International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 710
ISSN 2229-5518

Wireless Sensor Networks: A Survey

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Abstract-The rising field of wireless sensor network (WSN) has potential benefits for real-time monitoring of a physical phenomenon. The Wireless sensors continuously monitor the physical process and transmit information to the base station. It is an information technology which integrates latest technological achievements in the network, micro-electronics and communications. Sensor nodes can communicate over the minimum distance through wireless medium and unite to accomplish a single task. Aim of this paper is give an overview of Wireless Sensor Networks.

Index Terms - Wireless Sensor Networks, Architecture of WSN, Applications, Research challenges.

1 INTRODUCTION

Due to the recent developments in low powered tiny sensor technologies, the sensor nodes are used in wide range of applications in environmental monitoring [1]. It can hold potential to revolutionize segments of the economy and life. There could be one or few sink nodes and a fixed number of sensor nodes in Wireless Sensor Networks and all the sensor nodes have contact with the base station. A Wireless Sensor Network has been designed to perform the high-level of information processing tasks like detection, classification and tracking. The energy of nodes, communication computing and storage capability in Wireless Sensor Networks are limited. So routing technique and congestion control mechanism play a key role to consume the efficient energy and support quality of services in Wireless Sensor Networks.

In alternative cases of ground access space of objectives needs to monitor is dangerous and troublesome. So sensors are the only solution in harsh environment monitoring. While not locating the position, the solely way to allow adequate target coverage by sensors to use multiple sensors than the fastened range. High sensor density will increase the chance of target coverage. The sensors are placed within target proximity. In sensing network, the main problem is network lifetime. The cost and size of network limits the accessible energy within sensor network to sense the Physical phenomenon. A general approach to energy saving is to use mechanisms for economical energy management. This technique is applied on programming

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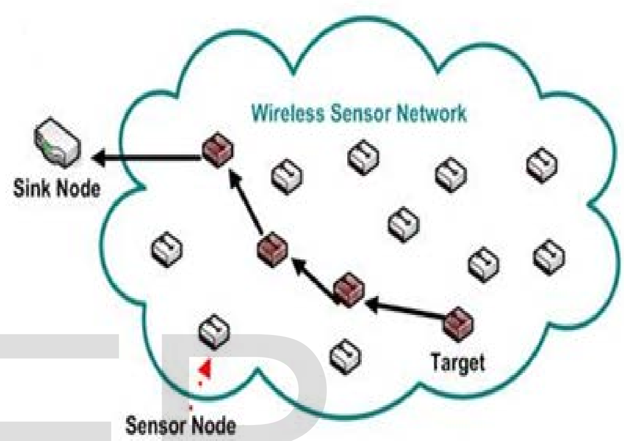

Figure 1.1: Structure of Wireless Sensor Networks [59]

the sensing activity. Thus, associate degree operation mode alternates active or monitor inactive battery states to extend the network period [4]. All targets are requires to monitor with sensing. Take into account massive number of the sensors that distributed haphazardly in the closed proximity to multiple objectives and transmit the observance information to the central process node [5].If active sensing is varied operationally only then the targets are lined. When the moment time is set to 1, then active disjoint set is turn on and the active set sensors are active and all other sensors are at rest. All the targets are monitored from each sensing set therefore interval time between two activations for sensing is longer. Sensing is active by reducing the fraction of time and thus application period can be proportional to the disjoint sets. Moreover, the density of active nodes can be reduced.

Present progressive sensing technology gives answer to develop and style the varied kinds of wireless sensing applications. Present framework of sensing technologies has specified in sensor which includes generic nodes and entrance way nodes. A multi-purpose generic sensing node task has requirement of measurements from monitored environment [8]. It should be equipped with various

ISSN 2229-5518

devices with physical attributes like as light, humidness, acceleration, temperature, atmospheric pressure, acoustics, force field, velocity etc. The bridge nodes collect the data from generic sensors or relay them to base station. Entranceway nodes contain higher process battery power and transmission capability. A mixture of generic and entranceway nodes are generally developed to create a WSN [9]. Each sensing node has a personal system. To support totally different variety of application software system on sensing system, the event of newest platforms and storage schemes is required. The communication protocols manage communication between the sensors and application. They permit the communication between sensing nodes. The services are developed to improve network potency and system performance [10]. Sensing nodes can arrange themselves very efficiently within the network. Sensing nodes can be restricted in the process capability, storage, power, communication protocols. So the efficient management services have been required to fulfil the needs.

