A Review on Wireless Sensor Networks Applications and Protocols

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Abstract— The design of an energy-efficient wireless sensor network protocol is one of the major issues in wireless sensor networks (WSN). In this study, we present a review of protocols adapted to a particular class of WSNs. These protocols are mainly used for nodes energy efficiency. It could be used by WSNs dedicated to environment monitoring where each node senses a parameter periodically.

Key words: WSN, routing protocol, energy efficiency

I. INTRODUCTION

Wireless sensor networks (WSNs) are a widely used technology in particular for monitoring various environments. WSNs are composed of small wireless devices (sensors) connected to transducers. In general, WSNs are dedicated for monitoring physical environment and collecting data from it. They are used in various domains [1], [2] as ground monitoring, patient monitoring, and animal monitoring, thus, many works deal with WSNs where various interesting challenges and research issues have been tackled. WSNs were previously only dedicated to catch data from an environment and to transmit them to a sink or base station. For this reason, many researches focus on new methods to transmit data efficiently in order to reduce the energy consumption [2], [3] or to guarantee messages arrival [4], [5].

Our idea is to suggest a technique able to schedule communications over all nodes in an ordered way. This structure will contribute to assign a specific slot for each node to listen its previous neighbor, to compute aggregated data and to send modified data to its next neighbor. This method ensures to save high amount of energy.

II. ROUTING CHALLENGES IN WSN

Some of the routing challenges in WSN are as follows.

A. Energy Consumption:

As sensor nodes in WSN have limited battery power, it becomes challenging to perform computation and transmission while optimizing energy consumption [1]. In fact the transmission of one bit of data consumes more energy than processing the same bit of data. Sensor node life time strongly depends on its battery life.

B. Node Deployment:

Sensor nodes are usually densely deployed in the field of interest depending on application thus influencing the performance of a routing protocol. The deployment can be either deterministic or self-organizing. In deterministic case, the sensor nodes are manually placed and sensed data is routed through determined paths. In self-organizing systems, sensor nodes are scattered randomly creating a topology in an adhoc manner [2]

C. Data Delivery Models:

Data delivery models can be time driven, data driven, query driven and hybrid (combination of delivery models) depending on the application of sensor nodes and time criticality of data reporting. These data delivery models highly influence the design of routing protocols especially with regard to reducing energy consumption [3], [4].

D. Node Capability:

Depending on the application, a sensor node can have different role or capability such as relaying, sensing and aggregation since engaging all these functions on the same node would drain the energy of that node more quickly. Different capabilities of sensor nodes raise multiple issues related to data routing and makes routing more challenging [5],[6],[7].

E. Network Dynamics:

Most of the network architectures assume that sensor nodes are static but the mobility of base stations and sensor nodes is necessary in some applications [8]. Routing packets in such dynamic architectures becomes challenging in addition to minimizing energy consumption and bandwidth utilization.

F. Data Aggregation:

Since sensor nodes generate redundant data, cluster heads or base stations may receive similar packets from multiple nodes and these packets need to be aggregated before being forwarded to the base station. Signal processing methods can also be used for data aggregation [9].

1) Taxonomy of Routing Protocols

We present taxonomy of routing protocols for WSNs based on various classification criteria such as data centric, hierarchical, location based, negotiation based, multipath based, quality of service and mobility based as shown in figure 1

The objective of taxonomy is twofold:

- To provide a framework Wireless Sensor Network in which routing and data dissemination protocols for WSNs can be examined and compared; and
- To gain new insights into the routing and data dissemination protocols and thereby suggests avenues for future research.

