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THE SURVEY OF CLUSTER BASED DATA COLLECTION PROCESS FOR IOT ENABLED WIRELESS SENSOR NETWORK USING SEVERAL OPTIMIZATION TECHNIQUE

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SUMMARY

Offers a detailed analysis of optimization algorithms and routing protocols are created to overcome the issues on energy efficiency with the Internet of Things (IoT) Enabled Wireless Sensor Networks (WSNs). The study analyses nature-based metaheuristic methods such as the Genetic Algorithms, Particle Swarm Optimization, Firefly Optimization, Gray Wolf Optimization and Water-Cycle Algorithms, and specialised protocols of clustering, routing and data aggregation. Both approaches address such important issues as poor cluster head selection, energy disproportion, data duplication, network overloading, and early node failure that affect network lifespan and performance adversely. The research examines the energy optimization achieved by these algorithms in the form of intelligent cluster arrangements, traffic conscious routing, task scheduling processes and data aggregations. Particular attention is focused on the resource constrained contexts in which it is not viable to swap batteries, such as smart agriculture and smart cities. The discussion shows that hybrid metaheuristic solutions with improved optimization solutions can do better in terms of meeting several goals such as minimizing energy usage, improving throughput, increasing the ratio of packets delivered and Quality of Service demands. This survey can supply useful information about the development of energy-saving solutions and define new tendencies in the optimization of IoT networks.

Key words: *iot, wsn, optimization technique, clustering, sensor node and ch node.*

INTRODUCTION

Sensor nodes are the components of wireless sensor networks that can be described by its small size, having a limited battery capacity in addition to being cheap [2][12][16]. Inter-node communication is a serious problem that contributes to energy loss in the work of WSNs [25]. Energy spending also goes up with the spatial distance of the nodes [4][5][26]. Therefore, several studies have aimed at maximizing transmission distances between sensor nodes to increase the lifespan of networks [1][27]. Clustering strategies have been identified to be effective to the applications of environmental surveillance. In sensor networks, the use of cluster architecture reduces transmission distances among most nodes and only a few nodes are required to communicate over a long distance among them including Base Station (BS) [10]. The network under cluster-based protocols is subdivided into several clusters [6][17]. In every cluster, there is a cluster- head (CH) that collects information in all the member nodes. These CHs then conduct data aggregation on information that has been collected and then send it to the BS [21].

An up-and-coming paradigm, the Internet of Things (IoT), which is based on the concept of wireless sensor networks (WSN), has proven to be a solution well needed and necessitating urgent application in time-sensitive systems such as industrial systems, health care, smart city, and automotive industries [8][18][24]. The massive usage of wireless communication technologies coupled with internet-centric frameworks such as cloud computing has fostered the intensification of IoT enabling a universal use in various fields of application [9][19][22]. IoT ecosystems sensor nodes are small, autonomous, and smart gadgets battery-powered; these ubiquitous components have self-configuration functionality and work within energy constraints and execute specific monitoring business in physical environments without human supervision [3][20].

Today, clustering algorithms that use optimization can take the leading research in wireless sensor networks [7][13][14]. Clustering allows WSNs to cover a wide area and have a higher level of expansion. In this methodology, there is a single cluster head (CH) of every cluster which communicates the sensed data to the base station. Clustering has the main aim of enhancing energy saving and operational life span of the network [23]. In the past decades, there have been many optimization algorithms, many of which have been actively researched, such as Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), Genetic Algorithm, Grey Wolf Optimization (GWO), Fruit Fly Optimization Algorithm (FOA) and watchdog systems optimization models [11][15]. These methods have the simplicity, flexibility, and data free nature character, and have a beneficial effect of avoiding data transmission interference.

WIRELESS SENSOR NETWORK SYSTEM ARCHITECTURE AND FUNCTIONALITY

The Wireless Sensor Networks (WSN) architecture that was developed to assist with the environmental monitoring, smart data processing, and distributed collection among various points. As a modern approach to massive sensor deployments, this framework integrates components of hardware, communication standards and data management systems in a resilient and scalable monitoring system. The design reflects the way sensor nodes are linked to processing units, communication networks, and remote access capabilities, which places the design as the most suitable solution to a wide array of applications such as industrial automation, environmental surveillance, as well as smart urban infrastructure development.

