closer to node D compared to itself. Node S will find out that neighbour node W is more closer to node D than itself. It will then forward the packet to node W. Node W will check its table and will fetch location of all its neighbours, then it will calculate the distance between those neighbours and the destination. Now, it will check which neighbour is more closer to node D than node W itself. So, node Y is more closer to node D. Node W will forward packet to node Y. Node Y also will repeat the same process. Node Y will see its neighbours and whichever neighbour is more closer to node D will forward the packets to neighbour. This is how greedy forwarding works.

- **Advantages of Greedy Forwarding:**
  A sensor just has to remember the location of neighbours within one-hop neighbour.
- **Limitation of Greedy Forwarding:**
  Now, the question is that why is required perimeter forwarding? So, there are cases where this greedy forwarding will fail.

Fig. 3 shows scenario of how greedy forwarding fails:

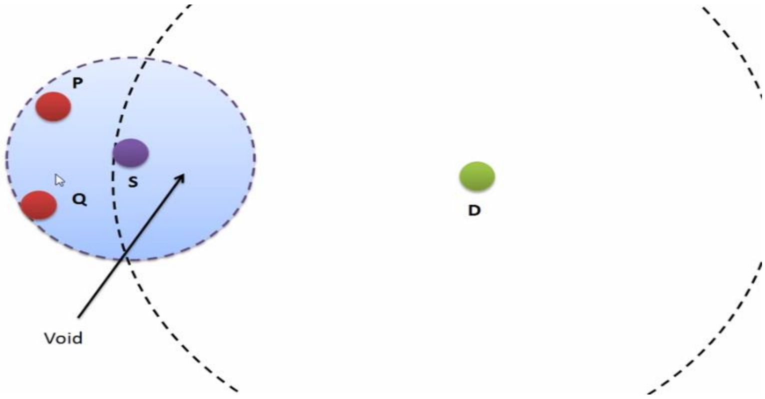

Fig. 3 Greedy Forwarding Fails

In this case node S wants to send a data to node D. Node S will check its neighbours and node S will not find any neighbour which is having less distance than node S. As shown in the Fig. 3 all the neighbours of node S having more distance, that are not closer. In this case greedy forwarding will fail so, other approach is needed which can forward packet in case of failure. The reason of failure is there are no neighbour in that region of Fig. 3 this area is denoted as "hole". So, this area is also known as void. When a node is not having any neighbours in that particular area at that point of time this forwarding will fail.

➢ **Perimeter Forwarding (The Right-Hand Rule)** [8]

Greedy forwarding will fail where next-hop node is not closer to the sink node than any other neighbour node. Another approach is required which is perimeter forwarding mode which will be used to route the packet when greedy forwarding will fail. Perimeter forwarding is shown in below Fig. 4:

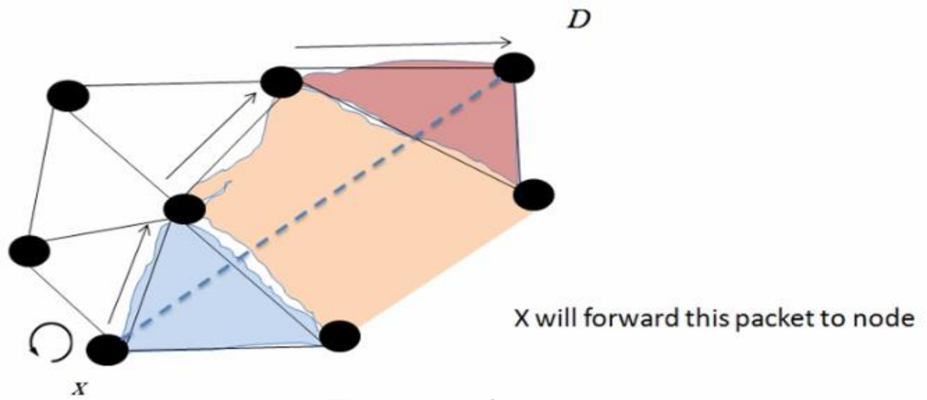

Fig. 4 Right-Hand Rule

If node x wants to send a data to node D and at the node x this greedy forwarding fails. So, from node x packet has to be forwarded in perimeter forwarding or in perimeter mode. So this dotted line is denoting the xD in the direction of node D. So xD line is crossing three faces. Closed two are Interior and the middle one is Exterior. So, there are three faces. Node x will forward the packet only to the node which is connected to this faces. So node x is having two options. Node x uses right-hand rule for selecting best next-hop. From line xD it will see in anticlockwise direction that, which edge is coming next. So, node x will forward its packet to its immediate neighbour node. After receiving a packet from that edge node x can transmit or forward packet to node D. Further path will be decided again using right-hand rule applying in anticlockwise direction. At this node there are two possible paths and packet will follow right hand rule and based on this packet is forwarded to nearby xD. Fig. 5 shows Right-hand rule with an example.

