CHALLENGES & DESIGN ISSUES IN WSN

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Abstract: Wireless Sensor Networks have become an important research topic in last years. WSN is a collection of tiny, large number of densely deployed sensor node; these sensor nodes are smart, effective which is very powerful and versatile networking where traditional wired and wireless networking is unable to deploy. These sensor nodes have limited transmission range, processing and storage capabilities as well as their energy resources. In sensor networks, minimization of energy consumption is considered a major performance criterion to provide maximum network lifetime. When considering energy conservation, routing protocols should also be designed to achieve fault tolerance in communications. In this paper, we present a review of some major challenges & issues related to wireless sensor networks.

Keywords: WSN, energy optimization, routing protocols, network lifetime.

I. INTRODUCTION

Due to advance information technology, Wireless sensor networks (WSN's) are rapidly developing area in both research and application. The wireless sensor networks are based on the co-operation of a number of tiny sensors and which are depending upon the four parts: sensor (motes), processor, transceiver, and battery. The Sensor get information from surrounding area and processor change the analog information into digital information. Wireless sensors have the ability to perform simple calculations and communicate in a small area. Wireless sensor networks have critical applications in the scientific, medical, commercial, and military domains [1]. Although WSNs are used in many applications, they have several limitations including limited energy supply and limited computation and communication abilities. These limitations should be considered when designing protocols for WSNs.

There are two types of WSNs: structured and unstructured. An unstructured WSN is one that contains a dense collection of sensor nodes. The sensor nodes may be deployed in an ad hoc manner into the field. Once deployed, the network is left unattended to perform monitoring and reporting functions. In an unstructured WSN, network maintenance such as connection management and failures detection is difficult since there are so many nodes to take care of. In a structured WSN, all or some of the sensor nodes are deployed in a pre-planned manner. The advantage of a structured network is that fewer nodes can be deployed with lower network maintenance and management cost. Fewer nodes can be deployed now since nodes are placed at specific locations to provide coverage while ad hoc deployment can have uncovered regions.

The wireless sensor networks are based on the cooperation of a number of tiny sensors and which are depending upon four parts: sensor (motes), processor, transceiver, and battery. The Sensor get information from surrounding area and processor change the analog information into digital information[2]. These sensors sense and detect various environmental parameters such as temperature, pressure, air pollution etc. They are also deployed in monitoring of agriculture, smart homes, structures, passive localization, tracking etc. Then transceiver transmits the converted data to the base- station directly, or through neighboring sensor. Figure 1 shows the architecture of a typical Wireless Sensor Network with the components of a sensor node.

ISSN: 2278 – 7798

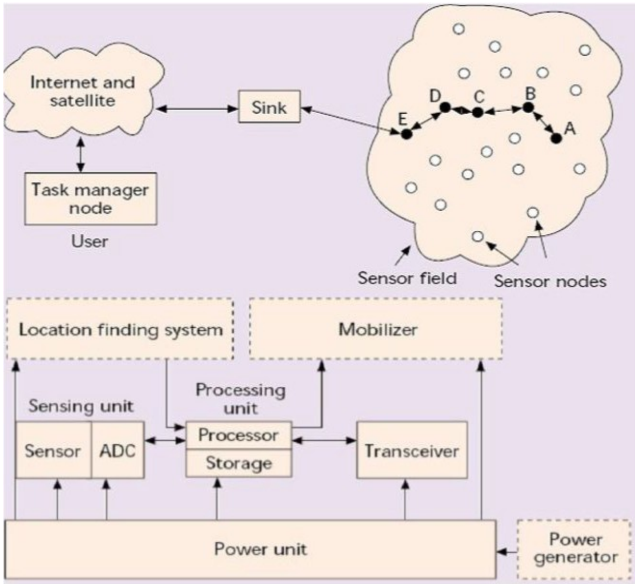

Fig 1. Sensor node and WSN Architecture

II. ROUTING CHALLENGES & DESIGN ISSUES IN WSN

In this section first we discuss some of the characteristics and requirements that are sought in the design and development of a wireless sensor node. When a WSN is being implemented, particular sensor nodes features must be taken into account. These are the following:

• High energy efficiency, in order to increase the node autonomy.
• Low cost, as a network that covers a large area can consist of hundreds or thousands of nodes.
An estimation of the number of the nodes that are required to cover a given area is presented in.
• Distributed Sensing, in order to cover a large area despite the obstacles in the environment.
• Wireless communication, as it is the only choice for nodes deployed in remote areas or where no cabling infrastructure is available.
• Multi-hop networking. Depending on the radio parameters, it can be more efficient to reach a distant node or a base station using two or more wireless hops than a single large distance hop.
• Local data processing in the node, like zero suppression, data compression and parameter extraction can reduce the transmitted payload, and, thus, the power consumption.