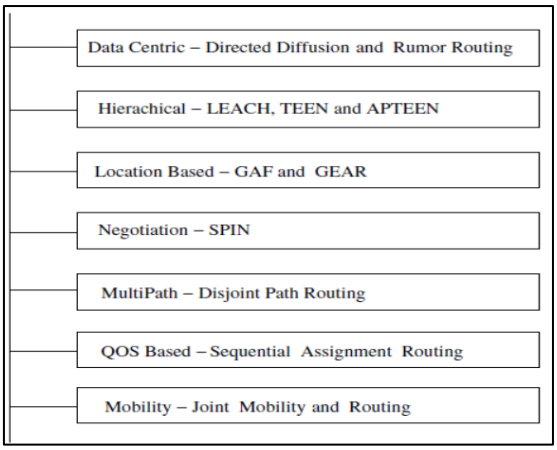

Fig. 1: Taxonomy of Routing Protocols in WSN

III. EXISTING ROUTING PROTOCOLS

A. *Location –base protocol-*

In this protocol all sensor nodes are addressed by means by their locations. By which calculate the distance between two particular nodes to estimate the all energy consumptions. In this section some location-based routing protocols proposed for WSNs.

1) GAF (Geographic Adaptive Fidelity):

The aim of this protocol is to make the performance of wireless sensor network more effective by identifying equivalent nodes with respect to forwarding packets. When two nodes maintain the same set of neighbor nodes and belong to the same communication routes, they are considered to be equivalent. Nodes positions are necessary to identify the equivalent nodes. Additionally, a virtual grid is constructed [1]. In GAF, sensor field is divided into grid squares. GPS or other location systems provide location information which is used by every sensor. The purpose of location information is to associate itself with particular grid in which it resides [2]. The grid is formed by cells whose size allows to task that all the nodes in one cell can

2) SPAN: (Coordination of power saving with routing)

Span can be applied to WSNs as its goal is to reduce energy consumption of the nodes. Span also primarily proposed for MANETs. SPAN motivational goals are

Firstly, span elects "coordinators" from all nodes in the network, so that so that every node is in radio range of at least one coordinator. Secondly, it ensures that all nodes share the task of providing global connectivity roughly equally that is done by rotating the coordinators [4]. Third, to increase the network lifetime, it attempts to minimize the no. of nodes elected as coordinators. It is done without suffering a significant loss of capacity. Fourth, it elects coordinators in which each node consults state stored in local routing table during the election process, which is known as decentralized manner of using local information.

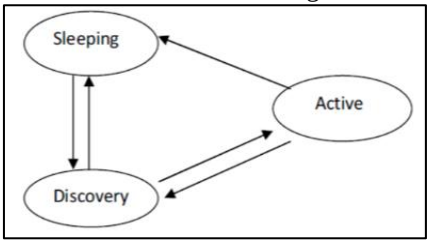

Fig. 2: Example of Routing Protocols in WSN

B. *Data-Centric protocol:*

1) SPIN (Sensor Protocols for Information via Negotiation):

SPIN is a family of protocol that was designed to improve classic flooding protocol and overcome the problems they may cause, for example, implosion and overlap. In SPIN, every node uses meta-data, where nodes running a SPIN communication protocol name their data using high-level data descriptors. The sensors running the SPIN protocols are able to compute the energy consumption required to compute, send and receive data over the network. The SPIN protocols are based on two key mechanisms namely, Negotiation, in which Meta data uses negotiations to eliminate the redundant data transmission throughout the network, and secondly in Resource Adaptation, it disseminates information among sensor network. In addition, every node in wireless sensor network can make its communication decisions based on both Application-Specific knowledge of the data and knowledge of the resources available to them, which allows sensors to distribute data efficiently with limited energy.

There are two protocols in SPIN family:

For Point to Point network, SPIN-PP and SPIN-EC, and for Broadcast network, SPIN-BC and SPIN-RL

In Point to Point networks, the sender announces a new data to each neighbor with an advertisement message [5]. When the receiver (neighbor) receives the messages, then the node checks the meta data to know that it is already stored data or not. If not and the neighbor is interested in the information, it responds with a request message. Sender receives it, and transmits the information in a data message. Again the neighbor that receives the data, inform about its availability to its own neighbors with an advertisement message, and then three-handshake protocol is repeated. This is the process of SPIN-PP [6]. the algorithm SPIN-EC is based on the technique in which when their current energy resource do not exceed a predefined threshold that is required to complete the three hand-shake protocol, they do not participate in the process. The disadvantages of SPINs protocol are firstly, it is not scalable. Secondly, if the sink is interested in too many events, then the nodes around a sink could deplete their battery quickly.