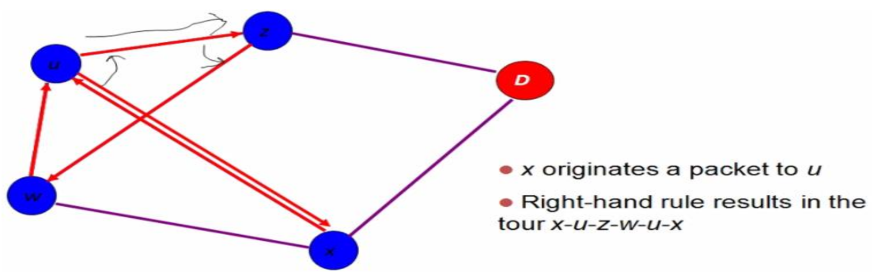

Fig. 5 Right-Hand Rule Fails

In above Fig. 5 packet arrive or not from u to x. So, look counter clockwise and the next edge will be (u,z) and the packet will be forwarded to z and from there by checking counter clockwise (z,w) is edge can be obtained. It will be forwarded to node w and then node u and then node x. So, in this case right-hand rule will fail. In order to avoid this situation one heuristic is used. The heuristic is known as no-cross heuristic. So, this heuristic shows that, if in a network if two edges are crossing then just remove second one. So, this can be blindly removing an edge which is crossing with another edge. Heuristic actually works in maximum time but sometimes what this technique will do? This technique will partition the network. It may be possible that as this heuristic is going to remove. Removal of that edge will lead this network into two different partitions and that happens in this case of algorithm mode that is not finding to route of the destination. So, there comes the concept of planarized graph.

- **Planarized Graph** [7]

A planarized graph is a graph in which no two edges are crossing each other, and here this technique uses two graphs: 1) RNG (Relative Neighbourhood Graph) and 2) GG (Gabriel Graph). So, these two techniques graph are actually show GPSR is used for converting a non-planarized graph into planarized one.

1) RNG

RNG is technique to find node's immediate neighbours. Fig. 6 shows that graph is actually having a property and it says that, an edge between (u,v) exists only if distance between u and v is less than or equal to distance between every other node i.e., w, and whichever of u and v is farthest from w.

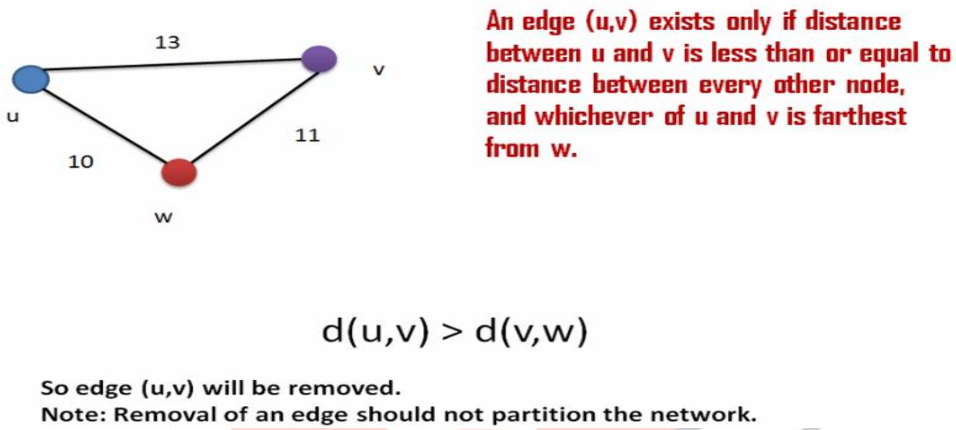

Fig. 6 Example of RNG

In above example, it's checked that whether edge (u,v) exists or not. All the other nodes which are connected to node u and node v node have to be checked. In this scenario only a single node w is considered, this node is connected to both node u and node v. Here, two distances i.e., edge (v,w) and edge (u,w) are compared. Edge (v,w) having more distance as compare to edge (u,w). Now, weight 13 will be compared with weight 11. So, weight 13 is maximum. So, edge (u,v) will be removed. Instead of weight 13 let's assume this is weight 10, so in that case edge (u,v) will exists. And one should keep in mind that at the time of removing edge, removal of edge should not partition the network. Otherwise, the route will not be able to forward a packet to the destination.

2) GG

This technique says that an edge (u,v) exists only if there is no other node in circle whose diameter is uv.

