IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727
PP 12-16
www.iosrjournals.org

Network Life Time Enhancing Protocols in Mobile WSN: A Survey

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Abstract: *WSN consists of a collection of nodes where each node is connected to one or more sensors which are intended to function for years without any human intervention. Today WSNs play very important role in event sensing, information processing and data communication.WSNs have been replacing the traditional networks because of its ease of deployment, extended transmission range and self-organization. Many of the current routing protocols in WSN assumes that nodes and sink are static. Disadvantage of static WSN is that the neighbor nodes of sink consumes more energy and thus leads to network isolation(hotspot problem).This problem can be avoided by providing mobility to nodes thereby improving the network life time. In this paper we are conducting a comparative study on various protocols used in mobile WSN.*
Keywords: *Static wsn; mobile WSN; Network Life time; hot spot problem; sink Node;*

I. Introduction

A computer network is a collection of computers and other computing hardware devices that are linked together through communication channels to allow communication and resource-sharing .The communication link can be either wired or wireless. Wireless networks can be equipped with sensor nodes which can be deployed in a region for monitoring various physical and environmental parameters where a conventional networks may fail.

A WSN typically consists of a large number of low-cost, low-power, and multifunctional wireless sensor nodes, with sensing, wireless communications and computation capabilities[1].Each node consists of a radio transceiver with an internal antenna or connection to an external antenna ,a microcontroller, an interface with the sensors and a battery. These sensor nodes collect and forward the data towards a sink node (base station(BS)) which may be located either far away from the sensor field or within the sensor field. The base station does the processing and decision making depending upon the applications. Today WSNs are used in many industrial and consumer applications such as industrial monitoring and control, target tracking in battle field, wild life monitoring etc.

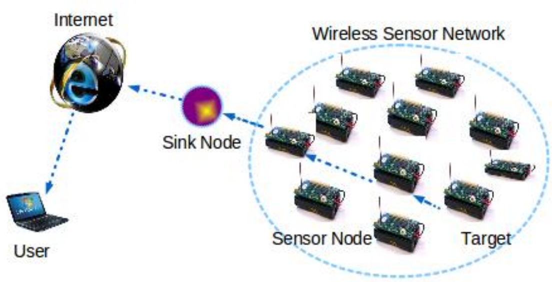

Fig 1: Wireless sensor node

WSN can be either static or mobile .Static WSN consists of sensor nodes which remain static once deployed. Mobile WSN consists of sensor nodes that can move and interact with the physical environment. Static network may cause serious issue on energy threat- hot spot problem. As the sensors near the base station have to collect and transmit data frequently on behalf of other sensors, they will drain their energy very quickly. It results in sudden death of that sensors .Hence the life time of whole network will be threatened. Effective solution to this issue is to allow mobility to sink node so that the sink node will propagate dynamically and there would not be a fixed set of nodes that have to work as a relay agent to the base station.[2,3].An outline of this paper is as follows: Section II presents related works, Section III presents comparison of different routing protocols in mobile WSN.

II. Related Works

Routing is main challenge faced by wireless sensor network. Routing is complex in WSN due to dynamic nature of WSN, limited battery life, computational overhead, no conventional addressing scheme, self-organization and limited transmission range of sensor nodes [11]. As sensor has limited battery and this battery cannot be replaced due to area of deployment, so the network lifetime depends upon sensors battery capacity. A Careful management of resources is needed to increase the lifetime of the wireless sensor network. Quality of routing protocols depends upon the amount of data (actual data signal) successfully received by Base station from sensors nodes deployed in the network region. Hot spot problem can be avoided by using mobile WSN.

