International Journal on Future Revolution in Computer Science & Communication Engineering ISSN: 2454-4248
Volume: 3 Issue: 8 172 – 175

A Survey: Location Based Protocols for Wireless Sensor Networks

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Abstract – The application of sensor nodes is growing rapidly in present environment. There is a need of sensor networks to collect data in effective way. The requirement for sensor networks depends on various factors based on their applications. The need for robustness and scalability leads to the design of localized algorithms, where sensors communicate with other senso nodes in restricted vicinity and have at best an indirect global view. Sensor nodes are addressed by means of their locations in location based protocols. Energy consumption is estimated by the distance between two sensor nodes and so location information is essential. Some queries from sensor nodes are also location specific and so location based sensors find a wide number of applications. In this paper, some location based protocols and their limitations were discussed.

Index Terms - *Geographic and Energy Aware Routing (GEAR), Geographic Adaptive Fidelity (GAF), Minimum Energy Communication Network (MECN), Small Minimum Energy Communication Network (SMECN), Coordination of Power Saving with Routing (SPAN)*

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I. INTRODUCTION

Sensor networks will be composed of a large number of densely deployed sensor nodes. Each node in the sensor network consist of one or more sensors, a low power radio, portable power supply, and possibly localization hardware, such as a GPS (Global Positioning System) unit or a ranging device. A key feature of such networks is that their nodes are untethered and unattended. Consequently, they have limited and nonrenewable energy resources. Therefore, energy efficiency is an important design consideration for these networks. An efficient way to disseminate the geographic query to a specified region is to leverage the location knowledge in the query and to route the query directly to the region instead of flooding it everywhere. The rest of the paper is organized as follows. We briefly discuss various location based protocols in Section 2. Comparison of these protocols and some applications related to these protocols in Section 3. Section 4 presents the conclusions.

II. REVIEW OF PROTOCOLS

(i) Geographic and Energy Aware Routing (GEAR):

Without proposed geographic routing support, there is low rate data flooding throughout the network. GEAR protocol can route the packets efficiently to the destination region and helps to conserve energy.

Geographic and Energy Aware Routing (GEAR) technique requires energy level information of nodes and geographical information of neighbor nodes for selection to route a packet towards the target region. There are two phases to transmit a packet:
1. Selecting a node
2. Disseminating the packet within the target region

1. Selecting a node:
Forwarding the packets towards the target region: GEAR uses energy aware information and geographical neighbor selection approach to route the packet towards the target region. There are two approaches :
a) When a neighbour close to the sink exists near the source, then it uses next hop packet forwarding to disseminate the packet towards the sink.
b) When neighbour to sink exists far away from the source then it uses cost computation functions and computation of HOLES to deliver the packet to the sink.

Gear packets are targeted for region and not for WSN. Each node knows its location, Remaining energy and Location & energy of its neighbor. Links between nodes are bi-directional. Energy Aware Neighbour Selection In this case there are two functions that are taken under consideration are Learned Cost and Estimated Cost.

Learned Cost *h(Ni, R)* is calculated by any node in the network where Ni is number of nodes and R is the target neighbour region. Each node infrequently updates its status to its neighbours. Each node collects the above calculated information and updates itself to this learned cost.If the node does not have sufficient enrgy, then it calculates the estimated cost to a node which is far away from that node as described in Figure 1.Estimated cost is denoted by c(Ni, R) and is calculated as

$$C(Ni, R) = \alpha d(Ni, R) + (1-\alpha) e(Ni)$$

Here, α is tunable weight ranges from 0-1; e(Ni) is energy consumed by node Ni , it is the normalized function among all the nodes; d(Ni, R) is the normalized distance from Ni to center of region R. After a node picks a next hop neighbor *Nmin* , it sets its own *h(N; R)* to *h(Nmin; R)+C(N; Nmin)* where the latter term is the cost of transmitting a packet from *N* to *Nmin*. *C(N; Nmin)* can also be a combination function of both the remaining energy levels of *N*, *N min* and the distance between these two neighbors.

