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Deciding Clustering Algorithms for Wireless Sensor Networks

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***Abstract*—** Undoubtedly, the wireless sensor networks (WSN) is one of the important topics in recent years, where there were many studies have focused on some topics and omission others. Because WSN dealing with limited resources, such as a small memory and limited power, improving these determinants accounted for developers and researchers. This article compared the most common cluster based routing algorithms In many respects and highlights the advantages and weaknesses of each algorithm to serve as a guide for developers to choose What fits with them requirements. Furthermore, this article provides advice and guidance for future topics and highlights neglected aspects in this topic.

***Keywords*—** Node sensors; Clustering protocols; routing; energy efficiency;

I. INTRODUCTION

Typical Wireless Sensor Networks (WSN) via a wireless environment consists of hundreds or even thousands of interconnected sensor nodes. The sensor has its own battery, RF adapter, the microcontroller and the sensor boards constitute an integral structure. These nodes and organize their own network, is not a pre-programmed network topology in question. Due to limitations connected to the battery life. WSN, self-organized, flexibility, ease of installation and is becoming available due to a wide variety of possible applications [1]. Also be applied in almost all the surrounding environment, in particular the working of the existing wired network is impossible or cannot be used when available. General area of use of sensor networks can be listed as follows [2, 3]:

- *Military Applications*: WSN military command, control, communications, computing, intelligence, supervision, discovery, and has become an integral part of the target detection system.
- *Environmental Monitoring*: spanning hundreds or thousands of small, inexpensive, self-adjust nodes in a specific geographic area can be used in a wide range of applications in environmental monitoring or environmental control process.
- *Disaster prevention and recovery:* WSN would probably be effective in disaster areas in which they are placed in an emergency or disaster situation. Accurate and timely locating made through distributed WSN are vital in the rescue operation, place the number of dead next to the identified potential sources of danger or emergency, identification and rescue operations.
- *Medical Services*: WSN with the provision of timely and effective health care is quite helpful in the creation of a healthier environment.
- *Smart Home:* It can monitor gas, electricity, room temperature. It also can run out of the parking meter time transmit to the vehicle owner.
- *Smart Space:* After recent developments in technology, devices can attach to the individual furniture of various wireless sensors is made possible, so that the autonomous network may be formed. For example, according to an intelligent fridge family doctor diet programs from holding the inventory of the refrigerator, it will send the list to the personal digital assistant holding the shopping list.
- *Scientific Research:* automatic operation effectively placed nodes are capable of higher scientific research, also can be used in advanced and deep environments (such as space and the depths of the ocean).
- *Interactive Containment:* WSN's have produced promising mechanisms for collecting the information of mine. Also can used to strengthen the education of young children by designing spread of cheap and small wireless sensors, such as children watch.
- *Surveillance Application:* it is one of the important applications inspired by the instant and remote surveillance. For example, using acoustic surveillance network for bridge foot fortitude, residential areas, airports, train stations, etc.

Although clustering has benefits but in same time there are some drawbacks for this methodology [4-6]:

Focus node: the traffic near the BS is more than others because all nodes sent the data to BS. Therefore these nodes lose energy earlier, as result the BS will be isolated and energy stored in the other nodes will be wasted.

Stationary condition for node to obtain clusters: For moving sensor node networks, sensor node must be assumed to be stationary for cluster formation phase so that mobile sensor nodes are able to obtain neighboring information.

Re-Clustering effects: re-election of one cluster head may affect the structure of many clusters.

CH location: CH is selected either by ID number or residual energy of the sensor nodes. Yet both methods cannot guarantee that the cluster heads (CH's) to be always at the center of the cluster. Of the CNs are at the edge extra energy will be lost for transmission.

Extra wasted energy by routing: Energy is wasted by flooding in route discovery and complexes transmission of data by multiple routes from the source to the destination.

Computation round for Clustering: computation rounds are the number of rounds that are required for a cluster formation procedure. Unbounded time complexity represents a non computation round of clustering schemes.

II. CLUSTER BASED NETWORKING

In this article various cluster based routing protocols has been reviewed. Nodes are grouped into clusters consist of a CH which its main aim is to transfer data to other CH's or to the base station (BS). Data travels from a lower clustered layer to a higher one. The most popular energy-efficient hierarchical clustering algorithms for WSN's are Low-energy adaptive clustering hierarchy (LEACH), TEEN (Threshold sensitive Energy Efficient sensor Network), APTEEN (Adaptive Threshold TEEN), HEED (Hybrid, Energy-Efficient Distributed Clustering) and PEGASIS (Power efficient Gathering Sensor Information System).

