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A Review on Energy-Efficient Data Gathering Protocol in Industrial Automation Application

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***Abstract*— Wireless sensor networks (WSNs) have shown investigation & development interests in a variety of areas, including interaction, farming, industrial, smart health, checking, & tracking. In farming, IoT-based WSN has been utilized to monitor output conditions & automate agricultural accuracy using different devices. These devices are used in agriculture to increase production outputs via intelligent farming choices & to collect data on crops, plants, temperature monitoring, moisture, & irrigation facilities. However, devices have limited computing, energy, transmission, & storage capacities, which may have a detrimental effect on agricultural output. Aside from efficiency, the safety & safety of these IoT-based agricultural devices from hostile attackers are also critical. In this article, we review on IoT-based WSN framework with various design stages as an application to smart agriculture.The most significant issue in wireless sensing systems is increasing energy efficiency. Because detecting data is linked in many sensing system applications, prior studies have suggested methods for reducing network energy usage by leveraging the spatial relationship between detected data. In this article, we propose an energy-efficient data collecting protocol in industrial automation applications utilizing IoT and WSN framework that makes use of the wireless medium's transmitting feature to enhance energy efficiency.**

***Index Terms*— Industrial Automation, Internet Of Things, Wireless Sensors Networks, Energy-Efficient Data Gathering Protocol, Clustering Based Protocol, Tree-Based Protocol.**

I. Introduction

Automation is a growing requirement in businesses as well as in-home applications. Automation lowers human work by substituting human labor with self-operated systems. Commercial mechanization is the use of control devices, like computers or robots, & information technology to substitute people in various activities & equipment in an organization. In the context of civilization, it is the second stage beyond automation. When it comes to the Internet of Things (IoT), you're talking about a network of interconnected machines that can transmit data without needing human or computer involvement. This includes things like machines, animals, & humans. The Internet is one of the increasing platforms for automation, through which significant steps are created, allowing one to quickly monitor & manage the device through the internet. Because we are using the Internet, the system becomes safer, & real-time analysis is also feasible with the IoT device. The IoT is a rapidly evolving field that plays a critical role in the control of physical devices capable of gathering data via the internet. IoT in factory automation has developed into a ubiquitous advancement in production & is being investigated as a game-changer for automation. The IoT aids in the development of new technologies that help to accelerate operations to increase productivity. The IoT is a network of physical objects equipped with detectors, digital machines, actuators, hardware, & algorithms that enable these things to interact & exchange data via the internet. The impact of IoT on automation in organizations is enormous, prompting us to utilize smartphones, tablet computers, virtual systems, & other devices. The use of IoT for automation in enterprises has impacted commercial technology in various applications. Providing new & promising solutions IoT has gotten a lot of interest in industries, home automation, smart cities, smart grids, linked vehicles, & smart agriculture. The primary advantage that this technology provides in business intelligence represents enormously difficult advantages for industrial companies in their digitalization endeavor by integrating IoT with industrial infrastructures.(Singh & Shimi, n.d.). Because of its benefits over wired systems, WSNs are increasingly being used in the industrial sector. WSNs, in addition to lowering cabling costs, expand the range of settings that may be monitored. They, therefore, give detecting & acting abilities to physical things & enable the connection between these objects or with services in the future Internet.(Christin et al., 2010).

Because of its benefits over wired systems, WSNs are increasingly being used in the industrial sector. WSNs, in addition to lowering cabling costs, expand the range of settings that may be monitored. They, therefore, give detecting & reacting abilities to practical things & enable the connection between these things or with services in the future Internet.(Polavarapu & Panda, 2020).

The installed devices may be static or mobile throughout data transfer. Static devices are also known as non-adaptive devices since their routing tables are set. On the other hand, the routing tables of sensing devices are dynamic & regularly change as the network architecture varies. Static routing solutions are more reliable than dynamic routing; nevertheless, systems based on static algorithms are not suitable for broad areas or network evolution. IoT technology has been heavily integrated with other areas in recent years to improve communication in terms of network speed, resource usage, & load distribution. Many physical devices are connected in IoT to transform data while using the Internet. Furthermore, WSN technology serves as the basis for IoT systems, assisting in the observation & transmission of physical environment conditions(Haseeb et al., 2020).

Furthermore, providing extra energy or even replacing the

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battery is not an option. The primary function of WSNs is data collection, which also serves as the primary source of energy consumption. Information collecting entails every node in the sensor network regularly detecting quantitative information & then forwarding it to the sink through one or more steps. The two major work modes are precision data collecting or linked information collecting. However, current research mostly summarizes from the viewpoint of the routing protocol.