2) Direct Diffusion:

This protocol based on Data-Centric routing algorithm in which all communication is based on data. It consists of four elements:

- Interests, is a task description, which a sensing task can be described by list of attribute-value pairs.
- Data message, in this data are named using list of attribute-value pairs.
- A Gradient, specifies both firstly data direction along which events should be sent and secondly data rate.
- Reinforcement is a process of selecting a single path from multiple paths. At a beginning of Direct Diffusion process, a sensing task can be performed by interest that is diffused or flooded towards nodes in the interested region. The sensor node activates its sensors when it receives the interest and then begins to monitor interested events. The sense data then returned back or follow reverse path of the interest propagation. In the beginning of

the process, low data rates for incoming events are specified by the sink. After that, the sink can reinforce one particular sensor to send event with a higher data rate by resending the original interest message with a smaller interval [7]. Likewise, if a a neighboring sensor receives this interest message and observes that the sender's interest has a higher data rate than before, and this data rate is greater than that of any existing gradient, it will reinforce one or more of its neighbors.

C. Hierarchical Routing Protocol

1) TL-LEACH (Two Level Hierarchy LEACH):

TL-LEACH is two levels of clusters heads (Primary and Secondary) instead of a single one. It is a proposed extension to the LEACH Algorithm. Here the primary cluster head in each cluster communicates with the secondaries, and the corresponding secondaries in turn communicate with the nodes in their sub-cluster. With as in LEACH, Data Fusion can also be performed in TL-LEACH. Communication process is achieved in two steps:

In secondary node data fusion can be performed. This node collects data from node in their respective clusters. Then Primary nodes collect data from their respective secondary clusters.-LEACH avoids the overhead of data. By performing data fusion, large energy gains can be achieved. Thereby requiring much less data to be transmitted to the base station The TL-LEACH uses following techniques to achieve energy and latency efficiency:

- Randomized, adaptive, self-configuring cluster formation.
- Localized control for data transfer. These key features are maintained in TL-LEACH protocol.

The main difference between TL-LEACH protocol and LEACH protocol consists in the set-up phase. In the set-up phase clusters are created and a node elected as a primary cluster head second cluster-head or simple node (SN). Main aim of the TL-LEACH protocol is that it reduces the amount of nodes that need to transmit to the base station, so it is the energy efficient approaches and avoids the overhead of data.

2) APTEEN (Adaptive Periodic Threshold Sensitive Energy Efficient Sensor Network Protocol):

APTEEN is an improvement to TEEN to overcome its limitations and aims to both capturing periodic data collections (LEACH) and reacting to time –critical events (TEEN). APTEEN is a hybrid clustering –based routing protocol in which sensors sends sensed data periodically and also reporting to the CHs for their corresponding values if any sudden changes in the values of the sensed attribute. The architecture is same as TEEN. Clusters are formed by base station; the cluster heads broadcast the attributes, the threshold values and the transmission schedule to all nodes. Data aggregation is performed by cluster heads in order to save energy [8]. APTEEN supports three different queries

3) EECS (An Energy Efficient Clustering Scheme):

EECS is a clustering algorithm in which for a given round cluster head candidates compete for the ability to elevate to cluster head. In this competition neighboring candidates gain residual energy broadcasting by candidates. A node becomes a cluster head if a given node does not find a node with more residual energy. Cluster formation in EECS is totally different from LEACH. In LEACH, LEACH forms clusters based on minimum distance of nodes to their corresponding cluster head. EECS different from LEACH, it extends this algorithm by dynamic sizing of clusters based on cluster distance from the base station. The result is that the clusters at a greater range from the base station require more energy for transmission than those that are closer.
Ultimately, this improves the network performance by distributing the energy throughout the network. This result provides better resource usage and also extended network life time.

