Enhanced Location-Aware Routing Protocol for Wireless Sensor Network

Divya Mittal, Sukhjinder Kaur

Abstract*: Minimizing Energy consumption is considered as one of the most important principles in the development of routing protocols for Wireless Sensor Networks (WSN). In this, we propose a Location based Energy-Aware Reliable routing protocol (LEAR) for WSN based on sensor position and clustering. Clustering-based routing protocols are more useful in the context of energy efficiency where several sensor nodes in the communication range of one another form a cluster. Each cluster has a cluster head (CH), which coordinates all the nodes of a cluster. There may be a number of base stations (BS) also known as sink in a WSN that communicate with other networks. Most of the existing geographic routing protocols make use of greedy routing to forward packets from source to destination. Enhance Greedy Forwarding is proposed to perform a geographic, efficient and reliable routing for WSN. A comprehensive simulation study illustrates that the lifetime of WSN can be consequentially extended with LEAR. Finally, LEAR algorithm has been developed, tested and validated through a set of experiments to illustrate the relative advantages and capabilities of a proposed algorithm. Existing cluster-based mobile routing protocols such as LEACH-Mobile, LEACH-Mobile-Enhanced and CBR-Mobile consider only the energy efficiency of the sensor nodes. However, reliability of routing protocols by incorporating fault tolerance scheme is significantly important to identify the failure of data link and sensor nodes and recover the transmission path. In this study the authors, we propose a location-aware and fault tolerant clustering protocol for mobile WSN (LFCP-MWSN) that is not only energy efficient but also reliable. LFCP-MWSN also incorporates a simple range free approach to localize sensor nodes during cluster formation and every time a sensor moves into another cluster.

Index Terms*: Wireless Sensor Network, Location Based Energy Aware Reliable Routing Protocol(LEAR), Base Station.

I. INTRODUCTION

A wireless sensor network (**WSN**) in its simplest form can be defined as a network of (possibly low-size and low-complex) devices denoted as nodes that can sense the environment and communicate the information gathered from the monitored field through wireless links; the data is forwarded, possibly via multiple hops relaying, to a sink that can use it locally, or is connected to other networks (e.g., the Internet) through a gateway.

- The nodes can be stationary or moving.
- They can be aware of their location or not.
- They can be homogeneous or not.

A WSN consists of anywhere from a few hundreds to thousands of sensor nodes. The sensor node equipment includes a radio transceiver along with an antenna, a microcontroller, an interfacing electronic circuit, and an energy source, usually a battery. The size of the sensor nodes can also range from the size of a shoe box to as small as the size of a grain of dust. As such, their prices also vary from a few pennies to hundreds of dollars depending on the functionality parameters of a sensor like energy consumption, computational speed rate, bandwidth, and memory. Wireless sensor nodes are small, embedded computing devices that interface with sensors/ actuators and communicate using short-range wireless transmitters. Such nodes act autonomously, but cooperatively to form a logical network, in which data packets are routed hop-by-hop towards management nodes, typically called sinks or base stations. A Wireless Sensor Network (WSN) comprises of a potentially large set of nodes that may be distributed over a wide geographical area, indoor or outdoor. Wireless Sensor Networks (WSNs) enable numerous sensing and monitoring services in areas of vital importance such as efficient industry production, safety and security at home as well as in traffic and environmental monitoring. Traffic patterns in WSNs can be derived from the physical processes that they sense. WSNs typically operate under light load and suddenly become active in response to a detected or monitored event. Early research studies in WSNs targeted military applications, especially for battlefield monitoring. In the last few years, due to the progress of low powered units and improvements in radio technologies, wireless sensor networks technologies have gained momentum. WSNs are now being deployed in civilian areas and being used for habitat observation, health monitoring, object tracking etc. In addition, lately, there is an emergence of mission-critical applications. Emergence of mission-critical and information demanding applications in WSNs renders performance control essential, for mission accomplishment. Heavy traffic load is a major factor that affects the performance of any type of network. The situation worsens in low powered, unreliable WSNs. Thus, a prominent factor that under specific circumstances, can improve or deteriorate the performance of WSNs, can be the way that nodes are placed on the monitored field. Proper node placement is essential to ensure good sensing coverage and communication connectivity. Recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks based on

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collaborative effort of a large number of nodes.

