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Dynamic cluster Selection based on less energy dissipation in Wireless Sensor Network

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Abstract: **— The ever-rising demands for real time transmission requirement has widened up the scope for wireless sensor network. From the conventional use of gathering, processing and transmitting data via network for offline and online analysis, WSN sensing devices are now used in various industries for efficiently monitoring and controlling real time requirements. However, the rapid consumption of energy and its wastage is still a major challenge. Therefore, in this research study, we will propose a new algorithm to select a cluster head in the wireless sensor network as these cluster heads play a very significant role in the reduction of energy consumption while enhancing the lifetime of the whole network.**

***Index terms*: Wireless Sensor Network, cluster head, energy, algorithm, challenge, monitoring.**

I. INTRODUCTION

Wireless Sensor Network is a latest high end technology that holds its significance in successfully monitoring and tracking a targeted physical or environmental condition like light, temperature, pressure, sound and so on to efficiently pass on the data through its network to the main site. This revolutionary information gathering technology came into existence with the idea of keeping surveillance checks in the wars or battlefields. Today, it is effectively used in the industries for monitoring the health of machineries, or other monitoring and controlling applications.

The wireless sensor networks (WSN) are actually spatially dispersed and dedicated autonomous sensor nodes which are laced with sensors to sense and identify the physical occurrences. A WSN may have a few sensory nodes to a hundreds or thousands of nodes that are connected with a single or multiple sensors. Each sensor node has a radio transceiver to connect it with the external link, an electronic circuit called microcontroller to interface the sensor nodes and an energy source such as a battery. Each node is connected with one another to build a network for transmitting the data. This network can either be a simple star shaped network or a multi-hop wireless mesh network in which the propagation of data can be routing or flooding.

The most common and vastly used applications of wireless sensor networks comprises of area monitoring wherein WSN is set up within a particular region to scrutinize certain physical conditions such as enemy intrusion during war, geo-fencing of gas and oil pipelines; healthcare monitoring to keep a check on the overall health of the patient in the hospital and at home; environmental monitoring in which air is monitored for the concentration of dangerous gases in it, forest fire detection, for landslide to detect even a slight movement in the soil; analyze the properties of water in the rivers, lakes, seas and oceans. In addition to this, the application of WSN in the industries for monitoring the health of machineries, data center, data logging, structural health of a building or infrastructure and so on. It is an avant-garde technology that efficiently and effectively caters to the ever-rising harsh physical phenomena with constantly reducing power supply.

With the advancement of wireless sensor network and miniaturizing of sensor nodes, researchers from around the world are allured in finding ways to widen up the scope of WSN and take it to new heights where limitations of the existing WSN would no longer limit the capability of the extremely minute sensors in the real-time applications. However, there is yet another rigorous and inflexible need of the sensory node which is to make the most of the already given or provided energy source. This efficient usage of energy source by the sensory nodes defines and determines the lifetime of a wireless sensory network. Although WSN comprised of low-power, multi-functioning sensor nodes that deals under isolated settings with highly restricted computational and sensory aptitudes, still the sensory nodes communicate information with other connected nodes in the network. Nevertheless, it is the careful and diligent selection of cluster head that can enhance the lifetime of WSN and maximize the data to be communicated.

A number of researchers from around the world have proposed various algorithms on the basis of cluster analysis, which is a process of grouping a set of objects which are similar in one way or the other to competently manage the energy required by each and every node in the WSN. This WSN divides the network into clusters, each with a cluster head (CH) and a network of sensory nodes to gather, process and transmit the data/ information to the sink called base station. The selection of cluster heads are either done randomly or on the basis of one or more criteria whereas the sensors are arranged in abundance to efficiently cater to the coverage requirement while facilitating a few sensor nodes to switch to sleep mode for energy saving.

