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A review paper on wireless sensor network techniques in Internet of Things (IoT)

Kamal Gulati [a,*], Raja Sarath Kumar Boddu [b], Dhiraj Kapila [c], Sunil L. Bangare [d], Neeraj Chandnani [e], G. Saravanan [f]

[a] ASIBAS, Amity University, Noida, India
[b] Department of CSE, Lenora College of Engineering, Rampachodavaram, Andhra Pradesh, India
[c] Department of Computer Science & Engineering, Lovely Professional University Phagwara, India
[d] Department of I.T., Sinhgad Academy of Engineering, Pune, India
[e] Military College of Telecommunication Engineering, Mhow, Madhya Pradesh, India
[f] Department of Electrical and Electronics Engineering, KPR Institute of Engineering and Technology, Coimbatore, India

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A B S T R A C T

In recent times, it has been witnessed that wireless systems based on IoT-based have developed rapidly in various sectors. The IoT (Internet of Things) is the network in which physical devices, equipment, sensors and other objects can communicate among themselves without human involvement. The WSN (Wireless Sensor Network) is a central component of the IoT, which has proliferated into several different applications in real-time. The IoT and WSNs now have various critical and non-critical applications impacting nearly every area of our everyday life. WSN nodes are usually small and battery-driven machines. Thus, the energy effective data aggregation techniques that increase the lifespan of the network are highly significant. Various approaches and algorithms for energy-efficient data aggregation in IoT-WSN systems were presented. This paper reviews the literature with specific attention to aspects of wireless networking for the preservation of energy and aggregation of data.

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1. Introduction

Our everyday life has changed significantly in all respects with the beginning of wireless networking technology. The Internet of Things (IoT) is especially one of the fastest evolving technologies of the future. Multiple devices can be associated in the physical world, which basically changes our everyday life, by adding IoT. The need for communications everywhere and every-time, particularly in fields with increased activity, is, therefore, increasing rapidly.

The IoT has been viewed as integration and communication between intelligent objects (things). IoT's supremacy contributes to new technologies and applications. Such sensors and actuators (for example, home appliances, security cameras and sensors for environmental monitoring) are usually fitted with various types of transceivers, microcontroller devices, and protocols for communication of control and sensor data [1]. Such real time modules such as sensors, are interconnected with one another to transmit sensed data to the centralized repositories, in which the data is cumulatively stored and accessible for users with the right to access. In comparison to conventional wired or wireless networking systems, the features of IoT utilizing wireless technologies are somewhat different as the number of communication devices is quite high [2]. However, IoT-based traffic is not usually much critical because of every IoT device senses and transmits some data to a respective IoT Server, thus data produced by a large number of objects might have some effects collectively on efficiency of the network. Therefore, for a long time without any human interference, the IoT networks will run in a safe and sustainable manner.

Heterogeneous WSN that link a wide range of intelligent sensors has become the cornerstone for the IOT-based systems all around us, introducing significant enhancements in the near future [3]. The rapid development of these devices has resulted in energy consumption problems [4], which have become highly attractive. On one side, the drastic rise in the rate of communication and

* Corresponding author.
E-mail address: gulatikamal88@gmail.com (K. Gulati).

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the sharing of information has contributed to unsustainable rises in energy usage and carbon emission [5]. The sensor nodes, on the other side, are required to operate efficiently for longer periods (even years) for different application specifications in most applications (e.g. for environmental control, protection, agriculture, border surveillance and protection etc.) [6]. The application's durability depends primarily on energy consumed by sensors, whereby the dead nodes can affect device compatibility and dependence and accuracy of data. However, a sensor node is typically composed of four major units:

- the processing unit,
- the sensing/identification unit,
- the communication unit and
- the power supply unit [7,8],

It is shown in Fig. 1.

The afore mentioned components have secondary components, like filters, amplifiers, transducers, comparators, etc. The sensing device collects / senses data from workplace. The processing unit conducts different tasks for data manipulation like data collection, whereas the communication unit transmits data at the BS (base stations), and the power unit, usually a battery-limited one, provides energy to all other devices.