II. LITERATURE SURVEY

Wireless Sensor Network (WSN) is an emerging technology that received much attention from research community in the recent years. It provides the possibility to monitor different kind of environment by sensing physical phenomenon. However the consumption of energy by WSN devices is considered as one of important issues that need to be aware due to the batteries lifetime. In this context, many researchers have focused on methods of reducing energy consumption of WSN nodes.

Authors in (Ito and Yoshigoe, 2009), investigated ways of preserving the energy of actively sensing nodes in WSN. They proposed a consumed Energy-Type-Aware Routing (CETAR) method. The idea is to discourage some active node in participating in routing task in order to preserve their energy. By collecting statistics of energy consumption per type of activities at each sensor node such as sensing and data processing, data transmission as a source node and data receiving or transmission as routing node, CETAR encourages a node which plays a role of source node as routing node to preserve the energy of active source node in order to prolong the WSN device life time.

Hsin-chih-lin (2003) proposed a way to reduce the routing problem and increment in the protection topology. A new heuristic algorithm called “Steiner Node Heuristic” (SNH) for solving the Steiner Tree problem in graphs and, consequently, for routing multicast calls in mesh optical Wireless sensor Networks, is presented.

Rajendra Kumar Dwivedi CSE Department, [2012], He purposed a Modified Reliable Energy Aware Routing Protocol for Wireless Sensor Network. In this paper, a novel reliable energy aware routing protocol is proposed, which is based on reliability and energy efficiency. Since in the wireless environment, link quality is difficult to guarantee, the reliable routing protocol is quite important issue to study. In this protocol, a backup path, alternative path and critical value is used for reliability and low energy conservation. MREAR attempts to take precaution against error, instead of finding a solution after encountering an error.

Luis Javier García Villalba, Ana Lucila Sandoval Orozco, [2009]. He purposed Routing Protocols in Wireless Sensor Networks. The applications of wireless sensor networks comprise a wide variety of scenarios. In most of them, the network is composed of a significant number of nodes deployed in an extensive area in which not all nodes are directly connected. Then, the data exchange is supported by multi-hop communications. Routing protocols are in charge of discovering and maintaining the routes in the network. However, the appropriateness of a particular routing protocol mainly depends on the capabilities of the nodes and on the application requirements. This paper presents a review of the main routing protocols proposed for wireless sensor networks. Additionally, the paper includes the efforts carried out by Spanish universities on developing optimization techniques in the area of routing protocols for wireless sensor networks.

K. Padmanabhan, Department of Computer Applications, [2011].He purposed A Study on Energy Efficient Routing Protocols in Wireless Sensor Networks. Recent developments in the sensor networks field initiated for designing new protocols for wireless sensor networks (WSNs). The routing protocols designed for wireless sensor networks cannot be used for other adhoc networks due to its battery powered nodes. These sensor nodes have some constraints due to their limited energy, storage capacity and computing power. The energy efficiency is an important issue in WSN. Routing protocols makes the transmission in an efficient manner and ensures reliable delivery over multiple-hop relay in WSN. This paper analyses the routing protocols and its classifications.

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III. PROPOSED SYSTEM

Wireless sensor networks are often deployed to sense, process and disseminate information (e.g., temperature, humidity, or sound) of targeted physical environments. In many of these applications Minimizing Energy consumption is considered as one of the most important principles in the development of routing protocols for Wireless Sensor Networks (WSN). In this study, we propose a Location based Energy-Aware Reliable routing protocol (LEAR) for WSN based on sensor position and clustering. Geographical routing protocols are efficient and convenient for optimum energy consumption and bandwidth utilization. Most of the existing geographic routing protocols make use of greedy routing to forward packets from source to destination. Enhance Greedy Forwarding is proposed to perform a geographic, efficient and reliable routing for WSN. A comprehensive simulation study illustrates that the lifetime of WSN can be consequentially extended with LEAR. Finally, LEAR algorithm has been developed, tested and validated through a set of experiments to illustrate the relative advantages and capabilities of a proposed algorithm's real-time data mining sensor data to promptly make intelligent decisions is essential. A Wireless Sensor Network (WSN) usually consists of a huge number of small, low- cost sensor nodes spread over a large area and high density with one or possibly more powerful sink nodes gathering readings of sensor nodes. The sensor nodes are equipped with data processing and communication capabilities. Each node is usually integrated with a wireless radio transceiver, a small microcontroller, a power source and multi-type sensors. These sensors have the ability to communicate either among each other or directly to an external Base Station (BS). A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. These sensors measure ambient conditions in the environment surrounding them and then transform these measurements into signals that can be processed to reveal some characteristics about phenomena located in the area around these sensors. The sensor sends such collected data typically via radio transmitter, either directly or through a data concentration center (a gateway) to a command center (sink). The decrease in the size and cost of sensors, resulting from such technological advances, has fueled interest in the possible use of large set of disposable unattended sensors. However, sensor nodes are constrained in energy supply and bandwidth. Such constraints shared with a typical operation of huge number of sensor nodes have posed many challenges to the design and management of sensor networks.