Dynamic Clustering is yet another successfully algorithm which has been used in the wireless sensor network with the idea of reducing the energy dissipation of the network. Dynamic clustering is an energy efficient algorithm, which was coined by ABC in reference to k-means clustering that is a means of dividing a large set of data into k clusters with roughly the same number of n neighbor nodes closest to them. These k-means of clustering serves as a prototype of the cluster, however, the dynamic clustering has more similarities with the k-nearest neighbor algorithm wherein classification is done on the basis of the majority votes of the neighbors. The core idea behind dynamic clustering is its basis of constant comparisons and re-examination of the new data classifications with the original data to decide the next mode of classification. Dynamic clustering algorithm optimizes the energy dissipation by periodically re-electing the Cluster Head (CH) to bring a balance amongst the nodes in each cluster. The neighbor nodes of a cluster works at low level in comparison to the cluster heads that work at high level hierarchal to form two level hierarchies in cluster formation. These sensory neighbor nodes process and transmit its data to the cluster head that later cumulate the data and send it to the base station either directly or through an intermediate or other cluster head. This way cluster head being few in number as compared to the sensor nodes end up exhausting ample amount of energy while transmitting the data to the base station. Energy consumption in WSN is based on the transmission of the data, amount of data, distance covered, optimal routing protocol and so on. Therefore, periodical re-election of cluster head on regular intervals not only helps in the reduction of energy consumption but also enhances the lifetime of the WSN network.

It is the selection of cluster head that affects the lifetime of WSN. Many researchers have proposed various algorithms on the basis of various factors to select the cluster head and enhance the lifetime of WSN. But a lot more research needs to be done in this area as majority of the existing algorithms have their own drawbacks.

II. LITERATURE SURVEY

The ever rising demand for smart and intelligent monitoring and management of an assortment of infrastructure systems has given a thrust to the emergence of sensory nodes and networked embedded devices. However, the increasing use of wireless sensor network has posed certain questions in terms of the efficient usage of the energy source coupled with the enhancement of WSN lifetime. Although many researchers have proposed and presented various algorithms to select the cluster head for effectively improve the lifetime of WSN, still a lot more needs to be done in this area to get over the limitations of already existing algorithms for cluster selection.

Buddha Singh et al. [1] in their research study proposed Particle Swarm Optimization (PSO) approach for generating energy-aware clusters by optimal selection of cluster heads. The PSO eventually reduced the cost of locating optimal position for the head nodes in a cluster.

Blessy Varghese et al. [2] in their research study stated that to achieve enhancement in network lifetime, efficient communication and reliability in WSNs, deploying a good clustering technique is essential. Secured clustering was done using Associativity based cluster formation schemes based on the spatio-temporal stability. Secure & Fault Tolerant Clustering algorithm worked on sensor networks, the complete process of selection was refreshed after every second to finalize the cluster head, thereby ended up enhancing the lifetime of WSN.

Bijan Kumar Debroy et al. [3] in their research study proposed Energy-Cost Ratio Based Cluster Head determining Protocol (ECRBCP) for cluster head selection based on sensor nodes' energy per unit cost. ECRBCP utilized the high-energy base station to perform most energy related tasks. ECRBCP contributed to the study of wireless sensor networks by addressing the problem of increasing system lifetime and maximizing data communication via proper cluster head selection.

Choon-Sung Naam et al. [4] in their research study proposed adaptive cluster head selection that reorganized the clustering, considering the position between a cluster head and the nodes in a cluster.

Hu Junping et al. [5] in their research study presented a Time-based Cluster-Head Selection Algorithm for LEACH. They called this new protocol TB-LEACH. They provided a comparison between their protocol and LEACH protocol and showed that their algorithm outperformed original LEACH by about 20 per cent to 30 per cent in terms of system lifetime.

Indranil Gupta et al. [6] in their research study stated that a fuzzy logic approach to cluster-head election was proposed which showed that depending upon network configuration, a substantial increase in network lifetime could be accomplished as compared to probabilistically selecting the nodes as cluster-heads using only local information.

Ma Chaw Mon Thein et al. [7] in their research paper proposed an energy efficient cluster-head selection algorithm for adapting clusters and rotating cluster head positions to evenly distribute the energy load among all the nodes. It successfully implemented better load balance and prolong the lifetime of the network.

Puneet Azad et al. [8] in their research paper presented a Fuzzy multiple attribute decision-making (MADM) approach to select CHs using three criteria including residual energy, number of neighbors, and the distance from the base station of the nodes. This approach was more effective in prolonging the network lifetime than others.