The rest of this paper is as follows: In section II present a detailed overview of Industrial automation. IoT Based Industrial Automation gives in section III, Section IV and V present a deep description of Wireless Sensor Networks and Data gathering. Energy efficiency in WSN data collection is given in Section VI. In section, VII presents the Energy efficiency in routing protocols like clustering-based and tree-based protocols. In the second last section, VIII gives related work published in previous works. Lastly, conclude this survey paper in section IX.

II. INDUSTRIAL AUTOMATION

Industrial automation has been effectively used in a wide range of sectors, from food to energy. Even though the goods vary by sector, the automated processes may be divided into three major levels, as suggested by (Christin et al., 2010): the production planning system layer, the plant-floor automation layer, & the enterprise resource planning layer The Essentially, the Internet links all of these levels together and makes it possible for the information to be exchanged. It may be used as a backbone to connect different production locations within a business, to send near-real-time production control information to headquarters, or to integrate providers into a manufacturing process.

Industrial Automation also includes a large number of hardware technologies like instruments & sensors, actuators & drives, signal conditioning electronics, communication & display, embedded & stand-alone computer networks, & so on. The use of IT develops significantly as Industrial Automation systems become more progressed in terms of the knowledge & techniques they utilize, as they combine larger areas of the business containing a few units or a whole factory, or even several of them, & as they combine manufacturing with other aspects of business like sales & customer service, finance, & the company's supply chain. Lower-level automation systems, on the other hand, that only interact with one or a few devices, depend on hardware, electronics, & embedded computers rather than IT(Yadav & Engineering, 2017).

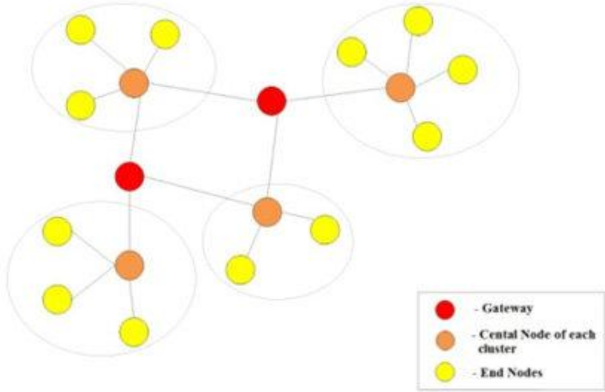

Figure 1: Industrial automation for WSN

Apart from the above, there are several additional distinctive characteristics of IT for the industry that set it apart from its more common equivalents utilized in offices & other commercial settings. (Yadav & Engineering, 2017):

- Industrial information systems are usually responsive in the sense that they absorb inputs from their discourse universe & respond by stimulating their surroundings. The interface to the outside world is, of course, a vital part of an industrial information system.
- The number of industrial information systems must be real-time. That is, the calculation must not only be accurate but must also be generated on time. An tried to ensure that is not time may be preferable to a less accurate one that is delivered on time. As a result, systems must be built with the express goal of fulfilling computation time deadlines.
- Many industrial information systems are deemed mission-critical in the sense that failure may have catastrophic implications in terms of human life or property damage. As a result, great care must be taken throughout their creation for them to be perfect. Despite this, complex procedures are often used to guarantee that any unexpected situations may also be handled predictably. Faulttolerance to crises caused by hardware & software flaws is often required.

All of this may be accomplished via automation in the following ways:

- Material
- Energy
- Manpower
- Infrastructure

Several variables influence a product's total manufacturing time. All of these variables are influenced by automation. To begin with, automated equipment have considerably shorter manufacturing times. In machine tools, for example, substantial setup periods are required for establishing the operating configuration & variables whenever a new component is put into the machine. When a diversity of goods is produced, this may result in considerable wasted time for costly equipment. Set-up time in Computer Numerically Controlled (CNC) Machining Centers has substantially decreased thanks to Automated Tool Changers & Automatic Control of Machines from a Separate Class loaded in the machine computer. As a consequence of the improved real metal cutting time, capital costs are lowered & production output is enhanced.

III. INTERNET OF THINGS

Itis presently one of the most popular technical ideas in which people & things are linked everywhere & at any time utilizing wired & wireless technologies like WSNs, ZigBee, NFC, RFID, GPRS, LTE, & Bluetooth. Both the business & academic areas have given IoT a huge amount of attention in the past ten years. Many major benefits to application areas may be provided by an IoT method. The goal of this area of research is to demonstrate a fundamental understanding of clever environmental observation systems that depends on IoT. Several studies in the past have indicated that IoT is plagued by a slew of problems like authentication, identity, availability, safety, & confidentiality. The phrase "Internet of Things" refers to a broad range of research & innovation that enables Internet users may connect with the physical world things. Nevertheless, there are two fundamental interpretations of what the Internet of Things involves &, as a consequence, what kind of technological advancements should be included. However, methods like Radio Frequency Identification (RFID), low-power wireless communications, real-time localization, & network sensors are often associated with IoT. According to this perspective, the most important aspect of IoT is the usage of wireless detector communications, which allows devices to work. However, one line of research indicates that the word "thing" should not be limited to a physical item, but should also encompass conceptual & virtual components, especially those related to service.From this perspective, the present effort seeks to bridge the gap by attempting to combine such distinguishing services(Chijioke World, Azrul Amri Jamal, 2019).

