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Wireless Sensor Network Performance with Energy-Efficient Approaches: A Review

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***Abstract*: -** The widespread use of wireless sensor devices and their advancements in terms of size, deployment cost, measurement of environmental events and user friendly interface have given rise to many applications of wireless sensor networks (WSNs). WSNs are usually characterized as self-organizing networks which can be deployed without requiring any specific infrastructure in harsh and/or hostile area. In this paper are studied of different types of clustering protocol favors higher period in lieu of overall network lifetime. In cluster, a predetermined number of CHs are selected in deterministic fashion on the basis of residual energy of nodes. The focus is to balance the load among nodes and provide full network coverage.

Keywords:- Wireless Sensor Network, Cluster Head, Routing Protocol

I. INTRODUCTION

The recent advancements in the technology and manufacturing of small and low-cost sensors have made application of these sensors technically and economically feasible [1]. These sensor nodes are designed to possess certain sensing, computing and wireless communication capabilities. These sensors measure ambient conditions in the environment surrounding them and then convert these measurements into signals that can be processed to reveal some information about phenomena located in the area around these sensors. A large number of these sensors can be networked in many applications that require unattended operations, hence creating a wireless sensor network (WSN) [2]. One of the benefits of remote sensors networks(WSNs) is their capacity to work unattended in brutal situations in which present-day human observing plans are hazardous, wasteful and now and then in attainable. Regularly, WSNs contain hundreds or thousands of these sensor hubs, and these sensors can convey either among one another or legitimately to an outer base station (BS). A greater number of sensors allow sensing over larger geographical regions with greater accuracy. Figure 1 shows a schematic diagram of sensor node components [3].

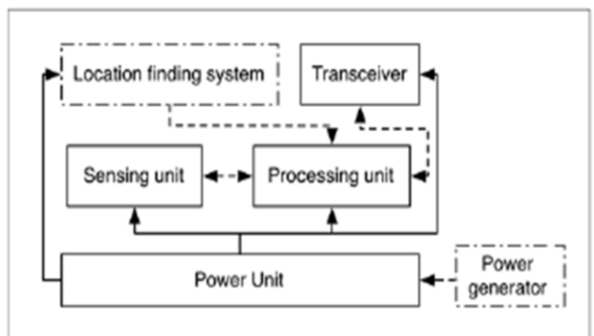

Figure 1: Functional blocks in a Sensor Node

Basically, each sensor node comprises of sensing, processing, transmission, power units and optional units like location finding system. Sensor nodes are usually scattered in a sensor field in an area where the monitoring is required. Sensor hubs facilitate among themselves to create brilliant data about the physical condition. Every sensor hub puts together its choices with respect to its main goal, the data it right now has, and its information of its registering, correspondence, and vitality assets [4].

Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external BS(s) [5].

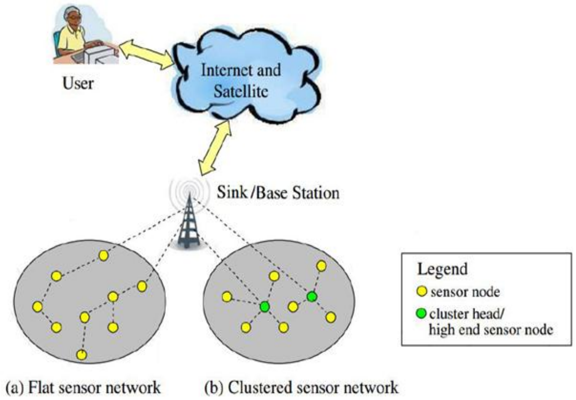

Figure 2: Architecture and operation of WSN

A BS may be a fixed or mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data. Figure 2 shows the architecture of WSN with flat & hierarchical topology [6].

Despite the numerous applications of WSNs, these networks have several constraints, such as limited energy supply, limited computing power, and limited bandwidth in the wireless linkage between the connecting sensor nodes. One of the main design goals of WSNs is to carry out data communication from sensing field to base station, while trying to prolong the lifetime of the network and prevent connectivity degradation by employing severe energy management techniques [7, 8].

The plan of steering conventions in WSNs is impacted by many testing factors. These components must be defeated before productive correspondence can be accomplished in WSNs. Some of the routing challenges and design issues that affect routing process in WSNs are:

Deployment of Nodes: Node deployment in WSNs is application dependent and it affects the performance of the routing protocol. The deployment can be either predetermined or random in nature. In pre-determined deployment, the sensors are placed manually and data is routed through pre-determined paths. However, in random deployment, the sensor nodes are scattered randomly creating an infrastructure in an ad-hoc manner. If the resultant distribution of nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy efficient network operation with routing through multi-hop communication [9].

