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Applications, Challenges & Design Issues in Wireless Sensor Network

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Abstract: Recent technological improvements have made the deployment of small, inexpensive, low power, distributed devices, which are capable of local processing and wireless communication, a reality .Such nodes are called as sensor nodes. Each sensor node is capable of only a limited amount of processing. But when coordinated with the information from a large number of other nodes, they have the ability to measure a given physical environment in great detail. Previously, sensor networks consisted of small number of sensor nodes that were wired to a central processing station. However, nowadays, the focus is more on wireless, distributed, sensing nodes.

Keywords*:* Sensor network, Sensor node, Routing in sensor network, Protocol stack, Fault tolerance

I. INTRODUCTION

A sensor network can be described as a collection of sensor nodes which coordinate to perform some specific action. Unlike traditional networks, sensor networks depend on dense deployment and co-ordination to carry out their tasks. When the exact location of a particular phenomenon is unknown, distributed sensing allows for closer placement to the phenomenon than a single sensor would permit. Also, in many cases, multiple sensor nodes are required to overcome environmental obstacles like obstructions, line of sight constraints etc.

In most cases, the environment to be monitored does not have an existing infrastructure for either energy or communication. It becomes imperative for sensor nodes to survive on small, finite sources of energy and communicate through a wireless communication channel. Another requirement for sensor networks would be distributed processing capability.

II. APPLICATIONS OF SENSOR NETWORK

Sensor networks consist of various types of sensors such as seismic, thermal, visual, infrared, acoustic, magnetic and radar, which are able to monitor a wide variety of ambient conditions such as humidity, light, temperature, pressure, soil conditions, noise levels, stress and detection of specific objects. These applications can be broadly categorized into military, environmental, health, home and other commercial areas.

A. Military Applications

Due to the self-organization, rapid deployment and fault tolerance characteristics of wireless sensor networks, they are useful in monitoring friendly forces, arms and ammunition; target tracking; battle damage assessment and nuclear, biological and chemical attack detection and reconnaissance.

Monitoring friendly forces, arms and ammunitions:
Small sensors in wireless sensor networks are attached to each of the troop, equipment and ammunition to report individual status which are then gathered in sink nodes and sent to the military commanders and leaders to monitor the activities of friendly troops and the availability of the equipment and the ammunition in the battlefield.

Also approach routes and paths in battlefield can be easily detected and critical activities of opposing forces can be monitored with sensor networks.

Target Tracking:
Sensor networks can be incorporated into guidance systems of the intelligent ammunitions for tracking the targets in sea.

Battle damage assessment:
To gather the battle damage assessment data, sensor networks can be deployed in the battle field before and after the attacks.

Nuclear, biological and chemical attack detection and reconnaissance: Sensor networks can be deployed and used as chemical and biological warning systems in the friendly region to provide a detailed survey after an NBC attack is detected.

III. Environmental Applications:

The environmental applications of sensor networks include tracking the movements of birds and animals; monitoring environmental conditions that affect crops and livestock; precision agriculture; biological and environmental monitoring in marine, soil , forest fire detection; and flood detection .

Tracking the movements of birds, small animals, and insects:

To perform a biological study of the habitats of birds and animals, sensor networks can be used to collect reports at regular intervals and further integrated to study their life cycle.

Monitoring environmental conditions that affect crops and livestock:

To enhance the agricultural productivity, it is necessary to detect the various factors that affect crops and livestock. Sensor nodes monitor the environmental conditions that can influence their growth and accordingly design measures to overcome it.

Forest fire detection:

Sensor nodes can be randomly and densely deployed in a forest to detect origin of fire at the exact geographical location and the report can be forwarded to the end users before the fire is spread uncontrollable.

Flood detection:

To protect human lives, flood detection technique is designed which alerts the conditions of flood in advance. An example of flood detection is the ALERT system deployed in the US. Several types of sensors deployed in the ALERT system are rainfall, water level and weather sensors. These sensors supply information to the centralized database system in a pre-defined way.

Precision Agriculture:

Sensor networks are also helpful in monitoring the pesticides level in the drinking water, the level of soil erosion, and the level of air pollution in real-time.

IV. Health Applications:

Sensor networks are also helpful in tracking and monitoring doctors; drug administration in hospitals; tele-monitoring of human physiological data and providing interfaces for the disabled.

Tele-monitoring of human physiological data:

To cure a patient now a day, the physiological data is first collected by the sensor networks to determine his/her past history and pre-defined symptoms of the disease. The treatment is then provided that facilitates the life of individual.