1) IoT Based Industrial Automation

The Industrial IoT is the best method to link industrial machines & sensors to each other through the internet, enabling authorized industry users to utilize data from these connected devices to analyze the acquired data in a useful manner. Data collection, consolidation, analysis, & visualization are common features of IoT-connected applications. Computers, intelligent gadgets, connected & wireless connectivity, & cloud computing are all part of the IoT architecture. Bluetooth & RF methods were previously employed to measure & manage industrial applications, but they were restricted to short distances. The user has to be within the Bluetooth connection range or in the Radio Frequency region. Industry automation based on IoT is a solution to short-distance communication. We can operate & monitor this system from anywhere in the globe. Automation through IoT may assist to eliminate the need for short-distance communication. Thus, incorporating the internet into businesses may assist in gaining control of the application from anywhere in the globe.

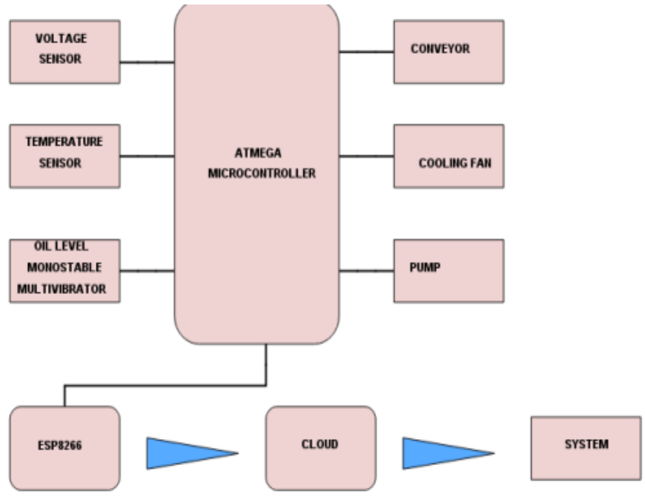

Figure 2: IoT-based industrial automation (Sangeetha et al., 2019).

The Above block diagram (Fig 2) represents the block diagram for IoT-based industrial automation (Sangeetha et al., 2019).

Hurdles:

- The internet connection is not good in many places & varies, which is a significant issue that must be addressed. Furthermore, the security of data in the cloud is a significant concern.

Advantages:

- Long-distance controlling & trackingare possible.
- Faster production & cheaper labor cost.
- Can perform the task beyond human capability.

Applications:

- Home applications: Artificial intelligence can monitor & manage household items like fans, TVs, & refrigerators.
- Industries & offices: utilizing the IoT technology to monitor & operate equipment & instruments.
- Hospitals and labs: The doctor may use his Android phone to examine the current condition of the patient's body by putting sensors on the patient's body & utilizing artificial intelligence & IoT.

IV. WIRELESS SENSOR NETWORKS

These are currently recognized as one of the most cost-effective & efficient data collection mechanisms on the industrial shop floor. Industrial WSN (IWSN) is gaining traction in a variety of sectors as the lowest layer technology for gathering original data from the shop floor. Apart from gathering data, the sensor nodes may also identify abnormal circumstances in the activity that they are monitoring. WSNs are networks made up of tiny, battery-powered computer devices outfitted with sensors & devices. WSNs are simple to install & may self-organize to meet application objectives. WSN is generally considered one of the major technologies that will enable future ubiquitous computing. WSN nodes are self-organized & create an ad-hoc network to monitor activity in the target area & transmit data to a base station (Figure 3)(Shripad & Devale, 2013).

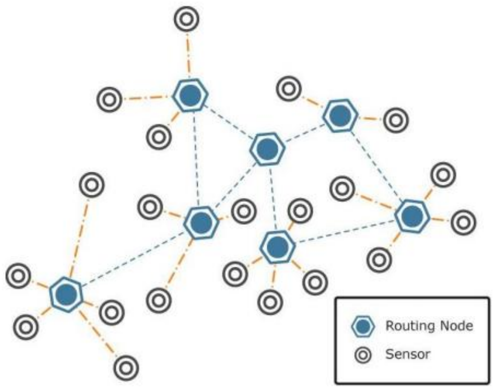

Figure 3: Wireless Sensor Network

Significant progress has been achieved in addressing WSN-specific problems like energy-efficient communication, dependability, fault-tolerant networking, & so on. When deployed in large numbers in the field of interest, these sensor nodes act as a single homogeneous system that can be used to keep scanning variables of the specific target system & report events or data using radio communication to a special node called a sink node, that is in charge of processing & sending the data further up the network hierarchy & finally to the Internet(Shripad & Devale, 2013).