Energy consumption: Sensor nodes use up their limited supply of energy performing computations and transmitting information in a wireless environment. Sensor node lifetime is strongly dependent on the battery capacity. In a multi-hop WSN, each node plays a dual role as data sender and data router. The depletion of energy of a specific node may lead to malfunctioning and can further cause significant topological changes and sometimes, require rerouting of packets and reorganization of the network [10, 11].

Data Reporting: Data sensing and reporting in WSNs is the main purpose of its application. Data reporting varies with the application and its time criticality. Data reporting can be categorized as time-driven (continuous), event-driven (upon occurrence of an event), query-driven (query from the user), and hybrid. The design of the routing protocol is highly influenced by the data reporting model [12].

Fault Tolerance: Some sensor nodes may fail due to depletion of energy, physical damage, or environmental interference. The failure of such sensor nodes may lead to overall malfunction of the sensor network. In the event of node failures, routing protocols must configure to re-establish new links and routes to send the data to base stations without any disruption. This may require active adjustment of transmission power and data rates on the existing links to reduce energy consumption, or reroute packets through regions of the network where more energy is available [13, 14].

Node Heterogeneity: In several studies, it is assumed that all sensor nodes are homogeneous, i.e., having equal capacity in terms of computation, communication, and power. However, depending on the application, sensor nodes can have different role or capability. The existence of heterogeneous set of sensors can mitigate the burden of transmission of data to the BS. For example, hierarchical protocols designate a cluster-head node different from the normal sensors. These cluster heads can be chosen from the deployed sensors or can be more powerful than other sensor nodes in terms of energy, bandwidth, and memory [15].

Scalability: The number of sensor nodes deployed in the sensing area may be in the order of hundreds or thousands, or more. Thus, routing scheme must be able to work with any number of sensor nodes. In addition, sensor network routing protocols should be scalable enough to respond to dynamic changes in the environment [16].

Network Dynamics: In most of the applications, the sensor nodes in a network are assumed to be stationary. However, some applications demand mobility of either BS‟s or sensor nodes (Ye et al 2002). Routing messages from or to moving nodes is more challenging since maintenance of route stability and network topology becomes an important issue, in addition to energy, bandwidth etc. Moreover, the sensed phenomenon can be either dynamic or static depending on the application, e.g., detection of moving target or forest monitoring for early fire prevention. Monitoring of static events generates traffic only when reporting and dynamic events require periodic reporting, and generate significant traffic in the network [17].

Quality of Service: In some applications, quality of the data delivered might be more important. In such cases, the delivery of data within the stipulated time is very essential or otherwise the data will be deemed useless. In time constrained applications, confined latency for data delivery is another condition. In general, many applications of WSN demand conservation of energy rather than the quality of data sent, in order to extend the network lifetime. As the energy gets depleted in sensor nodes, the quality of the data is compromised to obtain the reduction in energy dissipation in the nodes [18].

II. LITERATURE REVIEW

Nashreen Nesa et al. [1], energy conservation is a challenging concern with the growing advancement in Internet of Things (IoT) technologies and is currently one of the attractive issues among researchers working in the IoT domain. In this paper, they address this issue by devising a dynamic sensor activation algorithm inspired by the popular PageRank algorithm called Sensor Rank. Unlike Page Rank algorithm which only requires the out links to rank webpages, Sensor Rank, on the other hand, dynamically analyses the network topology in terms of relative distances and link qualities between devices and the remaining energies of the devices, based on which the sensors are ranked. Optimal subsets of sensors are activated that take part in data fusion and the inactivated sensor data are regenerated with the help of Compressing Sensing technique.

Xiuwen Fu et al. [2], in these routing protocols the routing survivability under harsh environments is questionable. To tackle this issue, in this paper by referencing the concept of potential field, they design an environment-cognitive multipath routing protocol (ECMRP) in order to provide sustainable message forwarding service under harsh environments. In ECMRP, routing decisions are made according to a mixed potential field in terms of depth, residual energy and environment. The basic idea of this approach is to instruct data packets to select routes with the tradeoff among latency, energy conservation and routing survivability. As the environmental field is constructed and updated using the sensing capability of WSN itself, constructed routes can avoid crossing through the danger zones to keep the paths safe. The experimental results show that ECMRP can obtain significant improvements in packet delivery ratio and network lifetime under harsh conditions.

