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Evaluating the Gaps of Different Energy Efficient Protocols of WSN

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Abstract- This paper presents a review on well-known energy efficient protocols of WSN. Wireless sensor network (WSN) is becoming popular day by day due it is used in wide range of critical applications. But in WSN each node also called sensor node has a battery and each battery has limited lifetime. Therefore each sensor node will become dead after the consumption of this battery. So using the battery in efficient way becomes critical issue. The LEACH protocol and its extensions are used to achieve the maximum possible lifetime. Each LEACH extension enhances the lifetime by introducing better selection of cluster head among sensor nodes. This paper has focused on found the gaps in existing literature. This paper also ends up by defining a hypothesis for a new improved WSN protocol which has proficiency to reduce the gaps in the existing literature.

Index Terms- Energy, LEACH, Network Lifetime, WSN

1. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The development of wireless sensor network was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

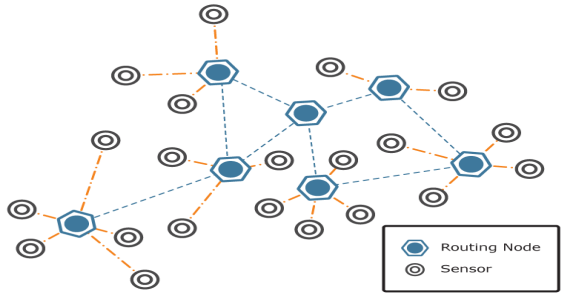

Figure-1 Sensor Network

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts:

- a radio transceiver with an internal antenna or connection to an external antenna
- a microcontroller
- an electronic circuit for interfacing with the sensors and an energy source
- A battery or an embedded form of energy harvesting.

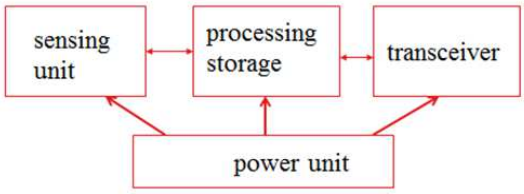

Figure 2- Sensor Node

A sensor node might vary in size from a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

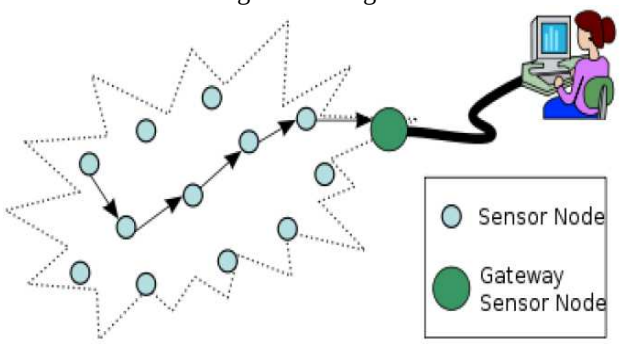

Figure 3- Typical Wireless Multi-hop sensor network

2. LEACH- LOW ENERGY ADAPTIVE CLUSTERING HIERARCHY

Low Energy Adaptive Clustering Hierarchy ("LEACH") is a TDMA-based MAC protocol which is integrated with clustering and a simple routing protocol in wireless sensor networks (WSNs). The goal of LEACH is to lower the energy consumption required to create and maintain clusters in order to improve the life time of a wireless sensor network.

LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station (sink). Each node uses a stochastic algorithm at each round to determine whether it will become a cluster head in this round. LEACH assumes that each node has a radio powerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy. Nodes that have been cluster heads cannot become cluster heads again for P rounds, where P is the desired percentage of cluster heads. Thereafter, each node has a 1/P probability of becoming a cluster head in each round.

At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data. All nodes that are not cluster heads only communicate with the cluster head in a TDMA fashion, according to the schedule created by the cluster head. They do so using the minimum energy needed to reach the cluster head, and only need to keep their radios on during their time slot.