This technology has been utilized effectively to enhance network performance in a variety of areas. The primary rationale for using various sensors in the environmental sector is because they are manageable & simple to set up. Furthermore, the sensor nodes function independently & build the network architecture on the fly. Nodes in such infrastructure do not have a fixed network topology & may join the more appropriate neighbor for data transmission depending on a variety of variables. With the assistance of certain gateways & cluster heads, the sensor nodes detect the observing data & send it to the BS. These cluster heads are in charge of collecting incoming data packets & relaying them to the BS. The cluster heads build a single-hop or multi-hop route to the BS & serve as a focal point for the whole data transfer. In addition, the cluster heads store the received data in their memory & use the store & forward process. End-users connect to the centralized BS through the Internet or other web-based apps to obtain the necessary observation data(Haseeb et al., 2020).

A. Sensor Node Architecture

Sensors, a compact Processing Unit (processor & memory), a transceiver (transmitter & receiver), & a small cell (power unit) that can power this sensor node are the key elements of the sensor network design. The WSN's application determines the sensing node's architecture; for instance, in some apps, the sensor node can contain a Location Identification System (like GPS) or a mobility controller or mobilizer unit as shown in figure 4.

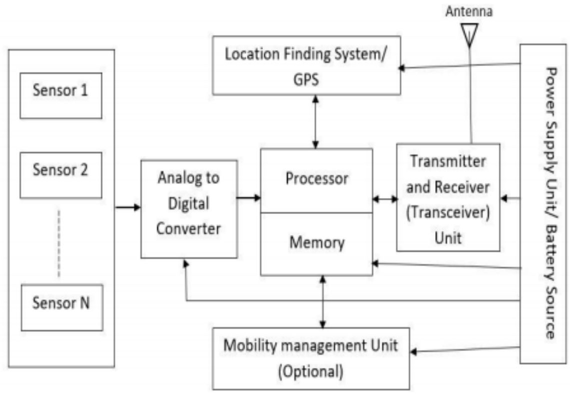

Figure 4: Sensor Node Architecture

V. DATA GATHERING

Data collecting, or the collection of detected data from each node to the Base Station, is an essential function of WSN. In WSNs, a wide variety of networking protocols are utilized for aggregation, reduction, & recovery. They make use of the spatiotemporal properties of real-world signals. However, the vast majority of them fail to provide satisfactory results in terms of energy savings & signal reconstruction reliability. The quantity of data collected from each node in the sensor network will be huge, which will have an indirect impact on the network's energy efficiency.To minimize the cost of energy, the complexity of the data gathering process is minimized by including the nodes which have significant information. This process is named Compressive sensing. The collection of the significant nodes in the sensor areadepends on the knowledge of correlation among the data samples(Ramanan & Baburaj, 2010)(Zheng et al., 2012)(Francis, n.d.).

1) Data Gathering Protocols

The energy-aware routing protocol is indispensable for the networks operating in isolated and unreachable places where recharging batteries is not possible. So, to increase the lifespan of the network, the protocol should perform well in decision-making to suit the dynamic behavior of the network. A WSN is subjected to rapid topological changes due to node mobility and failure. Hence the optimization of the network behavior is a challenging process. A major portion of the energy is drained during the repeated rounds of data gathering. The data gathering protocols are mainly classified based on data-centric, hierarchical, location-based, topology control, etc.

a) Data-Centric Protocols

- **Flooding**: In this protocol, every node is free to broadcast the packet received. This method does not require specific route discovery algorithms. The disadvantage of this method is that each node may receive a copy of the same message which it has already received.
- **Direct Diffusion:** In this protocol, each sensor node generates requests for receiving the data sensed by all the other nodes in the network. The destination for these data requests can be either the Base Station or a network node itself.
- **SPIN:**Sensor Protocols for Gathering

Information Through Negotiation For routing, this protocol employs a negotiation method. SPIN generates three kinds of messages: ADV, REQ, & DATA. An ADV message containing the actual data will be sent out by a sensor node. The receiving node will issue a REQ message if it is interested in the data. After that, the sensor node sends the actual DATA to that particular neighbor. The neighbor again sends ADV to its neighbors and this process is repeated to propagate the data within the whole network.

b) Hierarchical Routing Protocols

- **LEACH:**It's a clustering-based protocol. The operation of this method depends on the spatial density of the sensor network. The protocol randomly elects nodes as cluster heads, sends the fused data to the destination, and performs periodic re-election of cluster head nodes. These cluster head nodes can be advanced i.e. nodes that are equipped with an additional amount of energy.
- **PEGASIS:** Power-efficient gathering for Sensor Information systems. In this protocol, it is assumed that each node knows the current location of every other node in the network.

