EERS: Energy-Efficient Renewable Scheme for Wireless Sensor Networks

S. Kawsalya[1] Dr. A. Kalaivani[2] M. Vijayakumar[3] P. Boopathy[4] V.Visalakshi[5]
[1,2,3,4,5]Assistant Professor
[1,3,4,5]Department of Computer Science Engineering [2]Department of Computer Applications
[1,2,3,4]Nehru Arts and Science College, Coimbatore, India [5]Sri Ramalinga Sowdambigai College, Coimbatore, India

Abstract— We analyze unequal energy utilization in a broad class of many-to-one sensor networks in this article. All sensor nodes in a many-to-one sensor network generate constant bit rate (CBR) data and send it to a single sink through multi-hop transmissions. This sensor network has a wide range of possible applications, including environmental monitoring and data collection. Based on the observation that sensor nodes near the sink would relay more traffic than other nodes in the outer sub-regions, our study confirms that nodes in the inner rings have much higher energy consumption rates (ECR) and thus have much shorter predicted lifetimes. We suggest an energy-efficient renewable scheme (EERS) to save energy based on the overall energy usage review. We argue that the basic advantages provided by developments in WSN technology can be put to good use for local distributed intelligence and control. The collected experimental data is analyzed to gain insight into the characteristics of the proposed solution.

Keywords: EERS, WSN, ECR, CBR, Renewable Energy

I. INTRODUCTION

Sensor technologies and smart networks have been used in various applications in recent years, including transportation, hospitals, and environmental sensing and monitoring. For several years, these networks offered critical responses to many issues considered significant for humanity worldwide, such as the air contamination crisis. Indeed, recent developments in wireless communications and electronics have allowed the creation of cost-effective, low-power, small-size, multifunctional sensing systems capable of communicating untethered over short distances to detect and track many environmental issues, such as air pollution [1][2]. The issue of exhausting electricity has severely impacted WSN during long-term activities due to WSN's batteries' insufficient energy and the difficulties of repairing the outdoor fields' energy supply facilities. The solution to the WSN energy dilemma is close [3].

The type of dispersed generation and utilization that will occur through future electrical networks provides an appropriate implementation domain for implementing dense monitoring and control organizations in the context of wireless sensor networks (WSN) [5]. This class of networked embedded systems facilitates distributed networking and computation. It may contribute to optimized decentralized control systems using the mesh networks and local processing capacities of individual nodes [6].

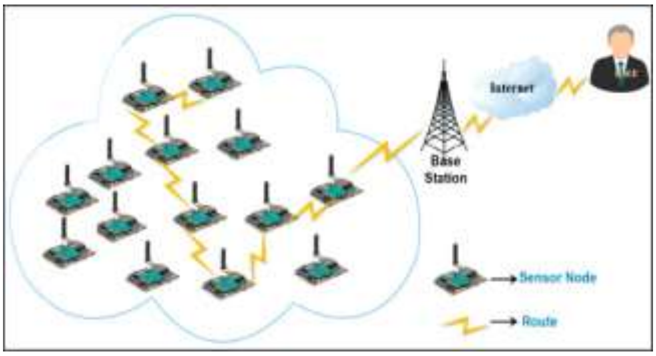

Fig. 1: Sample Wireless sensor Networks

Although the energy median and distance median problems have previously been studied independently, they are revisited in this work to analytically demonstrate that their solutions are equal when a unique shortest path tree occurs in the network [8]. Except in the general case, it is shown that the node that solves one of the two problems cannot be a neighbor node of the node that solves the other. These theoretical findings provide a connection – for the first time – between two distinct yet equally important issues. Specifically, energy usage and mobile recharging are linked to the energy hole issue and network lifetime extension in WSNs [7].

II. BACKGROUND STUDY

Bouachir, O. et al. [1] presented an opportunistic routing and data dissemination protocol for EH-WSN that is focused on cross-layer constructs that enable synchronization and communication between application layer resources and the routing protocol. Each board produces two traffic forms: Urgent Traffic (UT), which demands a low delay and packet error rate, and Delay Tolerant Data (DTD), which is sent to the sink regularly. Only when there is a sufficient residual energy level on each board does it relay its sensed data. It chooses a possible relay node from among its neighbors depending on two factors: the number of hops generated by generating the forwarder list and the neighbors' residual energy level.