LEACH, which was presented by Heinzelman in 2000, is a low-energy adaptive clustering hierarchy for WSN. The operation of LEACH can be divided into rounds. Each round has two phases:

- Set-up phase
- Steady phase

During the set-up phase, each sensor node tries to select itself as a cluster head. For selecting a cluster head, each sensor node generates a random number δ between 0 and 1. If the δ is less than the threshold T(n), the sensor node selects itself as a cluster head for current round, the threshold is presented as follows:

$$T(n) = \begin{cases} \dfrac{k}{N - k\left[r \bmod \left(N/k\right)\right]} & if\ n \in G \\ 0 & otherwise \end{cases}$$

where N as the total number of sensor nodes in the network, k as the number of cluster head nodes for each round, r as the number of the current round, and G is the set of nodes that have not been selected as cluster heads in the last N/k rounds.

During the steady-phase, the cluster head keeps its receiver on to receive all the data from the nodes in the cluster. Once the cluster head receives all the data, it can operate on the data, and then resultant data are sent from the cluster head to the base station. In order to minimize the set-up overhead, the steady-state phase is long compared to the set-up phase.

3. LITERATURE REVIEW

M M Islam; et al. (2012) [1] using “hierarchically Clustered” technique discussed in a paper entitled “Extended Stable Election Protocol (SEP) for Three level Hierarchical Clustered Heterogeneous WSN” proposed an extended Stable Election Protocol (SEP) algorithm for cluster head selection in a hierarchically clustered heterogeneous network to reorganize the network topology efficiently. The presented algorithm considers that sensor nodes are static and randomly distributed in the heterogeneous network, the coordinates of the sink and the dimensions of the sensor field are known. Islam’s results showed that the extended SEP algorithm achieves better performance than the existing SEP algorithm in terms of network lifetime and throughput.

Georgios smaragdakis; et al. (2004) [2] using “weighted election probability” technique discussed in a paper entitled “SEP: A Stable Election Protocol for clustered heterogeneous wireless sensor networks” proposed SEP, a heterogeneous-aware protocol to prolong the time interval before the death of the first node (refer to as stability period), which is crucial for many applications where the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. Simulation showed that SEP always prolongs the stability period compared to (and that the average throughput is greater than) the one obtained using current clustering protocols. SEP yields longer stability region for higher values of extra energy brought by more powerful nodes.

Lazar Berbakov; et al. (2013) [3] using “energy harvesting” technique in a paper entitled “Optimal transmission policy for cooperative transmission with energy harvesting and battery operated sensor nodes” considered a scenario where one energy harvesting and one battery operated sensor cooperatively transmit a common message to a distant base station. The goal was to find the jointly optimal transmission

(power allocation) policy which maximizes the total through put forgiven deadline.
First, the case in which the storage capacity of the energy harvesting sensor is infinite was addressed. In this context, the necessary conditions for such optimal transmission policy were identified. On their basis, firstly the problem is convex was shown. Then one step beyond was proved that (i) the optimal power allocation for the energy harvesting sensor can be computed independently; and (ii) it unequivocally determines (and allows to compute) that of the battery operated one.

B. A. Sabarish; et al (2012) [4] used "Data Mining" technique discussed in a paper entitled "Improved Data Discrimination in Wireless Sensor Networks" proposed an algorithm to collect data values both at node and cluster level and find the principal component using PCA techniques. Using Data Mining Technique data discrimination is done at node and cluster level leading to a comparison made in the Statistical and Bucket-width outlier detection algorithm that improves efficiency.

Cedric Walravens; et al (2012) [5] using "parallel prefix-sums" technology discussed in a paper entitled "Design of a Low Energy Data Processing Architecture for WSN Nodes" 2012 anticipated an architecture to calculated energy-efficiency consisting of several parallel processing elements (PEs) structured as a folded tree. Profiling SystemC models of the design with ActivaSC helps to improve data-locality resulting in an improvement in terms of energy as compared with traditional MCUs found in sensor nodes. An alternative low power ASIC approach for WSN data processing in sensor nodes without sacrificing too much of the flexibility found in traditional MCUs is introduced.

Yingying Liu; et al (2012) [6] has discussed a paper entitled "Balance-Aware Energy-Efficient Geographic Routing for Wireless Sensor Networks". A balance-aware energy-efficient geographic routing protocol (BEGR) is proposed. Both energy consumption in communication and residual energy at nodes are considered in BEGR. Liu proved that their protocol is loop-free and can adapt to dynamic scenarios resulting in prolonging network lifetime greatly based on first-dead time. A cost metric is proposed. The optimal relay is the node which has the least cost among the nodes within a certain search region. The least-cost routing algorithm is aimed at extending the battery's lifetime of network, focused primarily on the very first dead node due to energy depletion.