S. Taruna et al. [9] in their research paper proposed and analyzed a new approach which involved choosing the cluster head that lied closest to the midpoint of the base station and the sensor node. Their proposed routing algorithm was related with energy and distance factors of each nodes and effectively extended the network lifetime with less consumption of energy in the network.

Stanislava Soro et al. 10] in their research paper took a unique look at the cluster head election problem and proposed an approach based on a set of coverage-aware cost metrics that favored nodes deployed in densely populated network areas as better candidates for cluster head nodes, active sensor nodes and routers to increase the time from 25 per cent to 4.5×, depending on the application scenario.

Sang H. Kang et al. [11] in their research work proposed a distributed CH selection algorithm that took into account the distances from sensors to a base station that optimally balanced the energy consumption among the sensors. It outperformed existing algorithms in terms of the average node lifespan and the time to first node death.

Ying Liang et al. [12] in their research work proposed an optimal energy adaptive clustering algorithm to optimize LEACH's random cluster-head selection algorithm and ensure the balanced energy depletion over the whole network thus prolonging the network lifetime. Their algorithm outperformed LEACH by about 20 per cent to 35 per cent when 1 per cent, 50 per cent, 100 per cent of nodes died for different network sizes and topologies.

Yaoyao Yin et al. [13] in their research work proposed a centralized cluster head selection approach using analytical hierarchy process (AHP). The proposed approach was effective in prolonging the network lifetime.

III. WSN APPLICATION: REQUIREMENTS & CHALLENGES

Wireless Sensor Network (WSN) being a resource constraint network, needs to arrange and manage its energy resources capably to remain active in transmitting sensitive data to the base station without any delay. As Wireless Sensor Network is deployed in mission critical applications, its effective and efficient working holds great significance, for which it requires to have a prolonged system lifetime and unhindered data communication. In order to ensure successful data transmission and energy transaction, clustering is considered as the best solution to cater to all its requirements. Cluster scheme divides the network into a Cluster Head (CH) and sensor nodes and selection of this CH decides the fate of the WSN. Although CH can be selected randomly but the requirements are generally taken into account while selecting a CH, which are – highest residual energy, maximum number of neighbor sensor nodes, lesser distance from the base station. These requirements enable the cluster head in utilizing the limited energy in the most efficient manner in order to enhance the lifetime of the WSN and data communication.

Despite meeting these requirements in the most efficient manner, the applications of WSN and selection of CH face several challenges in terms of its design and implementation. With majority of the clustering algorithms selecting the cluster heads either on the basis of highest residual energy or periodical rotation of the cluster heads to equalize the energy consumption. However, they completely forget to consider the location of base station that often leads to the issue of hotspot failure. In addition to this, the CH located near the base station face heavier relay traffic, which leads to the early death of cluster head in comparison to the ones located far away from the base station. However, when it comes to preserving the exchanges messages, keeping the total time complexity constant and independent irrespective of the growth of the network, it has become a big challenge.

Besides this, the strength of WSN based applications must be of high priority while designing the cluster schemes and routing protocols. Also, the designed protocols must adapt to the requirements of the applications, which includes: Security of Data, wherein the communicated data must be preserved for security as WSN technology is often deployed in mission critical applications such as military surveillance and so on; Synchronization mechanism in which neighboring nodes synchronize with each other in order to allow regular sleep intervals to save energy consumption; Data Aggregation that allows the data to get compacted for transmission purposes to optimize energy. However, these requirements will remain the fundamental challenges in WSN as their effective implementation in majority of the applications is directly not possible.

IV. RESEARCH GAP

With the advent of WSN sensing tools and gadgets, various industries such as transportation, electrical and other production equipment industries have started installing these devices to meet the comprehensive monitoring requirements for smooth functioning. The coming years will witness an exponential rise in the demand of these WSN sensing devices. However, the biggest challenge with these devices is their network reliability to transmit information and power consumption. A WSN device being cluster based requires a proper cluster head selection mechanism or algorithm to enhance the overall lifetime of the whole network. These cluster heads play a significant role in the aggregation and forwarding of the information sensed and identified by familiar nodes. However, all the research studies done in this field have one limitation or the other while selecting the cluster head and evenly dispensing the energy amongst the nodes.