LEAR takes the advantages of location information to make routing mechanism more efficient. In LEAR, each node sends its location coordinates to its neighbors. The location information that has been used in LEAR algorithm could be extracted from devices such as Global Positioning System (GPS). Each node in this geographic area starts constructing its routing table based on the distances to its neighbors. As in other routing algorithms, each node makes a decision about forwarding the message to the selected candidate. If the node holding the message decides not to transmit it to a given candidate, the following candidate is chosen from the list and a new decision is made. A node decides about the transmission path based on the position of its neighbors. Once the distance vector is constructed for each node, it compares the localization of the next hop destination. The source node propagates its message to the neighbor which has the shortest distance to its location. Many different concepts of closeness have been proposed for this context. The most common approach is comparing the Euclidean distances and selecting the shortest one to the source node. This process is repeated for each active node until the message reaches the intended destination. Energy aware concepts should be taken into any design consideration. Each sensor node is driven by its battery and has very low energy resources. This puts together energy optimization principle more complex in sensor networks because it involves not only decreasing of energy consumption but also extending the life of the network as much as possible. This can be prepared by having energy awareness in every phase of design and operation.

Since wireless sensor networks (WSNs) consist of hundreds and thousands of unattended, resource-constraint and low–energy sensor nodes designing energy efficient routing protocols is significantly important. Clustering-based routing protocols are more useful in the context of energy efficiency where several sensor nodes in the communication range of one another form a cluster. Each cluster has a cluster head (CH), which coordinates all the nodes of a cluster. There may be a number of base stations (BS) also known as sink in a WSN that communicate with other networks. A CH aggregates data that are received from all member nodes of a cluster and sends to the BS. Besides CH, there exist gateway nodes in a cluster which are used for inter-cluster communications. Hence, clustering protocols produce limited useful information from large amount of raw sensed data and transmitting this precise useful information to the BS of the network consume less energy. Most clustering protocols of WSN in the literature are designed for static sensor nodes. Thus, these protocols do not work for WSN applications that require mobile sensor nodes, such as habitat monitoring, wild life monitoring, target tracking and battlefield surveillance. Moreover, these protocols do not support localization of sensor nodes but only assume that each node know their location, which make these protocols inefficient. For instance, low energy adaptive clustering hierarchy (LEACH) Protocol is a standard static clustering protocol of WSN. LEACH is enhanced as LEACH-Mobile, LEACH-Mobile Enhancement, and cluster based routing protocol for mobile nodes in wireless sensor network (CBR Mobile-WSN) to support mobility of sensor nodes. In these protocols, which are presented in detail in Section, if a non-CH sensor node A does not receive Data Request packets from CH or CH does not receive data from node A after sending the data request packet, the node A is assumed to be moved from its previous location. Then the CH discards the timeslot of node A and allocates this free timeslot to a new mobile member node of this cluster. Node A also tries to find a new CH node of a cluster. However, this same condition may also arise for the failure of

CH and non-CH cluster members. Thus, these protocols cannot detect the failure of sensor nodes. 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. To alleviate this problem we 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. 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. The remainder of this paper is organized as follows. Section presents some existing mobile clustering protocols of WSN. Section presents the working principle of different phases of the proposed LFCP-MWSN protocol with pseudo-code. Section analyses the performance LFCP-MWSN protocol in terms of network energy consumptions. In Section experimentations are designed and performed to measure and compare the performance of LFCP-MWSN with LEACH-Mobile, LEACH-Mobile Enhancement protocols in terms of network lifetime, number of transmissions and end-to-end delay. Section discusses the LFCP-MWSN protocol and compares it with existing protocols. Section concludes the paper with some future research directions.

