



Routing Protocols for Mobile Wireless Sensor Networks

Ravinder Kaur¹, Dr. Trilok Chand Aseri²

ME Research Scholar¹, Associate Professor², Department of Computer Science and Engineering
PEC University of Technology, Chandigarh-160012
INDIA

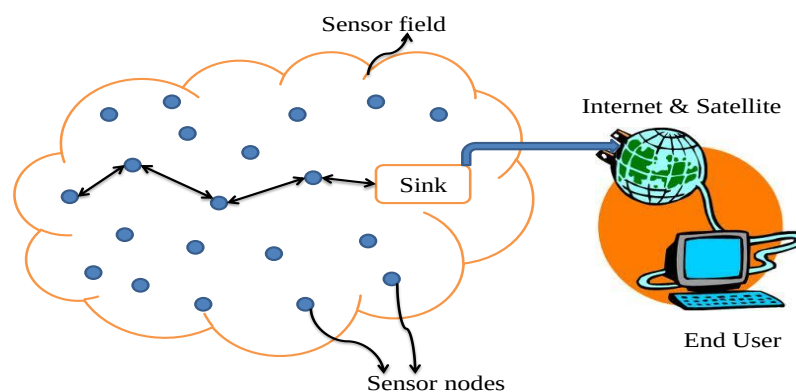
Abstract: Mobility of sensor nodes poses new challenges for the researchers particularly in energy consumption and packet loss. Routing protocols are responsible for discovering and maintaining the routes in the network. However, the efficiency of a particular routing protocol mainly depends on the capabilities of the nodes and on the application requirements. Some real world applications require environments composed of static and mobile sensor nodes in the same network, while others demand complete mobile sensors nodes to be deployed in the environment. Different routing protocols show different performance depending on the application scenario. So In this paper we present a review of recent routing protocols proposed by different researchers for mobile wireless sensor networks.

Keywords: Routing Protocols, Sensor networks, Mobile nodes, Mobility.

I. Introduction

A sensor network is composed of a large number of sensor nodes, which are densely deployed. The position of sensor nodes is not preset which allows random deployment in inaccessible terrains or disaster relief operations. Basically, each sensor node comprises sensing, computing, transmitting, mobilize, position finding system, and power units (some of these components are optional like the mobilize) [3]. Sensor nodes are usually placed in a sensor field, which is an area where the all the sensor nodes are densely deployed. On the other hand, this also means that sensor network protocols and algorithms must possess self-organizing functionalities. Another specific feature of sensor networks is the cooperative effort of sensor nodes. In WSN Instead of sending the raw data to the nodes responsible for the integration of data, sensor nodes use their processing capabilities to locally carry out simple computations and transmit only the required and partially processed data. In WSN, Sensor nodes sense the event that occurs and compute the whole information regarding that event. After performing some kind of processing, nodes send their data to base station or sink nodes. A WSN typically has no infrastructure. The major components of a typical sensor network are sensor field, sensor nodes, sink and task manager or end user, [20] as shown in figure below:

Figure 1 A Wireless sensor Network



II. Routing in Mobile Wireless Sensor Network

The dynamic nature of mobile wireless sensor networks introduces various challenges like data management, accuracy and precision, coverage, routing protocols, localization etc. Many of the above mentioned challenges related to a static deployment of the sensors are addressed by the most of the researchers. One of the most important constraints on sensor nodes is the route enabling when the nodes keep moving [6]. So here is the main function of routing begins that how efficiently route can be determined when the sensor nodes are moving, Routing is basically a process of determining a best possible path between source and destination for transmission of data. In WSNs the network layer is mostly used to implement the routing of the incoming data. It is well known that in multi-hop networks the source node cannot reach the sink directly because of presence of intermediate nodes. So, intermediate nodes have to pass their packets. The nodes' mobility in Mobile WSN poses a challenge to design an energy efficient routing protocol. Depending on the application, different architectures and design goals/constraints have been considered for sensor networks. Since the appropriateness of a routing protocol is closely related to the architectural model [3]. All of Routing protocols are different in nature, but all have the same basic objectives. Some protocols are better than others, but all routing protocols have their own advantages and disadvantages. All of the Routing algorithms are designed with the following objectives and goals:

- Optimal Routing
- Stability
- Rapid Convergence
- Ease of Use
- Flexibility

III. Routing Protocols for Mobile WSN

A routing protocol specifies how routers communicate with each other by propagating information that help them to select routes between any two nodes on a computer network. Routing protocols determine the specific choice of route from source to destination. Each router has a prior knowledge about the networks attached to it. A routing protocol helps to share this knowledge first among contiguous neighbors, and then throughout the network. In this way, routers gain knowledge of the topology of the network and use this knowledge to find best possible route from source to destination. In general, routing in WSNs can be divided into hierarchical- based routing, location based routing, flat-based routing, network flow and QOS aware routing protocol depending upon the network structure. Nowadays the hierarchical based protocol has gained more popularity as it helps to reduce the energy consumption. Here we are going to discuss some of the hierarchical routing protocols with their pros and cons.