Mobility can be achieved in three different ways: mobility in sensor nodes, mobility in sink nodes, and mobility in relay nodes [4].

a) Mobility in sensor nodes

In this category mobility is imposed in sensor nodes.

b) Mobility in relay nodes

In this classification mobility is provided to relay nodes which actually collects data from the sensor nodes and transmits to sink node.

c) Mobility in sink node

In the case of a static sink, nodes located in the vicinity of the sink deplete their energy (and die) much earlier compared to the nodes located farther away from the sink due to higher data relaying load. In order to address this issue, sink mobilization has been introduced, where the sink moves along a certain path through the network. It has also been shown that in most cases sink mobility helps in balancing the routing load and energy dissipation of the nodes. It is categorized as follows: random mobility, predictable mobility and controllable mobility

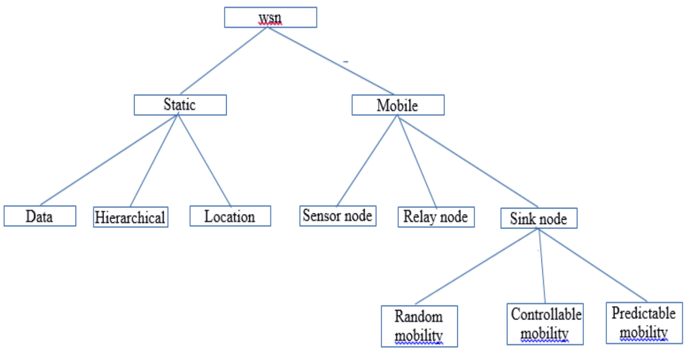

Fig 2: Classification of WSN

2.1 Algorithms

Low Energy Adaptive Cluster Hierarchy (LEACH) is a cluster based approach used in static WSN [5]. LEACH algorithm works in different rounds. Each round begins with set up phase followed by steady phase. In set up phase, Cluster Head (CH) for the current round is selected based on a threshold value T(n), where n is the sensor node number. T(n) is calculated as,

$$T(n) = \begin{cases} \dfrac{P}{1 - P\left(r \bmod \frac{1}{P}\right)} & if\ n \in G \\ 0 & othewise \end{cases}$$

Here *G* is the set of nodes that have not yet been selected to become cluster heads in the last 1/*p* rounds, *r* denotes current round number and *p* is a predefined value that represents CH probability and is equal to the required number of CH divided by total number of sensor nodes in the WSN.

In steady phase, all the other nodes send data to CH and then CH aggregate all data and send it to the base station. Since LEACH does not support mobile WSN, an improved version called LEACH-M is introduced. In this protocol mobility is imposed in sink nodes [7].

Consider a heterogeneous WSN which consists of a large number of sensor nodes, a few static cluster heads (CH) and a mobile Base Station (BS). Each sensor node periodically sends sensed event packets to its nearest CH. The CH should found an itinerary to send these event packets to the mobile BS.In general case, LEACH and its modified versions supporting mobile nodes are based on a mono-hop communication. In fact, it considers that all nodes can exchange data with the sink node. So, it is useful in indoor where the supply and people limit the wireless components radio range. But the multi-hop routing is a necessity to support a widest area like outdoor applications.

In military and several other applications the control of mobile units is strongly requested. As LEACH doesn't support moving nodes, an improved version that supports mobility is introduced-LEACH allows mobility of non-cluster-head nodes and cluster-head during the setup and steady state phase. M-LEACH also considers remaining energy of the node in selection of cluster-head. Initially all nodes are homogeneous, all nodes have their location information through GPS and Base station is considered fixed in M-LEACH. Distributed setup phase of LEACH is modified by M-LEACH in order to select suitable cluster-head. Optimum cluster-heads are selected to lessen the power of attenuation. Other criteria of cluster-head selection are mobility speed. Node with minimum mobility and lowest attenuation power is selected as cluster- head in M-LEACH. Then selected cluster-heads broadcast their status to all nodes in transmission range. Non-cluster-head nodes compute their willingness from multiple cluster-heads and select the cluster-head with maximum residual energy. In steady state phase, if nodes move away from cluster-head or cluster-head moves away from its member nodes then other cluster-head becomes suitable for member nodes. It results into inefficient clustering formation. When nodes decide to make handoff, send DIS-JOIN message to current cluster-head and also send JOIN -REQ to new cluster-head. After handoff occurring cluster-heads re- schedule the transmission pattern.