c) Topology Control Protocol

- **GAF:**The whole sensor field is split into a grid in this technique. All grid nodes will be able to interact with one another. The size of the grid must be determined.
- **STEM:**STEM is an acronym that stands for Sparse Topology & Energy Management. This protocol employs two channels, one for wake-up & one for data transmission. The wakeup channel is used to notify the receiver that a transmitter wishes to send data to it. STEM protocol is applicable when the nodes are in one of two states: monitor (when the nodes monitor but no event occurs) & transfer (where an event is recognized & data must be transferred). The entire time on the Wake-up channel is split between the asleep period & a listen period, which is combined from the wake-up period.

2) Cluster-based data gathering protocol

A cluster-based method is suggested to minimize communication costs generated by all nodes regularly interacting with the sink. The following is the protocol's primary concept(Peng, 2016).

As illustrated in Fig. 3, there are three types of nodes: common nodes, cluster heads, and sinks.Only the group leader node can connect directly with the source, whereas the group nodes may connect through multi-hop interaction with other group leaders. The group leaders are selected from the whole set of nodes, while the rest join their adjacent groups as members. Only the group leader collects data & sends it to the Sink node through several steps. The most common examples are LEACH8, HEED, & EEUC. LEACH was the first cluster-based data collection technique. The others are mostly suggested as a result of it. With LEACH, the major goal is to reduce the quantity of information that must be sent to the ground station by using localized coordination for cluster construction & local computation in each group.

As previously stated, grouping methods choose group leaders with the greatest residual energy & rotate cluster heads regularly. But they ignored hotspots. As the group leaders go closer to the Sink & send more data, they get hotter and more likely to perish. The EEUC technique was proposed to solve this issue. The nodes are divided into clusters of varying sizes, with the clusters nearest to the sink being smaller to save energy & extend the network's lifetime(Peng, 2016).

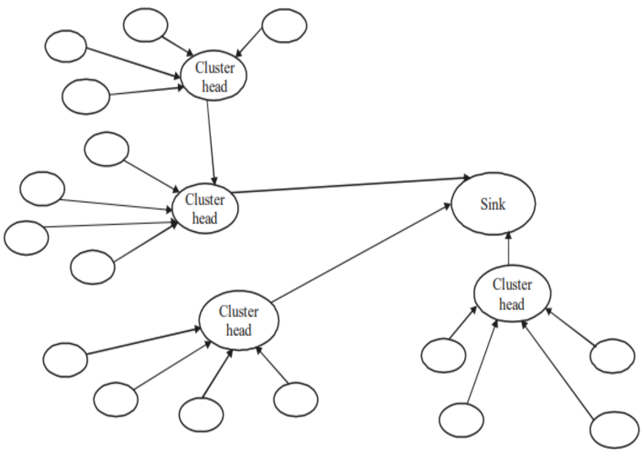

Figure 5: Cluster-based protocol

3) Tree-based data gathering protocol

4) There is a hot spot issue for accurate data collection in large-scale intense multi-hop sensor networks. To increase the lifespan of WSNs, a maximum lifespan spanning tree must be built. As shown in Fig. 6, all nodes in WSNs form a tree, & each node receives information sent by its child nodes before transmitting it to the parent node along with its sensing information. The primary research may be divided into two parts based on the algorithm's characteristics: centralized data collecting & distributed information collecting. The centralized data collecting method is presented in this section, followed by the distributed one(Peng, 2016).

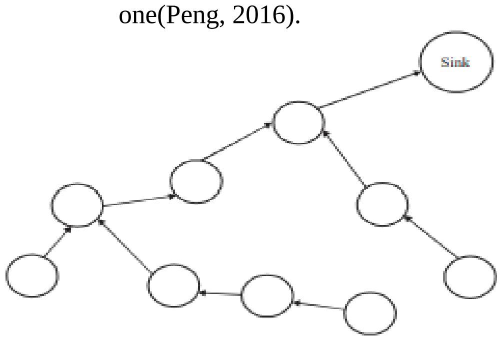

Figure 6: Tree-based data gathering protocol

VI. ENERGY EFFICIENCY IN WSN DATA COLLECTION

Energy efficiency is the most significant problem in WSN since sensor nodes are often rechargeable batteries, & it is not possible to substitute the energy of sensor nodes in many sensor network systems. Many suggestions for avoiding duplicate data from being sent & retrieved by leveraging the geographical relation between sensed data collected by sensor nodes have been proposed to enhance energy efficiency & prolong the network lifespan of sensor networks. Sensor nodes are often placed densely to provide adequate coverage; as a result, the sensing data obtained by sensor nodes are strongly linked(Lee & Lee, 2013).

