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Research Article

Wireless Sensor Networks

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Abstract

Wireless sensor networks are a trend of the past few years and emerging field of wireless sensor networks combines sensing, computation & communication into a single tiny device. A wireless sensor network is composed of tens or hundreds of spatially distributed autonomous nodes called sensors. A wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. This paper describes basic concepts and various applications such as area monitoring, environmental and health care applications etc. Then, discuss the wireless sensor node architecture and also describes architecture of wireless sensor networks (WSNs). Finally discuss the various research challenges in wireless sensor networks like fault tolerance, energy saving algorithms, location discovery and security.

Keywords: *Ad-hoc networks, wireless senor network architecture, WSNs applications, Design issues in WSNs.*

1. Introduction

Modern advances in micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics have enabled the development of low-cost, low-power, multifunctional sensor nodes that are small in size and communicate untethered in short distances. These tiny sensor nodes, which consist of sensing, data processing, and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes (Changed Akyildiz *et al*). The WSN is built of nodes - from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery. A sensor node might vary in size from that of a shoebox(Rivemet) down to the size of a grain of dust (Romer *et al*,Dec 2004), although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from hundreds of dollars to a few pennies, depending on the complexity of the individual sensor nodes (Romer *et al*,Dec 2004) Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth(Romer *et al*,Dec 2004) They have great long term economic potential, ability to transform our lives, and pose any new system-building challenges (Carlos F.Garcia-Hemandez *et al*). WSNs are mainly characterized by: (i) having a large number of sensor nodes; (ii) generally using broadcast communication; and (iii) having their location frequently changed (Angelo Brayner *et al*,July 2007). Sensor networks represent a significant improvement over traditional sensors, which are deployed in the following two ways (C.Intanagonwiwat *et al*):

- Sensors can be positioned far from the actual phenomenon, i.e., something known by sense perception. In this approach, large sensors that use some complex techniques to distinguish the targets from environmental noise are required.
- Several sensors that perform only sensing can be deployed. The positions of the sensors and communications topology are carefully engineered. They transmit time series of the sensed phenomenon to the central nodes where computations are performed and data are fused.

The ideal wireless sensor is networked and scale able, consumes very little power, is smart and software programmable, capable of fast data acquisition, reliable and accurate over the long term, costs little to purchase and install, and requires no real maintenance. Selecting the optimum sensors and wireless communications link requires knowledge of the application and problem definition. Battery life, sensor update rates,

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and size are all major design considerations. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. This paper organized as follows: In section II describes various applications of WSNs such as area monitoring, environmental and health care applications etc. Then in III section, discusses the sensor node architecture and also describes architecture of sensor networks. In IV define various research challenges in WSNs. Further in V section, all paper concluded by us.

2. Applications of WSNs

The applications for WSNs are varied, typically involving some kind of monitoring, tracking, or controlling. In a typical application, a WSN is deployed in a region where it is meant to collect data through its sensor nodes .

A. 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. For example, a large quantity of sensor nodes could be deployed over a battlefield to detect enemy intrusion. When the sensors detect the event being monitored (heat, pressure, sound, light, electro-magnetic field, vibration, etc.), the event is reported to one of the base stations, which then takes appropriate action (e.g., send a message on the internet or to a satellite). Similarly, wireless sensor networks can use a range of sensors to detect the presence of vehicles ranging from motorcycles to train cars.

B. 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 ASTEC Project and glacier monitoring.

C. 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.

D. Landslide Detection

A landslide detection system makes use of a wireless sensor network to detect the slight movements of soil and changes in various parameters that may occur before or during a landslide. And through the data gathered it may be possible to know the occurrence of landslides long before it actually happens.

E. Machine Health Monitoring

Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) (Tiware) as they offer significant cost savings and enable new functionalities. In wired systems, the installation of enough sensors is often limited by the cost of wiring. Previously inaccessible locations, rotating machinery, hazardous or restricted areas, and mobile assets can now be reached with wireless sensors. Often, companies use manual techniques to calibrate, measure, and maintain equipment. This labor-intensive method not only increases the cost of maintenance but also makes the system prone to human errors.

F. Water/Wastewater Monitoring

There are many opportunities for using wireless sensor networks within the water/wastewater industries. Facilities not wired for power or data transmission can be monitored using industrial wireless I/O devices and sensors powered using solar panels or battery packs.

G. 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.

H. Agriculture

Using wireless sensor networks within the agricultural industry is increasingly common. Gravity feed water systems can be monitored using pressure transmitters to monitor water tank levels, pumps can be controlled using wireless I/O devices, and water use can be measured and wirelessly transmitted back to a central control center for billing. Irrigation automation enables more efficient water use and reduces waste.

I. Fleet Monitoring

It is possible to put a mote with a module on-board of each vehicle of a fleet. The mote gathers its position via the GPS module, and reports its coordinates so that the location is tracked in real-time. The motes can be equipped with temperature sensors to avoid any disruption of the cold chain, helping to ensure the safety of food, pharmaceutical and chemical shipments. In situations where there is not reliable GPS coverage, like inside buildings, garages and tunnels, using information from GSM cells is an alternative for to GPS localization.

3. Wireless sensor network architecture

A. Wireless Sensor Node Architecture

A functional block diagram of a versatile wireless sensing node is provided in Figure 1 modular design approach provides a flexible and versatile platform to address the needs of a wide variety of applications. For example, depending on the sensors to be deployed, the signal conditioning block can be re-programmed or replaced. This allows for a wide variety of different sensors to be used with the wireless sensing node. Similarly, the radio link may be swapped out as required for a given applications' wireless range requirement and the need for bidirectional communications. The use of flash memory allows the remote nodes to acquire data on command from a base station, or by an event sensed by one or more inputs to the node. Furthermore, the embedded firmware can be upgraded through the wireless network in the field (Chris Townsend *et al*,June 2004) The microprocessor has a number of functions including:

- Managing data collection from the sensors.
- Performing power management functions.
- Interfacing the sensor data to the physical radio layer.
- Managing the radio network protocol.

