Survey on Wireless Sensor Network, Its Applications and Issues

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Abstract. WSN is a network comprising of various sensor nodes that are highly energy efficient used in various applications nowadays. It helps in transmitting data from sensor nodes to the base stations in a highly reliable and secured manner. It plays a very important role in real world and integrates with many other technologies like Cloud Computing, Internet of Things (IoT). Different researchers continuously attempted to work on different constraints under Wireless Sensor Network which further becomes research motivation. In this paper, we highlighted various issues facing by different researchers while data transmission among sensor nodes. WSNs are used in various areas in all over the world, and significant progress has been made to expand the use of sensor nodes over the past two decades.

1. Introduction

A computer network is a formation of number of computers which are connected to each other through some communication medium or protocol. The medium and protocol can have different architectures for communication due to which a variation in speed and reliability is observed. Broadly the network is being categorized in two segments namely wired and wireless network [1]. The word “wired” is any physical medium having cable. The cables can be of copper, twisted pair or fiber optics. In wired network, the various signals transfers in the form of current through some medium. Only one internet connection is used and one device is connected through which data is shared among different devices through wired network. “Wireless” means data transfer through electromagnetic waves or infrared waves. Wireless devices have sensors or antennas embedded in them. Few examples are mobiles, TV remote, Laptop etc. Instead of using wires for connecting devices, radio waves, fibre optic and broadband ADSL are used [2][3].

Wireless Sensor Network (WSN) comprises of small nodes that have certain components as 1) Battery 2) Sensor 3) Microprocessor 4) Radio Transmitter. WSNs have two broad categorical applications i.e., monitoring and tracking. In the current scenario, these WSNs operate on power sources like battery and hence organized energy consumption is highly required. These networks are highly reliable and are advantageous over conventional sensing devices. Also, they offer a very low-cost network deployment solution [4][5].
WSNs consists of tiny sensor nodes in which battery is attached individually. The efficiency of the network depends on these nodes. After the implementation of the network in the field, the batteries can’t be changed. Therefore, the lifetime is limited because of the limited energy of the battery. As shown in the Figure 1, circle indicates the nodes that is collectively known as sensor field, the route formed while nodes transmitting data is indicated by a dark circle and transmission direction is indicated by an arrow. Structured WSN and Unstructured WSN can be taken into consideration further for the better understanding of types of wireless sensor networks. Unstructured WSN is a thick collection of sensor nodes which are randomly placed into the specified area. After deployment of nodes, the network is left with no attention and it is ready to monitor and report functions. Maintenance of such network is a tedious task because of difficulty in management of connectivity between large number of nodes and failure detection in them. On the contrary, Structured WSN is a collection of pre-planned deployed sensor nodes. Its advantage is that fewer nodes has been placed with maintained network and managed cost at the low level [6][10][13].

1.1. Elements of Wireless Sensor Network
The elements in WSN are specified by sensor nodes and its well-defined architecture.

1.1.1 Sensor Node. The key element of WSN is sensor node. The responsibility of each node is to obtain information, process it and communicate and transmit it to its neighbour nodes. The network’s capacity and performance largely depend on the efficiency of these nodes only. So, it is essential to select the required nodes according to the need of application for which the network is going to be set [8]. Any sensor node can be represented with two things-(i) Structure, (ii) States.

1.1.2 Sensor Node structure. A structure is as in Figure 2.

Figure 1: Wireless Sensor Network (WSN) [32]

Figure 2: Functionality of Sensor Node [33]
• Controller: It helps in processing all relevant data. It is an integration consists of a CPU, memory, input output units, a clock and analog-to-digital convertors.
• Memory: Memory is needed to store data like RAM, ROM or EEPROM.
• Sensors: Various sensors has been used in a WSN such as Passive omnidirectional sensors, passive narrow beam sensors, active sensors.
• Communication: Both the transmitter and a receiver are present on a sensor node for effective communication.
• Power supply: Power available in the form of solar panel cells, power batteries etc [9].

