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Challenges and Design of Wireless Sensor Network: A Survey

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***Abstract*--** The need for connectivity has sparked substantial research and experimentation in the area of wireless sensor networks as a result of the exponential growth of wireless communication in the modern era. The wireless sensor network was created as a result of the need for wireless connectivity as well as recent advancements in material science, semiconductor technology, and networking. A wireless sensor network is made up of numerous little computers, or sensor nodes, that can wirelessly analyse, store, and transfer data and perceive their surroundings. These networks have a wide range of applications, from monitoring smart agriculture to offering comfort in your own home. Wireless sensor networks have gained increased attention in recent years. The challenges, issues, and requirements for the design of wireless sensor networks have been explored in the field.

***Keywords*-** WSN, sensing, ad-hoc network

I. Introduction

Wireless technology has prolonged the limits of our world. The rise of informatics originates the rapid development of networks and wireless communication technologies [1]. Wireless sensor networks are the next stage of technology-nature cohesion. Automated sensing, embedded computing, and wireless networking are not new ideas. However, it has been seen that computation, communication, and sensing have matured sufficiently to enable their integration, inexpensively, at low power, and at large scales. The convergence of the internet, communications, and information technologies coupled with recent engineering advances, is paving the way for a new generation of inexpensive sensors and actuators, capable of achieving a high order of spatial resolution, temporal resolution, and accuracy. Although a young technology, the applications have been varied and pledge to be even more diverse. It is a fast growing and exciting research area that has attracted considerable research attention in the recent past. The technology for sensing and control now has the potential for significant advances, not only in science and engineering, but equally important for a broad range of applications related to critical infrastructure protection, security, Health care, the environment, energy, food safety, production processing, quality of life, and the economy [2].

I. Wireless Sensor Network vs Ad-Hoc Networks

Wireless sensor networks are different from ad hoc networks as they are distributed, self-organized, and multi-hopped and lack a fixed infrastructure [3]. Wireless sensor network has a huge economic potential and the ability to transform our lives and cause many new sy-stem-building challenges. However, the main difference between an ad-hoc network and a WSN is that the latter has more power constrained, higher redundancy, low processing power, lower cost and lesser bandwidth since sensor nodes are limited in power computation capacities and memory. However, in an ad-hoc network the power constraint is not so stringent the processing power is much higher as compared to sensor network and the target applications are quite different [2]. The wireless sensor networks has been evolved with the aim to densely, spatially and temporally continuously monitor and gather data, which results in many-to-one correlated traffic pattern from the sensors to the base station. But the ad hoc network has been designed with the aim is to provide a one-to-one connection. Moreover, the number of sensor nodes in a sensor network is much more than that in an ad-hoc network. Sensor nodes are generally static and cooperate together to transfer the sensed data. In ad hoc networks, the number of nodes is much less, but

their mobility is very high. Sensor nodes mainly use the broadcast communication model, whereas most traditional ad-hoc networks are based on point-to-point communication [4]. The number of nodes in a wireless ad-hoc network can be several orders of magnitude lower than the sensor nodes in a wireless sensor network. These sensor nodes may not have global identification because of the large amount of overhead involved and huge number of sensors. The topology of the wireless sensor networks subject to frequent changes and the sensor nodes are prone to failure.

The end objective of wireless sensor network is not just communication; in fact the end goal of WSN is the detection and estimation of some event(s) of interest that distinguishes it from traditional mobile ad hoc networks (MANETs) [5]. To improve the detection performance from multiple sensor nodes data fusion is quite regularly used by the sensor nodes; it requires the transmission of data and control messages. The need of data fusion may impose the constraints on network architecture [6]. The large number of sensing nodes usually congests the network with redundant information. To solve these issues some sensors elected as cluster-heads and can aggregate the data, process the data by performing some computation (e.g., average, summation, highest value, etc.), and then broadcast the new sum up summarized information to the base station [7].

II. Technical Challenges In Wireless Sensor Network

The huge number of applications gives exponential growth in the development and research in the field of wireless sensor network, but there are several technical key challenges in wireless sensor networks, which include higher energy consumption, higher bandwidth requirement, quality of service (QoS) provisioning, data processing capabilities and cross-layer design issues [8]. To cope up with these issues, the need for the development of new technologies arises that support the low energy consumption and higher bandwidth. Wireless sensor networks face the challenging issue of variable delay and variable length capacity, which results QoS provisioning is a challenging task in a multi-media WSN. Following are the technical challenges of wireless sensor networks:**Power consumption**: There are many challenges need to be considered while designing a wireless sensor network, but power consumption is a central design consideratio. Whether the wireless sensor networks are powered using batteries or energy harvesters the power consumption is always the prime issue while designing the network that leads to the need for hardware that uses the power intelligently.

- **System Architecture:** No topology or architecture can be considered as stable and mature enough to build the different application of wireless sensor network. Most of the research prototypes and applications are vertically integrated in order to maximize performance.
- **Wireless Connectivity**: Wireless communication in indoor environments is still quite unpredictable using low-power consumption RF transceivers, in particular in cluster environments common in buildings, with many interfering electromagnetic fields, such as the one produced by elevators, machinery and computers, among others.
- **Programmability:** Sometimes it is desirable to re-program some specified networks. This re-programmability must be done in such a way that in that network the challenge of performing such task must meet the energy and communication conservation in an efficient manner [9].
- **Security:** Every level of network design demands the security challenges to be specified. From the system point of view, integrity and authenticity of information offered by various nodes is very crucial, since this information provides the feedback loop to some of the costly equipment, which controls the power consumption. From the spoofed and remains confined, since it may shape theprivacy of users [10].

