



Survey on Secure Energy Efficient Communication in Clustering for Wireless Sensor Networks

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Abstract:

This paper gives a survey on various clustering protocols in Wireless Sensor Network. Wireless sensor network consist of large number of nodes and each node has limited energy resource, and thus the lifetime of the network is one of the most critical issues. Energy saving is the crucial issue. Clustering sensors into groups, so that sensors communicate only through cluster heads and then the aggregated information is sent to the base station, which saves energy. Various clustering protocols are studied to get an efficient and optimal clustering protocol in WSN. Clustering protocol which optimizing energy of the network and increasing the lifespan of network. The paper studies various clustering schema in which energy, packet delivery ratio, throughput and delay is evaluated for the various clustering protocols.

Keywords: Wireless Sensor Network (WSN), Cluster Head (CH), Low-Energy Adaptive clustering Hierarchy (LEACH), Energy-Driven Adaptive Clustering Hierarchy (EDACH), Power-Efficient Gathering in Sensor Information Systems (PEGASIS), Base Station (BS).

I. INTRODUCTION

Wireless sensor networks have been evolving it is been used widely used in military and social applications for various purpose target tracking, surveillance, and security management. There are hundreds and thousands of low-cost, low power, multifunctional small sensor nodes. The sensor nodes are lightweight and small. They have limited energy. Therefore energy consumption is a very critical issue. The sensor node in a network is deployed to perform a given task. WSN is used as an integral part of communication. Intelligence, surveillance, targeting system, military, etc.[2]

WSN is consisting of a large number of sensor nodes and a base station. The base station processes and stores the information it receives from the sensor nodes [1]. The sensor nodes are usually deployed randomly in the region of interest. A sensor node, contains a limited energy, processing capability and memory, collaborates with other sensor nodes, queries the physical environment, collects the received data and transmits the information to the BS. The sensor node has capabilities for monitoring and control; the network can provide a fine global picture of the target area through the integrating the information collected from many nodes and transmitting the data in the network [5]. Since sensor nodes has a limited power supply which cannot be recharged or replaced, hence operation of sensor nodes needs to be energy efficient. The lifespan of the entire network is affect by d limited energy of the sensor nodes, so it is crucial to have an energy efficient network. To resolve the issue various protocols and algorithm have been developed in WSN [1].

Cluster-based routing technique is effective for prolonging the lifespan of WSN [10]. In this routing protocol, the nodes in the network take different roles according to a variety of conditions and metric. A cluster consists of collection of sensor nodes and each cluster has cluster-head and other sensors are nodes. The cluster-heads can form

another hierarchy among them. The clustering approach allows a WSN of high scalability and less consumed energy. Hence clustering increases lifetime for the whole network. This is due to the fact that most of the sensing, data processing and communication activities are performed within the clusters. The energy consumption at a cluster head is maximum and greater than that at other nodes as the CH is responsible for transmitting all the aggregated information to the sink node. This problem can be relieved by rotating the role of cluster-head among all nodes.

The protocol called low-energy adaptive clustering hierarchy (LEACH) [7] is a cluster-based protocol proposed to solve the energy consumption problem. The energy consumption is equally distributed in network among the sensor nodes which in turn increases the lifespan of the network. In LEACH, however, a cluster-head can cause a failure because of energy deficiency. The energy-driven adaptive clustering hierarchy (EDACH) approach is another protocol in which it puts more number of cluster-heads in the region relatively away from the BS. The number of member nodes in their clusters will be smaller than that of other clusters. This compensates the larger energy consumption because of large distance to the BS.

The proposed EDACH scheme significantly reduces energy consumption and increase the lifetime of the sensor network compared to the previous schemes. Due to the uniformly distributed cluster heads, the proposed scheme balances the energy consumption among the sensor nodes. The simulation result shows that the proposed scheme effectively and efficiently increases the network lifetime compared with the existing schemes. Comparison between LEACH scheme (leach protocol) and proposed clustering mechanism with EDACH protocol is done on various parameters and output is shown using graphs. And the Qos parameters such as end to end delay, energy spent, packet deliver ratio, throughput is calculated and the output is shown using graphs.[1]

II. RELATED WORK

Kyung Tae Kim, Man Youn Kim, Ji Hyeon Choi, Hee Yong Youn in [1] describes the energy efficient and optimal randomized clustering protocol. Authors have give comparison between different clustering algorithms. LEACH is Low-Energy Adaptive clustering Hierarchy [7] which is one of the clustering schemes. In LEACH sensors are organized into clusters consisting of sensor nodes and cluster head. The CH in the cluster is responsible of aggregation of data and transmitting them to the base station. The existing LEACH protocol the energy dissipation is around 5 percent of the total nodes act as CHs which has been evaluated. The working of LEACH protocol consists of two rounds. The first round is the set-up phase and the second round is steady-state phase. In the setup phase each node decides whether it becomes the cluster head or not. As the CH is chosen the CH broadcasts as an advertisement message to the all the other nodes. The nodes decide, to belong to a particular CH for that round depending

on the received signal energy strengths. In the second round ie. steady state phase, the member nodes start sensing and transmitting data to the CHs, and the fused information by the CH is sent to the BS.

