A SURVEY ON: APPLICATIONS OF WIRELESS SENSOR NETWORKS

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Abstract—Convergence of Micro Electronic Mechanical System (MEMS) technology, digital electronics, wireless communication has increased the feasibility of Wireless Sensor Networks(WSN).This paper explains the concept of wireless sensor networks. This paper also provides applications of WSN in detail.

Keywords— Wireless sensor networks; Ad hoc networks

I. INTRODUCTION

Recent developments in MEMS technology, wireless communications and digital electronic technology have entitled the advances of less-cost, less-power, multifunctional sensor nodes. These sensor nodes are small in size and communicate untied in small distances. These tiny sensor nodes consist of sensing, data processing and communicating components. Sensor networks show a significant improvement over old sensors by two ways [2]:

- *Sensors* can be located far from the real phenomenon to know something by sense perception. In this approach, large sensors that use some complex techniques to distinguish the targets from environmental noise are required [1].
- Many sensors that perform only sensing can be located. The locations of the sensors and communications topology are carefully engineered. They transmit time series of the sensed phenomenon to the central nodes where computations are done and data are merged.

A WSN is made up of large number of sensor nodes. These nodes are closely located either inside the phenomenon or very near to it. The location of sensor nodes need not be engineered or pre-determined. This allows random installment of sensor nodes in inaccessible areas or disaster relief operations. On the other hand, It also means that sensor network protocols and techniques must have self-organizing possibilities. Another unique attraction of WSN is the cooperative effort of sensor nodes. Sensor nodes are equipped with an on-board processor. Rather than sending the fresh data to the nodes responsible for the making the mixture, sensor odes use their processing abilities to locally pass out simple computations and send only the required and partially processed data [1].

The above features of sensors provide a broad range of applications for sensor networks. Realization of these applications and applications of other sensor network need wireless ad hoc networking techniques. Though several protocols and techniques have been recommended for usual wireless ad hoc networks, they are not well matched for the unique features and application needs of sensor networks. To prove this point, the differences between sensor networks and ad hoc networks [3] are defined below:

- The number of sensor nodes in WSN can be thousands of orders of magnitude larger than the nodes in an ad hoc network.
- Sensor nodes are heavily installed.
- Sensor nodes are susceptible to failures.
- The topology of a sensor network varies regularly.

- Sensor nodes mostly use broadcast communication model whereas utmost ad hoc networks use point-topoint communications.
- Sensor nodes are restricted in power, cyber capacities, and memory.
- Sensor nodes do not contain universal identification (ID) due to large amount of overhead and huge number of sensors.

As huge number of sensor nodes are heavily installed, adjacent nodes are very close to each other. Therefore, multihop communication is expected in sensor networks to expend less energy than the conventional single hop communication. Moreover, the level of transmission power can be put low, which is greatly preferred in hidden operations. Multihop communication can also successfully defeat some of the signal propagation effects practiced in long-distance wireless communication.

One of the most central bounds on sensor nodes is the less power consumption requirement. Sensor nodes carry fixed, generally unique, power sources. Hence, while conventional networks target to accomplish high quality of service (QoS) rations, first and foremost sensor network protocols must concentrate on power conservation. They must possess fixed trade-off methods that provide a choice of prolonging lifetime of network to end users at the cost of transmission delay and lesser throughput. Many of researchers are presently working on developing techniques that meet these needs. In this paper, a survey of protocols and proposed algorithms is presented, thus considerably for sensor networks. The aim of paper is to give a better realization of ongoing research issues. Also an attempt in paper shows that an investigation into referring to design bounds and define the use of specific tools to accomplish the design goals. The rest of the paper is structured as follows: Section II describes some of the useful sensor network applications. Section III concludes the paper.

II. APPLICATIONS OF SENSOR NETWORKS

Sensor networks may have several various kinds of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar[1].These sensors are able to watch a broad variety of environment conditions that contain the following [1,4]:

- Temperature,
- Humidity,
- Vehicular movement,
- Lightning condition,
- Pressure,
- Soil makeup,
- Noise levels,
- The presence or absence of specific types of things, stress levels of mechanical on supporting objects and
- The present characteristics such as speed, direction, and size of an object.