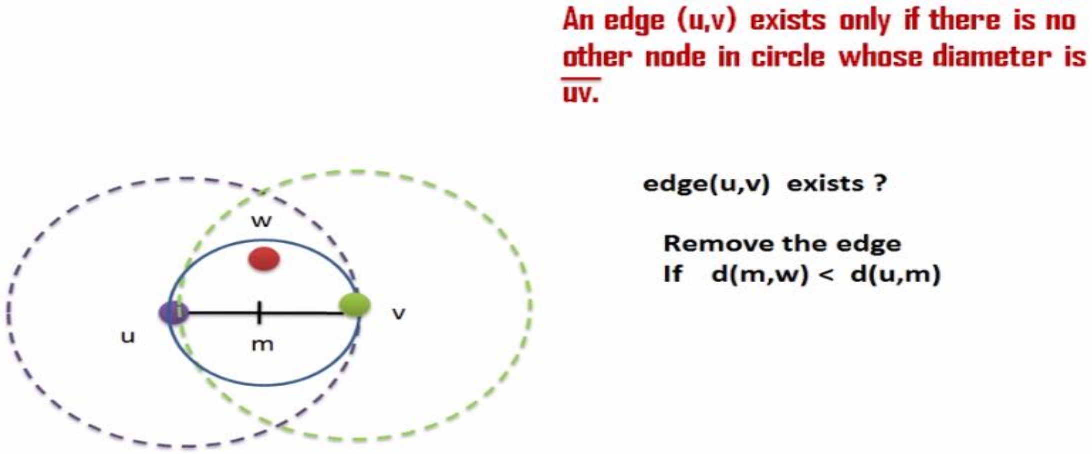

Fig. 7 Example of GG

Draw a circle by assuming diameter uv of that circle. If there is edge between node u and node v in the above graph, that edge will exists only if there is no other node in the circle whose diameter is uv. In this scenario it can seen node w is there inside the circle. So, in that case this edge u and v has to be removed from the graph. Now, the question is that how to decide whether a node w is inside the circle or not? Find out midpoint of this node u and node v, this midpoint "m" is also a centre of the circle. If a node w inside the circle, the distance between that node w and the circle will be less than the radius of this circle. The radius of this circle is um. So, it can be written that a property for removing the edge: If the distance between m and node w which is less than the distance between node u and m, and if d (m,w) < d(u,m). So, in that case node w will be inside the circle and that edge has to be removed. So, this technique also can be applied to convert a non-planarized graph into planarized one.

- **Drawback of Perimeter Forwarding**
  Perimeter forwarding algorithm chooses a longer path to the destination so it is less efficient.

➢ **GPSR Packet** [3]

