A Comparative Study on Location Based Routing Protocols in Wireless Sensor Network

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Abstract— Wireless Sensor Network (WSN) is an interesting research area in Computer Science. A WSN comprises of a set of sensor nodes which are responsible for gathering and transferring of information from source to destination. It provides the ability of sensing and processing information. This network also consists of different types of protocols with self organizing capabilities which are responsible for overall communication in the network. Routing protocols are responsible for finding the routes and to make sure reliable communication in the network. This paper is based on a survey of Location based routing protocols in which the information about the location of the node is used for communication.

Keywords— Wireless Sensor Network, Routing Protocols, Energy Efficient Routing, Location Based Routing Protocols.

I. INTRODUCTION

A wireless sensor network (WSN) basically comprises of large number of resource constrained sensor nodes, and some relatively powerful control nodes. The main components of a sensor node are a sensor device for sensing, a CPU for processing data, a power device for power supply and a transmission device for communication in a network [1]. WSN consists of several low-cost sensor nodes which interact to each other to do the overall communication. It is basically a distributed autonomous network to monitor different types of conditions like temperature, pressure, and sound etc and transmits the data to destination. Sensor nodes are basically some computing devices which interact and gather the data from its nearby node that comes within its range. Since sensor nodes have limited energy, it is very essential to manage the energy efficiently to extend the lifetime of the network [2]. In WSN, different routing protocols have been proposed with different working principle for the betterment of its energy consumption and location based routing protocol is one of them.

Location-based routing is based on the position of nodes rather than its network address. It is also known as geographical or position based routing because the source node knows the geographic location of the destination and sends messages to the destination based on this particular location information. In this type of routing, nodes do not have the location information of the whole network; it only knows the location of its direct neighbours to send the packets. Using the location information, the destination region is selected and the packet is sent to that selected region [3]. The main focus of this paper is to highlight the characteristics of different location based routing protocols and makes a comparison among them.

The rest of the paper is organized as follows: Section II explains about routing protocols and its types with related advantages and disadvantages. Section III explains detail descriptions of Location based routing protocols along with its type. Section IV explains the comparisons among the selected location based routing protocols and highlight the features. Last section includes the conclusion.

II. ROUTING PROTOCOLS

Wireless sensor network consists of different types of protocols and algorithms with self organizing capabilities [4]. Routing protocols are necessary for communication and sending data from source to destination by using multiple sensor nodes. These protocols are responsible in maintaining the routes in the network and reliable multi-hop communication. Routing protocols in WSNs have a

common objective of efficiently utilizing the resources of sensor nodes to extend the lifetime of the network.

A. Classification of Routing Protocol

Ensuring a successful transmission of the packet from source node to the sink or base station is the main reason behind routing [5].

Routing protocols are classified into three (3) different categories according to the network structure. These are: Flat, Hierarchical, and Location Based.
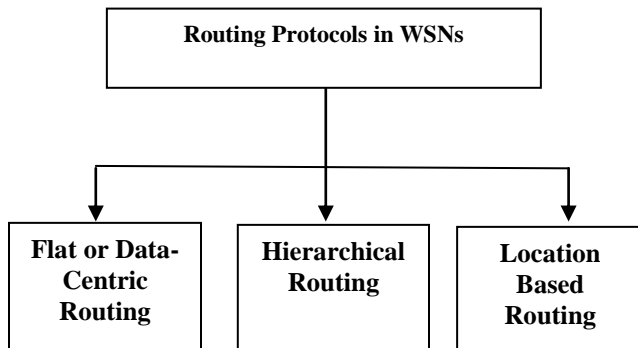

Figure 1: Types of Routing Protocol

- **Flat based routing**: Flat routing is a multi-hop routing where all nodes work at the same time [6]. While the network is usually large all nodes are to be assigned the same sensing task. Therefore, since all nodes transmit data, redundancy is likely to occur, which leads to high energy consumption.
- **Hierarchical based routing***: Nodes are unable to communicate to a very large distance [7]. Therefore, cluster based, hierarchical routing becomes a good solution. In this routing scheme different clusters are created and cluster-heads are assigned. The importance of this routing protocol is implemented data aggregation causing decreasing energy consumption, where the packets are sent to the sink.
- **Location based routing protocols:** In this scheme the location of nodes is known through a low power GPS on every node [8]. So nodes are addresses by their location. Therefore, not all nodes are demanded to work together, some may go to sleep to save energy while others sense events.