Sensor nodes provide continuous sensing data, incident detection, incident ID, position sensing and local monitoring of actuators. The micro-sensing and wireless connection of such nodes assurance several latest application areas. The applications are divided into environment, military, home, health and other commercial areas. It is easy to enlarge this classification with more types such as chemical processing, space examination and disaster relief.

A. Environmental Applications

Some of environmental applications of sensor networks contain tracking the movements of small animals, birds and insects. The monitoring conditions environment affect irrigation; crops and livestock; chemical/ biological detection; macro instruments for large-scale Earth monitoring and planetary exploration; precision agriculture; biological, Earth, and environmental monitoring in marine, soil, and atmospheric contexts; forest fire detection; meteorological or geophysical research; flood detection; bio-complexity mapping of the environment; and pollution study [5,6–7,8,9,10,11,12,13,14,15,16,17,18,19,20].

Forest fire detection: As sensor nodes may be intentionally, randomly and heavily installed in a jungle, sensor nodes can pass on the precise origin of the fire to the end users before the fire expand uncontrollable. Cores of sensor nodes can be installed and integrated by using radio frequencies or optical systems. Also, all sensor nodes may be fitted with useful power saving methods [21], such as solar cells, because the sensors may be left alone for months and many years. The sensor nodes will work together with each other to do distributed sensing and beat blockages such as trees and rocks, Such blockages will block line of sight of wired sensors.

Bio complexity mapping of the environment [22]:

A bio complexity mapping of the environment requires sophisticated approaches to integrate information across temporal and spatial scales [23,24]. The benefits of technology in the isolated sensing and automatic data collection have entitled higher spatial, spectral, and temporal resolution at a geometrically declining cost per unit area [25]. Along with these benefits, the sensor nodes also able to connect with the Internet. Internet permits isolated users to control, watch and observe the bio complexity of the nature.

Though satellite and airborne sensors give best observation in huge biodiversity, e.g., spatial complexity of dominant plant species[1], these sensors are not well enough to monitor small size biodiversity, which makes up most of the biodiversity in an ecosystem [26]. It results in a need for ground level installement of wireless sensor nodes to monitor the bio complexity [27,28]. One example of bio complexity mapping of the environment is done at the James Reserve in Southern California [1,9]. Three monitoring networks with each containing 25 to 100 sensor nodes will be used for fixed view multimedia and environmental sensor data loggers[9]. *Flood detection [20]:* An example of a flood detection is the ALERT system [29] installed in the US. Different kinds of sensors installed in the ALERT system are water level, rainfall and weather sensors. These sensors provide data to the centralized database system in a planned way. Research projects, such as the COUGAR Device Database Project at Cornell University [20] and the Data Space project at Rutgers [20] are reviewing distributed techniques to communicate with sensor nodes to give snapshot and long-running demands. *Precision Agriculture*: In this field, Some of the advantages is the ability to control the pesticides level in the drinking water, the level of soil erosion, and the level of air pollution in real time[1].

B. Military Applications

The WSN can be an integral part of military command, control, communications, computing, intelligence, surveillance, reconnaissance and targeting (C4ISRT) systems[1,9]. The fast distribution, self-organization and fault tolerance features of WSN make them a very hopeful sensing technique for military C4ISRT. As sensor networks are dependent on the dense installement of excessive and low-cost sensor nodes, damage of some nodes by unfriendly actions does not affect a military operation as much as the damage of a conventional sensor. This concept of sensor networks is a better approach for battlefields. Some of the military applications are monitoring friendly forces, equipment and ammunition; battlefield surveillance; reconnaissance of opposing forces and terrain; targeting; battle damage assessment; and nuclear, biological and chemical (NBC) attack detection and reconnaissance[1]. *Monitoring friendly forces, equipment and ammunition*: Leaders and commanders can constantly monitor the status of friendly troops, the condition and the availability of the equipment and the ammunition in a battlefield by the use of sensor networks. Every troop, vehicle, equipment and critical ammunition can be attached with small sensors that report the status. These reports are gathered in sink nodes and sent to the troop leaders. The data can also be forwarded to the upper levels of the command hierarchy while being aggregated with the data from other units at each level.

