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Review on Wireless Sensor Networks

Nishjeet Kour Bakshi
Department of Computer Science
SGGSWU
Fatehgarh Sahib, India
E-mail: bakshinishjeet6@gmail.com

Navdeep Kaur
Department of Computer Science
SGGSWU
Fatehgarh Sahib, India
E-mail: drnavdeep.sggswu@gmail.com

Abstract: Wireless sensor networks are one of the supreme technologies of this era. The tiny autonomous sensor nodes provide a substantial union of dispersed sensing, computing and communication. The nodes are usually randomly distributed. The location and connection between them decides the network topologies. The network topology of a wireless sensor network includes bus, ring and star. Most common wireless sensor network consist of layered architecture model. The wireless sensor networks provide applications in numerous fields like military, health, industries, agriculture and so on. However they are subjected to numerous challenges and issues like limited resource of energy, small memory, deployment, security. This paper presents different topologies, network protocols, applications and various challenges in a wireless sensor network.

Keywords: Wireless sensor network, Sensor nodes, Topology.

I. INTRODUCTION

A Wireless Sensor Network is the type of wireless network that comprises of a vast number of spatially dispersed self governing, low powered and minute sensor nodes called motes which monitor the physical domain conditions such as sound, pressure, temperature, etc. that cooperatively collect, process and transfer the data to the main location via network with controlled ability to compute and process the data.

The nodes vary from few to several hundreds or thousands. These nodes are minute computers which work together to shape the network. Each node comprises of various parts like radio transceiver, a microcontroller, an electronic circuit for interfacing with the sensor and an energy providing embedded battery. These nodes work together to accumulate the data from the surrounding to attain the particular application objectives.

II. TOPOLOGIES

The emergence of wireless sensor networks has given a new direction to the traditional network topologies. Different Wireless sensor network topologies are discussed below.

A. Bus topology

In a bus topology, there is a central line which connects all the devices. All the nodes are aligned in bus orientation in wireless media. Metrics like packet, range and number of nodes in the network are used to compare energy utilization [2]. In bus topology, a node sends message to another node connected on the network. A broadcast message is sent by the network to all other nodes connected onto a network, but the node that is expecting and is ready to receive the message accepts and processes the message. This topology is very easy to put into use but it sometimes results in the congestion of traffic. If the nodes are within a limited range this topology works best. However, if a few more nodes are joined onto the network bus, its performance starts to degrade [3].

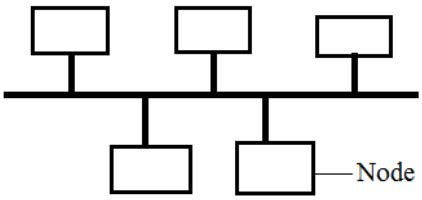

Fig 1 Bus Topology

B. Ring topology

In Ring topology, the nodes are set up in such a fashion that each node is connected to exactly two nodes which results in the formation of a continuous pathway for signal processing through each node and in turn a ring shaped structure is formed. The data proceeds from one node to the other and each node in the path handles each packet. The nodes consist of low rate capacities which allows limited power source and communication ability in difficult environment for very long time [2]. The data proceeds in the same direction that is either clockwise or anticlockwise in the ring. But if a single node breaks down in the network, then whole network can crumble down [3].

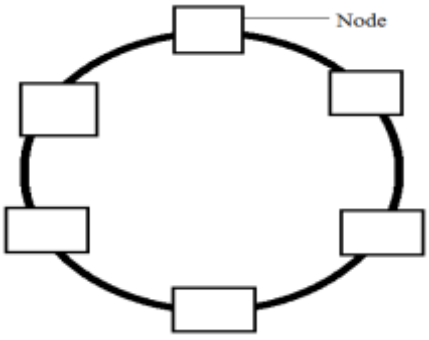

Fig 3 Ring Topology

C. Star topology

In Star topology a single sink node in the centre acts as a hub to which all the nodes are connected. Transmission occurs between source node and destination node, so hopping is not required among other nodes. As the nodes in the network increase, the energy of sink nodes dips in comparison with other topologies [2]. Due to the connectivity of the nodes to a central hub there is no intercommunication between the nodes. So each message has to pass through the central hub. Thus the hub in the centre performs as a server or sink and each node performs as a client [3].

