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New Design and Clustering of Sensors to Optimize Energy in the Internet of Things Network

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Abstract: The most important factor of the Internet of Things is the integration of several technologies and communication solutions. Identification and tracking technologies, wired and wireless sensors and active networks, protocols for increasing communication and intelligence of objects are the most important parts of the Internet of Things. In this article, since the sensors of the Internet of Things network have limited energy and when the energy of the sensors is exhausted, the lifetime of the network ends, energy optimization has been investigated. With the sleep/wake mechanism, it was checked to increase the lifetime of the network. In the proposed method, communication was established in the network using clustering. According to the clustering done, the sleep timing of the objects in each cluster is applied based on the presence of a threshold limit. In comparing the previous results with the obtained results, it was found that the proposed plan has worked optimally.

Keywords: energy optimization, smart grid, Internet of Things, clustering

I. INTRODUCTION

The Internet of Things (IoT) is a model that considers connecting everyday objects and integrating them with the Internet using microcontrollers, transceivers, and protocol stacks.

Its goal is to digitize a large number of applications with high social relevance. The applications of the Internet of Things in our daily life activities are very diverse, from smart transportation that offers a significant improvement in the transportation and logistics industry to the smart home that facilitates the activities of its inhabitants.

The Internet of Things covers various fields such as intelligent traffic, healthcare, agriculture, industry, and can even be found in our everyday objects such as pens, clothes, etc. As a result, the world has seen an explosive growth in the number of these devices. The number of connections to the Internet of Things in networks is strongly influenced by the emergence of 5G networks and the exploitation of new spectrum frequencies. In addition, IoT devices are usually small and battery limited, and mass data exchange between these devices causes very high energy requirements.

These requirements are often not supported by IoT devices and can quickly lead to battery drain and network downtime.Based on this, we are witnessing the emergence of the green Internet of Things, which focuses on saving and managing energy in Internet of Things networks in order to optimize and reduce energy consumption and increase the lifespan of Internet of Things networks.

Battery-powered devices such as smart sensors, home appliances, surveillance cameras, smartphones constitute a major part of IoT-based systems and play an important role in reconstructing the interconnections of our lives and daily activities. Heterogeneous sensor networks, which connect a large number of intelligent sensors, have become the backbone of IoT-based systems everywhere around us, paving the way for major breakthroughs in the near future.

On the other hand, sensor nodes in most applications such as environmental monitoring, precision agriculture, surveillance and border security are expected to continue working properly for a longer period of time, even years.

The lifetime of the application mainly depends on the energy consumed by these sensors, where the death of the node may affect the connectivity of the system as well as the reliability and accuracy of the data.

In general, a sensor node consists of four main units:

Sensing/identification unit, processing unit, communication unit and power supply unit.

The secondary components of filters, amplifiers, converters, comparators, etc. mainly exist as sub-elements of these four main components. The measurement unit collects/senses data from the work environment. The processing unit performs various data manipulation tasks such as data aggregation. While the communication unit is responsible for transmitting data to the base stations, and the power unit, which is usually a limited battery, is for providing energy for all other units. The actual energy consumption of the sensor node depends on the current operating conditions, which can be one of three modes: active, idle, or sleep mode. In the active mode, the node consumes the maximum amount of energy [1,2,3,34]. The largest amount is wasted by the communication unit due to data transmission and reception. While the least is consumed by the measuring unit. The processing unit consumes significantly less energy than the radio subsystem, but consumes more energy than the sensing subsystem.

It depends on the communication distance, monitored event, program requirements and activities performed in each of the units.

In the idle state, the node is in listening mode and waits for possible received data packets from other nodes. In the sleep mode, a much smaller amount of energy is wasted, where the node does not realize any processing tasks and the communication unit is turned off.

II. RELATED WORKS

Many research papers and studies have provided valuable insights and classification reviews on energy-saving techniques for IoT and sensor network-based networks.

The authors discuss power management and examine its cost, which is important when evaluating performance, regardless of the given objectives. They divided energy saving mechanisms into two main categories based on their main goals:

Passive and active mechanisms at a higher level. They then examined the different subcategories which are shown in the following table.Based on the importance of energy reduction approaches, they presented. First, they presented an analysis of the energy dissipation components of the sensor node and then discussed different designs according to their classification.

It is followed by a discussion about a transmission model to estimate the energy loss in the communication unit [4-8-30-32].

Energy efficient routing, data reduction, duty cycle, control reduction and topology control are presented by providing several definitions of network lifetime and examining different sources of energy loss. Then they examined each of the energy saving techniques in detail and identified more sub-categories and pointed out the sources of energy loss related to each one. A new classification point of view has been introduced, which this article proceeds by addressing the issue of energy loss and its modeling, then the proposed classification is presented [16-36].

which divides energy saving techniques into two main areas:
Local and distributed techniques. Special attention is paid to aspects of wireless communication such as machine-type communication, 3GPP, IEEE 802.11ah, Z-Wave and BLE [31-9-14].