LEACH is cluster-based protocol. It randomly selects nodes per cluster within a few nodes as cluster heads in WSN protocols. Studies have shown that selecting of %5 of nodes as Cluster head per cluster in the network is enough [7]. The main task of cluster head in the cluster is to ensure that all cluster nodes has equal level of the energy. Another task of the cluster head is to process the information and compress it to being transmitted to sink LEACH clustering is shown in Figure 1.

This protocol uses TDMA / CDMA and MAC protocols due to the data traffic in the network in order to minimize collisions [8]. One of the effective methods in reducing traffic is to send the collected data to sink periodically. LEACH protocol works in two phases. The first phase is the step of forming the network topology, and the second is the steady state where the provision of data transmission. LEACH time slot can be shown in Figure 2.

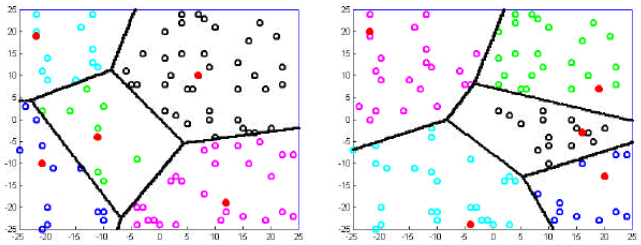

Figure 1. Low-energy adaptive clustering hierarchy

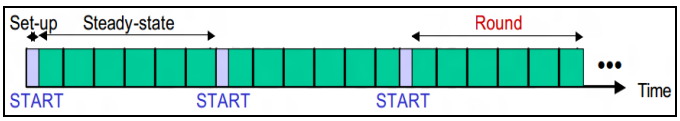

Figure 2. LEACH time division for states

LEACH protocol assumes that all the nodes have equal energy at every stage of and spends equal energy. Due to the nature of this protocol it has several disadvantages. They Are:

- Nodes will always assumed that the data to be similar in the immediate neighborhood. This will cause undue burden further processing and analysis of cluster head and as result unnecessary energy consumption.

- LEACH assumes that all the nodes have enough power to reach the sink. Randomly distributed nodes can sometimes be very distant from each other and cannot transmit data.
- During the creating of network topology, randomly manner CH determined in the network may not be homogeneously dispersed in the network.
- Some nodes may not find a cluster in a network after CH determination.
- Dynamic clustering structure used in the network structure brings additional processing overhead.

TEEN Protocol has been improved for data that is recommended for time critical applications where it should importance instantaneously. TEEN protocol's most important feature is the ability to plan work to do according to the energy level of the node. Accordingly, when node detection and orientation with a high energy level, the nodes which have a lower energy level does not allow the transmission of data over him by just detecting the neighbors. The main disadvantage of TEEN protocol specified energy cannot exceed the threshold level cannot be declared to nodes message and cannot begin to transmit data over the network [9]. TEEN protocol is shown in Figure 3.

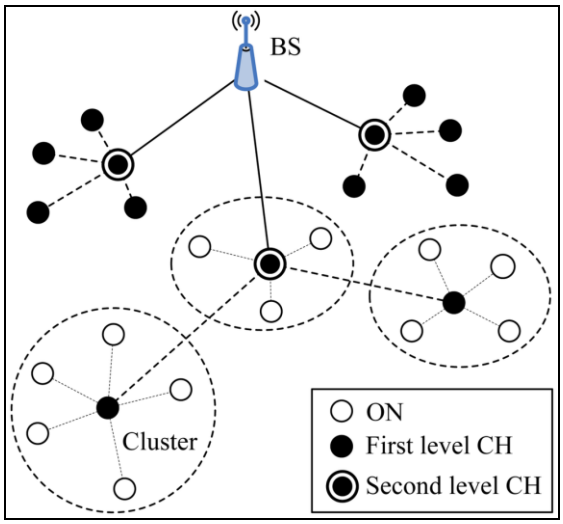

Figure 3. Threshold sensitive Energy Efficient sensor Network [10]

The weaknesses of TEEN protocol have been developed with APTEEN protocol. The protocol has also been made with APTEEN dynamic energy threshold level. Thus, the energy threshold level according to the shape and requirements of the application has become possible to determine the WSN It permits the selection among the energy efficiency of the network and data accuracy. Studies of TEEN and APTEEN protocols revealed that they are more effective than the LEACH protocol [11].