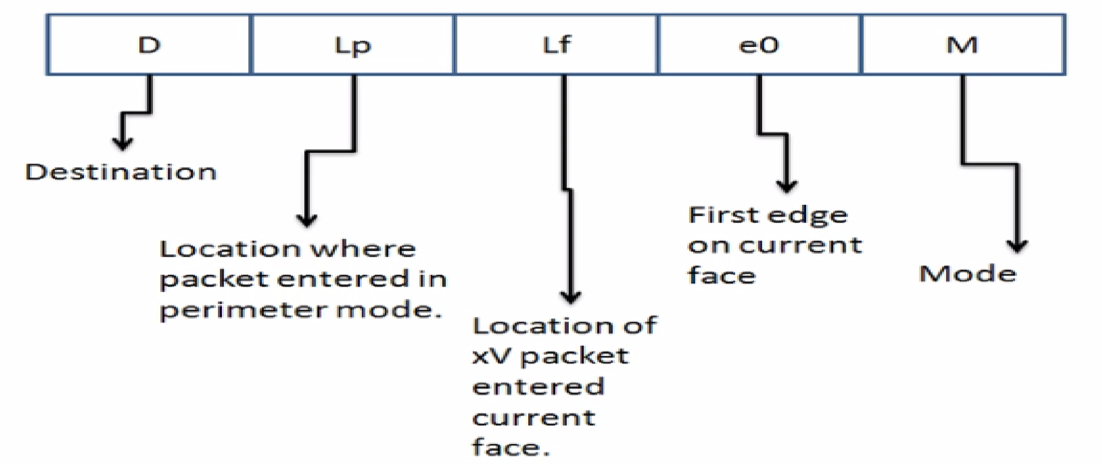

Fig. 8 GPSR Packet Format

➢ **Example of GPSR:**

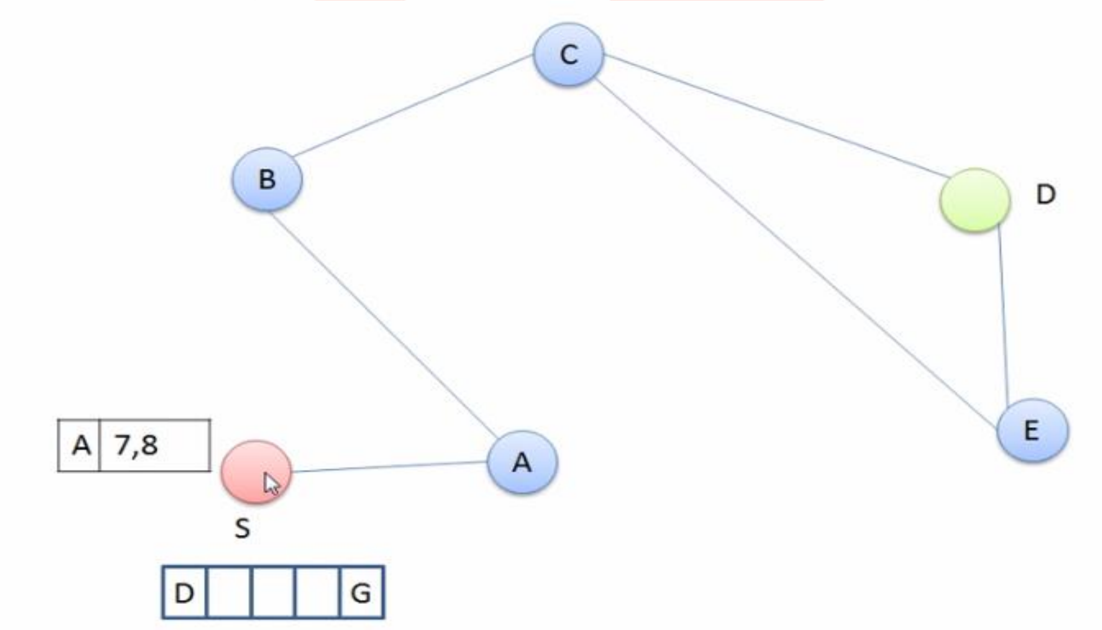

Fig. 9 Initially Greedy Mode

In above Fig. 9, source node S having only a single neighbour and this node S has to send a data to node D. So, initially this packet has destination node D. So instead of this node D location of the destination is kept in the packet and the mode of this packet is marked as greedy mode "G". So in greedy forwarding node S will forward this packet to its neighbour which is more closed to destination D node itself. Node S will forward this packet to node A.

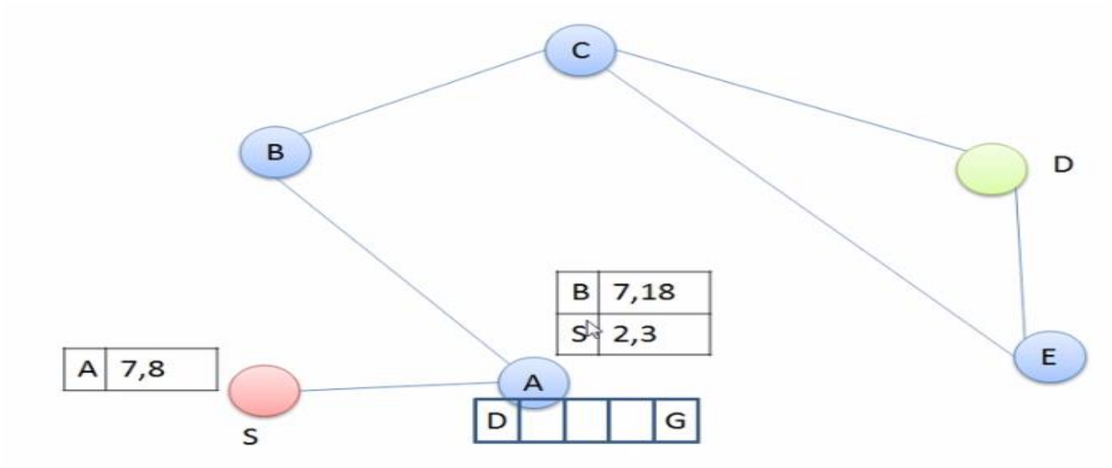

Fig. 10 Greedy Forwarding Fails

Now, node A will check its table and node A will compare its neighbour with itself whether their neighbour is more closer to D or not. So, node A is not having any neighbour which is more closer to D as compare to node A itself. So, at this point of time greedy forwarding approach will fail. So, this node A will mark this packet as perimeter mode "P". It means that now perimeter forwarding will going to be used and at this point at this node greedy forwarding fails. So, in the second field of packet this node information will be inserted. Now, in the perimeter forwarding how this GPSR works? In network every closed polygon known as interior face and the open one known as exterior face. Now, how GPSR use perimeter forwarding?