In the case of all neighbors are farther away, ***N*** knows it is in a *hole*. A node's learned cost ***h(N; R)*** and its update rule are combined to circumvent holes. Intuitively, when there is no hole in the path towards ***R***, the node's *learned cost* ***h(Ni; R)*** is equivalent to the *estimated cost* ***c(Ni; R)***. However, when there is a hole in the path towards ***R***, the node's *learned cost* represents "resistance" to following the

ISSN: 2454-4248
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path towards that hole; "resistance" that the *estimated cost* cannot provide. Fig. 1 is a grid topology. Assume the distance between the nearest two neighbors is *1*, and each node can reach its 8 neighbors. The nodes in black, i.e., ***G***, ***H***, ***I***, are energy depleted nodes, thereby cannot relay packets. Let node ***S*** wants to send a packet to region ***R*** with centroid at ***T***. For illustration purposes, we use ***T*** to denote this region.

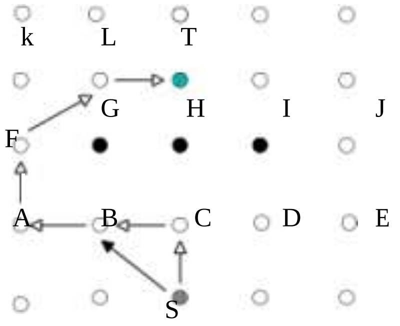

Figure 1: Learning routes around holes

2. Disseminating the packet within the target region:

Under most conditions, a Recursive Geographic Forwarding algorithm [1]-[2] is used to disseminate the packet within the region. However, if some low density conditions exist,then recursive geographic forwarding sometimes does not terminate routing around an empty target region before the packet's hop count exceeds some bound limit. Under such circumstances, restricted flooding can be used.

a) Recursive geographic forwarding:

In recursive geographic forwarding, in its recursive splitting process, to reach 4 subregions, a unicast packet is sent to its neighbors multiple times, and it is received only by the intended receivers.

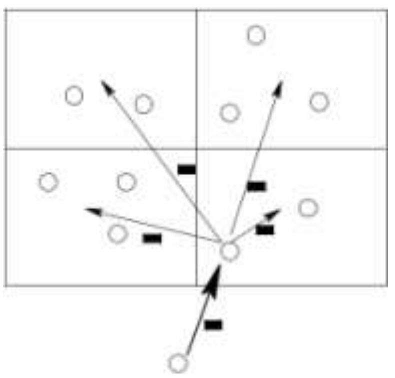

Figure 2: Recursive Geographic Forwarding

In this methodology, the region is divided into four sections as in above Fig. 2. In each section, the packet received from source is taken, duplicated and is transmitted to next hop of all these four regions. Again each region is further subdivided into four sub regions and the same process is repeated until the packet reaches the target node. The process stops when there is only one node is a region or region is empty. This methodology works good when more number of sensor nodes are present.

Within a region, it uses a recursive geographic forwarding technique to broadcast the packet. Although the energy balancing design of GEAR is motivated by sensor net applications, this protocol is general.

b) *Restricted flooding:*

In this methodology, the region is divided into four sections as in above figure 2.In each section, the packet received from source is taken and same packet is sent to one of the four regions without duplicating the packet.

This methodology works better when less number of sensor nodes are present.

Table1: Comparison of Recursive geographic forwarding and restricted flooding

Recursive geographic forwarding	*Restricted flooding*
Uses broadcast feature of channel	Uses broadcast feature of channel
Node broadcasts four packets during each transmission.	Node broadcasts packet only once during each transmission
It is good for more denser region of sensor nodes.	It is good for less denser region of sensor nodes.