Cui, X. et al. [3] To address WSN battery energy limitation, a solar energy prediction algorithm based on an adaptive filter and a clustering algorithm that performs well in the EH-WSN setting is suggested. This paper employs solar energy as a supplemental energy supply because of the universality of solar energy options. This approach, though, is not possible underwater, underground, or in any other conditions.

Li, J., & Mohapatra, P. [4] We discuss the problem of unequal energy use in sensor networks. Our intention was not to create a modern energy-saving technique. Instead, we created an analytical model to address the "energy vacuum" issue in many-to-one sensor networks. We investigate the efficacy of different current approaches for mitigating this issue based on our interpretation of the characteristics of the "energy vacuum" paradigm. These strategies can help align energy usage patterns in various sensor networks and create an equal network lifespan.

Sivasankar, P. T. et al. [7] The aim of the wireless sensor network's energy-efficient lifespan is accomplished by constructing as few nodes as possible to engage in contact. This paper discusses a strategy for finding the fewest number of attending nodes. Based on the residual energy, an initial collection of active nodes is defined.

III. SYSTEM MODEL

A. *Lead Acid Battery Fundamentals*

For more than a century, lead-acid batteries have been proved as a reliable technology for electrochemical energy storage. Their benefits include reduced costs, well-established industrial technologies, and proven behaviour. Lower energy density, susceptibility to charging and discharging environments, temperature impact, and lower usable power as deep recharge cycles limit the battery's useful life are all drawbacks. Because of permanent chemical phenomena that arise at low charge states, decreasing battery power, and lifespan, the battery state of charge (SOC), which quantifies the actual energy contained in the battery at a specified moment, must be constantly controlled. The two fundamental approaches included either tracking the voltage at the battery terminals or measuring the discharge current from a complete charge condition, defined as "coulomb counting." To calculate SOC from battery terminal voltage, look-up functions are used, equating the calculated voltage to the manufacturer's precise discharge curves.

B. *System Architecture and Networked Monitoring and Control Expansion*

We implement an accessible and cohesive architecture to allow repeatable and productive experimentation of modeling and control of storage systems in laboratory environments directly affecting real-world applications. The device is designed using a cyber-physical approach, with the following components: the actual battery/battery bank, a controller to track the system, and the control algorithm for adaptive charge and discharge activity. The primary aim is to maximize storage energy consumption while defending against potentially harmful situations such as overcharge and high discharge. This is done by taking into consideration the atmospheric temperatures and strong currents. Predefined interfaces at the boundary between the virtual and actual realms combine knowledge from both sides, resulting in the system's operation under evaluation [9].

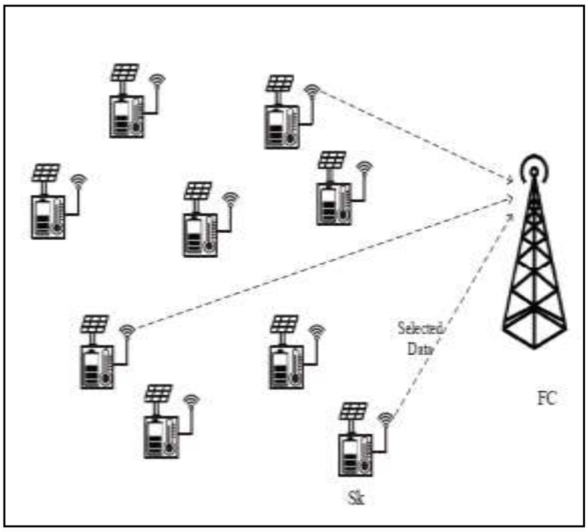

Fig. 2: WSN scenario with the renewable power source.

C. *Mobile Recharger and Battery Replenishment*

When data packet transfers occur, node batteries must be recharged. The deployment of a handheld recharger is believed to transfer and recharge the rechargeable WSN's nodes. The electricity used by the handheld recharger's single battery is used to transfer and replenish the network nodes' batteries. When the handheld recharger is near the sink nodes, it will refresh the battery by using its facilities. Let q denote the recharger's energy transfer rate and C the mobile recharger's battery's power.

D. *Energy management schemes*

Energy efficiency approaches use heuristics to maximize energy usage and make the most use of available energy. They did not, though, promise that they were the best option. For example, in the clustering process, they find an optimal number of cluster heads; in routing architecture, they find an optimal routing route selection to transmit data at the base station at the lowest cost; in the coverage region, they find the optimal number of relay nodes. Using various harvesting methods, both of the protocols provide efficient results in terms of network lifespan.