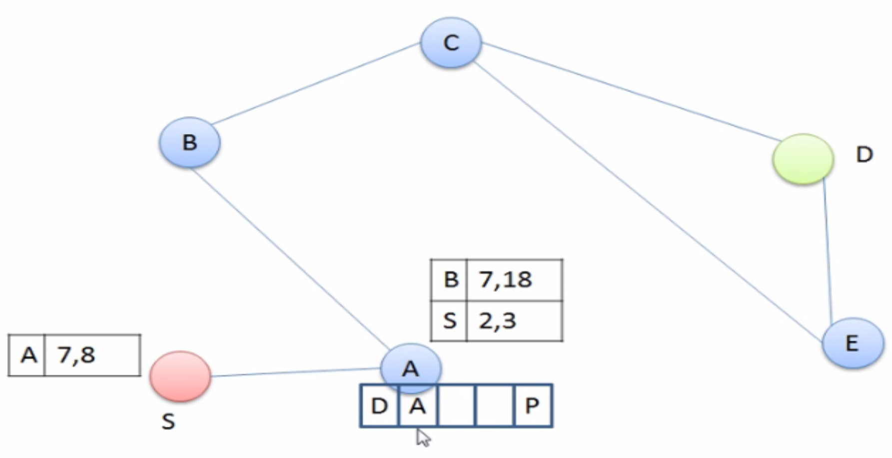

Fig. 11 Switch to Perimeter Mode

Now, node A going to forward this packet in the perimeter mode and third field of packet says that the first node in the current face. So, this is the current face which is crossed by this dotted line AD and node A is the first point in the current face.

