Challenges, Technologies and Components of Wireless Sensor Networks

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***Abstract*:- Wireless sensor networks (WSNs) enable new applications and require non-conventional paradigms for protocol design due to several constraints. Owing to the requirement for low device complexity together with low energy consumption (i.e., long network lifetime), a proper balance between communication and signal/data processing capabilities must be found. This motivates a huge effort in research activities, standardization process, and industrial investments on this field since the last decade. This survey paper aims at reporting an overview of WSNs technologies, main applications and standards, features in WSNs design, and evolutions. In particular, some peculiar applications, such as those based on environmental monitoring, are discussed and design strategies highlighted; a case study based on a real implementation is also reported. This paper highlights WSN, its architecture, challenges, applications and classification of various protocols concerning it. It also classifies various security protocols to make WSN a secure network. We illustrate its potential by using it in a scenario where a single WSN is shared by multiple applications; one of which is a fire monitoring application. We present the proof of-concept prototype we have built along with the performance measurements, and discuss future research directions.**

Keywords: Wireless sensor networks; enabling technologies; applications; challenges; protocols

I.INTRODUCTION

A Wireless Sensor Network (WSN) is a distributed network and it comprises a large number of distributed, self-directed, tiny, low powered devices called sensor nodes. It is otherwise called motes. WSN naturally encompasses a large number of spatially dispersed, petite, battery-operated, embedded devices that are networked to supportively collect, process, and convey data to the users, and it has restricted computing and processing capabilities. Motes are the small computers, which work collectively to form the networks.

Motes are energy efficient, multi-functional wireless device. The necessities for motes in industrial applications are widespread. A group of motes collects the information from the environment to accomplish particular application objectives. They make links with each other in different configurations to get the maximum performance. Motes communicate with each other using transceivers. In WSN the number of sensor nodes can be in the order of hundreds or even thousands. In comparison with sensor networks, Ad Hoc networks will have less number of nodes without any infrastructure. Now a days wireless network is the most popular services utilized in industrial and commercial applications, because of its technical advancement in processor, communication, and usage of low power embedded computing devices. Sensor nodes are used to monitor environmental conditions like temperature, pressure, humidity, sound, vibration, position etc. In many real time applications the sensor nodes are performing different tasks like neighbor node discovery, smart sensing, data storage and processing, 2 data aggregation, target tracking, control and monitoring, node localization, synchronization and efficient routing between nodes and base station.

Wireless sensor nodes are equipped with sensing unit, a processing unit, communication unit and power unit. Each and every node is capable to perform data gathering, sensing, processing and communicating with other nodes. The sensing unit senses the environment, the processing unit computes the confined permutations of the sensed data, and the communication unit performs exchange of processed information among 3 neighboring sensor nodes.

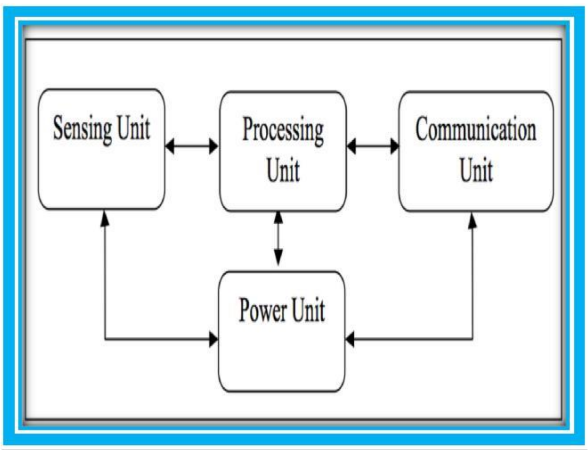

Fig 1: Wireless Networks

II.CHARACTERISTICS

The major characteristics of the sensor node used to evaluate the performance of WSN are *a. Fault tolerance:*

Each node in the network is prone to unanticipated failure. Fault tolerance is the capability to maintain sensor network functionalities without any break due to sensor node failures.