1.1.3 States of a Sensor Node: Various states are as follows:

• Sensing: The node examines the region, digitally transform the information and after processing, stored in its memory and later transferred to the base station.
• Relaying: It works as a bridge between source and destination. Data is received from nodes and transferred to base station.
• Sleeping: A sleeping node does not have any participation. It becomes active on a channel at certain time and listens to the channel for any required action. On a request, a state change to sensing or relaying may occur.
• Dead: A dead node cannot re-enter any other state. It is no longer available in the network.

2. Network Architecture
As shown in Figure 3, OSI (Open System Interconnection) is followed by WSN. Basically, five layers are needed for successful transfer. Added to these are the three cross layers planes. [7][8][9].

Cross Layers and OSI layers
Power management plane, mobility management plane and task management plane are the additional layers that helps in managing the network and make the sensors work together to increase the network efficiency.

2.1. The Power Management Plane
manages the power being used by a sensor node and an account of total power being consumed is considered.
2.2. **The Mobility Management Plane**
the movement of sensor nodes is detected and registered. Hence a route back to the user is always kept.

2.3. **The Task Management Plane**
helps in managing the tasks of sensing and detecting events from a specific area thereby not allowing all of the sensor nodes to perform at the same time and at the same area.

2.4. **Transport layer**
This layer provides reliability and congestion avoidance.

2.5. **Network layer**
Routing is the major concept of this layer. Reliable paths are defined.

2.6. **Data Link layer**
Responsible for multiplexing, framing, error control.

2.7. **Physical layer**
It provides an interface for transmitting bits over physical medium. Selection of frequency, detection of signal, Modulation and encryption of data are the tasks taken into consideration by this layer.

2.8. **Application layer**
It is responsible for traffic management where it provides software to translate the data related to queries of the customers.

3. **Applications of WSN in real world**
WSNs are considerably popular due to its flexible nature in solving problems in different areas as shown in Figure 4.

![Figure 4. Use of WSN in Real World [34]](image)

- Military applications [11].
- Area Monitoring [12].
- Transportation [4].
- Health applications [13].
- Environmental sensing [14].
- Structural Monitoring [15].
- Industrial Monitoring [16].
• Agricultural sector [11].

4. Pros / Cons of Wireless Sensor Networks
As WSNs are being used in so many applications, so it definitely contains some strong points in order to get utilized in essential aspects of life. Following are the advantages of WSNs [31].

4.1. Ability to work in rough environment
WSNs are small in size and have the ability to communicate through materials. That’s why, they are used for forest fire detection or seismic monitoring.

4.2. Wide areas Coverage
Wired networks may not be used due to infrastructural issues and economic issues. WSNs resolved the issue of wide area coverage.

4.3. Self-Organizing
With the help of multihop broadcast, WSNs are capable of self-organizing in a niche of time.

4.4. Mastery in overcoming node failures
WSNs have the ability of overcoming node failures by applying another routing protocol.

4.5. Mobility of nodes
Modern WSN protocols and architectures are flexible in nature thereby capable of handling areal shiftings and to maintain routing.

4.6. Dynamic Network Topology
The topology used in this are dynamic in nature depending upon the relationships between neighbouring nodes.

4.7. Heterogeneity of nodes
A special kind of wireless sensor network contain variety of nodes, each having multiple different sensors implemented on it.

4.8. Unattended operation
If designed and configured correctly, WSNs don’t need any kind of attention while working. Though wireless sensor networks have a wide variety of applications, it has certain challenges to overcome. These are as follows:

• Limited energy resources
  As WSN infrastructure is not fixed, nodes are managed to work with small amount of battery. This results in limited computational power and memory size. Hence Energy Consumption Problem arises.

• Low Data Rates
  WSNs are not so quick as wired networks due to low data transmission rates. The percentage of data being propagated depends on the frequency being used.

• Communication Failures
  Higher error rate due to error prone fragments transmission.

• Security Issues
The wireless channel is accessible to unwanted listeners thereby resulting in active and passive attacks.

5. Literature Survey

The popularity of Wireless Sensor Network (WSN) is growing now a days in a heterogeneous computing environment. The tendency of using WSN is increased due to wide area coverage, mobility of nodes, data processing capabilities and ability to work in rough environments. Sensors provides different facilities such as infrastructure, platform and applications to their users via wireless means. Wireless sensor networks are considered one of the most important technologies of the 21st century, where the distributed node automatically helps in creating a network for transmission of data and is known as the Sensor Network. Many researchers have referred to different types of technology in this context. Application scenario is important when designing a specific protocol for the sensor network based on different technologies.