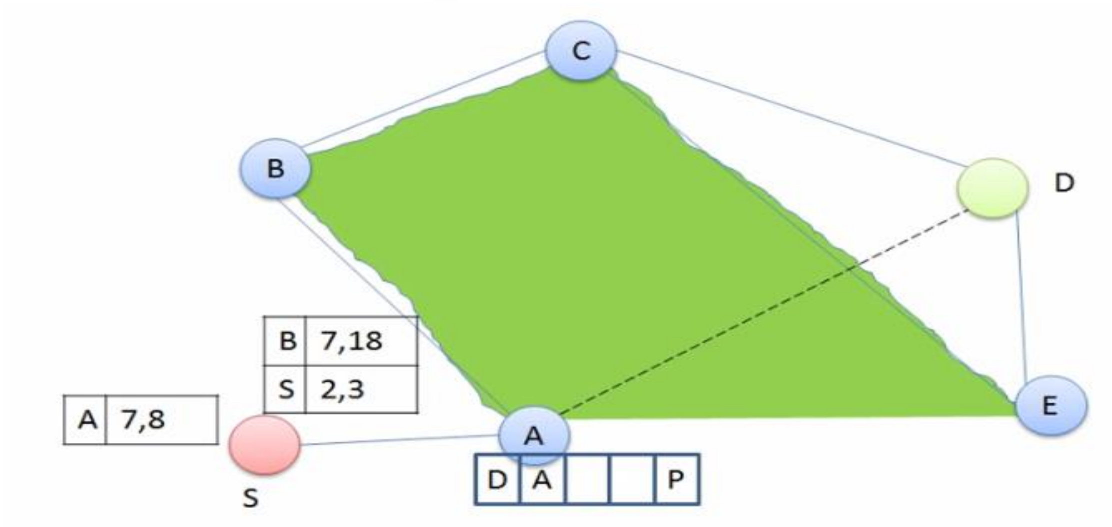

Fig. 12 Node A in Perimeter Mode

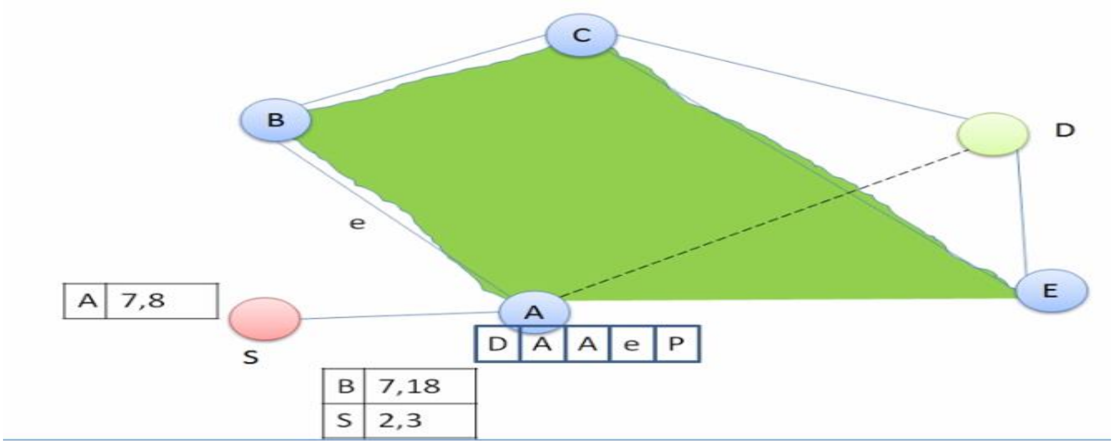

Fig. 13 Edge AB Denoting as "e"

Node A will be inserted in third field of packet and the fourth field is first edge in the current face. So this "e" is actually denoting edge between node A and node B. Now, node A will forward its packet at this edge because right-hand rule is used anticlockwise direction this edge is there. This packet will forward to node B.

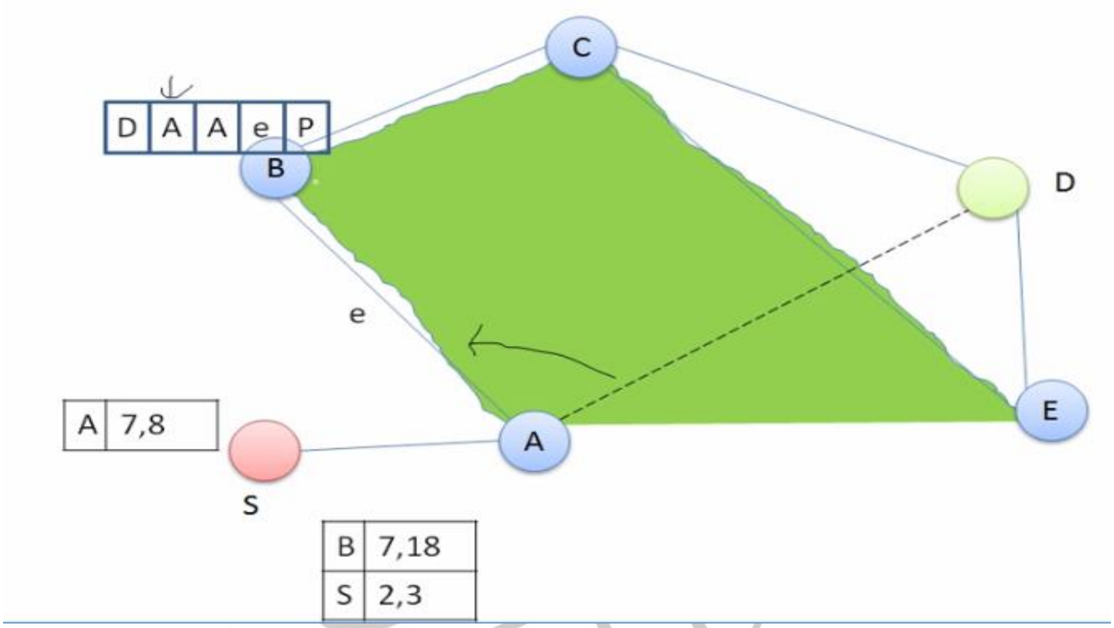

Fig. 14 Apply Right-Hand Rule

Node B will see that this node A is the point where greedy forwarding failed. Now, node B will compare its distance to node D and it also compare the distance between node A and node B. So, if the distance between node B and node D is less than the distance between node A and node B then, in that case node B will start using greedy forwarding. But here this is not the case. Node B is not closer to node D. So, node B will continue in perimeter forwarding and in anticlockwise it will forward its packet to node C.