Tracking and monitoring doctors and patients inside a hospital:

Small sensor nodes can be attached to each patient to record various results. Each sensor node has its specific task. For example, a sensor node can be used to determine the heart rate at one instance and at the other instance it might be used to detect the blood pressure. Doctors can also carry a sensor node that allows other doctors to locate them within the hospital.

Drug administration in hospitals:

Sensor nodes can be used to detect a patient's illness and accordingly choose the required medications to cure the disease.

V. Home Applications:

Smart sensor nodes can be embedded in electrical appliances, such as vacuum cleaners, micro-wave ovens, refrigerators, VCRs and air conditioners. These sensor nodes can interact with each other and can be remotely controlled and monitored.

VI. Architecture of a Sensor Network

A sensor node is made up of four basic components: a sensing unit, a processing unit, a transceiver unit and a power unit as shown in Fig. 1. It also possesses a location finding system, a power generator and a mobilizer.

The sensing unit consists of sensors and analog to digital converters (ADCs). The analog signals produced by the sensors based on the observed phenomenon are converted to digital signals by the ADC, which are then fed to the processing unit. The processing unit handles the various procedures so that the sensor nodes collaborate with the other nodes to carry out the assigned sensing tasks. A transceiver unit further connects the node to the network.

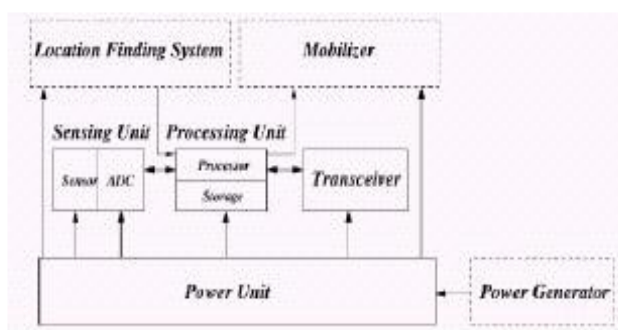

Fig. 1. Components of a Sensor Node

Power units comprise of a power scavenging unit such as solar cells. The location finding system determines the accurate location and the mobilizer moves the sensor nodes when some of the assigned tasks are to be carried out. The lifetime of a sensor network depends on the lifetime of the power resources of the nodes.

For wireless integrated network sensors (WINS), the total average system supply currents must be less than l A to provide long operating life. WINS nodes are powered from typical lithium (Li) coin cells (2.5 cm in diameter and 1 cm in thickness). The transceiver unit can be either an active or passive optical device or a radio frequency (RF) device. In most of the recent sensor network research projects, RF device is used because the packets generally transmitted are small, data rates are low and also the frequency re-use is high due to short communication distances.

A. Sensor Networks Communication Architecture:

The sensor nodes scattered in a sensor field are as shown in Fig. 2. Each of these scattered sensor nodes collects data and routes it to the sink and the end users by a multi-hop infrastructure less architecture. The sink communicates with the task manager node via Internet or Satellite.

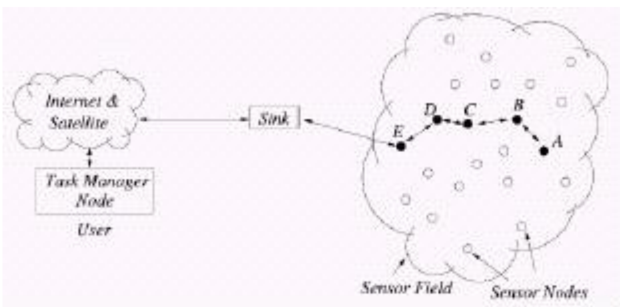

Fig. 2. Sensor Nodes Scattered in Sensor Field

As shown in Fig. 3, the sink and all sensor nodes use a protocol stack. The functions of protocol stack include combining power and routing awareness, integrating data with networking protocols, communicating power efficiently through the wireless medium, and promoting cooperative efforts of sensor nodes.

The protocol stack consists of the application layer, transport layer, network layer, data link layer, physical layer, power management plane, mobility management plane, and task management plane.