[17] Suggested a cross-layer-low-energy adaptive clustering hierarchy (CL-LEACH) model to increase the longevity of the network and the use of batteries. The proposed work uses the remaining energy to pick a group head that offers a transaction that is energy efficient. Author has shown that the proposed work uses the node’s residual energy to select the cluster head which preserves the overall energy consumption. Author demonstrated that the proposed work utilizes the remaining energy of the node for the cluster head selection that preserve the overall energy consumption. It has to be cleared from the obtained result of this work, it has produced enhanced outcomes in terms of dissipation of energy, cost to transmit along with total live nodes.

[18] Introduced a novel cluster solution in distributed nature to find the best CH corresponds to every cluster from WSNs with the aim to exchange the energy consumption and the end delay. It also proposes a new cost function for the multi-hop inter-cluster routing algorithm based on the current proposed delay model and offers a multi-hop routing algorithm from CHs to sinks with a minimum energy cost focused on the constraint of end-to-end delay. The result showed the proposed efficiency in terms of energy consumption and end-to-end delay much well than equivalent protocols.

[19] Suggest the P-LEACH routing protocol that was the combination of the PEGASIS (Power-Efficient Gathering in Sensor Information System) and LEACH technique for the enhancement of the energy efficiency in WSN. The proposed protocol uses the energy efficient routing scheme that utilizes the energy consumption while transferring of packet from one to another node. After the simulation on network simulator (NS2) and MATLAB, result indicate that proposed P-LEACH protocol perform better than that of LEACH.

[20] Introduces a modern hierarchical approach to Wireless Sensor Networks (HEBM), called Hierarchical Energy Balancing Multiple Routing Protocol. Author has shown that the HEBM method minimizes total energy consumption, balances the distribution of energy between the sensor nodes and ultimately extends the network life. After done the simulation on Network Simulator (NS2) and MATLAB, the result shows that the proposed HEBM protocol increases the energy gain and extends the network life from 32% to 40 % compared with the DEEAC reference protocol and from 25% to 28% compared to the FEMCHR protocol.

[21] Suggested an energy-efficient observation method for the non-stop cold chain management of table grapes to reduce the average energy consumption of WSN devices and improve the operation and transmission efficiency of WSN, and finally transparency, traceability and stabilization in the continuous monitoring of cold chains. Combining the WSN and the CS transmission mode for the acquisition and transmission of sensor data, the energy-efficient observation method in monitoring cold chains has been realized. The results show that CS transmission mode can reduce the average consumption of the WSN devices and improve the efficiency of the WSN operation and transmission.

[22] Introduced the PRIN MAC protocol QoS succeeds to prolong the network's life in terms of the minimum energy usage. By assigning different priorities to incoming packets according to the group's arrival priority list, the amount of energy consumed is reduced and the inter-arrival period is modified to improve the throughput. To demonstrate the improved performance of the proposed MAC protocol,
simulation results are compared with those of the synchronous MAC protocol in terms of QoS parameters.

[23] Implemented a new energy-efficient centroid-based routing protocol (EECRP) for WSN-assisted IoT to boost network efficiency. The proposed EECRP comprises three main components: a new distributed clustering technique enabling local node self-organization, a new set of cluster modification algorithms and rotation of the cluster head (CH), centered on the center location to align the energy distribution of the load equally between all sensor nodes and a new mechanism for minimizing energy consumption for long distance communication.

[24] Proposed an optimized cluster layout routing system, called the Dynamic K value LEACH (DKLEACH), with the aim to minimize energy consumption within the unevenly distributed WSNs. DK-LEACH takes into account the Cluster Heads (CHs) energy factor during cluster process. Simulation results show that the proposed approach performs better on energy savings than LEACH and extends the duration of network, the rate of surviving of nodes have improved by 8.75% as contrast to the LEACH.