The communication protocol has five protocol layers for the packet switching: application layer, transport layer, data-link layer, network layer, or physical layer [11]. Protocols at different layers address network dynamics and energy potency. Functions like as storage, localization, synchronization, security, coverage, and knowledge aggregation and compression can be expressed for sensing network services [12]. In the protocol stack, different layers of protocols are implemented which can control the energy consumption, system potency and end-to-end delay in order to reduce the energy usage, so it is significant to optimize the communication. The networking protocols are not designed to achieve the basic needs, thus they are not suitable for WSNs. [13]. However, new energy-efficient protocols are projected for all layers of the protocol stack. These protocols can do cross-layer optimisation by support interactions across the protocol layers to harvest and minimize energy consumption [14].

2 GENERATIONS AND ARCHITECTURE OF WSN

Wireless Sensor Networks evolved through many generations starting from simple sensors deployed in fields for military applications to hazardous industrial applications. Now, the sensor networks is mainly classified into three fields based on the applications i.e. in WSN, energy consumption is major issue and in MANET's, mobility of nodes consider as the major challenge for various mobile applications. Furthermore, in VANET's, important challenge is to minimize the path length [15]. Current Wireless sensing networks can be placed underwater and underground. Sensing network faces different challenges and constraints depend upon the atmosphere. So wireless sensor network can be classified as underwater WSN, terrestrial WSN, multi-media WSN, underground and mobile WSN [16].Terrestrial WSNs are commonly includes lots of wireless sensing nodes settled in the given space, either pre-planned or in ad hoc manner [17]. In unexpected placement, sensing nodes can be dropped from plane and notably placed into the geographic area. In pre-planned placement, there are optimum position, 2-D and 3-D placement models [57]. In exceedingly terrestrial Wireless sensing networks, reliable communication in associate atmosphere is important to communicate back to base station [18]. Terrestrial sensing nodes having secondary battery for power supply because primary source of battery can be prohibited and reversible. In wireless sensor networks, there are several approaches which can help to save energy. Some approaches are multi-hop fastened routing, network knowledge aggregation, eliminating knowledge redundancy, minimizing delays etc. Underground Wireless sensing networks involve the range of sensing nodes buried in caves to monitor underground conditions [19]. Additionally sink nodes can be placed within ground to relay knowledge from sensing nodes to base station. These sensing nodes are expensive result of acceptable instrument components that are opted to make sure the reliable communication via soil, water, rocks, and alternative mineral contents [20]. The atmosphere creates challenge in the wireless communication because of signal losses and high levels of the attenuation. Hence a typical sensor node should have sensing, processing and communication capabilities for observation. A node consists of a RF transceiver, microcontroller and power unit along with ADC/DAC and a sensor.

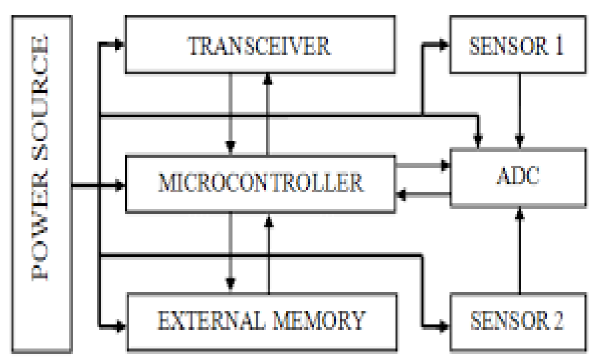

Figure 1.2: Architecture of a Sensor Node [61]

Underwater Wireless sensing networks involve the range of vehicles and sensing nodes placed underwater [21]. These sensing nodes are expensive as comparison to terrestrial WSNs. The autonomous underwater vehicle has been used for the exploration or collection of knowledge from sensing nodes. A typical underwater wireless communications can be established through transmission of the acoustic waves. The challenges in underwater acoustic communication are restricted information measure, long propagation delay and signal deterioration.

Multi-media Wireless sensing networks are enabled to see and track events in the variety of multimedia system like as video, audio and imaging. Multi-media Wireless sensing networks includes sensing nodes which have inbuilt microphones and cameras. These sensing nodes can be connected with other nodes in the network. In order to get coverage, these nodes are located in planned manner. The major challenges in WSN are high energy consumption, quality of the service provisioning, compression techniques, processing and cross-layer style. Multi-media content like as video stream wants high information measure for the content to be delivered [22]. High rate can cause high energy consumption. Transmission technique can support low energy consumption and high information measure.