The specific sensor node energy usage depends upon the operating situation, which may consist of three states- active, sleeping, or idle . The node uses the maximum energy in active mode. Thanks to the information transmission and receipt, the maximum energy is dissipated and the least is absorbed by sensing device. Though the energy required by processing unit is very less than that of the subsystem for radio, but larger than subsystem for sensing. It depends on the distance of communication, the monitoring case, the criteria of operation and the activities in all units. During idle mode, the node waits for data packets that and sent from another node. It may result in much higher energy consumption (by CPU, radio etc.) that can amount to up to 50%-100% energy dissipated for data receipt. A lot less amount of energy is drained away while sleeping, where the node fails to perform any processing activity and the unit of communication is turned off. Though, other energy dissipation sources, such as packet losses, packet collisions, physical channel errors, frame overhearing, overhead protocols and overhead computation, exist. The IoT group has therefore been inspired to develop energy-efficient and renewable IoT solutions.

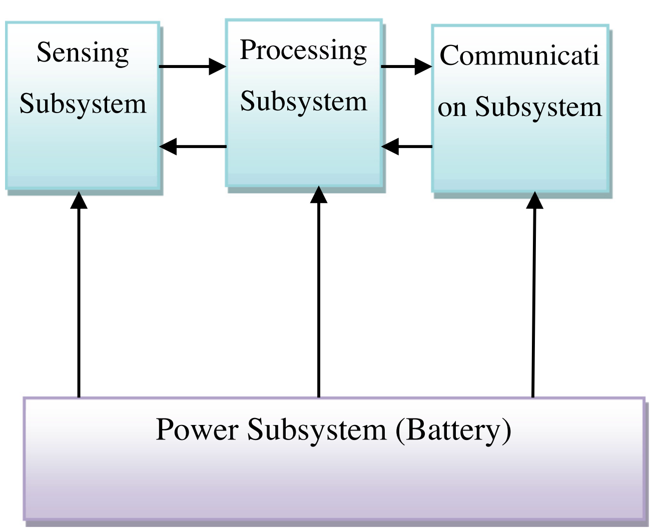

Fig.1. A typical IoT-based sensor node architecture.

Battery energy sources generally are used for operating devices in these IoT networks, which is why energy efficiency is of course of highest concern for system management. With a view to a specific WSN domain, battery-operated sensor nodes' energy efficiency, as well as life extension, have been problems for research from long time [9,10], whereby Medium Access Control (MAC) protocols emphasizes on optimizing sensor node operation and protocols for routing layer are built for aggregating data and transmitting it from multiple-to-one. Thus, a review is presented in this paper with specific attention to aspects of wireless networking for the preservation of energy and aggregation of data.

2. Role of IoT in WSN

Significant classification opinions and surveys of WSN and IoT-based energy-saving technologies have been supported by several research papers and studies. Throughout this section, some of these important literary works are reviewed, which present their main areas and different categories identified by them:

The paper [11] presented the design as well as the accomplishment of solar energy powered precision agricultural (PA) network with the WSN by utilizing IoT architecture to fulfil the requirement of identifying extremely effective ways for a smart agriculture management system. This presented system provided farmers with useful information in a user-friendly and easy to access way with real-time data communications through IoT about saltwater intrusions, the moisture of soil, level of water, wet conditions, temperature and the general state of the land.

The authors in [12] provided a study of IOT data gathering and the concepts of making a decision.

The operational and maintenance survey of PV systems and WSNs based on IoT for the monitoring of PV panels was presented in [13].

The research [14] suggested an approach used to enhnance energy usage in WSN-IoT environmental operations via the Chaotic Whale Optimization Process. The results of energy efficiency relative to other traditional approaches were obtained. The results demonstrated that in the WSN-IoT integrated system, the proposed approach achieves better energy efficiency.

The survey was performed in [15] on the delays, energies, jitters, throughput, packet-delivery ratios (PDR) from the viewpoint of WSN and performance of routing protocols was measured using latencies, bandwidth, jitter and delay. An algorithm was designed to improve AODV routing in IoT. Two tables were merged into one table, i.e. table of routing and internet access table for protocol optimization. This paper aimed mainly to analyze simulation studies of the IoT AODV routing protocol, and to utilize the NS2 simulator to improve AODV performance and IoT AODV performance. The latest version is available.