Wireless gadget use is becoming more prevalent in many aspects of human existence across the globe. Most of these devices, when put in the environment, are depend on tiny sensors that collect data from the surrounding without the need for human interference, resulting in WSN. Because of their limited battery, memory, processing capabilities, & transmission capacity, these small sensors are very energy-restricted. As a result of this limitation, one of the most studied subjects by WSN researchers is 'Energy Efficiency.' In the past, several energy-efficient information collection methods have been suggested in the research. WSN energy efficiency has an impact on network lifespan. The period spent from the commencement of network operation until the first (or final) node in the network reduces its energy is referred to as network lifespan (dies). A node can conduct useful activities such as receiving & sending data. On the otherhand, it may conduct superfluous activities such as retransmission owing to collisions, overhearing, broadcasting duplicate control packets, & listening to media while idle. By eliminating superfluous node activities, energy efficiency may be improved(Rohankar et al., 2015).

Regardless of the network's inherent difficulties, the data collecting protocol's primary goal is to optimize network lifespan, ensure coverage & connection, & reduce latency. The information collecting methods for 'Energy Efficient' has been extensively applied. To mention a few, these are data aggregation, sleep-wake scheduling, & transmission power adjustment. When designing energy-efficient protocols, variables suchas the number of control packets & a node's available residual energy are taken into account.

1) Energy-Saving Techniques Used in Data Collection

The in-network information collecting approach is used to decrease the number of correlated data packets delivered to the sink while extending the life of the network. It focuses on problems including implosion, overlap, & resource blindness. Data compressive sensing is an alternative technique for sending connected data effectively. It enables high-probability signal recovery via the use of random projections. Data is often detected regularly. As a result, depending on the activity, nodes may be turned off or on. A low duty cycle is an energy-efficient method of increasing network lifespan. Alternatively, the path-controlled traversing mobile sink or node approach increases data gathering efficiency & network lifespan. Node mobility enables ubiquitous data gathering, which is also extensible & offers continuous data transmission.

Topology The routing protocol's intrinsic topology has an impact on energy usage as well. The most often utilized topologies for collecting & merging spatially linked data are cluster-based. Data aggregation takes place at each level of the tree-based data collection structure. Cover sets or backbone building methods are employed in tree-based topology to eliminate loss owing to link failure. Cover sets or backbone building methods are employed in tree-based topology to avoid loss due to link failure.

VII. ENERGY EFFICIENCY IN ROUTING

Because energy economy is more essential for WSN than for conventional networks, more study has been done on WSN routing. In general, data transfer consumes more power than information processing in wireless communication. When nodes transmit a greater amount of data, their battery power decreases proportionally. We may use data fusion or aggregation methods to decrease data size. Data fusion is the process by which sensed data from several nodes aremerged at several points appropriate for distribution in its decreased size.

Even when it comes to the concept of data collection, there are 2 kinds. The 1stkind of information collection combines data from a variety of sources & provides the merged data in a reduced format. The problem with this approach is that data from various sensor nodes lacks precision & accuracy. The 2nd method combines information from different sources & transmits it to the ground station as a single header. Without affecting the original sensor data, header packets are aggregated and transmitted to the ground station. As a result, producing better quality.

These two major classifications of methods are brought together in a study on energy-efficient routing in WSN. They're(More & Raisinghani, 2017),

1) Clustering techniques

It is the process of dividing sensor networks into tiny manageable pieces. Though the primary purpose for using the clustering strategy is to enhance system capacity, it is also an essential element in ensuring energy-efficient data routing inside the network. Aside from attaining system capacity, it offers other benefits such as saving communication bandwidth within groups, preventing duplicate message transmission among sensor nodes, & localizing energy-efficient route design inside clusters. LEACH, HEED, DECA, & other cluster-based energy-efficient routing protocols are examples.

LEACH: It employs the grouping idea to divide the energy usage throughout its network. The network is split into groupsdepending on the information gathered, with group leaders selected at random. The group head collects information from its cluster's nodes. Let's take a look at the procedures that occur throughout each LEACH cycle.

- **Advertisement phase**: The LEACH process begins with this step. The eligible group leader nodes will invite to join their cluster to the nodes in their range. The nodes will take the proposal depending on the Received Signal Strength.
- **Cluster set-up phase:** The nodes will respond to

their chosen group leaders in this step.

- **Schedule creation:**The group leader must design a TDMA mechanism and inform its group members when it is time to transmit their information to it after receiving replies from the nodes.
- **Data transmission:**The information gathered by the single device will be sent to the groupleader during its period, & the cluster members' radios will be turned off for the rest of the time to save energy.

The LEACH technique addressed the issue of multi-cluster interference by utilizing distinct CDMA codes for each group.