Mobile Wireless sensing networks can involve the sensing nodes which can move and connect with the physical atmosphere. Mobile nodes can sense, and communicate like static nodes. Mobile node has capability of preparation and reposition itself within network. Data gathered by the mobile node could also be transmitted to the alternative mobile node. Mobile WSN faces various issues like deployment, localization, navigation, self-organisation and coverage, management, maintenance and energy etc [23].

3 CHARACTERISTICS

A Wireless Sensor Network is fundamentally a network of nodes that can jointly sense the physical environment. The main characteristics of WSNs are flexibility, Maintainability, Scalability, self-monitoring, property of fault tolerance [24, 25, 26]. Moreover, it provides quality of services and it can fulfil its task in harsh environment. Some problems can only be resolved by WSN like geographic scoping square measure. As compared with other networks, the services provided by wireless sensor network are real time and reliable.

4 ROUTING IN WSN

A sensing element node has restricted sensing and computation capacities, communication capability and power. These nodes can communicate with one another for obtaining information either directly or through other intermediate nodes. Therefore every node in an exceedingly sensing element network acts as a router within the network. In direct communication routing protocols, each sensing element node can communicates directly with Base Station. Base station can communicate with the end user either directly or through some existing network. The topology of the sensing element network changes frequently. Since the gap between the sensing element nodes and base station in case of direct communication is massive, but sensors consume energy quickly and become inoperative. In another approach, knowledge is routed via intermediate nodes to the base station and therefore saving node energy. A routing protocol may be a protocol that specifies how routers communicate with one another, scattering information that allows them to pick out routes between any two nodes on the network, the selection of the route being done by routing algorithms. Dynamic routing permits routing tables in routers because the attainable routes can change. In case of wireless sensing element networks, dynamic routing is usually used because nodes might modify their position and die at any moment. So the benefits and drawbacks of wireless sensing element networks will be summarized as follows:

- Network setups are complex.
- Ideal for the non-reachable places like across the ocean, mountains, rural areas or deep forests.

5 APPLICATIONS OF WSN

Wireless sensor networks (WSNs) are consisting of a large number of sensor nodes with limited energy resources. Major objective of WSN is to collect the information accurately and economically [28]. The improvement of WSN was inspired by applications such as crime investigation, target tracking, aircraft control, greenhouse monitoring [29, 30], marine environment monitoring [31, 31, 32]. Wireless sensor network has wide range of applications like industrial applications, medical applications, agriculture applications and many more [33, 34]. Few of them are following [60]:

Area observation: Area observation is a common application of WSNs [35]. In area observation, the WSN is deployed over a region to monitor the particular area and space [36].

Health care observation [37, 38, 60]: The medical applications are often of two types: implanted and wearable. Wearable devices area unit used on the body surface of an individual to monitor body position activity, and overall observation of sick patients at different locations. Implanted sensors will gather information regarding a person's health, fitness, and energy expenditure.

Environmental or Earth sensing [39]: WSNs are used to monitor the environmental conditions like habitat monitoring, animal life, breeding season, dense forest by deploying sensor with help of aeroplane or helicopter.

Air pollution observation [40]: Wireless sensing element networks are deployed in many cities to observe concentration of dangerous gases in the environment of the city. These are using wireless links instead of wired installations that additionally provide mobility for examining readings in various areas.

Forest fire detection: Sensing nodes are deployed in a forest to detect the fire and chances of fire [41, 42]. The first detection is important for victorious action of fire fighters to tackle the fire and fire brigade will be ready on the basis of first intimation of the sensors.

Landslide detection: A landslide observation system makes use of a wireless sensing element network to detect the changes in numerous parameters that will occur before or throughout a landslide. Through the gathered information it is easy to understand the prevalence of landslides long before it really happens [43, 60].

Water quality observation: Water quality observation involves analysing water properties in dams, rivers, lake, oceans, underground water reserves [44, 45]. The utilization of the many wireless distributed sensors allows the development of a lot of correct observation or map of the water standing and quality.

Natural disaster [46, 60]: Wireless sensing element networks can efficiently act to stop the natural disasters like floods, Tsunami and earth quakes. Wireless nodes can be deployed in rivers wherever changes of the water levels ought to be monitored in real time.

Machine health observation [47]: Wireless sensing element networks can be used for condition-based maintenance of machines as they provide vital price savings and can be placed in harsh and troublesome locations where a wired system is not possible like rotating machinery and unbound vehicles.