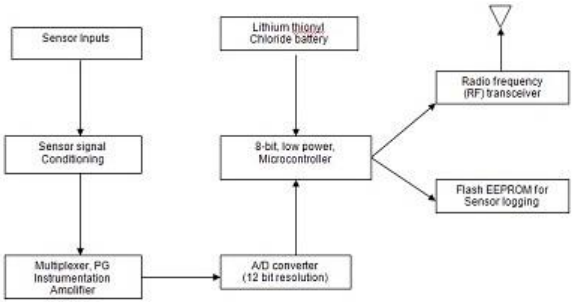

Fig. 1. Wireless sensor node architecture

A key feature of any wireless sensing node is to minimize the power consumed by the system. Generally, the radio subsystem requires the largest amount of power. Therefore, it is advantageous to send data over the radio network only when required. This sensor event-driven data collection model requires an algorithm to be loaded into the node to determine when to send data based on the sensed event. Additionally, it is important to minimize the power consumed by the sensor itself. Therefore, the hardware should be designed to allow the microprocessor to judiciously control power to the radio, sensor, and sensor signal conditioner.

B. Wireless Sensor Network Architecture

A wireless sensor network consists of hundreds or thousands of low cost nodes which could either have a fixed location or randomly deployed to monitor the environment. Due to their small size, they have a number of limitations. Sensors usually communicate with each other using a multi hop approach. The flowing of data ends at special nodes called base stations .A base station links the sensor network to another network (like a gateway) to disseminate the data sensed for further processing. Fig. 2 shows architecture of WSNs (Changed Akyildiz *et al*).

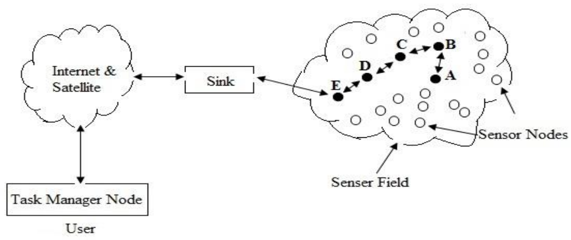

Fig. 2 Wireless sensor network architecture

Base stations have enhanced capabilities over simple sensor nodes since they must do complex data processing; this justifies the fact that bases stations have workstation/laptop class processors, and of course enough memory, energy, storage and computational power to perform their tasks well. Usually, the communication between base stations is initiated over high bandwidth links.

4. Wireless sensor networks research challenges

Due to sensors' limited capabilities, there are a lot of design issues that must be addressed to achieve an effective & efficient operation of wireless sensor networks.

A. Fault Tolerance

Some sensor nodes may fail or be blocked due to lack of power, have physical damage or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. This is the reliability or fault tolerance issue. Fault tolerance is the ability to sustain sensor network functionalities without any interruption due to sensor node failures. The reliability $R_k(t)$ or fault tolerance of a sensor node is modeled in (G Hoblos *et al* ,Sept 2000) using the Poisson distribution to capture the probability of not having a failure within the time interval (0; t):

$R_k(t) = \exp(-\lambda_k t)$

Where k and t are the failure rate of sensor node k and the time period, respectively. Note that protocols and algorithms may be designed to address the level of fault tolerance required by the sensor networks. If the environment where the sensor nodes are deployed has little interference, then the protocols can be more relaxed. For example, if sensor nodes are being deployed in a house to keep track of humidity and temperature levels, the fault tolerance requirement may be low since this kind of sensor networks is not easily damaged or interfered by environmental noise. On the other hand, if sensor nodes are being deployed in a battlefield for surveillance and detection, then the fault tolerance has to be high because the sensed data are critical and sensor nodes can be destroyed by hostile actions. As a result, the fault tolerance level depends on the application of the sensor networks, and the schemes must be developed with this in mind.

B. Energy Saving Algorithms

Since sensor nodes use batteries for power that are difficult to replace when consumed (remember that often sensor nodes are deployed in remote and hostile environments), it is critical to design algorithms and protocols in such a way to utilize minimal energy. To do so, implementers must reduce communication between sensor nodes, simplify computations and apply lightweight security solutions.

C. Location Discovery

Many applications can tracking an object require knowing the exact or approximate physical location of a sensor node in order to link sensed data with the object under investigation. Furthermore, many geographical routing protocols need the location of sensor nodes to forward data among the network. Location discovery protocols must be designed in such a way that minimum information is needed to be exchanged among nodes to discover their location. Since sensor nodes are energy constrained, solutions like GPS are not recommended. After all, cost is another factor that influences design; manufacturers try to keep the cost at minimum levels since most sensor nodes are usually needed for many applications. If the cost is high, the adoption and spread of sensor technology will be prohibited.

D. Security

Is it possible to introduce a new technology without addressing security? Of course not! However, as all other technologies, security is not the top priority when designing something new. This approach is acknowledged by almost everyone, and it is erroneous but they keep doing it anyway. Security solutions are constrained when applying them to sensor networks. For example, cryptography requires complex processing to provide encryption to the transmitted data.

Secure routing; secure discovery and verification of location, key establishment and trust setup, attacks against sensor nodes, secure group management and secure data aggregation are some of the many issues that need to be addressed in a security context. Future articles will analyze some of these issues to give you a good understanding of security related issues in wireless sensor networks.

Conclusions

In this paper basic concept and wireless sensor networks applications are discussed. After that wireless senor node architecture working is explained and wireless sensor network architecture is presented. Finally various design issues in wireless sensor network are discussed.

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