Da-Ren Chen et al. [3], to effectively save energy and prolong network lifetimes, networks typically adopt clustering protocols with hierarchical inter-cluster topologies for network management and data acquisition in WSNs. However, such solutions require cluster re-configuration due to early death of cluster heads (CHs) and energy inefficiency. This paper proposes a coverage- and energy-aware protocol with intra- and inter-cluster methods called CEMST based on newly defined parameters for sensor overlapping and node density functions. In addition, to adapt network dynamics while improving energy efficiency, a self-stabilizing algorithm is proposed with the Boruvka algorithm to respectively construct minimum spanning trees (MST) for intra- and inter-cluster routes.

Wael Ali Hussein et al. [4], have been designed for scalar data such as sensor data; which is small in size compared to multimedia data. The addressed challenges were the motivation to design mobile reliable routing protocol based on greedy routing structure. In this paper, we propose a new routing protocol for greedy forwarding based on throughput energy aware multi-path routing protocol (GFTEM), which is based on selection of next hop node that has the highest throughput and closer to destination node. GFTEM performance is seen and compared against Ad hoc on-demand distance vector routing protocol (AODV), Dynamic MANET on-demand routing protocol(DYMO) and greedy perimeter stateless routing for wireless networks (GPSR).

Hsiang-Hung Liu et al. [5], one of the confinements of a WSN is its constrained sensor hub vitality asset; this requires a vitality proficient steering convention that amplifies the general framework execution. Gossip directing is a great arbitrary walk steering convention that, tragically, isn't adaptable and can result in winding ways. They think about that the most brief separation between two is a straight line and that two straight lines in a plane are probably going to converge and create for WSNs an improved convention called straight-line steering (SLR), in which we build a straight way utilizing two-bounce data without the help of geographic data. SLR along these lines diminishes the vitality utilization of sensor hubs in WSNs. They propose upgraded plans to improve execution and monitor more vitality and, with broad reenactment results, show the viability of these SLR plots in examination with talk steering.

Akshay Verma et al. [6], have proposes a Grid and Fuzzy based Stable Energy-efficient Clustering (GFSEEC) Algorithm for Heterogeneous Wireless Sensor Networks (WSNs). It provides better stability period, throughput and network life time than LEACH, SEP and DEEC Protocols. This algorithm significantly improves the performance of two level as well as multilevel heterogeneous WSNs. It has been observed that with increase in stability period, lifetime of network reduces i.e. there is trade-off between stability period and network lifetime. Also the throughput of network is affected by stability period. Thus to provide better trade-off between stability period and network lifetime, this work has been further carried out in proposed GFSEEC algorithm.

Uday Kumar Rai et al. [7], this paper present the application of Maximum Likelihood Estimation (ML) algorithm for the cluster head selection with an unequal clustering protocol. In wireless sensor network it is generally found that each sensor node has their own limitation of power source which is generally not rechargeable. Therefore, an energy efficient clustering, routing and transmission scheduling has been always a priority that reduces the energy hole problem and increase the network lifetime.

Zhangbing Zhou et al. [8], with the development of the Internet of Underwater Things, shrewd things are sent under the water and structure the submerged remote sensor systems (UWSNs), to encourage the disclosure of huge unexplored sea volume. A steering convention, which isn't costly in bundles sending and vitality utilization, is central for tactile information assembling and transmitting in UWSNs. As a rule, CARP does not consider the reusability of recently gathered tactile information to help certain area applications a while later, which initiates information bundles sending which may not be gainful to applications. These two research issues have been tended to by our E-CARP. Reenactment results approve that our method can diminish the correspondence cost fundamentally and increment the system capacity partially.

Mohammed Abo-Zahhad et al. [9], have mobile sink-based adaptive immune energy-efficient clustering protocol (MSIEEP) to alleviate the energy holes. A MSIEEP utilizes the versatile insusceptible calculation (AIA) to manage the portable sink-dependent on limiting the all out disseminated vitality in correspondence and overhead control parcels. Additionally, AIA is utilized to locate the ideal number of group heads (CHs) to improve the lifetime and strength time of the system. The execution of MSIEEP is contrasted and the recently distributed conventions; to be specific, low-vitality versatile grouping chain of importance (LEACH), hereditary calculation based LEACH, alter LEACH, meeting, and portable sink improved vitality productive PEGASIS-based directing convention utilizing MATLAB. Reenactment results demonstrate that MSIEEP is progressively dependable and vitality productive as contrasted and different conventions.