EDACH is Energy-Driven Adaptive Clustering Hierarchy [1] which increases the lifespan and reliability of sensor network even in the presence of faults at the cluster head. K. T. Kim and H. Y. Youn describes this clustering protocol. In this protocol a proxy node is selected which plays the role of the current cluster head in one round of operation. The CH node is efficiently selected by detecting the faults in the faulty cluster head. The protocol is reliable and improves in the stability of the network. It reduces the overhead of re-clustering. The EDACH protocol increases the lifespan and solves the energy issue in WSN. The network shows trustworthiness of sensor network even in the presence of faults at the cluster heads. The EDACH protocol is based on detecting and handling the defects in the CH.

TABLE I. LITERATURE SURVEY.

Paper Name	Technique	Advantages	Disadvantages
An Energy Efficient and Optimal Randomized Clustering for Wireless Sensor Networks	Energy efficient and optimal randomized clustering protocol	Energy efficient clustering	Limited lifetime of network
Energy-Efficient Communication Protocol for Wireless Micro-sensor Networks	Low-Energy Adaptive Clustering Hierarchy	LEACH is completely distributed	LEACH assumes all cluster heads pay the same energy cost
Energy-Driven Adaptive Clustering Hierarchy (EDACH) for Wireless Sensor Networks	EDCACH protocol	Evenly distributes the energy dissipation	If subjected to attack the lifetime decreases
A Novel Algorithm for Optimized Cluster Head Selection	BEC-LEACH protocol	Effectively balance the energy consumption of nodes	Better than LEACH but not as efficient as EDACH

In the Table I the paper An Energy Efficient and Optimal Randomized Clustering for Wireless Sensor Networks gives comparison between various protocols. The Energy-Efficient Communication Protocol for Wireless Micro-sensor Networks paper gives an clustering protocols to reduce the communication cost of the WSN. The Energy-Driven Adaptive Clustering Hierarchy (EDACH) for Wireless Sensor Networks paper studies on how to maximize the network lifetime and is better than existing protocols such as LEACH and PEACH. The A Novel Algorithm for Optimized Cluster Head Selection paper gives comparison of LEACH and BEC-LEACH. BEC-LEACH protocol prolongs the lifetime of network.

III. PARAMETER FOR ROUTING CLUSTERING PROTOCOLS IN WSN

A. Designing parameters in Clustering Protocol in WSN:

The design of new routing protocols for WSNs is quite challenging as there are number of constraints that are applied on network. The various limitations in WSNs are Energy, bandwidth, storage, and CPU. The clustering protocols in WSN are required to fulfil the following requirements [3]:

Energy Efficiency: Routing protocols need to maximize network lifespan by limiting the energy consumption of the network.

Scalability: The Routing protocols specifically designed for WSN environments must satisfy scalability.

Reliability: The protocols must be reliable so as to integrate the data to be transmitted and should handle errors. The network clustering protocol should incorporate correction mechanism, so as to deliver the data under various circumstances like noise, time varying network, etc.

QoS support: In the wireless sensor networking environments, different problems can have different QoS requirements related to packet delivery ratio, packet loss ratio, latency, throughput, etc. Hence, the network protocol design must consider the QoS requirements for specific application and comparison between the different WSN clustering protocol.

B. Optimization Techniques for Routing in Wireless Sensor Networks

For optimization of energy efficient protocols the following specification should be taken into consideration:

Energy Efficiency: An energy efficient protocol should select the route which will maximize the lifetime of wireless sensor network,

Data Aggregation: A way to reduce energy consumption is data aggregation. Aggregation of data removes redundancy in the different data packets.

Location-based: Transmission of data should be done by taking into consideration the transmission route, position and the final destination.

Multipath Communication: It increases reliability and performance in the network.

Quality of Service: QoS ensures the data exchange. It gives sample rate, delay, packet loss, data delivery ratio, etc.

IV. PROTOCOLS

B. Low-Energy Adaptive Clustering Hierarchy (LEACH):

W.B.Heinzelman, [11] introduces a hierarchical clustering algorithm for sensor networks called the Low Energy Adaptive Cluster Hierarchy protocol (LEACH). It uses a random principle for selection of cluster head and is a very popular protocol. It forms clusters of sensor nodes so that the energy consumption is reduced. The cluster heads (CHs) of the cluster is used to transmit the data to the BS. This saves energy of the network as the transmissions will only be done by CHs rather than all sensor nodes. The optimal number of CHs is given to be 5 percent of the total number of nodes [1]. All the data is aggregated and then transmitted which is done by the CH of the cluster. CHs are randomly selected and are changed turn by turn randomly over time. Which will balance the energy consumption of all the nodes.

LEACH protocol contains two states:

1. Cluster setup state and
2. Steady state.

In the first stage, clusters are formed and selection of CH is done, in second state, data is transmitted.