Also, WSN-assisted IoT has many limitations, making it impossible for traditional routing protocols to be used directly. Energy is major constraint for IoT devices assisted by WSN. To communicate among sensor nodes, more power is consumed than sensing and computing. Consequently, effective energy management approaches are essential to extend the network's life. In paper [16], the author proposed an energy-conscious multi-user & Multi-Hop Hierarchical Routing Protocol (EAMMH-RP) which covers Communication with Multi-Hop wherein energy is distributed equally across cluster formation sensor nodes, a novel sequence of algorithms for cluster adaptation and rotating and a novel energy consumption reduction mechanism for long-range communications.

The sensors can be used to track the atmosphere and return the information for longer. A protocol was proposed in [17] which encompass a robust routing protocol for IoT sensing network. At first, in the centre of the network field, a rendezvous area was built. The strategies of clustering and multipath were utilized as it minimizes energy usage and improves reliability. In the Castalia simulator, the introduced protocol was simulated in order to achieve efficiency under different conditions, such as packet transmission, average energy usage, end to end delays and network longevity.

The routing algorithms and models were reviewed in [18] with respect to succession parameters, like reducing delay, energy usage and optimizing the data delivery ratio. The IoT and WSN algorithms based on IoT were divided into two classes for classifying: energy consciousness, delay, throughput, data transmission and packet loss aware.

The article [19] optimized the conventional routing protocol and introduced an innovative protocol with characteristics like a new data transmission system and an enhanced method of selection of CHs. Thus the gap of the WSNs in real world and the actual heterogeneous setting was related. With the help of performance measurements, the outcome of simulation revealed the contrast between existing Hy-IoT and projected protocol.

3. Challenges of WSN in IoT

Different heterogeneous artefacts presented and communicating in different settings accomplish IoT 's complexity and make deployment of security mechanisms even more complicated. Existing WSN security research offers primarily solutions to subjective issues, without taking into consideration the impact of the IoT principles and features as examined in this document.

3.1. 3.1. Real time management

For resource-controlled sensor networks, it is a difficult problem. In that case, an efficient service gateway design is needed in the IoT system to minimise the amount of data to be transmitted by constantly reviewing user data, and smart data-driven middleware design to communicate real-time information only when reading more than threshold.

3.2. 3.2. Security and privacy

In real world applications, safety, trust and privacy are also important issues. The way to achieve different levels of safety is both difficult and soft. These safety methods are suitable for M2 M deployments where the device and the server have an existing trust relationship. [30]

Besides its usual sensor functionality sensor nodes with this "IP to the field" paradigm have additional responsibilities. The sensor nodes will therefore confront new tasks or challenges with this additional responsibility. Three potential tasks will be discussed: security, service quality (QoS) and network configuration. The following are addressed.

3.3. 3.3. Security

WSNs can have security, verification, fairness and usability to data without Internet connectivity, depending on the complexity of the programme. The attacker requires physical activity near the WSN to add malicious nodes to the current network or to block or catch them. This establishment of WSNs to internet, however, enables attackers from around the world to carry out their malicious activities [31]. The WSNs should therefore definitively address the issues arising from this Internet connexion such as malware and others. The key and special effective gateway is provided to ensure efficient security by current WSNs. However, it is impossible to replicate the same security framework due to the limited amount of computing power, energy and memory constraints. Compared to other Internet networks, sensor nodes for greater secrecy have not yet embraced cryptography with key lengths such as RSA-1024. In addition , it is important that better security mechanisms [32] take existing resource constraints into account in order to avoid various attacks resulting from the Internet.

3.4. 3.4. Quality of service

Regarding the intelligence offered to the sensor nodes, all heterogeneous devices of the internet of things have to contribute to the quality of service. This heterogeneous devices allow a distribution of workload between the nodes with the resources accessible. The current QoS approaches available on the Internet still requires enhamnecemnt due to dynamic network configurations and link features [33].

3.5. 3.5. Configuration

Along with QoS management and security, sensor nodes need to manage various tasks, such as networking for the new node joining the network [34] and making sure self-healing by identifying and deleting of flawed nodes and addressing management for constructions of scalable network etc. However, it is not a standard function of self-configuring the latest node on the Internet. Therefore, the user must instal the appropriate software and take sufficient measures to prevent device failures if this network setup is to run easily.