b. Mobility of nodes:

In order to increase the communication efficiency, the nodes can move anywhere within the sensor field based on the type of applications.

c. Dynamic network topology:

Connection between sensor nodes follows some standard topology. The WSN should have the capability to work in the dynamic topology.

d. Communication failures:

If any node in the WSN fails to exchange data with other nodes, it should be informed without delay to the base station or gateway node.

e. Heterogeneity of nodes:

The sensor nodes deployed in the WSN may be of various types and need to work in a cooperative fashion.

f. Scalability:

The number of sensor nodes in a sensor network can be in the order of hundreds or even thousands. Hence, WSN designed for sensor networks is supposed to be highly scalable.

g. Independency:

The WSN should have the capability to work without any central control point.

h. Utilization of sensors:

The sensors should be utilized in a way that produces the maximum performance with less energy.

III.COMPONENTS

The components of WSN system are sensor node, rely node, actor node, cluster head, gateway and base station.

a. Sensor node:

Capable of executing data processing, data gathering and communicating with additional associated nodes in the network. A distinctive sensor node capability is about 4-8 MHz, having 4 KB of RAM, 128 KB flash and preferably 916 MHz of radio frequency.

b. Relay node:

It is a midway node used to communicate with the adjacent node. It is used to enhance the network reliability. A rely node is a special type of field device that does not have process sensor or control equipment and as such does not interface with the 7 process itself. A distinctive rely node processor speed is about 8 MHz, having 8 KB of RAM, 128 KB flash and preferably 916 MHz of radio frequency.

c. Actor node:

It is a high end node used to perform and construct a decision depending upon the application requirements. Typically these nodes are resource rich devices which are outfitted with high quality processing capabilities, greater transmission powers and greater battery life. A distinctive actor node processor capability is about 8 MHz, having 16 KB of RAM, 128 KB flash and preferably 916 MHz of radio frequency.

d. Cluster head:

It is a high bandwidth sensing node used to perform data fusion and data aggregation functions in WSN. Based on the system requirements and applications, there will be more than one cluster head inside the cluster. A distinctive cluster head processor is about 4-8 MHz, having 512 KB of RAM, 4 MB flash and preferably 2.4 GHz of radio frequency. This node assumed to be highly reliable, secure and is trusted by all the nodes in the sensor network.

e. Gateway:

Gateway is an interface between sensor networks and outside networks. Compared with the sensor node and cluster head the gateway node is most powerful in terms of program and data memory, the processor used, transceiver range and the possibility of expansion through external memory. A distinctive gateway processor speed is about 16 MHz, having 512 KB of RAM, 32 MB flash and preferably 2.4 GHz of radio frequency.

f. Base station:

It is an extraordinary type of nodes having high computational energy and processing capability.

IV.WSN ORGANIZATION

Any WSN can be configured as a five layered architecture.

✓ The physical layer is responsible for frequency selection, modulation and data encryption.

✓ The data link layer functions as a pathway for multiplexing of data streams, data frame detection, Medium Access control (MAC) and error control.

- The network layer is used to route the data supplied by the transport layer using special multi-hop wireless routing protocols between sensor nodes and sink nodes.
- The transport layer maintains the flow of data if the application layer requires it.
- The application layer makes the hardware and software of the lower layers transparent to the end user.

V.CHALLENGES

- Sensor networks do not fit into any regular topology, because while deploying the sensor nodes they are scattered
- Very limited resources
  - Limited memory,
  - Limited computation
  - Limited power
- It comes under fewer infrastructures and also maintenance is very difficult.
- Unreliable communication
  - Unreliable data transfer
  - Conflicts and latency
- Sensor node relies only on battery and it cannot be recharged or replaced. Hardware design for sensor node should also be considered.
- Achieving synchronization between nodes is also another issue.
- Node failure, topology changes and adding of nodes and deletion of nodes is another challenging issue.