It aids in preventing energy drain for the same sensor nodes that have been chosen as group leaders by utilizing randomization each time the cluster leader is replaced. The group leader is in charge of collecting& fusing information from the group members. At last, the merged information will be sent to the base station by each cluster head. When compared to prior treatments,LEACH has demonstrated significant improvement.

HEED: The LEACH procedure, on the other hand, is considerably more energy-efficient than its predecessors; nevertheless, one of the technique's main drawbacks is the random selection of group leaders. In the poor-case situation, the CH nodes may not be spread equally across the nodes, resulting in data gathering issues. A new technique known as HEED was developed to avoid random CH selection[6] was created that chooses CHs depending on both residual energy level & communication cost. This procedure is carried out in three stages,

- **Initialization phase:**The first CHs node proportion will be assigned to the nodes at this phase. Carob is the value that represents it. Each sensor node calculates its chance of becoming CH using the equation CHprob=Cprob * Eresidual/Emax, where Eresidual refers to the node's remaining energy level & Emax refers to the extreme battery energy. Because HEED allows heterogeneous sensor nodes, Emax can vary depending on the functionality & capability of each node.
- **Repetition phase:**This process was continued until the lowest transmission cost CH node was found. If the node is unable to find a suitable CH, the node in question is designated as the CH.
- **Finalization phase:**This is where CH's pick gets completed. The tentative CH node has now been upgraded to the final CH node.

DECA: It stands for Distributed Efficient Clustering Approach, which has been enhanced. The primary distinction between HEED & DECA is how the nodes make decisions & compute the score. DECA operations are divided into stages,

- **Start Clustering:**During the first phase, each node will calculate its score using the formula score=w1E+w2C+w3I. E denotes residual energy, C denotes node connection, & I denotes node identification. If the computed result exceeds a specific threshold, the result value, together with the node ID & cluster-ID, will be broadcast to the surrounding nodes after a brief delay.
- **Receive Clustering Message:**When a node receives a rating value greater than its own & is not connected to any group, it adopts the sender node as its CH.
- **Actual announcement:**Once the 2nd step is finished, when fresh nodes are already engaged nodes from another group form a group with a novel leader, the CHs ID, cluster-ID, & score value must be transmitted.
- **Finalize Clustering:**The HEED technique, which finalizes the current cluster's head for additional nodes, is comparable to this.

2) Tree-Based Approach

Besidesgrouping methods in WSN, another energy-efficient method of data routing across the network is the tree-based method. In this technique, aggregation points are created in a hierarchical way that mimics a tree structure. The source nodes are the leaves, while the sink nodes are the roots. The data is combined at the intermediary nodes as it travels. PEGASIS is the most effective energy-efficient routing system that uses a tree-based approach.

PEGASIS: Given the fact that cluster-based protocols like LEACH outperformed previous methods by an order of magnitude, further improvements were achieved by sending data to only one node's neighbor. "Power-Efficient Gathering in Sensor Information System" was the name given to this approach. Rather than transmitting packets from various groupleaders like in the LEACH method, each PEGASIS node will establish a chain structure with the ground station, by which data will be transmitted to the BS node.

It achieves energy efficiency by sending information to just one of its neighbor nodes. The gathered information is combined, & the consolidated information is transferred to a one-hop neighbor. Because all of the nodes are performing merging at their various locations, the nodes near the base station do not experience a rapid power loss. Every node will also have the option to transfer the gathered data to the ground station in this manner.

Only a range of data created by the device is transmitted to the ground station when the sensor readings are combined into a packet. In certain applications, a particular sensor data is not needed, thus it is not transmitted to the base station. Aside from the routing protocol's purpose, we may configure the sensor network database to use a multi-resolution method in which aggregated information is stored in the root node & finer information is retrieved through a tree traversal process. Given the fact that the Directed Diffusion & Rumor Routing techniques are tree-based, they are less energy efficient than the PEGASIS model.

VIII. LITERATURE REVIEW

This section highlights and discusses the existing review and survey studies in the IoT, WSN, and energy-efficient data gathering protocol research domains. The research fields are classified based on the sub-sections described below. Presenting and discussing these studies can help in solidifying the importance of conducting this kind of survey.

(Gokula Krishnan et al., 2021)This article proposes ensembles bio-inspired method depending on the Firefly & Spider Monkey Optimization (SMO) processes as a histogram routing protocol (RP) for WSN. By recycling frequent data from the origin node into the sink, the suggested technique avoids needless routing messages which could outcome in significant energy waste. This routing method is capable of determining the optimal routing route. The suggested method utilized different factors like node residual energy, inter-cluster distances to the sink, & cluster overlaps to choose the optimal group leaders at each round. The variables of the suggested solution may be adaptively changed throughout the grouping procedure to get the optimum network performance. When compared to bee colonies, PSO, SFLA, & GWO, imitation outcomes showed mean lifespan gains of up to 30.91 %, 32.12 %, 12.4 %, & 13.50 % in different network conditions.