Existing Routing Protocols

LEACH (Low Energy Adaptive Clustering Hierarchy):

LEACH is a self-organizing, adaptive clustering protocol. It uses randomization for distributing the energy load among the sensors in the network. The following are the assumptions made in the LEACH protocol:

a. All nodes can transmit with enough power to reach the base station.

b. Each node has enough computational power to support different MAC protocols.

c. Nodes located close to each other have correlated data.

According to this protocol, the base station is fixed and located far from the sensor nodes and the nodes are homogeneous and energy constrained. Here, one node called cluster-head (CH) acts as the local base station. LEACH randomly rotates the high-energy cluster-head so that the activities are equally shared among the sensors and the sensors consume battery power equally. LEACH also performs data fusion, i.e. compression of data when data is sent from the clusters to the base station thus reducing energy dissipation and enhancing system lifetime. LEACH divides the total operation into rounds—each round consisting of two phases: set-up phase and steady phase. In the set-up phase, clusters are formed and a CH is selected for each cluster. The CH is selected from the sensor nodes at a time with a certain probability. Each node generates a random number from 0 to 1. If this number is lower than the threshold node [T(n)] then this particular node becomes a CH. T(n) is given as follows:

$$T(n) = \frac{p}{1-p}[r \bmod (1/p)],\ n \in G = 0, \text{otherwise}$$

Where p is the percentage of nodes that are CHs, r is the current round and G is the set of nodes that have not served as cluster head in the past 1/p rounds. Then the CH allocates time slots to nodes within its cluster. LEACH clustering is shown in Figure 2. In steady state phase, nodes send data to their CH during their allocated time slot using TDMA. When the cluster head gets data from its cluster, it aggregates the data and sends the compressed data to the BS. Since the BS is far away from the CH, it needs high energy for transmitting the data. This affects only the nodes which are CHs and that are why the selection of a CH depends on the remaining energy of that node.

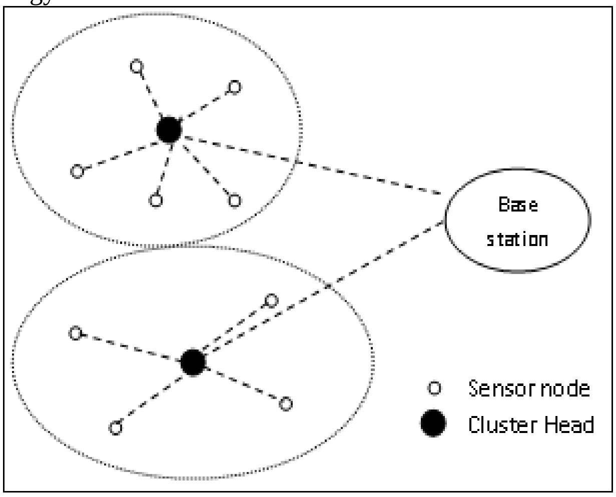

Figure 1. Clustering in LEACH Protocol.

SPIN (Sensor Protocols for Information via Negotiation):

SPIN is a family of adaptive protocols that use data negotiation and resource-adaptive algorithms. SPIN is a data centric routing protocol. It assumes:

A. all nodes in the network are base stations.

B. nodes in close proximity have similar data.

The key idea behind SPIN is to name the data using high-level descriptors or meta-data. Since all nodes can be assumed as base stations all information is broadcasted to each node in the network. So user can query to any node and can get the information immediately. Nodes in this network use a high level name to describe their collected data called meta-data. Figure 2 shows how SPIN works.