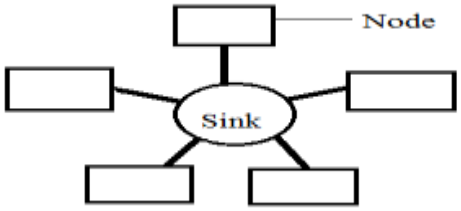

Fig 4 Star Topology

III. COMMUNICATION PROTOCOLS

Wireless sensor networks use layered architecture. Each layers functionality and characteristics are discussed below:

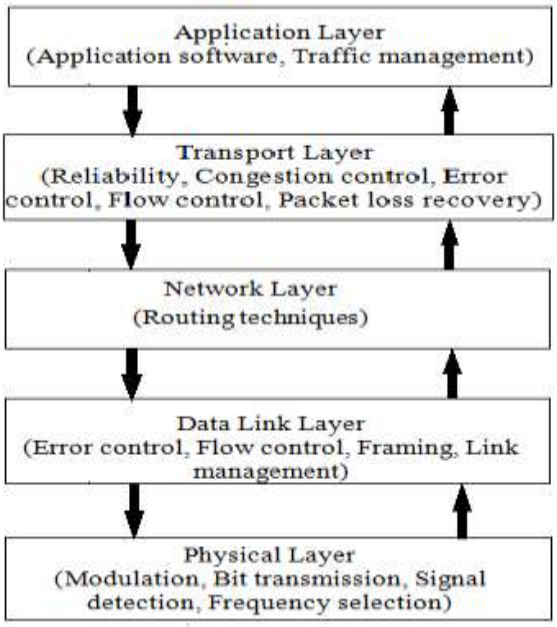

Fig 1 Wireless Sensor Networks Protocol Stack

A. Physical layer

The main aim of the physical layer is improve the reliability by reducing path loss and shadowing. It is reliable for data rate, connection recognition, modulation, signal detection and frequency generation, data encryption. Energy minimization is of prime concern over decay, scattering, shadowing, reflection, multipath, diffraction and fading effects when physical layer for wireless sensors are designed [4].

B. Data link layer

The main aim of data link layer is to make sure that communication between the nodes is interoperable. Data streams multiplexing, detection of data frame, error control and medium access is the responsibility of data link layer. Point-to-point and point-to-multipoint connections reliability is maintained by this layer [4].

C. Network layer

The Network layer provides the ideal path for routing. It routes the data from node to sink, node to node, node to cluster head, node to base station, and vice versa. For routing wireless sensor network uses ID based protocols and data centric protocols. In a wireless sensor network every node performs as a router to ensure that the routing protocol is secure. All the sensor nodes are dispersed quite heavily in a field, which are either inside the process going on or close to it. Multi-hop wireless routing protocols are required between sensor nodes and sink nodes. Power efficiency is the major principle during the design of network layer in wireless sensor network [4].

D. Transport layer

Using the transport layer setup communication in a wireless sensor network is a complex issue; however it can be used in external networks that are connected to internet. Thus this layer is needed when wireless sensor network has to communicate through internet. The transport layer in a wireless sensor networks are handled differently due to various factors like consumption of power, data centric routing, scalability etc.

E. Application layer

The main objective of application layer is to collect data, manage and process the data. Thus application layer ensures smooth flow of information to lower layers.

IV. APPLICATIONS

Due to easy availability of sensors at low prices, the application of wireless sensor networks has drastically increased and has in turn aided in the application of wireless sensor network in various streams like infrastructure, security, industrial sectors and others.

Different wireless sensor network may comprise of different type of sensors like sesmic, magnetic, visual, thermal, infrared, radar and acoustic which are intelligent to map huge amount of situation. Sensor nodes are put into use for regular sensing, event ID, event detection and control of actuators.

A. Military operations

Wireless sensor network can play a huge part in military commands, controlled transfer of messages, computation, intelligence reports, surveillance, locating and taking action upon certain structures. Properties such as self governing and fault resistance make wireless sensor networks a totally reliable sensing approach for military operations. In navy based operations the destruction of few nodes will not affect the whole operation as it happens in case of conventional sensors. Due to this the wireless sensor network became first choice for battlefields [4, 5, 6]. They are deployed in military operations such as tracking and environment monitoring. The sensor nodes are put into effective use at the feasible and self-interested space of the organization and then effectively operated by user for tracking the enemy movements and also to detect the security status using the networks.

B. Environmental and habitat monitoring

The most promising field to use the wireless sensor network is the habitat and environment monitoring due to the distribution of variables such as temperature being distributed over large geographical area [4]. As far as the use of wireless sensor network is concerned in the environment, it is used in coal mining, earthquakes, tsunami, flood detection, forest fire prediction, gas leakage, cyclones, rainfall range, water quality etc. A wireless sensor network is thus used for early detection of such catastrophic events and allows us to take certain necessary measures for our interest in advance. All the data is sensed through the sensors and further sent to the station handler through internet. It helps in taking necessary precautions and spread the awareness among people about the disaster.