Another clustering algorithm is HEED which the nodes elect themselves as CH's based on residual energy and node degree as a metric for cluster selection to achieve power balancing. It's a multi-hop cluster-based protocol. The efficient clustering in HEED protocol is also based on physical distance between nodes during cluster head selection. In HEED, the main important parameter is their residual energy of each sensor node and the secondary parameter is the intra-cluster communication cost as a function of cluster density [12].

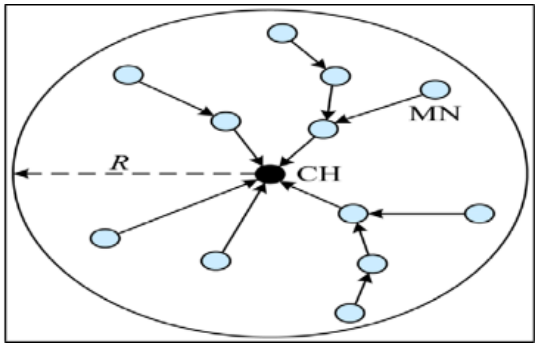

Figure 4. The Topology of HEED [13]

HEED protocol objective is related with prolonging network lifetime by distributing energy consumption, minimize energy during the process of cluster head selection and minimizing control over head. In HEED, each sensor node sets the probability CH probability of becoming a CH as show in Figure 4

And another popular clustering algorithm is PEGASIS, which has adopted the based chain protocol structure. To increase the lifetime of the network protocol;

- Nodes should contact the nearest neighbors. Nearest neighbors for each node is considered as the target node.
- Nodes start to transmit data to other nearest neighbor nearest neighbor that cannot be reached at the moment cannot reach the destination node by selecting the node itself a new frame.

PEGASIS protocol basically has two purposes. First, to increase each node's life time in cooperation with the network and thus to increase the overall lifetime of the network. And the second is to provide coordination between neighboring nodes to avoid the unnecessary traffic, and to use the bandwidth effectively. The main difference between PEGASIS protocol and LEACH protocol is using chain mechanism Instead of clustering methods [14]. Nearest neighbors are determined by the signal strength in PEGASIS. The resulting neighborly relations with this path are formed as a single chain. Thus, chain is formed from the nearest source node to the destination node; the node is emerging as a road. PEGASIS has succeeded in particular by reducing the number of no clustering and transmission costs. PEGASUS protocol biggest disadvantage is that target button is causing the delay of data coming from the remote node. Stages of the chain of communication between nodes within the time period could be clarified in Figure 5.

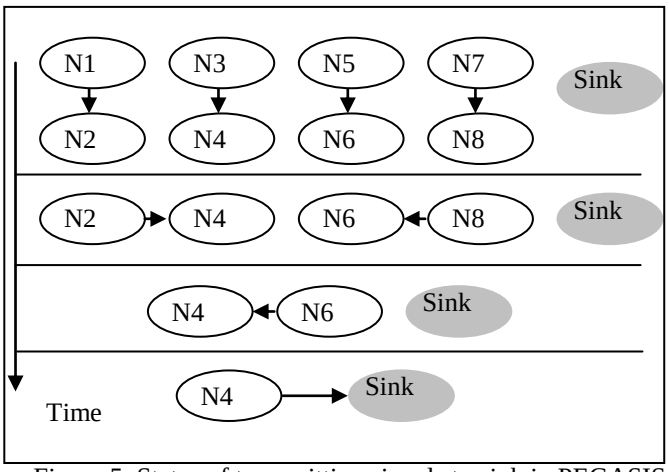

Figure 5. States of transmitting signals to sink in PEGASIS

III. OPEN ISSUES AND FUTURE PROPOSALS

- Studies generally focus on the reduction of energy through methods of communication between nodes and ways to send the signal. Few studies have focused on energy reduction in sensing period
- New studies should focus on new algorithms such as routing methods in acoustic sensor network where sensing and communication methods differ. And are ideal environment for the development of new algorithms
- Most algorithms and studies suppose that the creating of a cluster and CH was established over the stationary nodes. Whereas mobile nodes has become more common nowadays.

