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RESEARCH ARTICLE

Wireless Sensor Networks: Issues & Challenges

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Abstract: Wireless Sensor Networks (WSN) are highly distributed self organized systems. The basic idea of sensor network is to disperse tiny sensing devices; which are capable of sensing some changes of incidents/parameters and communicating with other devices, spread over a specific geographic area for some specific purposes like environmental monitoring, surveillance, target tracking etc. By combining sensing technology with processing power and wireless communication makes it lucrative for being exploited in abundance in future. The wireless communication technology inclusion also incurs various types of security threats. This paper provides a survey of Issues and challenges related to Wireless Sensor Networks.

Keywords: WSN, issues, challenges

I. INTRODUCTION

Wireless Sensor Networks have recently emerged as a premier research topic. They have great long term economic potential, ability to transform lives, and pose many system-building challenges. Wireless sensor networks also pose a number of new conceptual and optimization problems, such as deployment, location and tracking, are fundamental issues, in that many applications rely on them for needed information. Coverage basically, answers the questions about quality of service (surveillance) that can be provided by a particular sensor network. The integration of several types of sensors such as seismic, optical, acoustic etc. in one network platform and the study of the overall coverage of the system also presents many interesting challenges. With the refinement of energy harvesting techniques that can gather useful energy from blasts of radio energy, vibrations and the like, self-powered circuitry is a real possibility, with networks of millions of nodes, deployed through injections, paintbrushes and aircraft. Also, the introduction of an additional type of sensor node allowing the network to self-organize by embedding adaptive and smart algorithms. While on the other hand, the use of adaptive power control in IP networks that utilizes reactive routing protocols and sleep-mode operation, more powerful mobile agents, QoS (Quality of Service) to guarantee delivery, robustness, security mechanisms, and fault-tolerance. Wireless sensors have become an excellent tool for military applications involving intrusion detection, perimeter monitoring, and information gathering and smart logistics support in an unknown deployed area. Other applications include sensor-based personal health monitor, location detection with sensor networks and movement detection.

II. TYPES OF SENSOR NETWORKS

There are five types of WSNs: terrestrial WSN, underground WSN, underwater WSN, multi-media WSN, and mobile WSN.

- *Terrestrial WSNs [1]: TWSN* typically consist of hundreds to thousands of inexpensive wireless sensor nodes deployed in a given area, either in a pre-planned or in an ad-hoc manner. In pre-planned deployment, there is grid placement, optimal placement [2], 2- d and 3-d placement [3, 4] models. In ad-hoc deployment, sensor nodes can be dropped from a plane and randomly placed into the target area.
- *Underground WSNs [5, 6]: UWSN* consists of number of sensor nodes buried underground or in a cave or mine that are used to monitor underground conditions. Some additional sink nodes are located above ground to relay information from the sensor nodes to the base station. An underground WSN is usually more expensive than a terrestrial WSN in terms of equipment, deployment, and maintenance.
- *Underwater WSNs [7, 8]:* These consist of a several sensor nodes and vehicles that are deployed underwater. As compared to terrestrial WSNs, underwater sensor nodes are more expensive and fewer no. of sensor nodes are deployed. Autonomous underwater vehicles are used for exploration or gathering data from sensor nodes. Compared to a dense deployment of sensor nodes in a TWSN, a sparse deployment of sensor nodes is placed underwater. Typical underwater wireless communications are established through transmission of acoustic waves.
- *Multi-media WSNs [9]:* These have been proposed to enable monitoring and tracking of events in the form of multimedia. Multi-media WSNs consist of a several low cost sensor nodes equipped with cameras and microphones. These sensor nodes usually interconnect with each other over a wireless connection for data retrieval, process, correlation, and compression. Multi-media sensor nodes are typically deployed in a pre-planned manner into the environment to guarantee coverage. Challenges in such WSN include high bandwidth demand, high energy consumption, quality of service (QoS) provisioning, data processing and compressing techniques, and cross-layer design.
- *Mobile* WSNs: MWSN consist of a no. of sensor nodes that can move on their own and also interact with the physical environment. Mobile nodes have the ability to sense, compute, and communicate like static nodes. Mobile nodes also have the ability to reposition and organize itself in the network. A mobile WSN can start off with some initial deployment and nodes can then spread out to gather information. Information gathered by a mobile node can be communicated to another when they are within range of each other. Another key difference is of data distribution. In a static WSN, data can be distributed using fixed routing or flooding while in a mobile WSN, dynamic routing is used. Challenges in this type of WSN include deployment, localization, self-organization, navigation and control, coverage, energy, maintenance, and data process.