This system architecture is an expression of the current best practice in developing end-to-end monitoring solutions that are scalable with ease, and as well as, enduring high performance throughout in relation to distributed sensing tasks.

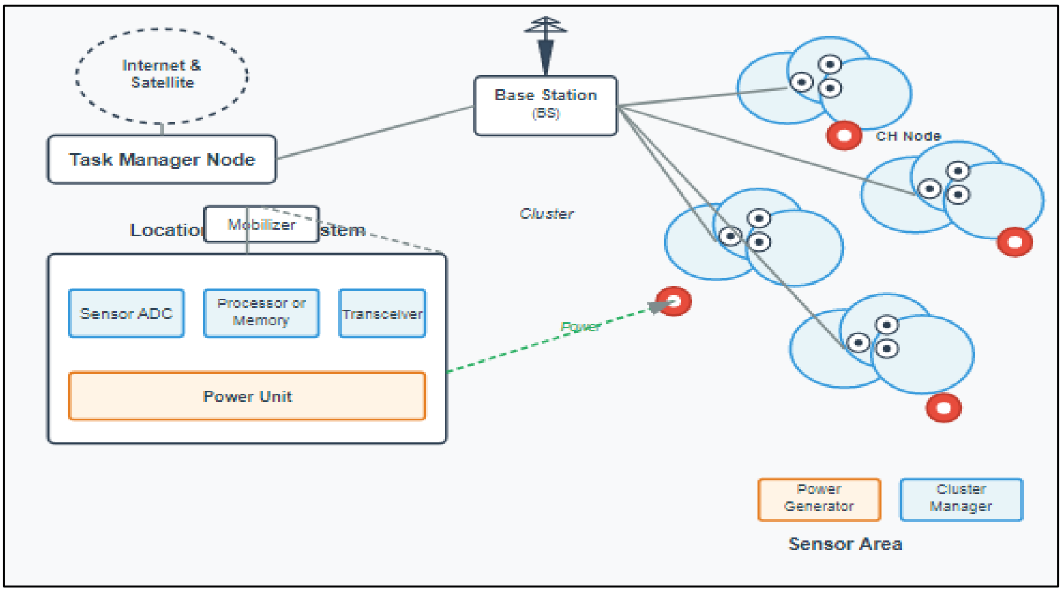

Figure 1: WSN architecture

The diagram below shows a Wireless Sensor Network (WSN) architecture with the elements of monitoring and data gathering having a few key elements (Figure 1):

Sensor Area

- Several sensor nodes (as illustrated as circular clusters) scattered on the monitoring space.
- That is, each cluster has a number of sensors arranged in a hexagonal pattern/cells.
- Clusters Each sensor cluster is controlled by a Cluster Head (CH) Node.
- A Cluster Manager Links clusters together.
- Power Generator supplies power to the sensor network.

Communication Infrastructure

- Base Station containing an antenna tower is the center of communication.
- Relates the sensor field with outside networks and systems.
- Allows transmission of data between the sensors and the control systems wirelessly.

Location Finding System (Left Side - Bottom): The mobilizer component includes:

- Sensor ADC (Analog-to- Digital Converter)- Matches sensor analog signals with digital data.
- Processor or Memory - processes and stores information collected.
- Transceiver - supports two way wireless communications.
- Mobilizer Comps - supplies power to the mobilizer components.

Management and Control (Left Side - Top)

- Test Manager Node- coordinates with testing and validation activities.
- Internet and Satellite connection- allows monitoring and access to data anywhere.

Data Gathering Mechanism in Wireless Sensor Networks

- Sensor Node: A sensor node is a basic operational component and is charged with various duties such as cluster formation, information collection, and routing information among communication hubs.