(ii)Geographic Adaptive Fidelity (GAF)

GAF [3] is an energy aware routing protocol proposed for MANETs but can also be used for WSNs because it aims at energy conservation. GAF turns off sensors which are not under transmission acitivity, while keeping a constant level of routing fidelity (or uninterrupted connectivity between communicating sensors). A sensor field is divided into grid squares and every sensor uses its location information.Location information can be obtaine ,with the help of GPS or other location monitoring systems. The sensor node establishes connections with other sensor nodes within a particular single grid and this helps GAF to identify the sensors.

The state transition diagram in GAF consists of three states:

Sleeping state: A sensor stops its signal processing in the sleeping state.

Discovery state: A sensor exchanges messages with its neighbor nodes to learn about other sensors in the same grid.

Active state: A sensor periodically broadcasts its discovery message to inform equivalent sensors about its state.

GAF aims to maximize the network lifetime by reaching a state where each grid has only one active sensor based on sensor priority. The residual energy levels help to prioritize the sensors. A sensor with a higher priority handles routing within their respective grids. As shown in Fig. 3, the state transition diagram of GAF has three states- *discovery*, *active*, and *sleeping*. When a sensor enters the *sleeping* state, it stops the process of signal processing to save energy. In the *discovery* state, sensor exchanges messages to know about other sensors in the same grid.

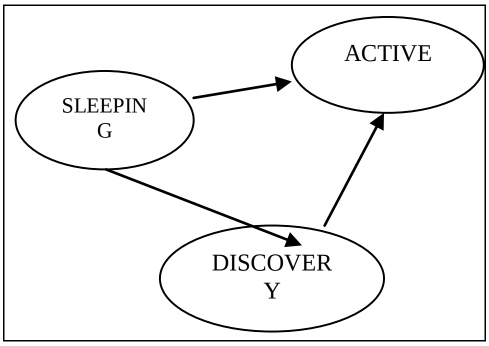

Figure 3: GAF:State transition diagram

Even in the *active* state, a sensor periodically broadcasts messages to inform equivalent sensors about its state. The time needed for each of these states to work depends on several factors, such as its needs and sensor mobility of the application being used. Network lifetime can be increased with the help of GAF,by reaching a state where each grid has only one active sensor based on priorities given to sensor nodes . The selection of sensors for transmitting packets is based on their residual energy levels. Thus, a sensor with higher energy will be able to handle routing efficiently within their respective grids. For example, a sensor in the *active* state has a higher priority than a sensor in the *discovery* state. A sensor with longer expected lifetime is estimated to transmit the packets.

(iii)Minimum Energy Communication Network (MECN):

MECN [3] is a location based protocol for achieving minimum energy for randomly deployed networks, which uses mobile sensors to maintain a minimum energy network. It computes an optimal spanning tree with sink as root that contains only the minimum power paths from each sensor to the sink. This tree is called minimum power topology. It has two phases:

(i) It is self-reconfiguring protocol that maintains network connectivity in spite of sensor mobility. It calculates an optimal spanning tree which is at the sink, called *minimum power topology*.This topology contain only the minimum power paths and shows the paths from each sensor to the sink.

(ii) It is based on the positions of sensors on the plane and consists of two activities, namely, *enclosure graph construction* and *cost distribution*. For a stationary network, in the first activity (*enclosure graph construction*), MECN develops a sparse graph, called an *enclosure graph*.It is based on the immediate locality information of the sensor nodes. An enclosure graph is a directed graph.It contains all the sensors as its vertex set.Union of all edges between the sensors and the neighbors which are located in their enclosure regions is considered as Edge set.In other words, a sensor will not consider the sensors located in its relay regions as potential candidate forwarders of its sensed data to the sink. In the second activity (*cost distribution*), non-optimal links of the enclosure graph are simply eliminated and the resulting graph is a *minimum power topology*. This graph consists of directed path between each sensor node to the sink and it absorbs the least total power among all graphs having directed paths from each sensor to the sink. Each sensor broadcasts its cost to its neighbors, where the cost of a node is the minimum power required for this sensor to establish a directed path to the sink.