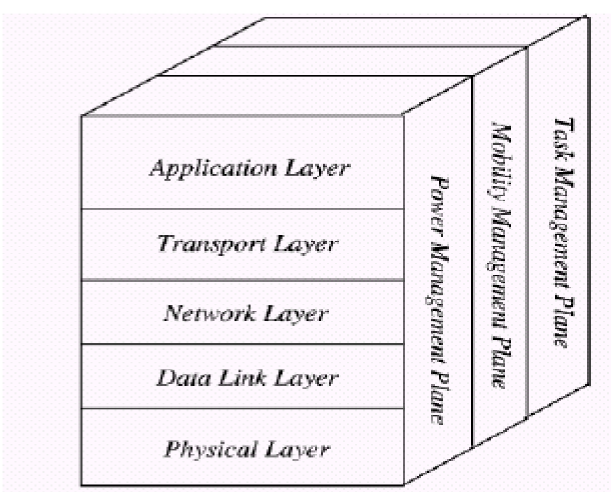

Fig. 3. Sensor Nodes' Protocol Stack

The application layer consists of different types of application software that are built depending on the sensing tasks. The transport layer maintains the flow of data in sensor networks.

The network layer performs routing of data supplied by the transport layer. The data link layer minimizes collision with neighbour's broadcast. The physical layer defines various transmission and receiving techniques. The power, mobility and task management planes the power monitor, the power, mobility and task distribution among the sensor nodes.

These planes help the sensor nodes coordinate the sensing task and lower the overall power consumption .The power Management plane keeps track of the way in which a sensor node uses its power.

The mobility management plane detects and records the movement of sensor nodes, so a route back to the user is always maintained, and the sensor nodes can keep track of their neighbour sensor nodes. Having this information the sensor nodes can balance their power and task usage. The task management plane balances and schedules the sensing tasks given to a specific region.

These management planes enable the sensor nodes to work together in a power efficient way, route data in mobile sensor network, and share resources between sensor nodes.

WINS networks provide a distributed network and Internet access to the sensor nodes, controls, and processors. Since the sensor nodes are in large number, the WINS networks take advantage of this short distance between sensor nodes to provide multi hop communication and minimize power consumption.

The way in which data is routed back to the user in the WINS networks is as shown in the architecture specified in Fig. 2. The sensor node, i.e. a WINS node, detects the environmental data, and the data is routed hop by hop through the WINS nodes until it reaches the sink, i.e., a WINS gateway. So the WINS nodes are sensor nodes A, B, C, D, and E according to the architecture in Fig. 2.

The WINS gateway communicates with the user through the Internet. The protocol stack of a WINS network consists of the application layer, network layer, MAC layer, and physical layer.

B. Routing Techniques in Wireless Sensor Networks:

All the routing protocols in WSNs are broadly classified depending upon their network structure and protocol operation. The classification is as shown in the Fig. 4.

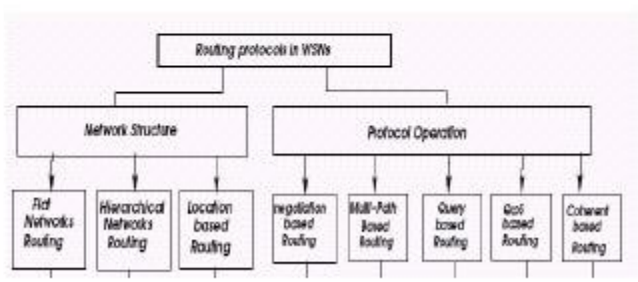

Fig. 4. Routing Protocols in WSNs

On the basis of network structure, these protocols can be further classified into flat, hierarchical and location-based protocols. Also depending on the protocol operation they are sub-divided into multipath-based, query-based, negotiation-based, QoS-based, and coherent-based protocols.

In flat-based routing, all nodes are assigned equal roles or functionality whereas in hierarchical-based routing, nodes are assigned different roles in the network. Here the nodes are clustered to form cluster heads that perform aggregation and reduction of data in order to save energy. Location-based protocols utilize the position information to transmit the data to the desired regions rather than the entire network.

Routing protocols can also be classified into three categories depending on the way a source finds a route to the destination. They are proactive, reactive, and hybrid protocols.

In proactive protocols, all routes are computed in advance whereas in reactive protocols, routes are computed on demand and Hybrid protocols are combination of the above two protocols. When sensor nodes are static, it is preferable to have table driven routing protocols rather than using reactive protocols.

Another class of routing protocols is called the cooperative routing protocols. In cooperative routing, all nodes send data to a central node. Here all the data is first aggregated and then sent for further processing, thus reducing route cost in terms of energy use.

Routing in Wireless Sensor Network:
Routing in wireless sensor networks can be divided into two categories:

- **Address Centric**: Finding shortest path between pairs of addressable end-nodes.