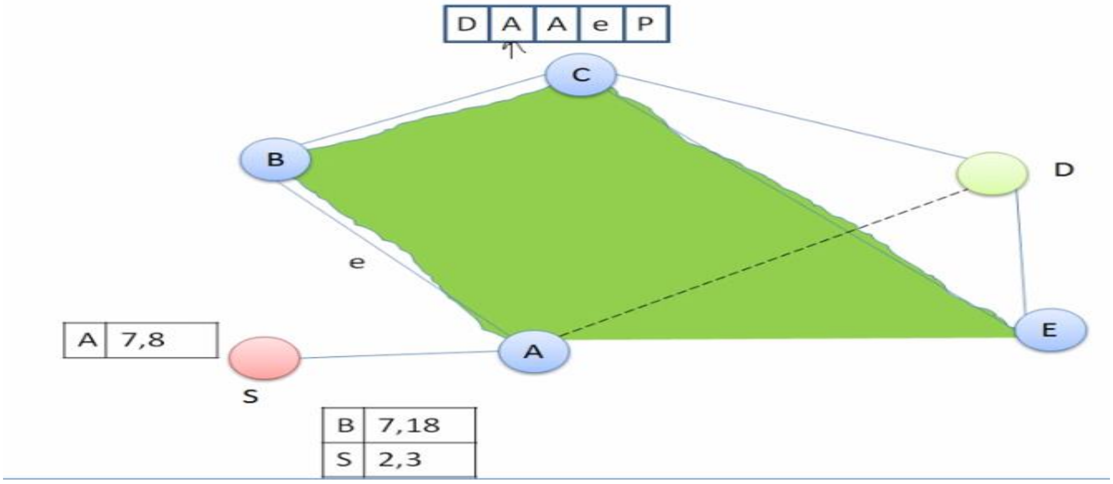

Fig. 15 Greedy Forwarding Fails

Now, node C will check that in greedy forwarding what is failed at node A because node A was not having any neighbour which is more closed to destination. So now node C will compare its distance between node C to D, and it will compare this distance with the distance between node A to D. So distance between CD is less. Now, node C will change the mode to greedy because now the route is available.

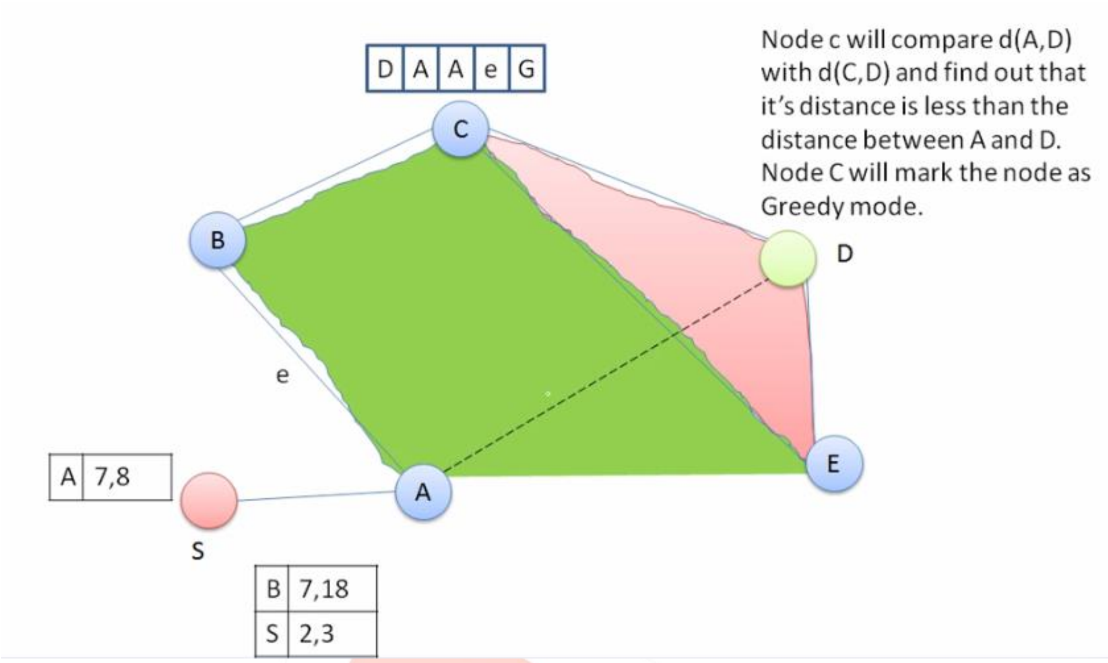

Fig. 16 Switch to Greedy Mode

Perimeter is only used to avoid the situation where a packet cannot be forwarded in greedy mode. So now node C will forward this packet to node D. And this packet is successfully delivered to node D.