A. LEACH(Low energy adaptive clustering protocol)

LEACH is one of the first hierarchical routing Protocols Used for wireless sensor networks to increase the life time of Network. LEACH performs self-organizing and re-clustering functions for every round [2][4]. Sensor nodes organize themselves into clusters in LEACH routing protocol. In every cluster one of the sensor node acts as cluster-head and remaining sensor nodes as member nodes of that cluster. Only Cluster-head can directly communicate to sink and member nodes use cluster-head as intermediate router in case of communication to sink. Cluster-head collects the data from all the nodes, add up the data and route all meaningful Compressed information to sink. Because of these additional Responsibilities Cluster-head dissipates more energy and if it remains cluster-head permanently it will die quickly as happened in case of static clustering. In this way LEACH maximizes life time of network nodes and also reduces the energy dissipation by compressing the data before transmitting. But there are some drawbacks of this protocol, The main drawbacks in Leach are as follows [7]:

- It is not applicable if sensor network contains mobile nodes.
- Leach is not applicable to networks that are deployed in large region as it uses single hop routing where each node can Transmit directly to the cluster head and the sink
- The cluster heads used in the LEACH will consume a large amount of energy if they are located farther away from the sink.
- Leach does not guarantee good cluster head distribution and it involves the assumption of uniform energy consumption for the cluster heads.
- Leach uses dynamic clustering which results in extra overhead such as the head changes , advertisement that reduces the energy consumption gain

B. LEACH-Mobile(Mobile Low energy adaptive clustering protocol)

Mobility support is an important issue in Leach routing protocol. Leach-M is proposed to mitigate this issue. Leach-M involves the mobility of non cluster head nodes and cluster head during the setup and steady state phase. The nodes in Leach-M are assumed to be homogeneous and have their location information through GPS. The basic idea in LEACH-Mobile is to confirm whether a mobile sensor node is able to communicate with a specific cluster head, as it transmits a message which requests for data transmission back to mobile sensor node from cluster head within a time slot allocated in TDMA schedule of a wireless sensor cluster [8]. If the mobile sensor node does not receive the data transmission from cluster head within an allocated time slot according to TDMA procedure, it sends join-request message at next TDMA time slot allocated. Then it decides the cluster to which it will belong for this moment by receiving cluster join-ack messages back from specific cluster heads. The LEACH-Mobile protocol achieves definite improvement in data transfer success rate as mobile nodes increase compared to the non-mobility centric LEACH protocol. LEACH-Mobile could be appropriate for mobility-centric routing protocol in wireless sensor network. The main drawback in are as follows:

- LEACH-M handles node mobility by assuming that the CHs are stationary.
- Hence, LEACH-M is not effective in terms of energy consumptions and data delivery rate because a large number of packets are lost if the CH keeps moving before selecting a new CH for the next round.

C. LEACH-ME(Low energy adaptive clustering protocol-Mobile Enhanced)

To alleviate this problem of LEACH-M, Kumar et al. propose LEACH-Mobile-Enhanced (LEACH-ME) [9][10] where a node with the minimal mobility factor is selected as a CH, if the residual energy of the node is not below a threshold value. They calculate mobility factor based on the number of times a node moves from a cluster to another cluster. Since mobility factor (or remoteness) is a function of distance among nodes it is calculated by multiplying node's velocity with the time required to move a node from a position to another. For this purpose, an extra timeslot known as ACTIVE slot is assigned during TDMA scheduling, where all member nodes wake up Simultaneously, broadcast their IDs with timestamp information and receive their neighboring nodes IDs by setting a time out. For example, node i can make use of IDs of all other nodes it hears and calculate $dij(t) = \text{Radio Velocity} * |t2 - t1|$, where at time $t1$ node i broadcast its ID and at time $t2$ it receives the ID of node j . This modified CHs election process of LEACH-ME provides a minimal data loss in case of node's mobility. In steady phase, a non-CH node A might not receive Data Request that is sent by the CH because of mobility and since the new location of node A is out of the range of CH. In this case if CH does not receive any acknowledgement from A in two timeslots in consecutive frames, then A is declared as mobile and its allocated timeslot will be deleted and A joins in a new cluster. The performance of LEACH-ME is better than LEACH-M in successful data transmissions in different mobility factors. The main drawbacks in Leach-ME is:

- LEACH-ME is not energy efficient since it consumes energy for determining mobility factor in active slots.