Kansal R; (2012) [7] using "distributed cluster formation technique" has discussed a paper entitled "Enhanced Uniform Distributed Clustering Algorithm (UDCA) In Wireless Sensor Network" presenting an ENHANCED UDCA (Uniformly Distributed Clustering Algorithm) which maximizes the network lifetime by reducing the number of communication among sensor nodes and base station. This algorithm includes new distributed cluster formation technique that enables self-organization of large number of nodes, algorithm for maintaining constant number of clusters by prior selection of cluster head and rotating the role of cluster head to distribute the energy load among all sensor nodes.

Kaur R; et al. (2012) [8] using "Genetic algorithms" discussed in a paper entitled "Efficient Energy Consumption In Wireless Sensor Consumption Technique" proposed an optimization of energy consumption in wireless sensor networks. Genetic algorithm is used to optimize this problem which reduces the energy consumption in wireless sensor networks.

Femi A. Aderohunmu; et al. (2011) [9] using "overhead-cost" technique discussed in a paper entitled "A Deterministic Energy-efficient Clustering Protocol for Wireless Sensor Networks" proposed a deterministic energy-efficient clustering protocol that is dynamic, distributive, self-organizing and more energy efficient than the existing protocols. It utilizes a simplified approach which minimizes computational overhead-cost to self-organize the sensor network. Simulation result shows a better performance with respect to energy consumption, which is reflected in the network lifetime in both homogeneous and heterogeneous settings when compared with the existing protocols.

Chi-Cheng Chuang; et al (2011) [1] used technique "compressing the volume of sensing data during communication" discussed in a paper entitled "Data Compression for Energy Efficient Communication on Ubiquitous Sensor Networks". An efficient compression mechanism for WSN by treating sensing data as the raw data of an image for compression has been proposed. Chuang also introduced the user-acceptable data error which can be defined by a user to enhance the compression efficiency. Experimental results show that their mechanism can reach a better compression ratio compared with other approaches in either higher or lower correlated data scenario.

More power can be saved during the radio communication due to lower volume of data. Furthermore, since their mechanism only involves addition and subtraction operations, the extra calculating burden resulted from compression can be

minimized and thus, the extra power used to such calculation is negligible compared with the power used for transmitting a single bit data.

Chih-Hsun Anthony Chou; et al (2011) [11] used technique "construction of dead-end free networks using a minimum number of active nodes" discussed in a paper entitled "A Dead-End Free Topology Maintenance Protocol for Geographic Forwarding in Wireless Sensor Networks" that a distributed dead-end free topology maintenance protocol, designated as DFTM, for the construction of dead-end free networks using a minimum number of active nodes. DFTM also successfully constructed a dead-end free topology in most of the simulated scenarios. Additionally, even when the locations of the sensors were not precisely known, DFTM still ensured that no more than a very few dead-end events occurred during packet forwarding.

4. GAPS IN LITERATURE

a) The time duration of the setup phase is non-deterministic and the collisions will cause the time duration too long and hence, the sensing services are interrupted. Due to that Leach may be unstable during the setup phase that depends on the density of sensors.
b) Leach is not applicable to networks that are deployed in large region as it uses single hop routing where each node can transmit directly to the cluster head and the sink
c) The cluster heads used in the LEACH will consume a large amount of energy if they are located farther away from the sink.
d) Leach does not guarantee good cluster head distribution and it involves the assumption of uniform energy consumption for the cluster heads.
e) Leach uses dynamic clustering which results in extra overhead such as the head changes ,advertisement that reduces the energy consumption gain

5. CONCLUSION

By conducting the survey it has been found that still much improvement is required in the field of the WSN. One of the best improvements is found by conducting the survey is to select that node as cluster head which has highest energy among available sensor nodes. This may also remove the constraint of the pure leach T(n) i.e. no node will become cluster head again in next 1/p rounds. The division of the energy will be done by taking deterministic decisions were random in most of the existing algorithms. In near future a news protocol will be proposed, that will be implemented using some well-known tools for sensor networks. As division among three kinds of nodes will come up with some potential overheads so in near future we will try to reduce these overheads as overheads may become bottleneck of protocol so we will try to prevent it.

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