VI. ENABLING TECHNOLOGIES FOR WSN

- Cost reduction
- For wireless communication, simple microcontroller, system on chip, sensing, batteries Miniaturization
  - Some applications demand small size
  - "Smart dust" as the most extreme vision
- Energy scavenging
  - Recharge batteries from ambient energy(light, vibration, …)

VII.WSN PROTOCOL STACK

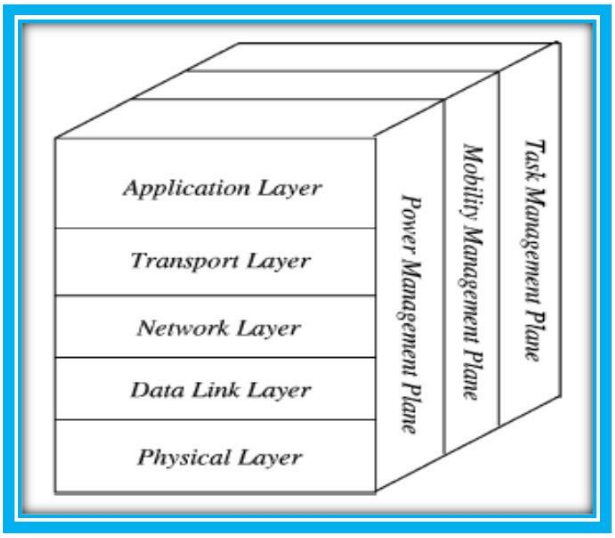

Fig 2: WSN Stack

- Sensor management protocol
  - Provides software operations needed to perform administrative tasks e.g. moving sensor nodes, turning them on an off.
- Sensor query and data dissemination protocol
  - Provides user applications with interfaces to issue queries and respond to queries.
  - Sensor query and tasking language (SQTL)
- Directed diffusion
- Sensor MAC (S-MAC)

VIII.WSN Applications

- Agriculture
  - Humidity/temperature monitoring
- Civil engineering
  - Structural response
  - Disaster management
- Environmental sciences
  - Habitat monitoring
  - Conservation biology
- Home and Office Applications

- ➢ Home and office automation
- ➢ Smart environment
- ✓ Health Applications
- ➢ Telemonitoring of human physiological data
- ➢ Drug administration in hospitals

IX.FACTORS INFLUENCING WSN DESIGN

- ✓ Fault tolerance
- ✓ Scalability
- ✓ Production costs
- ✓ Environment
- ✓ Hardware Constraints
- ✓ Transmission Media
- ✓ Power Consumption
- ➢ Sensing
- ➢ Communication
- ➢ Data Processing

X.ADVANTAGES

- ✓ It avoids a lot of wiring.
- ✓ It can accommodate new devices at any time.
- ✓ It's flexible to go through physical partititons.
- ✓ It can be accessed through a centralized monitor.

XI.DISADVANTAGES

- ✓ Lower speed compared to wired network.
- ✓ Still costly at large.
- ✓ More complex to configure than wired network.
- ✓ It does not make sensing quantities in building easier.
- ✓ It does not reduce costs for installation of costs.
- ✓ Gets distracted by various elements like Blue-tooth.

XII.FUTURE OF WSN

Sensors controlling appliances and electrical devices in house.

Better lighting and heating in office buildings.

The pentagon building has used sensors exclusively.

Fig 3: Pentagon Structure

XIII.CONCLUSIONS

The aim of this paper is to discuss some of the most relevant issues of WSNs, from the application, design and technology viewpoints. For designing a WSN, in fact, we need to define the most suitable technology to be used and the communication protocols to be implemented (topology, signal processing strategies, etc.). These choices depend on different factors, above all the application requirements. The paper is devoted to the discussion on the constraints that must be satisfied by the WSN and the different aspects that must be taken into consideration in the design of a WSN. WSNs possible today due to technological advancement in various domain. Envisioned to become an essential of our lives. Finally, the paper provides a vision on future trends of the short and long term research on WNSs.

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