3.6. 3.6. Availability

WSNs can be availed by presence of compromised nodes [35]. In order to incorporate encryption algorithm for WSN security, extra cost ould be charged. However, esearchers have developed significant methods in which some modified the code and reused it, some used supplementary communications to meet the goals. Besides this, methodologies have been designed to access the data. Thus, need of availability is imperative t preserve the operational services of WSN's. It also assist in the maintenance of the entire network till its termination.

Table 1**:** Numerous Data Aggregation Techniques

3.7. 3.7. Data integrity

WSN can be compromised when malicious node enters the network and injects the wrong data or vacillating wireless channel corrupts the original data [36]. For example, if a maovelent node transfers the false data to the packets received by the BS, it will affect the integrity of data. yet , the data loss or alteration in data might be caused due to faulty network. Thus, it is required that data integrity must be maintained throughout the transmission of data packets.

3.8. 3.8. Confidentiality

Security in IoT comprises of various challenges , amongst which confidentalityis the major aspect. The data is kept confidential by opting encryption functions such as common and shared secret key encryption algorithms, e.g., the Blowfish, AES block cipher, and Triple DES [37]. But encryption process is not sufficient to protect privacy of the data and information alone as a security mechanism. A traffic analysis for the cypher data can be carried out by the attacker so that sensitive data can be effectively published. Furthermore, the malicious node can effectively compromise the

Table 1
Numerous Data Aggregation Techniques.

Approach	Parameters	Projected design
hybrid QoS-Aware Data Aggregation (QADA) [20]	• Power Consumption • Network Lifetime	The paper [20] suggested a hybrid QoS-Aware Data Aggregation (QADA) method. The method incorporated the characteristics of the aggregation of the clusters and tree-based data and discussed a few of their essential drawbacks.
Compressed sensing (CS) [21]	• Reduce Global Scale Communication Cost	Compressed sensing (CS) was presented in [21] which is very useful for WSN data aggregation such that it gives high reliability in reconstruction with fewer samples than Nyquist Shannon, given the data is scanty in any domain[21]. Numerous methods have been studied in data aggregation using CS, showing that CS can maximize its network existence by reducing communication costs during data collection in WSN.
Cross-Layer Commit Protocol (CLCP) [22]	• Query Based IOT	The distributed Cross-Layer Commit Protocol (CLCP) was evaluated in [22] for collecting data and it supports IoT application based on query search.
CSDA [23]	• Energy Consumption	As data collection is a tool for integration and transmission of data from the different sensors, yet, when the sensor networks are installed in a harsh atmosphere, protection becomes crucial, as in the existence of malicious nodes, to assure robustness, precision and privacy. Many current systems have therefore been proposed to ensure secure data collection, however, the efficiency of these algorithms was not adequate. Therefore, paper [22] proposed a new algorithm i.e. Efficient-CSDA (Data Aggregation based on consensus) algorithm.
Mixed-integer programming [24]	• Energy Consumption	Mixed-integer programming formulas and algorithms were presented in [24] to deal with the problems of energy-efficient routing and multi-sink aggregation and also combined gathering and distribution of sensor data to IoT networks. The network optimization was taken into consideration both for minimum overall energy consumption and for minimal-maximum per node energy consumption. A conceptualization and algorithm were provided for efficient transmissions scheduling in the case of pure aggregation under the model of physical interference.
DiDAMoK [25]	• Life Span Enhancement Of Periodic WSN	The high-density installation of the sensor nodes results in a greater redundancy of data in the obtained sensor node readings. The energy-saving collection of data can be an important way to reduce data redundancies. In paper [25], the author proposed an approach i.e. Distributed Data Aggregation based Modified K-means (DiDAMoK), for enhancing the lifespan of WSNs. DiDAMoK was distributed within every sensor node. This functions in periods. Three stages were comprised in each process. Firstly, readings of sensor were recorded and stored in the sensor node. Secondly, the updated K-means was used to turn these readings into reading clusters. The cluster count relied on the obtained reading's nature. At last, a representative reading of each cluster was passed on to the BS.
Power Effective Gathering [26]	• Throughput • Energy Consumption • End To End Delay • Routing Overhead • Packet Delivery Ratio • Security	Energy, memory and bandwidth have been used by the data aggregation and routing algorithm during their operation. Previous data gathering and routing algorithms decrease usage of energy by preventing redundant data and thereby minimizing both the memory and bandwidth efficiently. In addition, the balanace amid security levels of data collection and routing and energy usage since the security level has a thorough computational operation and vice versa. Thus, for the effective aggregation of data and routing of IoT WSN, the author in [26] proposed the improved Enhanced Power Effective Gathering in Sensor Information System algorithm.
CTEEDG [27]	• Throughput • Energy Consumption	The paper [27] proposed a CTEEDG protocol to enhance the throughput and lifespan of WSNs. It utilizes the Fuzzy logic for selecting the locally gathered data based CH. During the communication within the cluster, the tree topology was created amongst the clusters to the BS, ensuring that the smallest path with no congestion to the BS is available. The obtained outcome revealed that the proposed approach performed better than FAMACROW and DL-LEACH with respect to throughput. Based upon simulation results, the CTEEDG proposed production is 28.81% more than that of FAMACROW and 38.28% above than that of DL-LEACH. Furthermore, the presented scheme reduces the average energy usage by 29.26 per cent and 49.29 per cent compared to previous methods.
ME [28]	• Network Lifetime	The issue of enhancing the lifespan of WSN was considered in [28] utilizing data aggregation algorithm based on cluster. A new way of dealing with this problem was proposed in this paper. In IoT environment, the Mobile Elements (ME) were used to function as CHs in a cluster-oriented aggregation algorithm. It had been realized that the use of IoT technology in combination with WSN technology attained better results.
Light Weight Compressed DA [29]	• Transmission Cost • Network Life Enhncement	Best possible data aggregation to optimize IoT network lifespan by reducing constrain on-board resource use is still a challenge. The author in paper [29] introduced a new Light Weight Compressed DA algorithm that splits the whole network into random data aggregation clusters without any over lapping of clusters. There were two significant benefits to arbitrary non-overlapping clustering: 1) efficient energy, because every node does have to only transfer its capacity to its CH; and 2) extremely sparse measuring matrix that results in a lower-complexity implementable system.