    Some advantages and disadvantages of location based routing are mentioned below [9,10]:

Advantages

  i.   It reduces control overhead.
  ii.   It reduces the energy consumption.
  iii.   It requires less memory.
  iv.   Scalability.
  v.   Maintenance is less.

Disadvantages

  i.   If the destination node lies in same region then the same old path is being followed, which leads to more power usage for specific nodes and some remained underutilized.

III. LOCATION BASED PROTOCOLS

Location based routing is based on the position/location of nodes rather than its network address.

In this type of routing, location information of a node is required by the sensor network to calculate the distance between two particular nodes so that energy consumption can be estimated.

There are various types of location based protocols available in WSN. These are [11, 12]:

- Geographic Adaptive Fidelity (GAF)
- Geographic Energy Aware Routing (GEAR)
- Minimum Energy Communication Network (MECN)
- Small Minimum Energy Communication Network (SMECN)
- Coordination of power saving with routing (SPAN)
- Greedy Perimeter Stateless Routing Protocol (GPSR)
- The Greedy Other Adaptive Face Routing (GOAFR)
- Trajectory Based Forwarding (TBF)
- Bounded Voronoi Greedy Forwarding (BVGF)

From the above mentioned routing protocols, here we only discuss five most commonly used location based protocols with details.

- **Geographic Adaptive Fidelity (GAF):** GAF is widely used location based energy aware routing protocol in WSN initially proposed for ad-hoc networks but later this protocol is also used in WSN [13,14]. It is a type of protocol which supports minimal energy conservation during the time of the transmission. GAF protocol is based on the mechanism of turning off the unnecessary nodes in order to minimize the energy consumption. In GAF, the whole network is partitioned into some grid squares and the size of the grid is based on the capacity of the sensor node

upto which range it can communicate. The sensors available in GAF routing use its location information provided by GPS to communicate with its other neighbours.
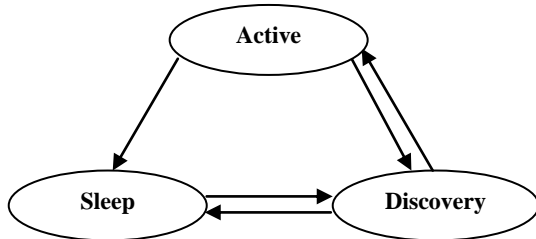

Figure 2: State Transition Diagram

In GAF routing, each node go through three different transition state namely Active, Sleep and Discovery. A node which is in active mode is actually participating in the transmission within the network. When a node enters into the sleeping state, it will turn off its antenna for saving its energy. In the discovery state, the sensor node exchange messages with other sensors within the same grid to highlight its presence. When a node which is currently in active state wants to select a neighbouring node, it sends the discovery message to all the neighbouring nodes present in the grid. After analyzing the energy left in a node, the node which contains the highest energy is considered as an active node and used in the transmission.

Advantages: The followings are the advantages of GAF routing:

     i. It optimized the performance of the network.
     ii. It is Scalable.
     iii. It increases the network lifetime.
     iv. It minimizes the energy consumption.

Disadvantages: The followings are the disadvantages of GAF routing:

     i. QoS not guaranteed.
     ii. It Supports less mobility
     iii. Limited

- **Geographic Energy Aware Routing (GEAR):** GEAR is a location based protocol which selects its neighbour of a particular target region in a sensor field to routing queries [14,15]. In GEAR, the sensors are equipped with some localization system like GPS to find its position and send packets to the specific target region rather than the target node. The sensors are also aware of their own residual

energy as well as residual energy of its neighbours. In this protocol, the cost in the transmission depends on two basic factors like distance between source to destination and their residual energy. In order to select the sensors to route the packets towards destination it uses location based energy aware methods which helps to minimize the energy consumption during transmission.

Advantages: The followings are the advantages of GEAR routing:

     i. It minimizes the delay.
     ii. It increases the lifetime of the network.
     iii. Balancing Energy.