- Sensor Specification: The detection components of the WSN infrastructure are covered by specifications in the form of bandwidth capacity, storage capacity, lifespan duration, radio signal strength indicator/ RSSI, and MRIC.
- New Node Integration: During cluster formation, the functional parameters are used which deal with the current cluster members, as well as, nodes which are connected to the network.
- Cluster Development: Clusters Groupings of nodes that satisfy the parameter criteria are logged into a cluster.
- Selection of Cluster Leader: In the process of selecting the cluster leader, the lowest cost and the shortest distance are evaluated to select the node that will serve as the head.
- Battery Power Limit: This checks the minimum required battery level by making a comparison with the present battery status of the cluster leader.
- Information Gathering: All the communication nodes are joined together and any information is stored in a remote storage facility where it will be retrieved later.
- Query Processing Module: The system receives the queries entered by a user via the user interface and retrieves the information that is required by a user in a database in relation to the particular query parameters.

COMPARATIVE ANALYSIS OF CLUSTER USING OPTIMIZATION METHODS

This paper analyzes the data collection efficiency of various optimization algorithms and routing protocols that are used in sensor networks that operate on wireless networks. The sensor nodes are randomly placed within an identified area with the base station in the middle, and MATLAB and NS2 simulation software have been used.

Table 1. Summary of energy-efficient IoT algorithms and their objectives

S.No	Method	Problem Statements	Objectives
1.	Efficient Data Aggregation Scheme (EDAS)	IoT nodes are equipped with irreplaceable batteries and are resource-constrained. Continuous sensing and data gathering leads to rapid energy depletion. Packet collisions and high energy consumption.	Optimizes energy consumption and extends network lifetime.
2.	Genetic algorithm based method (GABEEC)	Inefficient cluster formation that doesn't minimize communication distances. Cluster head selection that doesn't consider residual energy levels.	Minimize energy consumption during data transmission by optimizing communication distances. Reduce the total energy expenditure of the network.
3.	Firefly Optimization Algorithm (FOA)	Duplicate data packets consume substantial energy resources. Inefficient energy utilization due to redundant transmissions.	FOA that significantly improves energy efficiency and extends network lifetime.
4.	Particle Swarm Optimization (PSO)	Multi-hop data transfers and inherent difficulties of wireless links pose substantial obstacles to efficient data transmission.	Reduce energy consumption by optimizing cluster head selection processes Balance energy distribution among sensing devices to extend network lifetime.
5.	Optimized Evaporation Rate Water-Cycle Algorithm (OERWCA)	Inappropriate CH selection leads to non-uniform energy distribution Results in reduced network lifetime and inefficient routing	To Proposed OERWCA Algorithm is to achieves that addresses the fundamental challenges of energy conservation, network longevity and data transmission efficiency

6.	proficient bee colony-clustering protocol (PBC-CP)	Replacement of node batteries is extremely difficult or impossible in hostile environments.	Maximizes the lifetime of wireless sensor networks through optimized cluster head selection and energy-efficient data transmission.
7.	Energy Prediction and Task Optimization (EPTO) algorithm	The specific problem encompasses several interconnected issues and Reduced device lifespan due to inefficient energy management.	EPTO algorithm is to Develop a multi-dimensional energy profiling mechanism that captures various energy consumption patterns of IoT devices during task execution and Battery level assessment.
8.	Traffic Aggregation Techniques for Optimizing	smart city networks experience suboptimal performance metrics of Low throughput and High collision probabilities	traffic aggregation techniques that optimize IoT network is to achieves the Throughput Enhancement and Collision Reduction.
9.	Krill Herd Aggregation Mechanism.	wireless networks and IoT devices for computation and communication over the internet has dramatically increased network traffic, leading to congestion Insufficient wireless communication.	select the most capable cluster head for efficient traffic management technique performance of Increasing Packet Delivery Ratio, Improving network throughput and Reducing Packet Loss Ratio.
10.	IoT-based agricultural sensors	Agriculture for data collection, several critical issues of High packet drop rates due to poor link quality assessment	IoT-based WSN framework for smart agriculture that optimizes network lifetime and Minimize energy consumption through intelligent routing decisions
11.	Task Scheduling algorithm - modified Grey Wolf Optimization approach (TS-GWO)	task scheduling methods struggle to effectively balance make span minimization and Cloud execution reduces user energy consumption but increases delay	TS-GWO is to achieves Minimize make span Reduce energy consumption, Meet Quality of Service (QoS) requirements of IoT devices and Optimize task execution time.
12.	Enhanced Grey Wolf Optimization (EGWO)	Power consumption and Data Processing Overhead are fundamental limitation	Primary Objective is to develop an Enhanced Grey Wolf Optimization (EGWO) algorithm that Minimize transmission power while maintaining reliable communication between nodes.
13.	Performance and Cost algorithm using Gray Wolf Optimization (PC-GWO)	Cloud computing alone insufficient for time-critical applications Distance between cloud and IoT devices creates delays unsuitable for real-time services.	PC-GWO algorithm that enhances system performance while reducing energy consumption and costs.
14.	Multi objective Grey Wolf Optimization algorithm (QAMO-GWO)	Unequal energy consumption across nodes leads to premature node failures and network partitioning The majority of energy is consumed during packet transmission, especially over long distances	To develop a multi-objective Grey Wolf Optimization for Minimizing data latency, Maximizing data delivery rate, Optimizing residual energy of nodes and Reducing energy consumption
15.	hybrid metaheuristic optimization	System consumes enormous power, reducing lifetime of sensor devices. Network sustainability is compromised due to excessive energy usage. Network instability due to premature node failures.	Energy-efficient cluster head selection in IoT networks to maximize network lifetime and performance.
16.	Improved energy-efficient LEACH (IEE-LEACH)	Premature node death due to unbalanced energy consumption Poor energy load balancing across the network.	Substantially reduce energy consumption compared to existing protocols.