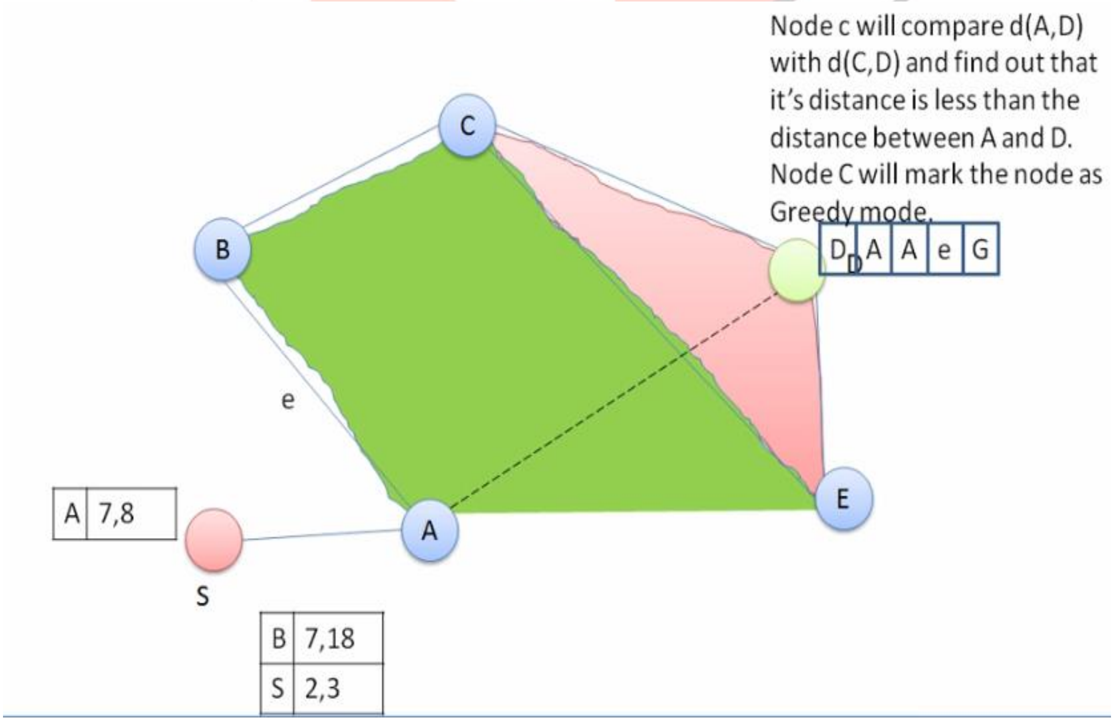

Fig. 17 Packet Receive Successfully

Sr_ No.	Paper_Title	Algorithm	Method	Performance_ Metrics	Observation
1	"An Enhanced Greedy Perimeter Stateless Routing Algorithm for Wireless Sensor Network", Qiang Xian, Yue Long, IEEE-2016	EGPSR	Forward Region Division and Node Probability Transmission Mechanism	Energy	Delay is more due to more overhead Does not check about the availability of sink node
2	"EA-GPSR, a Routing for Energy Harvesting Wireless Sensor Networks", Shuo Yi, Xin Huang, Conglin Wang, IEEE-2015	EA-GPSR	Energy-Harvesting Technology	Throughput, Packet Loss Rate	Take more delay, because it calculate the cost function Location of a node
3	"Analysis of a Novel Advanced Greedy Perimeter Stateless Routing Algorithm", Kim Kyu Seok, Navrati Saxena, IEEE-2013	A_GPSR	Energy Left Level	Packet Delivery Rate (PDR)	Choose edge node policy It requires more memory
4	"Improvised Geographic Scheme for Greedy Perimeter Stateless Routing", Debasis Das, Rajiv Misra, IEEE-2013	Improvised RNG–GG Algorithm	Adapting RNG and GG to Mobility	PDR, Path Length, Overhead	Position check only using witness node Less overhead
5	"Research and Improvement of the Wireless Sensor Network Routing Algorithm GPSR", Lijuan Wang, Haitao Liang, IEEE-2012	GPSRI (GPSR-Improved)	Greedy Forwarding Path Optimization Node-Disjoint Multipath	Delay, Hop Count	Improves the Greedy Forwarding's Local Minimum Problem Memory consumption Route discovery overhead Multipath Reliability
6	"Research on One Kind of Improved GPSR Algorithm", Liangli Lai, Qianping Wang, Qun Wang, IEEE-2012	Improved GPSR Routing Algorithm	Double- Hand Rule	Delay, Jitter, Packet arrival Rate	Improves the Planar Perimeter Forwarding mode's Right-Hand Rule To choose a better path to reach the destination node How to choose the next hop node better

Table-I Comparison Table

It has been noticed with the comparison table that the given work can be further enhanced using edge node policy, left-right hand rule. It has been developed much better GPSR than the existing one in all aspects such as energy usage minimized, delay minimized, improve in throughput and PDR.

III. CONCLUSION

Energy management is more important due to limited energy availability of the wireless devices in WSN. This paper presented many existing methods for energy efficient routing in WSN. It has observed that how GPSR works in WSN. In this paper, the comparison of various techniques of GPSR routing protocol in WSN has been shown. So, from the comparison and literature review it can be concluded that GPSR is best routing protocol to choose optimal path and shortest path.

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