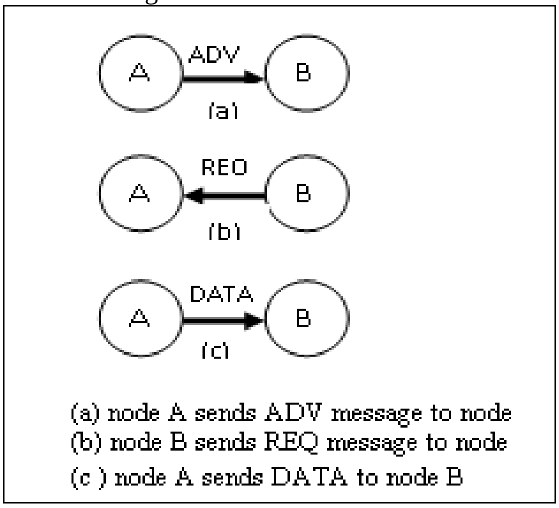

Figure 2. Data Transmission in SPIN.

The following are the outcomes of the proposed system.

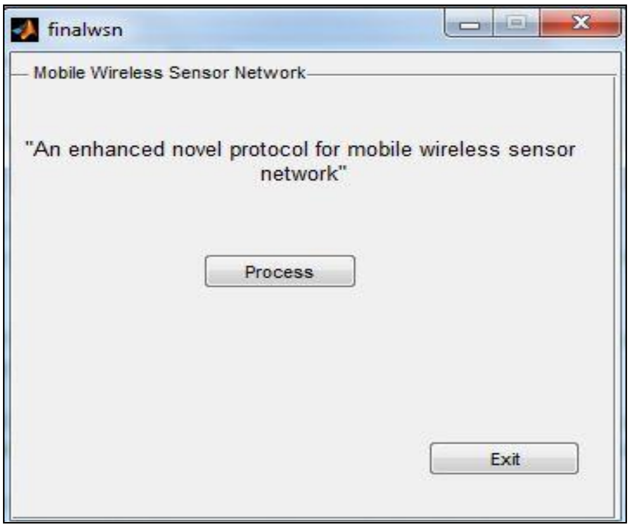

Figure3. The basic layout of the proposed system.

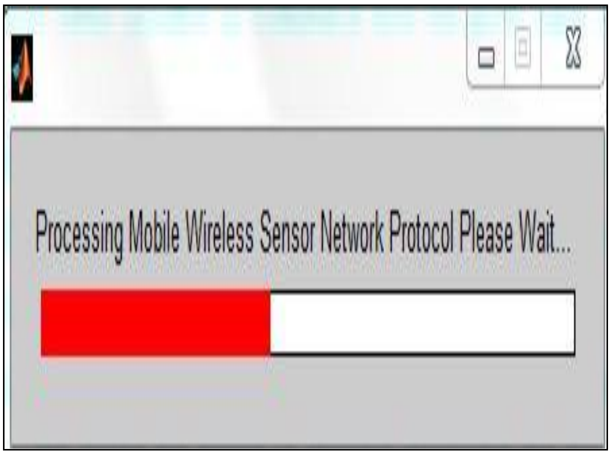

Figure4. The wait-bar is implemented into it.

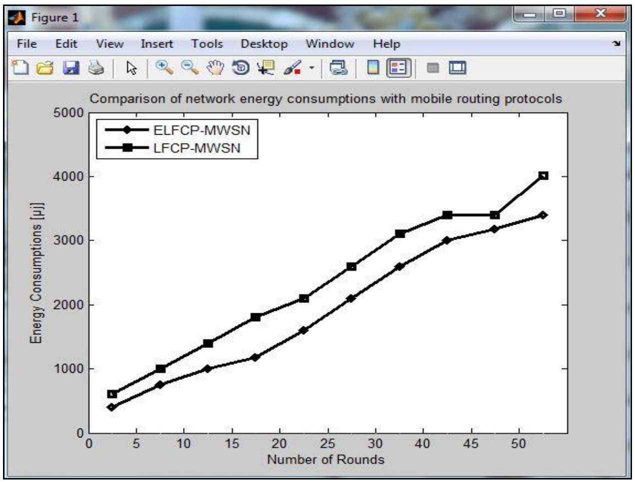

Figure5. The graphical representation between ELFCP and LFCP.