4) HEED (Hybrid Energy-Efficient Distributed Clustering):

The main drawback in LEACH approach is the random selection of cluster head. In the worst case the CH node may not be evenly distributed among the nodes and it will effects on the data gathering. To avoid this situation a new algorithm called HEED was introduced is based on both residual energy level and communication cost by which HEEDs selects the CHs. The main objective of HEED are-

- Distribute energy consumption to prolong network lifetime;
- During the cluster head selection phase it minimize energy;
- Minimize the control overhead of the network;

The phases involved in HEED protocols are-

- Initialization Phase: In this phase the residual energy of each node is used to probabilistically choose the initial set of cluster heads. Since HEED supports heterogeneous sensor node.
- Repetition Phase: In this phase if the node cannot find the appropriate cluster head, then the concerned node itself was selected as the CH.
- Finalization Phase: This last phase finalize the selection of CH. The tentative CH now becomes the final CH node.

5) PEGASIS (Power-Efficient Gathering in Sensor Information Systems):

PEGASIS is an extension of the LEACH protocol, it is based on data gathering and near-optimal chain-based algorithm, which forms chains from sensor nodes so that each node transmits and receives from a neighbor and only one node is selected from that chain to transmit to the base station (sink). By using data gathering and chain-based algorithm establishes the concept that energy conservation can results from node not directly forming clusters. Data fusion occurs at every node in the sensor network means in data fusion phase a sensor transmits to its local neighbors instead of sending directly to its CH as in the case of LEACH. In construction phase of PEGASIS routing protocol, it is assume that all the sensors have global knowledge about the network, specially, the positions of the sensors node. It follows the greedy approach. In which when a sensor fails or dies due to low battery power, the greedy approach is used to construct the chain by bypassing the failed sensor. Hence, PEGASIS achieves energy conservation in two ways:

- At most two data messages are received by the head node.
- The distance over which the data are transmitted to one hop neighbour is much less.

So, PEGASIS saves energy by reducing the no. of data messages gathering at head node.

IV. COMPARISON OF ROUTING PROTOCOLS

We have made comparison of various routing protocol for wireless sensor network into below table:

Protocol	Scalability	Mobility Support	Power Required	QoS	Multi-path	Energy-Efficiency
GAF	Limited	-NA-	-NA-	no	Nil	yes
Span	limited	-NA-	Limited	no	-NA-	-NA-
SPIN	limited	Could support	limited	no	No	no
Direct Diffusion	limited	Limited	limited	no	No	no
TL-LEACH	good	Fixed-BS	high	no	No	yes
APTEEN	good	Fixed BS	high	no	No	yes
EECS	-NA-	-NA-	limited	-NA-	-NA-	yes
HEED	-NA-	no	limited	-NA-	-NA-	yes

Table 1: comparison of various routing protocol

V. CONCLUSION

In this paper we have examined the three protocol of WSN, i.e. Location-based; Data Centric & Hierarchical based routing protocols with respect to their power and reliability requirements. Then we make a comparison between these algorithms with many parameters like scalability, mobility support, power requirement, Quality of Service, multipath, energy efficiency, attribute based, location based, data aggregation and application type. In this time many protocols are focused on the issue like minimizing of energy associated with clustered selection process or with cluster head selection to provide a energy efficient techniques that eliminates all overhead selection process .there are still some challenges that will come. As our study research, it is not possible to give a good, design a routing algorithm. Which will have good under all conditions.

The future research would be based on the issues that how the sensors network will integrates with wired networks (i.e. Internet). Security will also the next issue in my topic which will focus , how to secure the data that is collected from sensor nodes to be transmitted to a server so that future analysis can be done. So further research will based on handling these kind of situations.

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