The design of routing protocols[3] in WSNs is influenced by many challenging factors. These factors must be overcome before efficient communication can be achieved. Following some of the routing challenges and design issues that affect routing process in WSNs, are summarized.

1) *Node Deployment*

Node deployment in WSNs is application dependent and affects the performance of the routing protocol. The deployment can be either deterministic or randomized. In deterministic deployment, the sensors are manually placed and data is routed through pre-determined paths. However, in random node deployment, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner.

If the resultant distribution of nodes is not uniform, optimal clustering becomes necessary to allow connectivity and enable energy efficient network operation. Inter-sensor communication is normally within short transmission ranges due to energy and bandwidth limitations. Therefore, it is most likely that a route will consist of multiple wireless hops.

2) *Energy Consumption without Losing Accuracy*

The sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. As such, energy conserving forms of communication and computation are essential. Sensor node lifetime shows a strong dependence on the battery lifetime.

In a multihop WSN, each node plays a dual role as data sender and data router. The malfunctioning of some sensor nodes due to power failure can cause significant topological changes and might require re-routing of packets and reorganization of the network.

3) *Data Reporting Model*

Data sensing and reporting in WSNs is dependent on the application and the time criticality of the data reporting. Data reporting can be categorized as either time- driven (continuous), event-driven, query-driven, and hybrid. The time-driven delivery model is suitable for applications that require periodic data monitoring[4]. As such, sensor nodes will periodically switch on their sensors and transmitters, sense the environment and transmit the data of interest at constant periodic time intervals.

ISSN: 2278 – 7798

In event-driven and query-driven models, sensor nodes react immediately to sudden and drastic changes in the value of a sensed attribute due to the occurrence of a certain event or a query is generated by the BS. As such, these are well suited for time critical applications. A combination of the previous models is also possible. The routing protocol is highly influenced by the data reporting model with regard to energy consumption and route stability.

4) *Node/Link Heterogeneity*

In many studies, all sensor nodes are assumed to be homogeneous, *i.e.*, having equal capacity in terms of computation, communication, and power. However, depending on the application a sensor node can have different role or capability. The existence of heterogeneous set of sensors raises many technical issues related to data routing. For example, some applications might require a diverse mixture of sensors for monitoring temperature, pressure and humidity of the surrounding environment, detecting motion via acoustic signatures, and capturing the image or video tracking of moving objects.

These special sensors can be either deployed independently or the different functionalities can be included in the same sensor nodes. Even data reading and reporting can be generated from these sensors at different rates, subject to diverse quality of service constraints, and can follow multiple data reporting models. For example, hierarchical protocols designate a cluster-head node different from the normal sensors. These cluster-heads can be chosen from the deployed sensors or can be more powerful than other sensor nodes in terms of energy, bandwidth, and memory. Hence, the burden of transmission to the BS is handled by the set of cluster-heads.

5) *Fault-Tolerance*

Some sensor nodes may fail or be blocked due to lack of power, physical damage, or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. If many nodes fail, MAC and routing protocols must accommodate formation of new links and routes to the data collection base stations[5]. This may require actively adjusting transmit powers and signaling rates on the existing links to reduce energy consumption, or rerouting packets through regions of the network where more energy is available. Therefore, multiple levels of redundancy may be needed in a fault-tolerant sensor network.

6) *Scalability*

The number of sensor nodes deployed in the sensing area may be in the order of hundreds or thousands, or more. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor net-work routing protocols should be scalable enough to respond to events in the environment. Until an event occurs, most of the sensors can remain in the sleep state, with data from the few remaining sensors providing a coarse quality.

7) *Network Dynamics*

Most of the network architectures assume that sensor nodes are stationary. However, mobility of both BSs and sensor nodes is sometimes necessary in many applications [8]. Routing messages from or to moving nodes is more challenging since route stability becomes an important issue, in addition to energy, bandwidth etc.

Moreover, the sensed phenomenon can be either dynamic or static depending on the application, e.g., it is dynamic in a target detection/tracking application, while it is static in forest monitoring for early fire prevention. Monitoring static events allows the network to work in a reactive mode, simply generating traffic when reporting. Dynamic events in most applications require periodic reporting and consequently generate significant traffic to be routed to the BS.

8) *Transmission Media*

In a multi-hop sensor network, communicating nodes are linked by a wireless medium. The traditional problems associated with a wireless channel (e.g., fading, high error rate) may also affect the operation of the sensor network. In general, the required bandwidth of sensor data will be low, on the order of 1-100 kbps. Related to the transmission media is the design of medium access control (MAC). One approach of MAC design for sensor networks is to use TDMA based protocols that conserve more energy compared to contention based protocols like CSMA (e.g., IEEE 802.11).