Battlefield surveillance: Critical terrains, approach routes, paths and straits can be rapidly covered with sensor networks and closely watched for the activities of the opposing forces. As the operations evolve and new operational plans are prepared, new sensor networks can be deployed anytime for battlefield surveillance.

Reconnaissance of opposing forces and terrain: Sensor networks can be deployed in critical terrains, and some valuable, detailed, and timely intelligence about the opposing forces and terrain can be gathered within minutes before the opposing forces can intercept them.

Targeting: Sensor networks can be incorporated into guidance systems of the intelligent ammunition.

Battle damage assessment: Just before or after attacks, sensor networks can be deployed in the target area to gather the battle damage assessment data.

Nuclear, biological and chemical attack detection and reconnaissance: In chemical and biological warfare, being close to ground zero is important for timely and accurate detection of the agents. Sensor networks deployed in the friendly region and used as a chemical or biological warning system can provide the friendly forces with critical reaction time, which drops casualties drastically. We can also use sensor networks for detailed. reconnaissance after an

NBC attack is detected. For instance, we can make a nuclear reconnaissance without exposing a recce team to nuclear radiation.

C. Home Applications

Home automation: As technology advances, smart sensor nodes and actuators can be buried in appliances, such as vacuum cleaners, micro-wave ovens, refrigerators, and VCRs [1]. These sensor nodes inside the domestic devices can interact with each other and with the external network via the *Internet or Satellite*. They allow end users to manage home devices locally and remotely more easily. Smart environment: The design of smart environment can have two different perspectives, i.e., human-centered and technology-centered [1]. For human-centered, a smart environment has to adapt to the needs of the end users in terms of input/ output capabilities. For technology-centered, new hardware technologies, networking solutions, and middleware services have to be developed. A scenario of how sensor nodes can be used to create a smart environment is described in [3]. The sensor nodes can be embedded into furniture and appliances, and they can communicate with each other and the room server. The room server can also communicate with other room servers to learn

about the services they offered, e.g., printing, scanning, and faxing. These room servers and sensor nodes can be integrated with existing embedded devices to become self-organizing, self regulated, and adaptive systems based on control theory models as described in [3]. Another example of smart environment is the ‘‘Residential Laboratory’’ at Georgia Institute of Technology [25]. The computing and sensing in this environment has to be reliable, persistent, and transparent.

D. Health Applications:

Some of the health applications for sensor networks are providing interfaces for the disabled; integrated patient monitoring; diagnostics; drug administration in hospitals; monitoring the movements and internal processes of insects or other small animals; telemonitoring of human physiological data; and tracking and monitoring doctors and patients inside a hospital [8,12,28,18,].

Telemonitoring of human physiological data: The physiological data collected by the sensor networks can be stored for a long period of time [30], and can be used for medical exploration [15]. The installed sensor networks can also monitor and detect elderly people’s behaviour, e.g., a fall [9,16]. These small sensor nodes allow the subject a greater freedom of movement and allow doctors to identify predefined symptoms earlier [56]. Also, they facilitate a higher quality of life for the subjects compared to the treatment centers [5]. A ‘‘Health Smart Home’’ is designed in the Faculty of Medicine in Grenoble—France to validate the feasibility of such system [30].

Tracking and monitoring doctors and patients inside a hospital: Each patient has small and light weight sensor nodes attached to them. Each sensor node has its specific task. For example, one sensor node may be detecting the heart rate while another is detecting the blood pressure. Doctors may also carry a sensor node, which allows other doctors to locate them within the hospital.

Drug administration in hospitals: If sensor nodes can be attached to medications, the chance of getting and prescribing the wrong medication to patients can be minimized. Because, patients will have sensor nodes that identify their allergies and required medications. Computerized systems as described in [18] have shown that they can help minimize adverse drug events.

III. CONCLUSION

The flexibility, fault tolerance, high sensing fidelity, low-cost and rapid deployment characteristics of sensor networks create many new and exciting application areas for remote sensing. In the future, this wide range of application areas will make sensor networks an integral part of our lives.

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