III. ISSUES RELATED TO WSN

A. DESIGN ISSUES:

- Fault –tolerant Communication: Due to the deployment of sensor nodes in an uncontrolled or harsh environment, it is not uncommon for the sensor nodes to become faulty and unreliable [10].
- Low latency: The events which the framework deals with are urgent which should be recognized immediately by the operator. Therefore, the framework has to detect and notify the events quickly as soon as possible.
- Scalability: A system, whose performance improves after adding hardware, proportionally to the capacity added, is said to be a scalable system**.** The number of sensor nodes deployed in the sensing area may be in the order of hundreds or thousands, or more.
- 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.

- Coverage Problems: One fundamental problem in wireless sensor networks is the coverage problem, which reflects the quality of service that can be provided by a particular sensor network. The coverage problem is defined from several points of view due to a variety of sensor networks and a wide-range of their applications.

B. TOPOLOGY ISSUES

- *Geographic Routing:* Geographic routing is a routing principle that relies on geographic position information. It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address.[11]
- *Sensor Holes:* A routing hole consists of a region in the sensor network, where either node are not available or the available nodes cannot participate in the actual routing of the data due to various possible reasons. The task of identifying holes is especially challenging since typical wireless sensor networks consist of lightweight, low-capability nodes that are unaware of their geographic location.
- *Coverage Topology:* Coverage problem reflects how well an area is monitored or tracked by sensors. The coverage and connectivity problems in sensor networks have received considerable attention in the research community in recent years. This problem can be formulated as a decision problem, whose goal is to determine whether every point in the service area of the sensor network is covered by at least k sensors, where k is a given parameter.

C. OTHER ISSUES

The major issues that affect the design and performance of a wireless sensor network are as follows:

- Hardware and Operating System for WSN
- Wireless Radio Communication Characteristics
- Medium Access Schemes
- Deployment
- Localization
- Synchronization
- Calibration
- Network Layer
- Transport Layer
- Data Aggregation and Data Dissemination
- Database Centric and Querying
- Architecture
- Programming Models for Sensor Networks
- Middleware

IV. CHALLENGES RELATED TO WSN

A. Challenges in real time:

WSN deal with real world environments. In many cases, sensor data must be delivered within time constraints so that appropriate observations can be made or actions taken. Very few results exist to date regarding meeting real-time requirements in WSN. Most protocols either ignore real-time or simply attempt to process as fast as possible and hope that this speed is sufficient to meet deadlines. Some initial results exist for real-time routing. To date, the limited results that have appeared for WSN regarding real-time issues has been in routing. Many other functions must also meet real-time constraints including: data fusion, data transmission, target and event detection and classification, query processing, and security. New results are needed to guarantee soft real-time requirements and that deal with the realities of WSN such as lost messages, noise and congestion. Using feedback control to address both steady state and transient behavior seems to hold promise. Dealing with real-time usually identifies the need for differentiated services, e.g., routing solutions need to support different classes of traffic; guarantees for the important traffic and less support for unimportant traffic. It is important not only to develop real-time protocols for WSN, but associated analysis techniques must also be developed.

B. Challenges in power managements:

Low-cost deployment is one acclaimed advantage of sensor networks. Limited processor bandwidth and small memory are two arguable constraints in sensor networks, which will disappear with the development of fabrication techniques. However, the energy constraint is unlikely to be solved soon due to slow progress in developing battery capacity. Moreover, the untended nature of sensor nodes and hazardous sensing environments preclude battery replacement as a feasible solution. On the other hand, the surveillance nature of many sensor network applications requires a long lifetime; therefore, it is a very important research issue to provide a form of energy-efficient surveillance service for a geographic area. Much of the current research focuses on how to provide full or partial sensing coverage in the context of energy conservation.