D. CBR Mobile WSN(Cluster based routing protocol for mobile nodes in WSN)

Awwad et al. propose [11] cluster based routing protocol for mobile nodes in WSN (CBR Mobile-WSN) to reduce energy consumption and the number of packets loss of LEACH-M. CBR-M is an adaptive protocol that avoids wastage of Time slots and hence, ensures efficient bandwidth utilization. Each CH keeps some free timeslots to enable other incoming mobile nodes from other clusters to join its cluster. A CH sends data request message to the non-CH nodes and if the CH does not receive data from a member, the packet is considered to be lost and the CH discards the nodes membership, at the end of the frame. Consequently, if a sensor node A does not receive data request message from its CH then A tries to join in a new cluster to avoid loss of packets. If the sensor node A receives Data Request message from CH but A has no data to send, A will not hold any time slot and this timeslot can be assigned to another member node that has data to send. In another scenario, if a sensor node A moves and hence, does not receive data request message from its CH at its allocated timeslot A sends its data to the free CH to avoid the loss of data. Then A sends a registration message to join the cluster of a nearby CH. When a CH finishes receiving data messages from all sensor nodes in a round, the CH checks whether it receives data messages from all members, and then removes the sensor nodes from which the CH did not receive any data. Each sensor node A wakes up one timeslot before its scheduled timeslot to check whether it has really been assigned that timeslot. If A has not been assigned any timeslot it goes back to sleep mode and its

timeslot might be used by a mobile sensor node that enters the cluster. This phenomenon reduces energy consumptions. However, CBR-mobile has more average delay as compared to LEACH-M since the moved sensor nodes send data to the free CH whenever that sensor node did not receive any data request from its CH which adds delay to the network whereas in LEACH-mobile assume packets are lost when sensor nodes do not receive any data request from CH. This protocol overcomes the disadvantage of high packet loss and it helps to reduce energy consumption. The main drawback of CBR-MWSN and LEACH-ME are as follows:

- These protocols cannot detect the failure of sensor nodes. They just assume that the nodes are moved if CH do not get response from them.
- Moreover, these protocols work in rounds and initiate a new cluster formation phase at every round, where each round comprises cluster formation, CH selection and data transmission phases. This is also not considered energy efficient since a large number of messages are transmitted to form a cluster.

E. LFCP-MWSN(Location aware fault tolerant clustering protocol for mobile WSN)

All of the protocols which we have discussed in this survey or purposed by researchers take an assumption that the position of sensor nodes is already know by some GPS system or satellite. To achieve reliability and to detect failure of nodes Recently an author purposes a protocol, which will be discussed in the next section, where the sensor localize themselves using some localization technique and after performing localization they perform routing tasks. This is unique protocol in literature which performs self localization of sensor nodes [13][14]. To address the problems of CBR-MWSN and LEACH-ME author propose a location aware fault tolerant clustering protocol for mobile WSN (LFCP-MWSN). In this protocol, a special packet is sent by a non-CH node A if A has no sensed data to send to the CH at its allocated timeslot and thus, saves energy by not sending data at every timeslot. At the end of a round a node with the least mobility is selected as a new CH, which is calculated as the ratio of the number movements of a node inside and outside of its cluster [14]. Moreover, CH does not receive data or special packet from a node A at its allocated timeslot if (i) data or special packet transmission fails (ii) node A moves out of the cluster or (iii) node A dies. In such case, CH waits until the next timeslot for node A to confirm the transmission failure. If CH does not receive data or special packet from node A in the next timeslot CH deletes node A from its member list, discards the timeslot of node A and also notifies BS the ID of node A. In each frame, a timeslot is kept free for allowing the moving nodes to notify the CH of a new cluster. Thus, if node A moves into a new cluster it sends a JOIN REQUEST message to the CH of new cluster at the free timeslot. CH of this new cluster accepts the JOIN REQUEST of node A only when a timeslot becomes free because of the moving of another node out this cluster. Then the CH of this cluster sends the ID of node A to BS. Thus, if BS receives ID of the node A from two different CH as a leaving node from a cluster at frame x and a new node into a cluster at frame $x + t$, then node A is considered to be moved from a cluster. Otherwise, node A is considered as a failed node. In addition to this, LFCP-MWSN supports sensors localization in the cluster formation phase and every time a node moves to a new location since without location information sensors data are meaningless for most of the applications. Simulation results show that LFCP-MWSN protocol is more efficient in terms of energy consumptions, network lifetime and data transmissions than those of the existing LEACH-M and LEACH-ME protocols[14].

IV. Conclusion

In this article, we surveyed recent contributions to the problem of improving network routing process by leveraging mobility. Network routing is an important performance metric for various applications in WSNs. Traditional approach to improve routing process is to deploy a great amount of stationary sensor nodes and then apply routing algorithms to schedule sensors' activity in an efficient way. By leveraging mobile nodes, many network-wide performance metrics can be greatly improved. Routing in mobile wireless sensor networks has attracted a lot of attention in the recent years and introduced unique challenges compared to traditional data routing in wired networks or static wireless sensor network. In this paper, we have summarized recent routing protocols for Mobile WSN to address the issues like energy efficiency, end to end delay etc. The objective of routing protocol is not only to improve routing process but also to improve network lifetime, data report timeliness and reliability at the same time.

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