(Sheth et al., 2021)The proposed scheme provides an energy-efficient solution through the meta-heuristic algorithm of modified firefly to perform routing within the networks. In terms of system characteristics like connection lifespan, mean remaining energy, & the number of packets sent to the ground station, the findings show that the suggested method beats state-of-the-art algorithms.

(Khedr & P V, 2020)In this paper, they analyzed the influence of multi-levels of power diversity & accessibility of randomly deployed nodes to create an Energy-Efficient Heterogeneous groupdepending onthe Data CollectingMethod (MHCDP) for Mobile HWSNs, that may improve data distribution, fuel effectiveness, & network lifespan. To help pick the most appropriate node as CH, the proposed weighted CH selection option analyses remaining energy, mean comparative distance, & connectivity among nodes. As compared with existing methods, simulation outcomes show that theirsuggested MHCDP method is more effective in extending WSN lifetime &decreasing energy consumption.

(Sahraoui & Bilami, 2020)In this article, they present an Energy-efficient approach for Reinforcement Learning-based Multi-channel MAC (ERL MMAC), that uses a shared tree to conduct mixed stream allocation for multi-channel data collection in WSNs. The work aims to save energy and decrease dispute connections on one side as much as possible by using the least selected default channel allotment in 2 lunges instead of one leap, & by utilizing parent selection rather than parent default channel selection strategy in the learning method to avoid repeat texts on the other edge.The findings of comprehensive simulation tests indicate that our method improves network lifespan at a rate of 97.53 %.

(Sun et al., 2018)They suggest an E2E-DDR network reliability framework for forecasting & enhancing the dependable efficiency of WSNs in this paper. The E2E-DDR techniques provide a method for recording the mappings between the packet reception ratio, background noise, & acquired signal intensity. They use an alpha-stable distribution to appropriately represents background noise, & they use simplified log-normal route loss measures to correctly characterize the RSS.They also offer a comprehensive efficiency review employing the E2E-DDR framework to forecast network-level reliability & optimize WSN installation parameters in a real-world case study.

(Leao et al., 2018)This article offers a Fast-HyBeS (Hybrid Beacon Scheduling) method for a periodic redesign of array WSNs. The basic concept is to arrange a downstream chance window regularly to enable quicker control of message distribution. This chance window is scheduled using a top-down method that priorities downstream traffic. As compared to static improve cast scheduling methods, simulation findings indicate that using Fast-HyBeSmay substantially reduce the end-to-end communication latency for handlingmessages. Furthermore, the simulation findings show that Fast-HyBeSdoes not affect the monitoring traffic's end-to-end communication latency.

(Vijayalakshmi & Manickam, 2017)Current research is focusing on ways to decrease the energy consumption of detector nodes to rise the node's lifespan. Characteristics that set the suggested method apart from others include: 1) Mobilink's - Pathuniqueness, made possible by convergent sites 2) Efficient Data Collecting - The IMPR protocol improves data collection success rates. In the suggested study, many design aspects were addressed & thoroughly evaluated. Both theoretical & simulation studies show that the overheads & give an acceptable performance in determining optimal routing routes for efficient data collection in WSN.

(Razaque et al., 2016)Researchers developed the Low Energy Adaptive Clustering Hierarchy (LEACH) & Power-Efficient Gathering in Sensor Information Systems (PEGASIS) technologies to decrease network energy consumption. However, the current routing protocols have many flaws in terms of energy & power usage. Because of its cluster-based architecture, LEACH has dynamicity but also limitations, while PEGASIS solves LEACH's constraints but loses dynamicity. PEGASIS-LEACH (P-LEACH) is a near-optimal group chain protocol that beats both PEGASIS & LEACH in this paper. This protocol utilizes an energy-efficient routing technique to transfer data in WSN.They evaluate the performance of P-LEACH using Network Simulator (NS2) & MATLAB to verify its energy efficacy.

IX. CONCLUSION

IoT automation may assist to eliminate the need for short-distance communication. Thus, incorporating the internet into businesses may aid in gaining control of applications from all over the globe. The IoT is a critical component of the next era of industrial automation systems (IASs). Developing IoT standards, if utilized properly, have the potential to solve several problems in the creation of IASs. The usage of IoT & the REST architectural paradigm on which IoT is built, on the other hand, is not a simple job for the automation engineer. This review paper's major contribution is that it highlights the applications of IoT & WSN in industries with the use of an energy-efficient data collecting protocol to monitor & manage the industry. The article discusses existing technologies for controlling physical objects over the internet. We propose an effective industrial automation system that enables users to operate industry appliances/machines over the internet.

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