E. *Clustering and routing*

The clustering strategy creates a local sub-network to reduce the amount of data sent to the base station. Using a routing procedure, data is processed from one cluster to another or from one cluster to the base station. In WSNs, the relationship between cluster and routing is often referred to as a cluster-based routing protocol.

F. *Clustering:*

Clustering is a technique for grouping sensor clusters, and each cluster has its cluster head. One of the sensors for each is chosen or voted to be the cluster leader (CH). The CH is responsible for coordinating its cluster members. The clustering protocol's key problem is cluster head selection. In general, it is determined by the energy state of the sensor nodes.

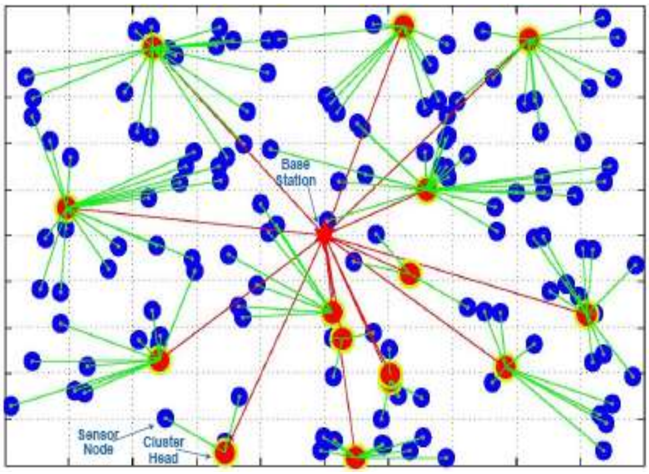

Figure 3: Cluster-based routing

G. Energy balancing

Since sensor nodes may be distributed in either a deterministic or random fashion, energy balancing is important in the sensor network. Tracking details can be available if sensor nodes are implemented in a deterministic manner; otherwise, it is difficult. However, if energy is insufficient or unbalanced across sensor nodes, it may cause network problems; hence, energy balancing is critical in sensor networks. Some methods have been used throughout the network for energy balancings, such as dynamic filtering, task rotation, scheduling techniques, time synchronization, and delay minimization.

H. Coverage awareness

Sensor coverage recognition assesses the nodes' sensing potential and establishes a geometric relationship between certain goal points and sensor nodes. The sensing coverage model displays various sensing characteristics, such as the information transformation feature, sensitivity, precision, and dynamic sensing range. Every node in the sensor network has its sensing range for neighboring nodes and sends data or gathered information to the base station.

IV. DISCUSSIONS

The average energy used in the network is inextricably linked to the charging mechanism. If the absorbed energy is elevated, the recharging phase should be more intensive, resulting in long recharging distances covered by the handheld recharger. The previous methodological findings justify the implementation of a current recharging strategy. To build on the recharging distance study findings, the suggested recharging strategy is applied to demonstrate that when both the mobile recharger and the sink node are located at the solution of either of the two listed problems, both the (network) energy consumption and the (mobile recharger) recharging distance are reduced. Besides, two other policies are listed in this segment for future comparative purposes. The latter occurs to determine whether the research findings refer to current policies; and (ii) whether the new strategy, centered on local facts, may interact with policies that use global knowledge.

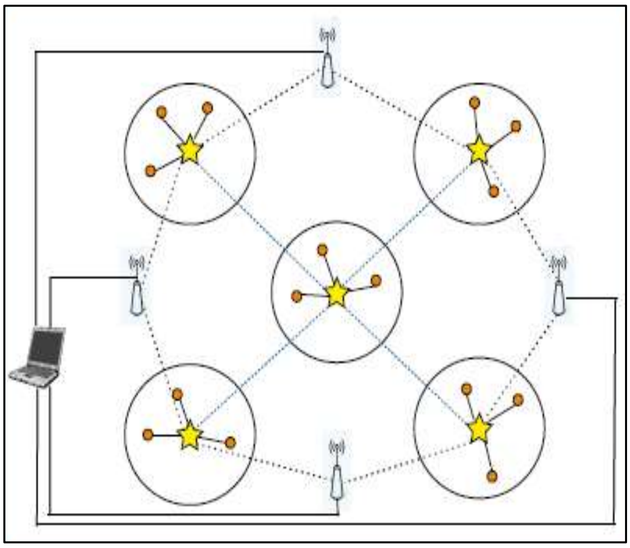
Fig. 4: Energy harvesting in the sensor network with multiple fusion centers