The paper concludes with expected future solutions in this area, such as the use of picocells and femtocells. In this paper, we review various efficient and green energy techniques in traditional networks and restricted networks based on the Internet of Things.

Different classification efforts are discussed and a new classification of energy saving techniques is presented. The main goal is to address the limitations of the current taxonomy and provide a general and comprehensive taxonomy that presents everyone in a common and up-to-date taxonomic perspective [17-18-19].

This facilitates the identification of appropriate techniques to develop effective solutions based on key factors affecting power consumption, application requirements, and network environment.

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How we can provide an energy-saving system with fully autonomous behavior through a measurement-based algorithm that automatically identifies and diagnoses electrical devices in the Internet of Things [5-20-12-13].

In this research, we show how the example of IoT and machine learning techniques may be useful to achieve autonomous energy efficiency. A new system architecture is presented for effective monitoring and operation on distributed sub-networks of electrical appliances.

A method for automatically extracting behavioral rules from consumption data in order to apply or feed into the embodiments of such an architecture is presented. It is used for energy-oriented productions, large offices and other large-scale facilities such as hospitals, public buildings or structures such as railway stations and airports [11-10-7-6].

For these possibilities, we intend to develop a new approach that uses environmental and user-centric data. In this research, the example of Internet of Things and machine learning techniques for (1) defining a new system architecture for centralized energy efficiency in distributed sub-networks of electrical appliances, (2) extraction of behavioral rules, identification of the best practices and identification of the device used [15-21-35-33].

Table 1: Summary of the background of the research

Author / year	Title	Algorithm / Technique	Results
Masoud Moradi et al. / year 2012 [22]	Reducing energy consumption in wireless sensor networks using hash distribution table	Wireless sensor networks, controlled propagation algorithm and Anita Kanavalli algorithm	Extending network life and reducing energy consumption
Ramin Sidi et al. / 2013 [23]	Dynamic cluster head selection to increase lifetime in wireless sensor networks with Bloom filter	Energy generation reduction algorithm of LEACH adaptive cluster hierarchy	Avoid wasting a lot of energy to obtain the remaining energy of the nodes
Li Wong et al. / 2012 [24]	CKN algorithm with energy saving for wireless sensor networks with task rotation	k-nearest neighbor algorithm and CKN based on energy consumption	Energy consumption in fully balanced EC-CKN algorithm
Shubha and et al. / year 2018 [25]	Energy efficiency mechanism based on SDN for limited networks	Energy efficiency mechanism based on SDN (SDNEEM).	leading to the removal of unnecessary data at lower levels and efficient storage of resources for prominent and important data, achieving an increase in system performance and energy efficiency
Abdul Salam Shah et al. / year 2019 [26]	A review of energy consumption optimization techniques in intelligent construction environments based on the Internet of Things	Fuzzy logic algorithms, fuzzy controller and optimization algorithms	Optimizing energy consumption in smart homes
Sima Abdullah et al. / year 2020 [27]	Message scheduling algorithm and energy saving with common routing mechanism in network layer in Internet of Things	Routing algorithm and scheduling algorithm for the shortest SPT processing time	The remaining energy of the node, the number of nodes that are alive and the total wasted energy of the nodes have reached great efficiency and effectiveness.
Derakhshan et al. 2023 [28]	Connection control in wireless sensor network: a new mechanism	Routing algorithm and energy consumption reduction algorithm	Choosing the best route and suitable nodes with low energy consumption and using the battery in an optimal state
Derakhshan et al. 2011 [29]	Designing minimum power transmission for cognitive radio networks in non-stationary environment	Power optimization algorithm and energy consumption reduction with evolutionary algorithm	Optimization of network and sensor power consumption

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III. SIMULATION PARAMETERS

In the simulation, the Internet of Things network is considered with 100 homogeneous sensor nodes that randomly placed in a square environment. The sink or base station is located in the center of the environment. The sensor nodes do not move after placement. Sensor nodes have limited initial energy or E_{init}. While the energy of the sink is unlimited. The data transmission ranges of the sensor nodes are set to 30 meters. All nodes need to send data packets to the sink during one cycle.
A number of sensor nodes are selected for work in each round, and the remaining nodes are selected for sleep mode and energy storage. In the proposed method, this mechanism is called sleep-wake process. It removes all data, header bits and gathers important data and sends it to the base station. After the end of the time period, until the lifetime of the network is over, these steps are executed. The lifetime of the network ends with the death of all nodes.Of course, nodes that are far away are also considered as dead nodes due to not sending data.