Marwan Al-Jemeli et al. [10], presents a cross-layer activity model that can improve the vitality utilization and framework throughput of IEEE 802.15.4 MWSNs. The proposed model coordinates four layers in the system task: 1) application (hub area); 2) arrange (directing); 3) medium access control (MAC); and 4) physical layers. The area of the versatile hubs is inserted in the directing activity after the course revelation process. The area data is then used by the MAC layer transmission control to modify the transmission scope of the hub. This is utilized to limit the power used by the system interface to decrease the vitality utilization of the node(s). The model utilizes a system to limit the neighbor disclosure communicates to the dynamic courses as it were. Diminishing control bundle communicates between the hubs lessens the system's expended vitality. It additionally diminishes the occupation time of the remote channel. The model task drives the system to devour less vitality while keeping up the system parcel conveyance proportion.

III. PROBLEM FORMULATION

The major concern while designing and planning WSNs operation is energy consumption. Therefore, it is important to be aware regarding the residual energy and configuration of power consumed by different components of SNs. It is equally important to study the efficient algorithms that assist the organization and operation of WSN effectively.

The main objective of this research work is to design and develop communication protocols for energy constrained networks to achieve energy efficiency while maintaining good energy-delay tradeoffs. The focus is on WSNs as a class of energy constrained networks which are generally static, have little or no mobility, and have limited battery supplies. Ideally, these protocols should prolong network lifetime, without overly compromising on other performance metrics that are of interest to the application. In this dissertation, novel energy efficient communication protocols are presented that not only address the limitations of existing protocols, but also achieve good tradeoffs for energy constrained networks.

IV. COMPARATIVE STUDY

Table 1: Comparison of cluster based routing protocol

Title	Protocol	Methodology	Parameters
Sensor Rank: An Energy Efficient Sensor Activation Algorithm for Sensor Data Fusion in Wireless Networks	Popular PageRank	PageRank algorithm which only requires the outlinks to rank webpages and Sensor Rank	Lifetime enhance-ment and Throughput
Environment-Cognitive Multipath Routing Protocol in Wireless Sensor Networks	Cognitive multipath routing	ECMRP, routing decisions are made according to a mixed potential field in terms of depth, residual energy	Packet Delivery ratio and network lifetime
Context-Aware and Energy Efficient	Adopt Clustering	Prolong network lifetimes, networks typically adopt	Network Lifetime

Protocol for the Distributed Wireless Sensor Network		clustering protocols with inter-cluster topologies	
Design and performance analysis of high reliability-optimal routing protocol for mobile wireless multimedia sensor networks	Greedy forwarding based on throughput energy aware multi-path routing	GFTEM performance is seen and compared against AODV, Dynamic MANET on-demand routing protocol	End to end delay, Packet loss ratio, Energy efficient
On Energy-Efficient Straight-Line Routing Protocol for Wireless Sensor Networks	Rumor routing is a classic random-walk routing	The shortest distance between two points is a straight line and that two straight lines	Improve-ment of energy
Grid and Fuzzy based Stable Energy Efficient Clustering Algorithm for Heterogeneous Wireless Sensor Network	Stable Energy-efficient Clustering	This algorithm significantly improves the performance of two level as well as multilevel heterogeneous WSNs.	Stability of the network
Maximum Likelihood Estimation based Clustering Algorithm on Wireless Sensor Network-A Review	Maximum Likelihood Estimation	Routing and transmission scheduling has been always a priority that reduces the energy hole	Increase Network Lifetime
E-CARP: An Energy Efficient Routing Protocol for UWSNs in the Internet of Underwater Things	Channel-aware routing	To achieve the location-free and greedy hop-by-hop packet forwarding strategy	Network Capacity
Mobile Sink-Based Adaptive Immune Energy-Efficient Clustering Protocol for Improving the Lifetime and Stability Period of Wireless Sensor Networks	Mobile sink-based adaptive immune energy-efficient clustering	A MSIEEP uses the adaptive immune algorithm (AIA) to guide the mobile sink-based on minimizing the total dissipated energy in overhead control packets	Stability, Packet delivery ratio
An Energy Efficient Cross-Layer Network Operation Model for IEEE 802.15.4-Based Mobile Wireless Sensor Networks	cross-layer operation model	This model integrates four layers in the network operation: 1) application (node location); 2) network (routing); 3) MAC; and 4) physical layers.	End to end delay, comparative packet delivery ratios, Packet Overhead

V. CONCLUSION

Scalability is an important aspect which is used to save the energy in WSNs. The proposal which is used to save the energy for small networks consisting of few nodes can also be applicable for large network, i.e., it should be adaptive to adjust for the larger network domain. There is another parameter named stability that cannot be ignored while designing an energy efficient routing protocol. Most of protocols sited in the literature improve the operational lifetime of the network by ignoring its effect on the robustness or stability period of the network. There is a tradeoff between operational lifetime and stability period of the network, which needs to be handled wisely.

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