In Mono hop LEACH each node, elected to be CH, and broadcasts a message to other nodes in the same cluster. These nodes have to join this CH and then send their collected data to their closest CH. If a node has not taken the new CH ID, the old one should inform this node. The CH for each cluster receives the data from cluster members and then searches the BS in its range to send its data through a single-hop relay.

In Multihop LEACH distance between Base station and CH has no effect. Data transmitted from CHs to base station in single hop communication. As diameter of network increased, distance between Cluster head (CH) and base station also increased . Power consumption of battery will increase as distance increased. Therefore in order to reduce energy consumption modified protocol Multihop LEACH introduced. In Multihop LEACH data broadcasts from cluster head (CH) to base station occur in multi hop communication [8]. In Multihop LEACH data transmitted from one CH to other CH, then to other CH, CH which is near to Base station transmits whole data to Base station (BS). Multihop LEACH is a distributed routing protocol based upon clustering. Cluster Heads (CHs) perform data aggregation to the data receive in order to reduce the total data broadcasted in the network.

Mobility of the network sensor nodes may accelerate energy depletion and increase the need for effective energy-conserving WSN routing protocols. For data transport to the network base-station (network sink), it selects only nodes that balance the mobile WSN energy saving distribution. Decision of whether a node participates in disseminating information must be related to the energy level in each sensor node. Higher number of nodes broadcasting the same messages will quickly reduce the overall energy of WSNs.Energy saving can be achieved by selecting routing path through nodes with high energy level so that it increases the probability for message delivery to the WSN sinks (base-station). The MSN Adaptive Energy Saving Algorithm (MSN-AESA) [9] is a solution to the energy-saving problem of mobile WSNs. MSN-AESA addresses such needs of mobile sensor network while allowing long nodes life time. Here if a node receives a new message, it checks for its energy and memory. If both resources are available, node schedules the corresponding message for a rebroadcast after some time period .If either the node's energy or node's memory is not available, node discards the message and records the rejection. During the waiting for rebroadcast, the node listens for other messages to arrive. On the arrival of next message, it is received and if it is a duplicate message queued in memory (scheduled to be broadcast), node checks that message does not exceed the maximum allowable number of duplicates. If this is satisfied, node then reschedules the message for a different period. If not, node rejects the message second message and records the dropping If an ACK message is received from a base-station (BS) during the waiting period, node drops the related message from its memory buffer. The waiting time itself is a function of the remaining energy level of node number of messages buffered (scheduled in the local memory), and number of duplicates heard by the node. It allows WSN nodes to cooperate in selection of the best candidate node for message retransmission.

In a typical WSN, the sensor nodes are highly resource constrained. The sensor nodes are inexpensive, disposable, and expected to last until their energy drains out. Therefore, energy is a very limited resource for a WSN. Here both sink and sensor nodes are mobile. E^2R^2 [10] is a hierarchical and cluster based energy-efficient routing protocol for WSNs. Each cluster consists of one cluster head (CH) node, two deputy CH nodes, and some ordinary sensor nodes. The reclustering time and energy requirements have been minimized by introducing the concept of CH panel. At the initial stage of the protocol, the BS selects a set of probable CH nodes and forms the CH panel. Some sensor nodes are intelligently scheduled for dormant state, which is a low-power state. Those nodes are scheduled for dormant state, whose services are not required at a particular instant in time. At a later stage, these nodes may perform state transition and again become active while needed. The state transition is dictated by the BS. This saves significant amount of energy at the nodes. Thus, the battery lives of the sensor nodes get prolonged. The CH nodes do not transmit data directly to the BS, unless it is the nearest one to the BS. The communication pattern or the route for the CH nodes is determined by the BS and distributed to the respective CH nodes.