C. Health care monitoring

Most benefited area from sensor networks is Healthcare and medical research. The sensors provide important symptom monitoring and recognize accidents. The most important issue this time is to take care of the old aged people especially if they are suffering from cognitive issues. The specialized networks can help them by monitoring their activities and often help them in carrying out their daily activities. The appliances having sensors can help them by reminding them of their meals and medications from time to time. They can capture their vital signs and in real time send all the data to medical practitioners so that they can get immediate medical attention in case of emergency. All the data of the patient can be monitored by wearing sensor nodes [7].

F. Industrial sensing

Wireless sensor networks can aid the industrial by means of use of smart sensors that can effectively reduce the cost of manufacturing and save a lot of time. They can effectively monitor the wear and tear of the machine and send signals to the master regarding the degradation in performance or when the repair is needed. This can benefit in saving the cost and time and also save human lives which may result due to the failure of machinery. Chemical plants and oil refineries can deploy the sensors to check the condition of long pipelines. They are also used as alert systems in case of a failure.

G. Home intelligence

Wireless sensor can be deployed to make homes smarter. They can be used to monitor meters such as water, gas, electricity and send all the recorded data to the concerned centers through wireless communication [8]. The sensors can be implemented into daily household activities such as vacuum cleaners, DVD players, Microwave and an interconnection can be made among the devices which can be operated with the use of a network or satellite and in turn help in effective management of the devices. Wireless sensor networks allow the interconnection among the devices and thus in turn provide convenience to the users at home [10].

H. Agriculture

With the advancement of the sensors, the use of wireless sensor network has occurred at a tremendous rate in the field of agriculture. They aid farmers by freeing them from tedious work of maintaining of wires. Gravity feed water systems can be monitored all the time using the sensors which in turn will provide the constant check of water levels in tanks. Wireless I/O devices can be used to control the pumps. Water that is used can be measured and wirelessly sent to a central control station for billing. Sensors can be used in irrigation which aid in efficient water use for the ultimate cost saving and higher productivity [10].

V. RELATED WORK

This chapter includes various research studies related to the wireless sensor network. Topology, protocols, applications and issues are various research directions that attract the researchers in this field.

S. Santha Meena, et al. [2] presented various types of topology like bus, star, ring and evaluated them on the basis of energy received, energy in the idle state and number of packets that are sent and received in the network. An effective model of the topology is presented in which the energy of individual nodes is conserved in wireless sensor network.

Divya Sharma, et al. [3] divided the network of wireless sensor network on the basis of topologies. The dynamic network topologies in wireless sensor network are compared on the basis of performance.

Chee-Yee Chong, et al. [4] traced the research that has been done over the past few years in wireless sensor network. A review of the technology trends that impact the development of wireless sensor network is carried out. Various applications like infrastructure security, habitat monitoring and traffic control are presented.

B.P.Sreeja, et al. [5] outlined the various applications of the assorted wireless sensor networks. The wireless sensor network programs are evaluated on the basis of the characteristics of the sensor networks.

I.F. Akyildiz, et al. [6] discussed the concept of sensor networks. Various applications of the sensor networks is discussed and the factors that affect the design of sensor networks are provided. The architecture of sensor networks, protocols and open research issues are also discussed.

S.R.Jino Ramson, et al. [8] studied various deployments of wireless Sensor Networks. The characteristics such as flexibility, high sensing, dependability, fault tolerance, low-cost and quick employment have been analyzed. Various applications of wireless sensor networks like animal tracking, precision, environmental monitoring, security and surveillance, smart buildings etc has been presented.

S.Prasanna, et al. [9] presented various applications of wireless sensor networks like military, health, environmental, water, industries, home, agriculture and so on. Various security related issues in wireless sensor networks has also been discussed.

Ahmad Salehi S, et al. [11] presented an extensive review about the challenges of wireless sensor networks security and the threats in the wireless sensor networks which affect various layers along with their defense techniques is presented.

Sukhwinder Sharma, et al. [13] gave an overview of the broad research issues and challenges that affect the design of wireless sensor networks. Various issues like energy conservation, synchronization, quality of service, architecture, computation costs etc are presented.

Hande Alemdar, et al. [15] Evaluated how wireless sensor technologies benefited people living in homes and provided them with better quality of life. It also threw light on the issues that need to be kept in check while developing sensors. Various systems have been contemplated for obtaining and elucidating context information for the omnipresent disposition of wireless sensor networks. The results obtained in this study urged a strong probability for wireless sensor networks to open new research outlook for energy-efficient, low-cost and ad hoc deployment of multi-modal sensors for a better quality of medical care. An analysis of the issues from a healthcare point of view of WSNs is presented.