MECN acts like a self-reconfiguring protocol.Hence it is fault tolerant protocol (in the case of mobile networks).But it suffers from a severe battery depletion problem when applied to static networks. MECN does not consider the available energy of each sensor node and hence the optimal cost links emerge as static. In other words, a sensor will always use the same neighbor to transmit sensed data to the sink. Hence, the neighbor node would die very quickly and the network thus becomes disconnected. To overcome this problem, the enclosure graph and thus the minimum power topology must be made dynamic based on the residual energy of the sensors.

Cost distribution: In this phase non-optimal links of the enclosure graphs are simply eliminated and the resulting graph is a topology with minimum power. This graph has a directed path between each sensor node to the sink.This graph absorbs the least power among all graphs having directed paths from each sensor to the sink. Every sensor broadcasts its cost to its neighbors, where the cost of a node is the minimum power required for this sensor to establish a directed path to the sink.

(iv)Small Minimum Energy Communication Network (SMECN):

SMECN [3] is a routing protocol that improves MECN by constructing a minimal graph characterized with regard to the minimum energy property. This property ensures that there s minimum energy efficient path between any pair of sensors in a graph that has the smallest cost in terms of energy consumption over all possible paths. In SMENC protocol every sensor broadcasts a neighbor discovery message using some initial power to discover its neighbors. It then checks whether the theoretical set of neighbors that are computed analytically is a subset of the set of the set of sensors that replied to that neighbor discovery message. The sensor uses a corresponding power p to communicate with its immediate neighbours for this case and else it increments p and rebroadcasts its neighbour discovery message.

(v) Coordination of Power Saving with Routing (SPAN):

SPAN [4] is a routing protocol is applied to WSNs though it was proposed for MANETs since it is energy efficient. This protocol turns off the radio when not in use since the wireless network interface of a device is often the single largest consumer of power. Span helps sensors to join a forwarding backbone topology as coordinators that will forward packets on behalf of other sensors between any source and destination.

III. APPLICATIONS OF PROTOCOLS

The following table shows the Advantages, Disadvantages and suitable Applications [9] of above Location Based Routing Protocol.

Table2: Advantages, Disadvantages and suitable Applications of Location Based Routing Protocol.

Protocol	Advantages	Disadvantages	Suitable Applications
GEAR	A.Increase the Network lifetime B.Reduces Energy Consumption C.Recursive forwarding algorithm to D.Disseminate the packet inside the target region	A.Limited Scalability B.Limited Mobility C.Limited Power Management D.High overhead E.Doesn't take care Of qos	Home automation
GAF	A.Optimize the Performance of WSN B.Highly Scalable C.Maximize the Network lifetime D.Limited energy Conservation	A.High overhead B.Doesn't take care of qos during data transmission. C.Limited mobility D.Limited power Management	A.Habitat monitoring B.Object tracking
MECN	A.Maintains energy Network with low power B.Fault tolerant C.Optimal Spanning	Battery depletion	Remotely controlled landmines
SMECN	A.Less Energy Than MECN Links B.Maintenance cost Is less	A.Maximum power Usage B.No. Of broadcast Messages is large	Remotely controlled landmines
SPAN	A.Reduces the energy B.Consumption of nodes C.Less over head D.Supports data aggregation	A.Scalability is limited B.High overhead C.No qos	Habitat monitoring

IV. CONCLUSION

Routing in sensor networks has large number of applications in the recent years and introduced unique challenges compared to traditional data routing in wired networks. There are lot of real time applications that can be created to facilitate smart working and environment in todays life. One of the main challenges in the design of routing protocols [10] for WSNs is energy efficiency due to the scarce energy resources of sensors.Energy needed for data transmission and reception by sensor nodes is less compared to that consumed by sensor nodes. Therefore, routing protocols designed for WSNs should be energy efficient to increase the lifetime of each sensor nodes.This also increases the network lifetime. In this paper, we have surveyed a location-based routing protocols by taking into account several issues that include location information, energy factor, network lifetime and QOS requirements. For each of these protocols, we have discussed advantages, disadvantages and some applications that are suitable to these protocols.

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