It is assumed that the BS has an idea about the expected number of data packets (i.e., the volume of data) to be arrived in it during a specified time interval. Therefore, the BS keeps on monitoring the actual volume of data arrived from different clusters in the network. If the BS observes less arrival of data packets from some clusters in comparison with a prespecified threshold level, then it informs the respective CH nodes to check their connectivity with their cluster members. The CH considers this as feedback from the BS and accordingly checks the current connectivity with its cluster members. If the connectivity status of the cluster members with the respective CH is very poor, the BS decides to shift the charge of cluster headship to another suitable member from within the CH panel. Depending on the connectivity scenario, the cluster headship may be transferred to one of the two DCH nodes also. The routing decisions are made at the BS and then communicated to the sensor nodes.

The sink mobility brings about the problem of sink localization, requiring frequent advertisement of the changing sink position across the network. This operation may result in a significant overhead, which should be minimized to benefit from the energy savings introduced by the mobile sinks. An effective mobile sink routing protocol should also avoid an extreme increase in the sensor data delivery latencies. Ring Routing [13], is a hierarchical routing protocol for wireless sensor networks with a mobile sink. The protocol imposes three roles on sensor nodes: ring node, regular node, and anchor node. Ring nodes form a ring structure which is a closed loop of single-node- width. It reduces the overhead in mobile sink protocols by advertising the sink position to the ring. The regular nodes obtain the sink position information from the ring whenever necessary, and nodes transmit their data via the anchor nodes, which serve as intermediary agents connecting the sink to the network. The sensor nodes can change roles during the operation of the WSN. Sink selects anchor nodes (ANs) among its neighbors as it moves. The AN manages the communications between the sink and the sensor nodes. Initially, the sink selects the closest node (e.g., the node with the greatest SNR value) as it's AN, and broadcasts an AN.Selection (ANS) packet. Before the sink leaves the communication range of the AN, it selects a new AN and informs the old AN of the position and the MAC address of the new AN by another ANS packet. Since now the old AN knows about the new AN, it can relay any data which is destined for it to the new AN. The current AN relays data packets directly to the sink.

Ring Routing is based on a virtual ring structure which is designed to be easily accessible and easily reconfigurable. This protocol mitigates the anticipated hotspot problem observed in the hierarchical routing approaches and minimize the data reporting delays considering the various mobility parameters of the mobile sink. It is suitable for the random sink mobility scenarios.

Circular joint sink mobility [14] protocol is based on minimum distance and low energy consumption of nodes with mobile sink. It replaces the concept of fixed single sink into two mobile sink. These two sinks move in circle in opposite direction (clock wise and counter clockwise) simultaneously. Each node calculates its distance with both sinks and sends packet to the closest sink.

III. Protocol Comparison

The protocols discussed in section II are compared and summarized in the given table.

No:	Protocol Name	No of sinks	Mobility is provided to	Sink mobility pattern	Structure type	Network Life Expectancy	Hop Count
1	LEACH-M	Single	Sink	Random	Hierarchical	Poor	Single
2	MSN-AESA	Single	Sensor node	Stationary	Hierarchical	Good	Multiple
3	E^2R^2	Single	Sink and Sensor node	Random	Hierarchical	Good compared to LEACH-M	Multiple
4	Ring Routing	Single	Sink	Random	Ring	High	Single
5	CJSM	Multiple	Sink	Random	Cluster	High	Single

IV. Conclusion

Traditional routing protocols used in WSN results in limited network life time. This is due to the fact that the nodes that are closer to sink node consumes more energy than other nodes in the network. In this paper we surveyed routing protocols in mobile WSN.A comparative study of routing protocols based on characteristics like no of sinks, node to which mobility is provided, mobility pattern, structure type, network life time and hop count is also presented.

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