Each of the challenges discussed above place the direction for various Information technology research needs.

III. Design Metric For Wireless Sensor Network

While designing a wireless sensor network, knowledge of a wide variety of research fields including networking, digital signal processing, software engineering embedded system, and wireless communication required. The performance of sensor network can be evaluated on the basis of a number of design metrics [11]. These metrics include hardware constraints, production cost, sensor network topology, energy efficiency, latency, accuracy, fault tolerance and scalability.

Hardware constraints: A wireless sensor device consists four components; a sensing unit, a processing unit, a transceiver unit and a power unit.

Sensing Unit: A sensing unit includes several sensor units, which have the information gathering

capabilities of the physical world [11]. Each Sensing unit composed of two parts: a sensor and an analog to digital converter (ADC). An analog signal sensed are converted to a digital signal by the ADC, and then transmitted to the processing unit.

Processing Unit: The processing unit is the main controller of wireless sensor network that can manage every other component in the system [11]. It enables the sensor unit to perform the sensing operation, collaborate with other nodes through wireless communication and run associated algorithms.

Transceiver Unit: A transceiver unit is used for the communication between any two nodes. Essentially the wireless sensor network is connected to the network through this unit.

Power Unit: Each component of the wireless sensor is powered through this unit, usually battery power is used, but other energy sources can also be used and power constraints of this unit require an energy efficient operation to be performed by each component [11].

WSN Topology: Topology management is a challenging and most critical issue in wireless sensor networks due to the large number of unattended and inaccessible sensor nodes, which are prone to failure also. The node deployment is also a critical issue in WSNs. The issues related to topology maintenance are described next in the section.

- **Pre-deployment and Deployment Phase:** Sensor nodes can be deployed in the network field through many ways. They can be deployed by dropping from an aircraft; delivering by rocket, or missile; placing one by one either by robot or human being. The initial deployment must provide (1) Reduction in installation cost (2) Elimination of the need for any pre-plannin (3) Promote fault tolerance and self-organization.
- **Post deployment phase:** There could be many reasons for topology changes after deployment such as node failure, jamming noise, or moving obstacles. These changes require different operation than the initial deployment of the network [8]. Consequently, the networking protocols should be able to adapt these short-term, long term and periodical changes in the topology.
- **Redeployment phase of Additional Nodes:** Additional sensor nodes need to be re-deployed in network affected by the changes in the topology. sensors can be re-deployed at any time to replace the malfunctioning nodes or due to changes in task dynamics.

Production Costs: Sensor network consists of thousands of sensor nodes. The overall cost of the network can be justified by calculating the cost of every single sensor node. The cost of the network depends upon many units since a sensor node may also equip with power generator, a location finding system and a mobilizer depending on the applications. These additional units add to the cost of the sensor devices. As a result, the cost of a sensor node is a very challenging issue in wireless sensor network [11].

Energy efficiency: The energy is a key design parameter in wireless sensor network as in several many scenarios; nodes have to rely on a limited supply of energy (e.g., batteries). As in various applications, sensors are battery operated, it is generally not practically feasible to simultaneously replace or recharge these energy sources in the network field. It is sensible to supervise energy to prolong the lifetime of the network .

Latency: Most of application demands that the sensed information must be transmitted to the end user within a certain delay. Many sensor applications (e.g., multimedia networks) require delay guaranteed service. These applications, requires that the data must be delivered within a defined time period or in a certain delay.

Accuracy: Some of the sensor applications need to obtain accurate information from the surrounding without error or low probability of error or noise. The accuracy of information can be improved through joint detection and estimation of multiple sensors wireless sensor networks.

Fault tolerance: When nodes or link failures occur within a wireless sensor network, routing protocols must be designed in such a manner that a wide variety of robustness guaranteed network service. The realistic methods can be implemented through redundancy and collaborative processing and communication .

Scalability: Scalable routing algorithm can function efficiently in a wide range of sensor network, which contains a huge number of sensor nodes of nodes. It is desirable that the performance of the network must not degrade as the node density or the network size increases. The design and implementation of such routing protocols promise the future generation sensor network. The design of a routing algorithm consists of the resolution of numerous trade-offs of between energy consumption, delay and throughput, etc.

IV. Conclusion

The ever-increasing capabilities of sensor nodes, which include sensing, data processing, and communicating, enable the realization of wireless sensor networks based on the collaborative effort of a large number of sensor nodes. The design of wireless sensor networks requires ample knowledge of a wide variety of research fields, including wireless communication, networking, embedded systems, digital signal processing and software engineering. This is motivated by the close coupling between several hardware and software entities of wireless sensor devices as well as the distribution operation of a network of these devices. Consequently, several factors exist that significantly influence the design of wireless sensor network. The intrinsic properties of individual sensor nodes pose additional challenges to the communication protocols in terms of energy consumption. General discussions about the wireless sensor network along with its applications and design issues have been presented in this paper.

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