[25] Introduced multi-hop LEACH to extend the lifetime of energy based wireless sensor networks by summarizing the limitations adjoining the existing works. The proposed multi hop model has been advantageous by two operating process such as, levelling and generic to improve packet delivery ratio and network lifetime of sensor network.

[26] In this work, have presented a modified LEACH with the aim to enhance the network life time through utilizing the process of heterogeneous node selection. Bunches were selected in the process based on a given threshold value, despite continuation of group head selection in-simulation round.

[27] In this work authors have resolved the limitations of WSN, specifically in two aspects such as; network lifetime and consumed energy by utilizing LEACH. This cluster approach is enhanced through identification of cluster head nodes.

[28] A new bid for the hierarchical heterogeneous WSN called the mobile-energy aware group-based multi-hop routing protocol. It selects the cluster head by means of the equation of probability in which only the highest energy nodes are chosen as cluster head (CH). In presented approach the EM algorithm is also included in which the network area is divided into different sectors for CH selection.

[29] Studied about the cluster-based routing strategy in WSN including the aim to analyzed benefits and drawback of LEACH protocol. Some pointed issues from existing works are; the selection criterion of CH, processing of node, and inter cluster routing challenges. Those have been resolved through presented approach named as LEACH-Impt. The key objective of this approach is to get the scientific as well as correct forwarding of route to transmit data by utilizing reduced amount of energy.

[30] The method was implemented using vague logic, taking efficient energy from WSN into a very complexity, called medium-access conscious LEACH. To overcome the short life of the network and the vulnerability of WSNs under unpredictable condition. This presented MAC-LEACH based routing process has optimized through fuzzy inference system including residual energy as well as retransmission amount.

6. Issues found during literature survey
Over the past two decades, WSN is the most flourishing area along with its various applications. It is a network that collects, processes and distributes wireless data to the required data repository. But still after so many advancements, there are certain challenges regarding security, architecture, sensor nodes deployment, collection of data, network coverage and these should be taken into consideration while working on WSN. As WSNs are in-charge of sensing and transferring required information to the intended database station, these operations require full power source without any interruption that is also a challenge in case of its deployment at remote areas. The solution of this problem is to have the surety of efficient power consumption. Other than this, several other issues prevail that are discussed as follows [26]:

6.1. Network Security Threats
Network Security depends on the deployment of the network as the sensor nodes are more vulnerable to attacks that are deployed at remote sites. Conventional Security is not suitable as WSN are having limited power consumption, communication and processing operations, security and being stable at the same time is the requirement and this can only be fulfilled by unique protocols and solutions.

6.2. Data Collection
For the intended result of getting secured data, two prime issues are to be considered. First is troublesome long-distance communication resulting in excessive energy loss between sensor nodes to base station and secondly confronting delays in collecting data. These two issues need to be solved simultaneously as they proportionally reciprocate each other. The solution proposed for this have been a cluster head-based algorithm and PEGASIS.

6.3. Deployment Techniques
As WSNs are easily deployed, it results in the wide emergence and application. Its presence at remote location also helps in various research fields but sometimes its deployment at remote locations results in limited usage of the network.

6.4. Coverage Problem
The positioning of the sensor node plays a very important role as it results in correct and accurate monitoring and tracking of the required application information for which the network is placed.

6.5. Network Architecture
Architecture is also one of the major issues as inadequate design results in wrong deployment of nodes thereby resulting in unauthorized access to critical data. Consequences are breached security. So careful consideration of design in terms of Cluster Heads, Sensor Nodes, Division of whole network into efficient modules should be taken into consideration.

7. Conclusion
Wireless Sensor Network is a highly potential field to enhance the quality of life in all aspects. Wireless sensor networks are infrastructures that have the potential of sensing and communicating that gives the ability of measuring the different aspects of environment to the users. It acts as an environment between the virtual and the physical worlds [22]. In the current era, WSNs are the power houses that helps in organization up to a very high level. WSNs helps in transmission of information from sender nodes to the receiver nodes and for that purpose some routing mechanism should be available so that the data should be transmitted effectively without any loss. These networks have higher reliability over the conventional sensor networks as having higher fault tolerance. Also, network deployment solution at low cost.

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