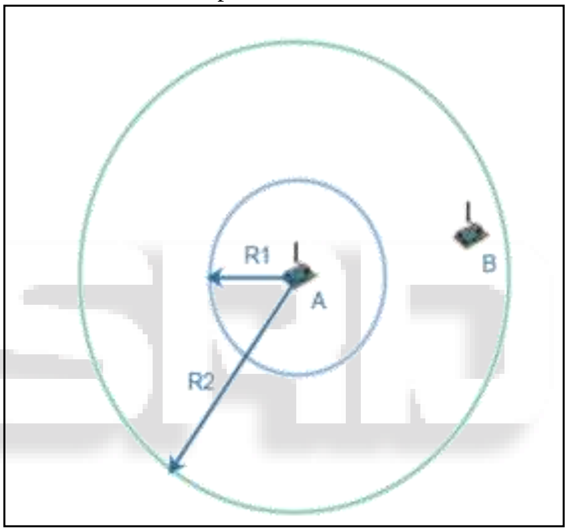

Fig. 5: Relation between sensing range and transmission range

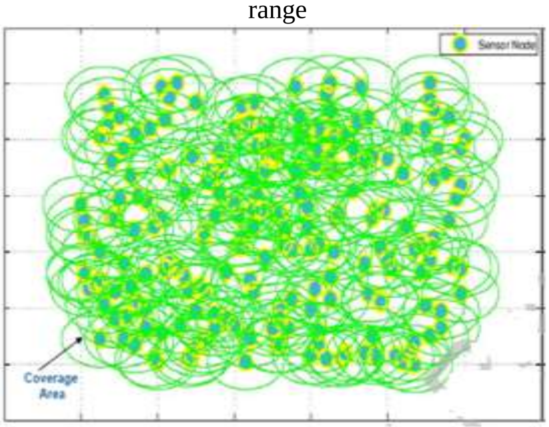

Fig. 6: Area Coverage

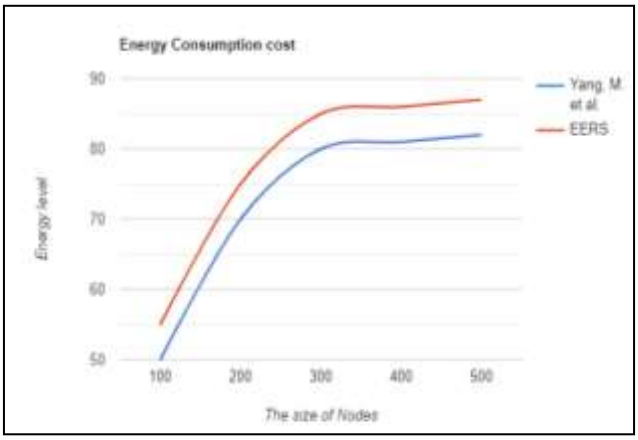

Fig. 7: Comparison chart for Renewable Energy consumption

The sensor nodes are designed to make the most use of available resources. The algorithm has been classified into two types: homogeneous and heterogeneous. Furthermore, sleep wake-up preparation is intended to carry out continuous operations with an energy harvesting device. Barrier coverage systems are mostly seen in military boundary surveillance. When it comes to barrier coverage, having at least one sensor node linked to other sensor nodes implies k = 1.

V. CONCLUSIONS

The paper (EERS) addressed the importance of energy storage in sustainable energy systems. A device architecture for the successful design of monitoring and control strategies and appropriate implementation and preliminary positive experimental findings was suggested. We contend that this strategy will improve efficiency and significantly affect the architecture of potential networks. The use of hardware-in-the-loop techniques reduces the time required to implement control strategies. Simultaneously, industrial sensor networks enable decentralized tracking and management of the renewable energy system's components. Future studies would provide an open testbed to develop control methods for renewable energy storage systems using embedded networked controllers. It is assumed that the developer can choose from a predefined library of models or build his or her own, and then choose the equipment they wish to use in the design. Long-term experiments are often expected to verify the storage system's stress behaviour.

VI. REFERENCES

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