Keeping the various issues and limitations of the existing algorithms for selecting the cluster head, this existing research work will present an algorithm to select the cluster head on the basis of three factors –

- Residual energy of the cluster heads at the end of the completed transaction.
- Implementing weighted cluster head selection algorithm to calculate the total number of neighbor nodes and their average distance from surrounding nodes.
- Optimal distribution of cluster heads within the wireless sensor network.

V. PROBLEM STATEMENT

In the proposed research study, we will be taking into account the cluster formation by analyzing the clusters for the total number of nodes that are handled by a particular cluster head and how much energy is dissipated in the process of transmitting data from sensor nodes to the cluster head and from cluster head to the base-end. Cluster heads transmits either directly or through intermediates and in certain cases through other cluster heads as well. A huge amount of energy is dissipated in this process, especially at the cluster head end. However, the presence of a black node directly connected with a sensory neighbor node in the network or breaking down of a node in the network further increases the energy consumption to manifold. This will also help us not only in understanding the selection pattern of cluster head in the WSN but also the various factors that speedup energy exhaustion in the network.

In addition to this, energy dissipation in a wireless sensor network is linked to data transmittance, either from sensor neighbor nodes to cluster head, from cluster head to another cluster head or from cluster head to the base-station. In other words, energy gets dissipated at every data transaction the existing paper stated that cluster head energy gets dissipated after every transaction. Although majority of the research papers talked and discussed about this energy dissipation but nothing concrete has been mentioned about checking the completion of data transaction. Also, if a data transaction failed to get completed either between a sensor neighbor node and cluster head or between a cluster head and the base station, what steps should be taken to successfully complete it. Therefore, we will try and attempt to answer all these questions in this proposed research paper.

VI. DISCUSSIONS & OPEN DIRECTIONS

The wireless sensor based mission critical applications make use of the dynamic clustering mechanism to collect data from the sensor nodes. These clusters are formed dynamically and repetitively in order to conserve energy and use it uniformly. However, these dynamic clusters show great variance with the size of the cluster and the total number of nodes in it. This variance can jeopardize the data aggregation requirement of certain WSN based applications as the aggregated data from large volume clusters cannot be placed in small cluster or fixed sized packets, which can ultimately lead to the loss of critical or sensitive information. In addition to this, redundancy of data in wireless sensor network is a common phenomenon as the densely places nodes collect, process and transmit the similar data time and again to the sink node, thereby wasting a lot energy. Although the purpose of data redundancy is to make communication reliable, however, a balance is required to maintain the traffic to the base-end while optimizing energy conservation and data reliability. This is when Data Aggregation comes into picture as it is the best technique to reduce redundancy in WSN. Data aggregation filters the information sent from each and every node in the dynamic cluster by passing it through an intermediate node to avoid redundancy and compact the data for transmission to the base-station. But instead of conserving energy, the data aggregation technique fatigues its intermediate node big time, leading to its early death. Although many researchers have proposed various algorithms to provide solution to the challenges involved with the data aggregation technique, still this area of WSN needs lots more exploring and discussions to find concrete solutions to these issues. Besides this, achieving accurate results while providing solutions to precision constraint problems of data aggregations are the open directions that still needs lots of working from the researchers in this field.

VII. CONCLUSION

In this research study, we proposed a new algorithm for carefully selecting the cluster head in a wireless sensor network. The selection was based on the residual energy of the cluster head, total number of neighbor nodes and their average distance from the surrounding nodes and the optimal distribution of cluster heads within the network. In this experiment, we kept a close watch not only on the energy that was being dissipated after every transaction but also on the number of packets that had been delivered by the nodes as well its neighbor nodes to determine the accuracy and efficiency of selected cluster head. In this study, our algorithm succeeded in the selection of appropriate cluster heads, thereby reducing the energy consumption of the nodes and its neighbor nodes while enhancing the overall lifetime of the wireless sensor network.

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