Data logging [48]: Wireless sensing element networks are also used for the collecting the environmental data. The advantage of WSNs over standard loggers is real time data transmission.

Structural Health observation [49, 50, 60]: In Structural health observation, Wireless sensing element networks are often accustomed to monitor the state of civil infrastructure and to connect the geo-physical processes in real time.

6 CHALLENGES IN WIRELESS SENSOR NETWORKS

The major technical challenges for realization of WSNs are identified as follows [51, 52, 58].

Resource constraints [53]: The planning and implementation of WSNs square measure forced by three scarce resources:

a) Limited energy.
b) Limited memory.
c) Limited computational capability.

Dynamic topologies and harsh environmental conditions: In Physical environments, the topology and property of the network could vary as a result of link and sensor-node failures. Moreover, sensors may additionally be affected from high humidness levels, vibrations, dirt and mud, or alternative conditions that can degrade the performance [58].

Quality-of-service needs: The big variety of applications envisaged on WSNs can have completely different QoS requirements and specifications. The QoS provided by WSNs refers to the accuracy between the information reported to the sink node and the actual reality of the event detected by sensors.

Data redundancy: Attributable to the high density within the network topology, device observations can be redundant. In addition, the character of the natural phenomenon constitutes the temporal correlation between every consecutive observation of the device node.

Packet errors and variable-link capacity: Compared to wired networks, Capability of every wireless link depends on the interference level and high bit error rates in transmission [58].

Security: Security ought to be a necessary feature within the architecture of WSNs to make the communication safe from external denial-of-service attacks and intrusion. WSNs have special characteristics that modify ways of security attacks. Passive attacks are carried out by eavesdropping on transmissions. Active attacks encompass modification, fabrication, and interruption that could embrace node capturing, routing attacks, or flooding.

Integration with web and alternative networks: it is necessary for the development of sensing network to provide several services which give access to retrieve any information at any time and thus it may be integrated with the internet for information retrieval [53].

7 STORAGE MANAGEMENT IN WSN

Storage management is an area of sensor network analysis that starts to attract attention of researchers. For storage management, data gathered by sensors is not transmitted to the sink in limited time period. In such applications, the information should be keep, a minimum of briefly, among the network till later collected by the sink. Therefore, storage becomes a primary resource, additionally to energy, that determines time period and coverage of the network. Trends that inspire the necessity for storage management discussed the appliance characteristics and numerous resource constraints that can influence the planning of storage management techniques in sensor networks [54]. Additionally, storage management break down into various components (1) system support for storage management; (2) cooperative storage; and (3) assortment. A storage management approach should be the balance of subsequent goals:

- **Minimize Size of stored information:** Since sensors have restricted storage offered to them, minimizing the dimensions of information that require to be keep ends up in improved coverage because the network will continue storing data for extended periods of time and becomes additional economical if the information size is small [55].
- **Minimize Energy Consumption:** Most of the sensors area unit are battery-powered and so energy could be a scarce resource, so storage management must be energy efficient.
- **Maximize information Retention or Coverage:** Aggregated information is the primary goal of the network. If storage is affected, information re-allocation should be applied efficiently to ensure coverage for new data. The management protocol ought to plan to retain relevant information at an acceptable quality level.

8 RESEARCH CHALLENGES IN WSNS

Wireless Sensor Network is a wide field of study. A lot of researchers proposed new techniques and compare the merits and demerits of their approaches with the previous existing approaches. Energy efficiency, Congestion and data loss in a wireless sensor network are the problems of concern in recent years. Congestion in any network degrades the quality of communication in the network which in turn leads to the packet loss in network. Energy conservation in Wireless Sensor Network (WSN) is also a part of concern for several researchers in recent years. Many techniques which includes machine learning algorithm have been introduced in recent years but still there is a gap for improvement in packet delivery and energy consumption in WSN [56].

9 CONCLUSION

This survey presented an overview of Wireless Sensor Networks. The survey described the generations, architecture, Routing and storage management of wireless sensor Networks. Applications areas and characteristics of WSNs are also described in this paper. There are still many challenges and constraints in the sensor networks including limited bandwidth and network lifetime of a node. The paper has also highlighted research challenges in WSN and identifies the future research directions.

ACKNOWLEDGMENT

Author is grateful to Punjabi University Patiala for providing adequate library and internet facility.

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