M. Magno, et al. [16] proposed a technique in which the sensors t have a low-power embedded platform and can be used to measure biomedical signals in either contact or non-contact mode is presented. The sensors are placed close to the heart rate and respiratory rate and the proposed low power system is optimized to compute it. The data that is to be transmitted to the host device is reduced by this technique. The platform used in this technique is independent and wearable. It can also be used in cars for detecting if the driver is feeling sleepy. Experimental measurements show how the data is acquired and processed from sensors and the low power consumption achieved with the node in different modes of operation

Elisa Pievanelli, et al. [17] introduced a wireless sensor network platform for the protection of workers employed in the building sector, exposed to critical physical agents, typical of their working scenario

Imron Rosadi, et al. [18] presented a model of a low cost wireless sensor network for multipoint measurement for monitoring temperature and humidity in a building.

Jun Zhang, et al. [19] presented the design and implementation of a wireless sensor network that monitor the home environment like resident tracking, energy-efficient home appliance control and home security. The system is proposed to make the living space more intelligent.

R.Gnanavel, et al. [20] proposed a Wireless Sensor Network based on smart home monitoring system for elderly people to monitor their health and provide them with a safe and secure living in a compact environment like home.

Bin Liu, et al. [21] proposed a new medium access control protocol to track and maintain the quality of service (QoS), under the dynamic environment dictated by human mobility and is to ensure the energy efficiency within such a resource-constrained network

Nilanjan Dey, et al. [22] presented a wireless ECG monitoring system that uses Zigbee technology for monitoring people at their homes. It can also used by physicians to monitor the patients periodically for providing suitable healthcare. The study presents the review and introduces the main idea about wireless ECG monitoring system. Various ECG signal models and power consumption formulas are discussed.

VI. ISSUES

Wireless sensor networks have many constraints which affect the design and the performance of it.

A. Security

Security is a broad term which collectively is comprised of authentication, privacy, integrity, non repudiation and anti playback. More the dependency is on the network about the information supplied greater becomes the risk of secure transmission of information over the network. Several cryptograph-

ic, steganographic techniques are applied to secure the data transmission over the network [1].

B. Power consumption

The wireless sensor node is the best fit when main supply towards sensor node is not feasible. But most of the time the wireless sensor node is placed in a hard to reach place so it becomes difficult to replace the batteries frequently. While installing the wireless sensor node it should be ensured that it has adequate power supply. Consumption of power by the sensors varies greatly and depends usually upon the protocols used for communication. For different operations sensors require power. Energy is used by the sensors for data collection, data processing and data communication. Sensors also listen continuously to the medium for data due to which a large amount of energy is required by the node components even during their free time. Batteries need to be replaced from time to time once they are consumed which is not always easy due to demographic conditions. So it remains a big challenge for the researchers to design, develop and implement energy efficient hardware and software protocols for wireless sensor networks.

C. Deployment

Although sensor networks provide us with the ability to monitor real world phenomenon's with great detail but the deployment of those wireless sensor networks is quite labor extensive task as environmental influences cause hindrance in the trouble free working of the nodes. The challenges presented by the environment are during the runtime and they cannot be predetermined during the deployment period. The real problem is that the output of the sensor nodes are highly governed by the environmental influences which often results in the network congestion as many concurrent attempts are made by several sensor nodes for transmission of data. Thus network delivers insufficient data which results in the low data yield in real world [13].

D. Limited memory and storage space

The memory space of the tiny sensors which is used to store the code has limited storage capacity with a few hundred kilobytes.

E. Fault tolerance

The prime aim of wireless sensor network is that it should function well even if a single node fails during the operation of network. If any fault occurs then network should be smart enough to adapt by changing its connectivity.

F. Node cost

A large set of sensor nodes are present in a sensor network. Cost of individual node is very important for the overall cost of the sensor network. So for the metrics to be acceptable the cost of each node should be as low as possible. In many instances a network is spread over a large area as incase of weather monitoring, so for the successful deployment of the wireless sensor network the cost has to be low.

VII. CONCLUSION

Wireless sensor networks are composed of a number of sensor nodes, which are distributed either inside a physical phenomenon to be monitored or very close to it. The wireless sensor networks are becoming an indispensable part of our lives because of the wide range applications of them in homes, health, ecology, industries etc. However several constraints need to be satisfied for an efficient design of a wireless sensor. Thus the different aspects of Wireless sensor networks attract the researchers to investigate more and more into this field.

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