9) *Connectivity*

ISSN: 2278 – 7798

High node density in sensor networks precludes them from being completely isolated from each other. There-fore, sensor nodes are expected to be highly connected. This, however, may not prevent the network topology from being variable and the network size from being shrinking due to sensor node failures. In addition, connectivity depends on the possibly random distribution of nodes.

10) *Coverage*

In WSNs, each sensor node obtains a certain view of the environment. A given sensors view of the environment is limited both in range and in accuracy; it can only cover a limited physical area of the environment. Hence, area coverage is also an important design parameter in WSNs.

11) *Data Aggregation/Fusion*

Since sensor nodes may generate significant redundant data, similar packets from multiple nodes can be aggregated so that the number of transmissions is reduced. Data aggregation is the combination of data from different sources according to a certain aggregation function, e.g., duplicate suppression, minima, maxima and average.

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. In this case, it is referred to as data fusion where a node is capable of producing a more accurate output signal by using some techniques such as beamforming to combine the incoming signals and reducing the noise in these signals.

12) *Quality of Service*

In some applications, data should be delivered within a certain period of time from the moment it is sensed; otherwise the data will be useless. Therefore bounded latency for data delivery is another condition for time- constrained applications. However, in many applications, conservation of energy, which is directly related to net-work lifetime, is considered relatively more important than the quality of data sent.

As the energy gets depleted, the network may be required to reduce the quality of the results in order to reduce the energy dissipation in the nodes and hence lengthen the total network lifetime. Hence, energy-aware routing protocols are required to capture this requirement.

III. OPEN ISSUES IN WSN

Wireless sensor networks pose certain design challenges due to the following reasons,

1) The sensor nodes are randomly deployed and hence do not fit into any regular topology. Once deployed, they usually do not require human intervention. This implies that setup and maintenance need to be autonomous.

2) Sensor networks are infrastructure-less. Therefore, all routing and maintenance algorithms need to be distributed.

3) An important bottleneck in the operation of sensor nodes is the available energy. Sensors usually rely on their battery for power, which in many cases should be considered as a major constraint while designing protocols. The wireless sensor node, being a microelectronic device, can only be equipped with a limited power source. In most application scenarios, replenishment of power resources might become impossible. The sensor node lifetime, therefore, shows a strong dependence on battery lifetime.

4) Hardware design for sensor nodes should also consider energy efficiency as a primary requirement. The microcontroller, operating system, and application software should be designed to conserve power.

5) Sensor nodes should be able to synchronize with each other in a completely distributed manner, so that TDMA schedules can be imposed and temporal ordering of detected events can be performed without ambiguity.

6) A sensor network should also be capable of adapting to changing connectivity due to the failure of nodes, or new nodes powering up. The routing protocols should also be able to dynamically include or avoid sensor nodes in their paths.

7) Real-time communication over sensor networks must be supported through provision of guarantees on maximum delay, minimum bandwidth, or other QoS parameters.

Several issues in WSNs are still open or not sufficiently addressed, such as:

- Uncertainty

ISSN: 2278 – 7798

Uncertainty is an important characteristic of WSNs which has been very little taken into account until now. The uncertainty is due to the nature of WSNs and relates to situations such as data delivery, event detecting etc. Some attempts to model these situations use probabilities associated with such events. The difficulty of taking the uncertainty of WSNs into account is mainly related to two factors. Firstly, measuring the distribution of events is not an easy task and is both environment and application dependent. Secondly, despite recent advances on robust optimization tackling such optimization probabilistic problems is difficult.

- Dynamicity

Dynamicity is a main consideration in WSN protocols but however including it in optimization problems models is still a challenge.

- Scalability

The eventually changes in network dimensioning may sometimes require to resolve the problem or to sufficiently increase the computation time. The scalability comes also together with multi sinks, and the need/problems for multi-sink/multi-commodity WSN design, which are not sufficiently considered in the theoretical studies.

IV. CONCLUSION

Wireless sensor networks represent an attractive research area due to several factors as the resource-constrained nature of sensor nodes, interference, data aggregation, power consumption model and the wide range of both commercial and military applications that this technology offers. WSNs are usually battery powered but nodes are typically unattended because of their deployment in hazardous, hostile or remote environments. A number of power saving techniques must be used both in the design of electronic transceiver circuits and in network protocols. The main characteristics required to make a wireless sensor node and the factors to be considered when implementing a WSN or ad-hoc network have been discussed in this paper. The energy conservation challenges and related issues emphasize the need for energy saving and optimizing protocols to increase the lifetime of sensor networks.

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ISSN: 2278 – 7798