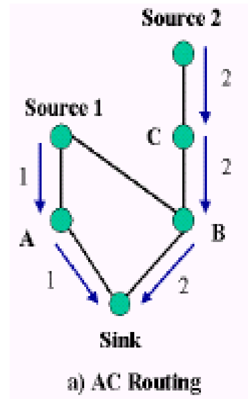

Fig. 5. Address Centric Routing

- **Data Centric**: Finding routes from multiple sources to a single sink, allowing data aggregation.

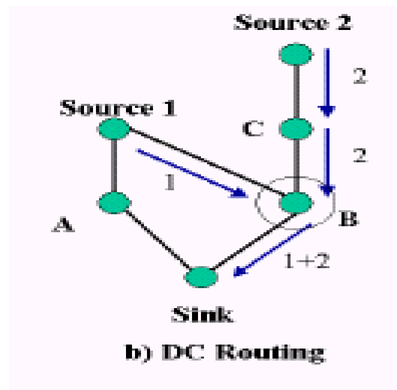

Fig. 6. Data Centric Routing

VII. ROUTING CHALLENGES AND DESIGN ISSUES IN SENSOR NETWORKS

In spite of the numerous applications of WSNs, these networks have several limitations, e.g., limited energy supply, limited computing power, and limited bandwidth of the wireless links connecting sensor nodes. To minimize these limitations, routing techniques were proposed for WSNs to route data from source node to destination node.

However, there are many factors that influence the design of routing protocols that needs to be overcome for efficient communication.

Some of these factors are listed below:

A. Node deployment:

Node deployment in WSNs is application dependent and can be either deterministic or randomized. In deterministic deployment, the sensors are manually placed and data is routed through pre-determined paths. Whereas, in random node deployment, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner. If distribution of nodes is non-uniform, then optimal clustering becomes necessary to allow connectivity and enable energy efficient network operation.

B. Fault Tolerance:

Due to physical damage or environmental interference, the sensor nodes might fail or get blocked. The failure of nodes should not affect the task of the sensor network. Hence, it is required to either choose new paths with more energy to communicate with the base stations in the network or to use the existing links so as to minimize the energy consumption.

C. Scalability*:*

Hundreds and thousands of sensor nodes are deployed in a sensor network. Any routing scheme must be able to work with each of these nodes and must be scalable enough to respond to the events generated in the environment

D. Transmission Media:

The sensor nodes communicate with each other through a wireless medium. The basic problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of the sensor network.

E. Coverage:

In WSNs, each sensor node has a specific range of action and can cover a limited physical area of the environment. Hence, area coverage is also an important design parameter in WSNs.

F. Data Aggregation:

Each sensor node generates its own set of observations for an application. Data aggregation is the combination of data from different sensor nodes so that redundant data, similar packet information from various sensor nodes can be eliminated so as to minimize the transmissions. This technique has been used to achieve energy efficiency and data transfer optimization in a number of routing protocols. Signal processing methods can also be used for data aggregation.

G. Quality of Service:

In many applications, conservation of energy is considered more important than the quality of data sent. If the energy gets exhausted then the network reduces the quality of the results in order to reduce the energy dissipation in the nodes and thus the total network lifetime will be increased. Hence, energy aware routing protocols are required to overcome this problem.

VIII. Conclusion and Future Work

The overall communication behaviour in a wireless micro-sensor network is application driven. We believe that it is useful to decouple the application communication used for information dissemination from the infrastructure communication used to configure and optimize the network. This separation will aid network designers in selecting the appropriate sensor network architecture that will best match the characteristics of the communication traffic of a given application. This will allow the network protocol to achieve the application-specific goals of energy-efficiency, low latency, and high accuracy in the sensing application.

We also believe that a sensor-initiated proactive path recovery approach with local patching will be beneficial in efficient information dissemination in wireless micro-sensor networks.

IX. References

[1] Nidhi Jain, "Wireless sensor Networks: Architecture, Routing Protocols and security"

[2] Sameer Tilak, Nael B., Abu-Ghazaleh and Wendi Heinzelman, "A Taxonomy of Wireless Micro-Sensor Network Models"

[3] Archana Bharathidasan, Vijay Anand Sai Ponduru "Sensor Networks: An Overview"

[4] Dr. Dheeraj sanghi, "Acquiring information from smart badges in an Emergency"

[5] Wendi Rabiner Heinzelman, Joanna Kulik, and Hari Balakrishnan, "Adaptive protocols for information dissemination in wireless sensor networks"

[6] I.F. Akyildiz, Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayirci, Georgia Institute of Technology, "A Survey on Sensor Networks"