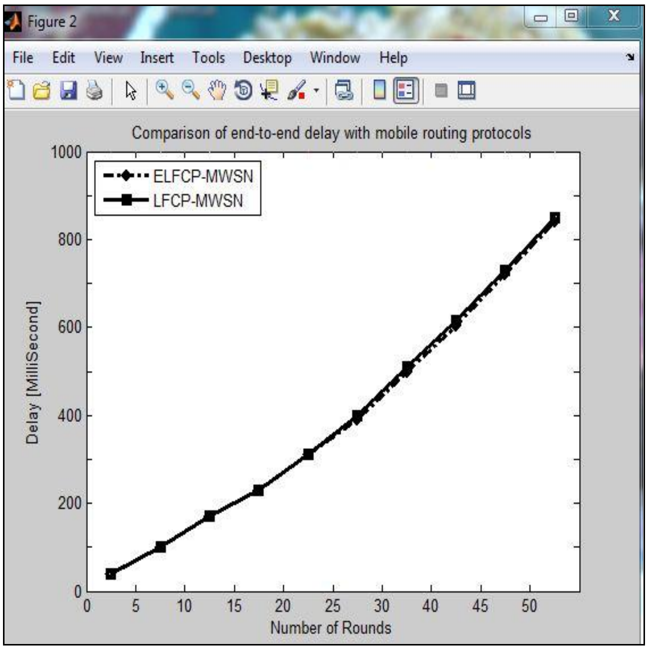

Figure5. The graphical representation between ELFCP and LFCP.

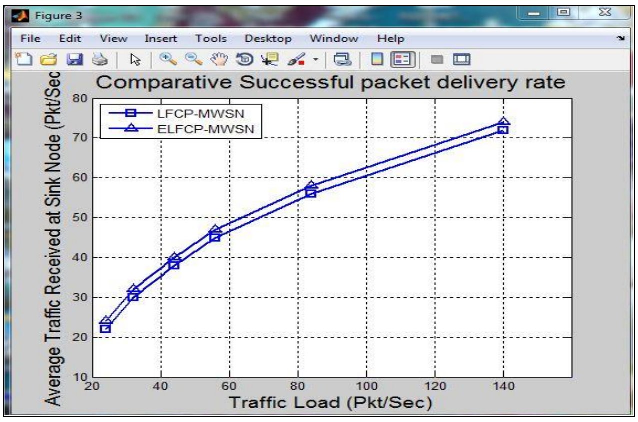

Figure6. Final outcome of the proposed system.

IV. CONCLUSION

The past few years have witnessed a lot of attention on routing for wireless sensor networks and introduced unique challenges compared to traditional data routing in wired networks. Routing in

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sensor networks is a new area of research. Since sensor networks are designed for specific applications, designing efficient routing protocols for sensor networks is very important. In our work, first we have gone through a comprehensive survey of routing techniques in wireless sensor networks. The routing techniques are classified as proactive, reactive and hybrid, based on their mode of functioning and type of target applications. Further, these are classified as direct communication, flat and clustering protocols, according to the participating style of nodes. Again depending on the network structure, these are categorized as hierarchical, data centric and location based. In this document we have discussed eight routing protocols and their comprehensive survey in Section. These eight protocols are LEACH, TEEN, APTEEN, PEGASIS, SPIN, DD, RR and GEAR. Since the sensor networks are application specific, we can't say any particular protocol is better than other. We can compare these protocols with respect to some parameters only. Future perspectives of this work are focused towards modifying one of the above routing protocols such that the modified protocol could minimize more energy for the entire system. In this paper, we propose a LFCP-MWSN that supports mobility of sensor nodes and sensors localization. Sensors localization is considered one of the most important features for WSN applications and unique in this proposed protocol as compared to most existing mobile routing protocols of WSN. LFCP-MWSN uses special packets, which are sent by member nodes of a cluster to CH when member nodes have no sensed event to send to CH but these special packets allow the LFCP-MWSN protocol to detect the mobility and failure of member nodes of a cluster. 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. Moreover, LFCP-MWSN detects the failure of sensor nodes. Although the analysis shows that LFCP-MWSN protocol should have less end-to-end network delay than LEACH-M and LEACH-ME simulations results and statistical analysis show that they are almost identical in terms of end-to-end delay. Hence, we aim to consider other factors such as variable timeslots duration for nodes at different clusters to reduce the end-to-end delay of LFCP-MWSN protocol as a future work. Moreover, in LFCP-MWSN protocol, we consider that once a node with the least mobility factor is selected as a CH, then the CH will not move out of the cluster in the current round. In future, we will also allow the mobility of a CH out of cluster in the current round.

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