Disadvantages: The followings are the disadvantages of GEAR routing:

     i. Less Scalability
     ii. Limited Mobility and Power.
     iii. QoS not guaranteed

- **Minimum Energy Communication Network (MECN):** MECN is also a location or geographic based protocol which is designed for minimizing the energy consumption during transmission in WSN [16]. The basic idea of this protocol is that instead of creating a larger one it establishes multiple small subnetworks so that the requirements of the energy must be less during transmission of data between nodes. This protocol is a self-reconfiguration protocol which is based on low power GPS technology and it can compute a minimum spanning tree which stores the minimum power path for each sensor to sink. The whole procedure of MECN is divided into two distinct phases. These are-

     i. **Graph Construction**: In this phase, MECN constructs an enclosure graph based on the locality of its neighbouring sensors which contain all the sensors and its vertices. Once the construction of the graph is done, it starts sending data through this graph.

     ii. **Cost Construction**: In this phase, MECN performs the cost distribution function in which all the non optimal links of the directed graph are simply deleted to form a new graph where every sensor is connected with a direct link to the sink and broadcast its cost to its neighbour.

Advantages: The followings are the advantages of MECN routing:

    i. It is a self reconfiguration protocol.
    ii. It consumes less energy.

Disadvantages: The followings are the disadvantages of MECN routing:

    i. Fault tolerant depends on specific applications.

- **Small Minimum Energy Communication Network (SMECN):** SMECN is another type of location based protocol which is also designed to achieve minimum energy during transmission [17]. Simply it is an extended version of MECN which is proposed to improve the quality of MECN. The basic idea of this protocol is also same with MECN but the size of the regions are smaller as compared to MECN. In SMECN protocol, every sensor discovers its immediate neighbour by broadcasting a neighbour discovery message. Since the size of the regions are smaller, it requires less energy to transmit a message for one node to another of a particular region.

    Advantages: The followings are the advantages of SMECN routing:

    i. Less energy consumption.
    ii. Link maintenance cost is less

    Disadvantages: The followings are the disadvantages of SMECN routing:

    i. Required more power
    ii. Maximum no of broadcast message.

- **Coordination of power saving with routing (SPAN):** SPAN is another position/location based routing protocol primarily proposed for MANET but later it can also be applicable to WSN's [18, 19]. The main aim of this protocol is to reduce the energy consumption of the node. To achieve the minimum energy consumption, it simply turns off the radio signal or antenna when a particular node is in idle state. In SPAN, it is not necessary to know location of the sensor to forward packets. It simply follows the backbone topology which can easily transfer the packets from one node to another. In this protocol, every node displays its status and coordinates to its neighbours during transmission.

Advantages: The followings are the advantages of SPAN routing:

    i. Limited energy consumption.
    ii. Supports data aggregation.

Disadvantage: The followings are the disadvantages of SPAN routing:

    i. QoS not guaranteed.
    ii. Limited mobility and Scalability.

IV. COMPARISONS AMONG LOCATION BASED ROUTING PROTOCOLS

In Table 1 the above mentioned Location based routing protocols are compared according to their characteristics [20,21]**:**

Table 1: Comparisons among Location Based Routing Protocols in WSN

Sl No	Protocols	Latency	Scalability	Data Aggregation	QoS	Power Uses	Mobility	Transmission Scheme
1	GAF	Moderate	High	No	Low	Low	Yes	Multi-hop
2	GEAR	Moderate	Moderate	No	Low	Low	Yes	Flat
3	MECN	Moderate	Low	No	Low	High	No	Multi-hop
4	SMECN	Moderate	Low	No	Low	High	No	Multi-hop
5	SPAN	Moderate	Low	Yes	Low	Low	Yes	Multi-hop

V.   CONCLUSION

Wireless sensor networks are generally designed for specific applications. It is mostly applicable for specific network especially in energy saving process. The energy efficient algorithms of WSN's are very much helpful in terms of data aggregation and energy saving.

In this paper, we have surveyed some location based routing protocols and made a comparison based on several criteria including Latency, Scalability, Data Aggregation, QoS, Mobility and network heterogeneity etc. For each of these criteria, we have considered a few existing protocols as an example.

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