Table 2: Simulation parameters

Parameter	Values
Network environment	$100 \times 100 m^2$
The number of nodes	100
The number of sending bits	512 bit
The initial energy of the nodes	0.25 J
E_{elec}	$50 pj / bit$
ε_{amp}	$0.0013 pj / bit$
Threshold distance limit	87m

The sum of the total residual energy of the nodes in the network represents the total residual energy of the network. This total includes the energy of live nodes and is measured during each round of communication.

IV. COMPARISON OF ENERGY CONSUMPTION

The proposed method is superior to the reference method in terms of energy consumption.

Since the sensor nodes are connected to the nearest cluster head, they consume less energy, and as a result, the total energy consumption of the network is reduced.

Also, by increasing the number of rounds, the remaining energy of the sensor nodes decreases, choosing the cluster head plays a very vital role in reducing energy consumption, and the proposed algorithm reduces the energy consumption of the network by choosing the appropriate cluster heads.

In the network, there are 100 nodes, each node has an initial energy of 0.25 joules.

Therefore, the maximum energy consumption will be 25 joules.

Over time, energy consumption in the network increases.
In all cases, the energy consumption of the proposed algorithm is much lower than the basic case.

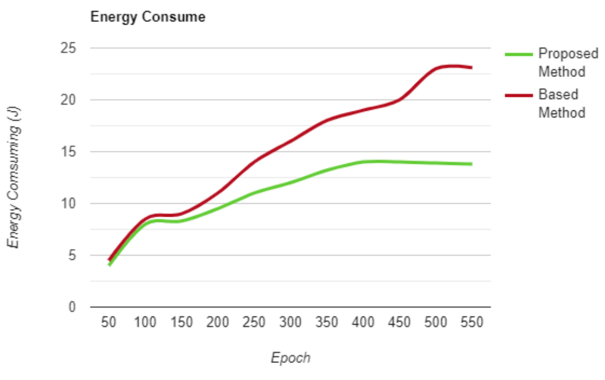

Figure 1: Energy consumption of the proposed method

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Network output is an important indicator that basically shows the performance of a protocol.

Network output refers to the number of packets in the network that are finally sent to the base station. Each member node transmits the received information in the form of packets, and the cluster heads sense this information and finally send the information to the base station in the form of packets. As the nodes in the network die continuously, the number of cluster heads in the network decreases and the success rate of sending packets to the base station also decreases.

Therefore, the number of data packets transferred in each round will gradually decrease,Until the last node dies. One of the important issues in wireless sensor networks is optimal energy consumption. If this problem is considered correctly, the lifetime of the network will increase. In this article, a method for creating cluster heads to reduce energy consumption and increase network lifetime has been introduced. The sleep/wake of the sensor nodes for each round is based on the threshold energy of the remote nodes. Nodes far away from the base station are more likely to go to sleep.

In this case, the nodes consume almost balanced energy to increase the lifetime of the network. For sensor networks, sleep timing is very important due to the limited energy of sensor nodes. If the nodes are placed in an active state for a long time, they consume a lot of energy. Therefore, in this research, an optimal sleep/wake control mechanism has been designed.

The sleep/wake mechanism is as follows:

The cluster head consumes more energy during transmission due to the information load of the cluster member nodes. The nodes send their information to the cluster heads based on the time division schedule. First, all the nodes are awake and during the transmission of monitoring information, the controller makes decisions and sends them to the nodes whose information transmission route has changed or their sleep state has changed. Nodes decide to sleep/wake up as soon as they receive data from the controller.

In the proposed method of this research, the nodes that have a higher energy level than the threshold stay awake, and the node that has a lower energy level is placed in a sleep state according to the conditions of its neighbors in order to save energy. In this way, energy is stored to prolong the life of the network.

V. CONCLUSION

The proposed method has been implemented with MATLAB software and the results have been compared with the basic algorithm.

According to the results, the proposed method improves energy consumption.

This research provides clear results about the lifetime of the network. Sensor nodes consume balanced energy and therefore increase the network's lifetime. The simulation results show that the proposed method of this research has a better performance than the previous designs regarding the network lifetime.

In this research, the network nodes are assumed to be fixed, but to continue the research, it can be changed in such a way that it gives a suitable answer in networks with moving nodes.

For future research, it is possible to examine the reliability in smart homes.

It is also possible to examine the proposed algorithm for different sink location situations.

To increase the efficiency of the proposed method, another parameter such as the importance of the number of cluster members can be added to the problem.

As a last suggestion, a research can be done to select the heads of clusters using evolutionary algorithms.

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