- Undoubtedly, the most important element in the Cluster is CH so that future studies should focus on the influential factors that effects the communication of CH with other CH's or with sink

IV. CONCLUSION

In this article common types of clustering algorithms for wireless sensor networks were explained. This article highlighted the advantages and weakness of this algorithms and the result were be shown in Table 1. At the same time it was proposed new methods for researchers to develop existing or add new protocols. Search results also compare common types of clustering algorithms for wireless sensor networks in terms of many different and comprehensive standards. Comparative results listed in detail in Table 2.

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Table 1. Advantages and weakness of common types of clustering algorithms

	Advantages	**Weakness**
LEACH	1. CH rotation creates flexibility in energy 2. No need to check the remaining energy every time slot	1. 1. Only in nearby distances effective 2. Each time the remaining energy needs examination and this generates energy consumption 3. Is residual energy after each session is not taken into account
TEEN	1. Fast data transfer 2. Clearer picture of the network 3. The changes on the entire network broadcast	1. CH lose energy rapidly as it in the case of a continuous sensor 2. Wasted time waiting for data from node that not case-sensitive 3. Unexpected cluster collision
APTEEN	1. count-time interval provides a flexible contract 2. more control by allowing user to set the count-time interval (CT)	1. Dealing with new functions such as Count Time and continuous query in multiple levels creates complexity in the group 2. The overall complexity of the network
HEED	1. Energy distribution for all nodes to prolong the life of the network 2. All nodes can do all tasks 3. Updated periodically to neighbors 4. Easy to make clusters	1. Continuous contact generates lost energy 2. periodically cluster configurations dispels energy
PEGASIS	1. Avoid multiple nodes tasks by giving the transfer function to a single node 2. Use aggregation to avoid sending unnecessary information and thus save energy	1. No consideration of node distance from BS 2. Contact depends on one node and this generates momentum and hence the delay in sending the information 3. Do not treat the nodes on the basis of the remaining energy

Table 2. Comparative results of common types of clustering algorithms

	LEACH	**TEEN**	**APTEEN**	**HEED**	**PEGASIS**
Scalability	**Great**	**Great**	**Well**	**little**	**Chains Based**
Cluster Scalability	**average**	**Great**	**little**	**Great**	**little**
Complexity	**little**	**Great**	**Great**	**average**	**Great**
Energy Efficiency	**little**	**Great**	**average**	**average**	**little**
Classification	**Clustering**	**Reactive/Clustering**	**Hybrid**	**Clustering**	**Reactive/Clustering**
Delivery Mod	**Cluster Head**	**Active Threshold**	**Active Threshold**		**Chains Based**
Data Aggregation	**Provides**	**Provides**	**Provides**	**Provides**	**not Provides**
Power Usages	**average**	**average**	**average**	**Great**	**Great**
QoS	**not Provides**	**not Provides**	**not Provides**	**not Provides**	**not Provides**
Query Based	**not Provides**	**not Provides**	**not Provides**	**not Provides**	**not Provides**
Over Head	**Great**	**Great**	**Great**	**average**	**little**
Resource Awareness	**Provides**	**Provides**	**Provides**	**Provides**	**Provides**
not Provides Mobility	**Fixed BS**	**Fixed BS**	**Fixed BS**	**Stationary**	**Fixed BS**
Routing	**Cluster Based**	**Hybrid**	**Hybrid**	**Cluster Based**	**Chains Based**

Balanced Clustering	**average**	**N/A**	**Great**	**Great**	**Great**
Multi-Hop	**not Provides**	**Provides**	**Provides**	**Provides**	**not Provides**
Power Management	**Great**	**Great**	**Great**	**N/A**	**Great**
Network Lifetime	**little**	**average**	**Great**	**Great**	**Great**
Heterogeneity	**not Provides**	**N/A**	**Provides**	**not Provides**	**Provides**
Head Selection Parameters	**Energy**	**Location/ Energy**	**Location/ Energy**	**Energy**	**Energy**
Clustering Method	**logical**	**logical**	**logical**	**refined**	**logical**
Cluster Count	**Fixed**	**Variable**	**Variable**	**Variable**	**Fixed**
Area of Use	**monitor machinery for fault detection and diagnose Provides**	**Time critical apps. intrusion detection explosion detection**	**periodic sensing habitat monitoring animal monitoring in the forest**	**prolonging the network lifetime rather than WSN needs**	**surveillance application motion detection, motion characteristic detection**