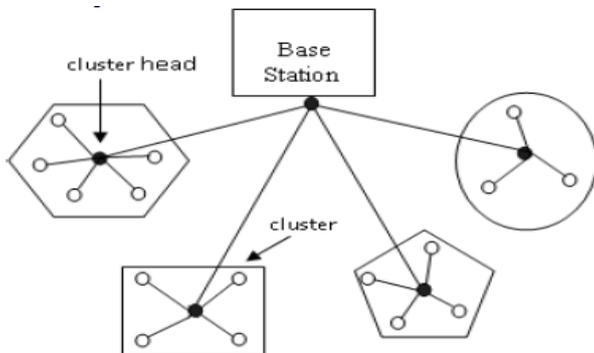


Figure .1. LEACH protocol

Shortcomings of LEACH Protocol [3][4] :

- (1) It assumes that nodes always have data to send & the nodes including CH are started with the same initial energy.

- (2) The number of CH is already defined from the total nodes. Approximately ranging between 5 to 10 percent of the total nodes. Hence, it may not cover entire area when sensor nodes are not uniformly distributed.
- (3) The CHs are randomly selected rotationally and Residual Energy of the node is not considered for cluster formation, etc.
- (4) CHs send aggregated data to BS in single hop manner so LEACH is not applicable to networks deployed in large regions.

C. Power-Efficient Gathering in Sensor Information Systems Protocol :

PEGASIS is considered an optimization of the LEACH algorithm. Rather than classifying nodes in clusters, the algorithm forms chains of the sensor nodes. Based on this structure, each node transmits to and receives from only one closest node of its neighbors. The nodes in the network adjust the power of their transmissions [8]. The node performs data aggregation and forwards it to the node in the chain that communicates with the sink. In each round, one node in the chain is elected to communicate with the sink. The chain is constructed with a greedy algorithm. Energy efficiency is low and the data delivery time is large.

D. Energy-driven adaptive clustering hierarchy:

Energy-driven adaptive clustering hierarchy (EDACH), is a protocol which is an enhanced version of the LEACH and PEACH scheme. The EDACH protocol has been discussed in detail in [9][10]. EDACH consists of rounds, the round one of its operation consists of the following two phases namely the set-up phase and the self-organized data collection and transmission phase. EDACH solves the possible problem of the CH by proxy node but in the LEACH approach it has insufficient energy for carrying out the task of a cluster-head. It, however, further improves the performance of PEACH by forming more clusters in the region far from the BS. Each round of EDACH begins with the set-up phase like the other protocols where the clusters are organized, followed by the self-organized data collection and transmission phase where data transfer to the base station occurs. The second phase also includes the proxy node selection process and Indicator Control Message (ICM) advertisement process. EDACH protocol can be deployed in large area in the wireless sensor network. EDACH had less packet loss ratio and delay as compared to other randomized clustering protocols. Load balancing is done efficiently. Therefore increasing the lifetime to the WSN system.

V. ENERGY COMPARISON

A critical need in wireless sensor networks is to have an energy efficiency during routing as the sensor nodes share limited energy resources. The efficient energy consumption is the most critical issue in wireless sensor networks. The efficient protocol should minimize the energy consumption.

Table. II. Comparison of clustering protocols

System	Achievement	Advantage	Remark
LEACH[4]	Adaptive clustering protocol for distributing energy load Among sensors in network.	Uses single-hop routing to transmits. Information directly to the CH or sink.	Not suitable for large network areas as homogeneous and static cluster nodes
PEGASIS[2]	Distribute the energy load evenly among the sensor nodes in the network	Resolves the data-gathering problem of the WSNs.	Better results than LEACH by removal of the dynamic cluster formation, overhead
PEACH[9]	Designed to operate on probabilistic routing protocols, in order to provide an adaptive multi level clustering	Power-efficient and adaptive clustering hierarchy protocol for WSN.	No overhead on CH selection and forms adaptive multi-level clustering as compared to the existing clustering protocol
EDACH[1][10]	Enhanced version of LEACH and PEACH	Solves the problem of CH having low energy using the proxy node approach	Enhances the network lifetime by distributing the CH according to the distance to the BS.

VI. A SURVEY ON ENERGY EFFICIENT HIERARCHICAL ROUTING PROTOCOL IN WIRELESS SENSOR NETWORK

Table. III. Analysis of hierarchical routing protocols

Protoc ol Name	Energy Efficien cy	Cluste r Stabili ty	Scalabil ity	Delat y	Complex ity
LEACH	Very Low	Moderate	Very Low	Very Small	Low
HEED	Moderate	High	Moderate	Moderate	Moderate
PEGASIS	Low	Low	Very Low	Large	High
EDACH	Very High	High	Moderate	Small	High

Table III analysis that EDACH is an energy efficient clustering protocol and is self -organized protocol in WSN.

VII. CONCLUSION

In this survey paper different WSN papers were studied and various clustering protocols evaluated by different authors for an energy efficient WSN.

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