range of other sensor nodes by using a shared group keypad and then wake up and decode sensitive information.

4. Data aggregation

As described — WSNs are essential IoT blocks that have proliferated in several diverse applications in real-time. WSN nodes are usually small and battery-driven appliances. Thus, the longevity of the network is a primary consideration for WSN data aggregation. During the collection of data, numerous problems like increased energy usage, i.e. energy ineffectiveness and increased lifespan, were found.

Data aggregation strategies are widely used to preserve acceptable servicing efficiency in the distribution of sensed data. The purpose of data collection program is to effectively incarcerate and distribute data packets so that energy usage, traffic congestion and network life, data consistency, etc. can be minimized.

Thus, in this field, numerous techniques were proposed which are discussed below:

5. Conclusion

Advancements in computer technology have contributed to the growth of WSNs, which at any time sense the requisite parameters. The IoT based WSN systems are gaining huge attention in recent times. Nonetheless, during point-to-point transmission, these systems suffer from restricted bandwidth, power and resources. Data gathering is an illustrious method for alleviating this problem. A key problem in sensor networks is how important information can be processed in a more energy-saving way. Thus, various data aggregation algorithms were used to reducing the power consumption which is reviewed in this paper. In this paper, the existing works defining the role of IoT in WSN is reviewed and then the various data aggregation approaches proposed in previous works is presented. The data aggregation techniques focus on the energy conservation, lifetime enhancement, better QoS and high-level security of the network.

CRediT authorship contribution statement

Kamal Gulati: Investigation, Writing - original draft. **Raja Sarath Kumar Boddu:** Conceptualization, Writing - review & editing, Supervision. **Dhiraj Kapila:** Formal analysis, Data curation. **Sunil L. Bangare:** Conceptualization. **Neeraj Chandnani:** Writing - review & editing. **G. Saravanan:** Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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