			Increase data transmission efficiency. Enhance network stability period.
17.	Energy Efficient and Reliable Routing Algorithm (DS-EERA)	Traditional shortest-path routing strategies creates Unbalanced Energy Distribution and Network Congestion	To develop an energy-efficient and reliable routing algorithm that simultaneously optimizes energy utilization, balances network load, and improves data transmission reliability.
18.	Intelligence Traffic Routing (ITR)	The traffic congestion leads to three critical performance issues of Packet Loss and Packet Delay	implement an Intelligent Traffic Routing (ITR) algorithm that effectively manages packet flow and eliminates traffic congestion.
19.	Energy Efficient Routing Protocol (EERP)	The proposed algorithm that creates several critical issues of inefficient clustering and routing protocols, Transmission of redundant data and leading to rapid battery depletion.	Energy Efficient Routing Protocol (EERP) for IoT-based Wireless Sensor Networks that significantly reduces energy consumption and Reduce Redundant Data Transmission.
20.	Traffic-Aware and Cluster-Based Energy Efficient Routing Protocol (TCER)	IoT devices typically have limited resources in terms of power, computation, and storage capacity. Lack of traffic-aware mechanisms leads to congested paths and packet losses. Inefficient energy utilization leads to reduced network lifetime.	Implement optimal cluster head selection among high-energy nodes to extend cluster lifetime Reduce clustering overhead through efficient CH rotation within clusters

This Table 1 summarizes various algorithms designed to optimize energy consumption and enhance network performance in IoT and wireless sensor networks. It includes the method name, associated problem statements, and the specific objectives each algorithm aims to achieve, such as extending network lifetime, reducing energy consumption, and improving data transmission efficiency.

CONCLUSION

This general Survey has systematically studied various optimization algorithms and routing protocols which can take care of the underlying challenge of energy efficiency in IoT and WSN environment. The discussion shows that nature-inspired metaheuristic-based algorithms, especially their improved forms of Grey Wolf Optimization, Particle Swarm Optimization, as well as hybrid models are much more advantageous in relation to the other protocols in terms of lifespan and energy efficiency of the networks. The study demonstrates that the effective energy optimization needs a multi-dimensional strategy including smart cluster head choice, reasonable data aggregation, traffic based routing and dynamic task scheduling procedures. Predictive algorithm implementation and real time traffic management has been shown to be useful in alleviating packet collisions, delays and enhancing the overall network throughput. According to the survey, one of the areas of information that future work needs to be done through are on the formulation of adaptive hybrid algorithms, which can dynamically adapt to varying network conditions and devices with divergent capabilities. The single objective to multi-objective optimization frameworks is one of the most essential changes towards the attainment of balanced performance in terms of energy consumption, latency, reliability and Quality of Service measures.

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