C. Network Scale and Time-Varying Characteristics of WSN

Under severe energy constraints, Sensor nodes operate with limited computing, storage and communication capabilities [12]. Depending upon the application, the densities of the WSNs may vary widely, ranging from very sparse to very dense. In these sensor nodes the behavior of sensor nodes is dynamic and highly adaptive, as the need to self organize and conserve energy forces sensor nodes to adjust the behavior constantly in response to their current level of activity. Furthermore, the sensor nodes may be requires adjusting the behavior in response to the erratic and unpredictable behavior of wireless connections caused by high noise levels and radio-frequency interference, to prevent severe performance degradation of the application supported.

D. Management at a Distance:

Sensor nodes will be deployed at our door field such as a subway station. It is difficult for managers or operators to manage the network directly. Thus the framework should provide an indirect remote control/ management system.

V. APPLICATIONS

The applications for WSNs are varied, typically involving some kind of monitoring, tracking, or controlling. Specific applications include habitat monitoring, object tracking, nuclear reactor control, fire detection, and traffic monitoring.

- Environmental monitoring: A number of WSNs have been deployed for environmental monitoring. Many of these have been short lived, often due to the prototype nature of the projects. Examples of longer-lived deployments are monitoring the state of permafrost in the Swiss Alps: The PermaSense Project, PermaSense Online Data Viewer and glacier monitoring.
- Vehicle Detection: Wireless sensor networks can use a range of sensors to detect the presence of vehicles ranging from motorcycles to train cars.
- Greenhouse Monitoring: Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses. When the temperature and humidity drops below specific levels, the greenhouse manager must be notified via e-mail or cell phone text message, or host systems can trigger misting systems, open vents, turn on fans, or control a wide variety of system responses. Because some wireless sensor networks are easy to install, they are also easy to move as the needs of the application change.
- Windrow Composting: Composting is the aerobic decomposition of biodegradable organic matter to produce compost, a nutrient-rich mulch of organic soil produced using food, wood, manure, and/or other organic material. One of the primary methods of composting involves using windrows.
- Flare Stack Monitoring: Landfill managers need to accurately monitor methane gas production, removal, venting, and burning. Knowledge of both methane flow and temperature at the flare stack can define when methane is released into the environment instead of combusted. To accurately determine methane production levels and flow, a pressure transducer can detect both pressure and vacuum present within the methane production system.
- Area monitoring: Area monitoring is a common application of WSNs. In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored.
- Landfill Ground Well Level Monitoring and Pump Counter: Wireless sensor networks can be used to measure and monitor the water levels within all ground wells in the landfill site and monitor leach ate accumulation and removal. A wireless device and submersible pressure transmitter monitors the leach ate level. The sensor information is wirelessly transmitted to a central data logging system to store the level data, perform calculations, or notify personnel when a service vehicle is needed at a specific well.
- Medical/ Health: Monitoring people’s locations and health conditions.

- Military: Military situation awareness. Sensing intruders on bases, detect ion of enemy units movements on land/sea chemical/biological threats and offering logistics in urban warfare. Battlefield surveillance. Command, control, communications, computing, intelligence, surveillance, reconnaissance, and targeting systems.
- Physical world: Monitor and control the physical world: deployment of densely distributed sensor/actuator networks for a wide range of biological and environmental monitoring applications, from marine to soil and atmospheric contexts; observation of biological, environmental, and artificial systems; environmental monitoring of water and soil, tagging small animals unobtrusively, and tagging small and lightweight objects in a factory or hospital setting.

VI. CONCLUSION

Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. As wireless sensor networks are still a young research field, much activity is still ongoing to solve many open issues. As some of the underlying hardware problems, especially with respect to the energy supply and miniaturization, are not yet completely solved, wireless sensor networks are having certain short comings, which are to be solved.

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