Overview of Wireless Sensor Network and its Applications

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Abstract – A wireless sensor network is type of wireless network. Basically it consist a collection of tiny devices called as sensor nodes. Sensor node has a resource constraint means battery power, storage and communication capability. These sensor nodes are set with radio interface with which they communicated with one another to form a network. Wireless sensor network has range of applications remote environmental monitoring and target tracking etc. The goal of our survey is to present a comprehensive review of the recent literature on various aspects of WSNs and to discuss how wireless sensor network works, its advantages and disadvantages over the traditional network systems.


I. INTRODUCTION

Wireless sensor network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind speed and direction, pressure, etc.

II. ARCHITECTURE

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 or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communication bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

III. SENSOR NODE

A sensor node, also known as a mote is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A mote is a node but a node is not always a mote.

Architecture of the sensor node

IV. COMPONENTS

The main components of a sensor node are a microcontroller, transceiver, external memory, power source and one or more sensors.

1) Controller

The controller performs tasks, processes data and controls the functionality of other components in the sensor node. While the most common controller is a microcontroller, other alternatives that can be used as a controller are: a general purpose desktop microprocessor, digital signal processors, FPGAs and ASICs. A microcontroller is often used in many embedded systems such as sensor nodes because of its low cost, flexibility to connect to other devices, ease of programming, and low power consumption. A general purpose microprocessor generally has a higher power consumption than a microcontroller, therefore it is often not considered a suitable choice for a sensor node.
Processors may be chosen for broadband wireless communication applications, but in Wireless Sensor Networks the wireless communication is often modest: i.e., simpler, easier to process modulation and the signal processing tasks of actual sensing of data is less complicated. Therefore the advantages of DSPs are not usually of much importance to wireless sensor nodes. FPGAs can be reprogrammed and reconfigured according to requirements, but this takes more time and energy than desired.

2) Transceiver

Sensor nodes often make use of ISM band, which gives free radio, spectrum allocation and global availability. The possible choices of wireless transmission media are radio frequency (RF), optical communication (laser) and infrared. Lasers require less energy, but need line-of-sight for communication and are sensitive to atmospheric conditions. Infrared, like lasers, needs no antenna but it is limited in its broadcasting capacity. Radio frequency-based communication is the most relevant that fits most of the WSN applications. WSNs tend to use license-free communication frequencies: 173, 433, 868, and 915 MHz; and 2.4 GHz. The functionality of both transmitters and receiver are combined into a single device known as a transceiver. Transceivers often lack unique identifiers. The operational states are transmit, receive, idle, and sleep. Current generation transceivers have built-in state machines that perform some operations automatically. Most transceivers operating in idle mode have a power consumption almost equal to the power consumed in receive mode. Thus, it is better to completely shut down the transceiver rather than leave it in the idle mode when it is not transmitting or receiving. A significant amount of power is consumed when switching from sleep mode to transmit mode in order to transmit a packet.

3) External memory

From an energy perspective, the most relevant kinds of memory are the on-chip memory of a microcontroller and Flash memory—off-chip RAM is rarely, if ever, used. Flash memories are used due to their cost and storage capacity. Memory requirements are very much application dependent. Two categories of memory based on the purpose of storage are: user memory used for storing application related or personal data, and program memory used for programming the device. Program memory also contains identification data of the device if present.

4) Power sources

The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. The energy cost of transmitting 1 Kb a distance of 100 metres (330 ft) is approximately the same as that used for the execution of 3 million instructions by a 100 million instructions per second/W processor. Power is stored either in batteries or capacitors. Batteries, both rechargeable and non-rechargeable, are the main source of power supply for sensor nodes. They are also classified according to electrochemical material used for the electrodes such as NiCd (nickel-cadmium), NiZn (nickel-zinc), NiMH (nickel-metal hydride), and lithium-ion. Current sensors are able to renew their energy from solar sources, temperature differences, or vibration. Two power saving policies used are Dynamic Power Management (DPM) and Dynamic Voltage Scaling (DVS). DPM conserves power by shutting down parts of the sensor node which are not currently used or active. A DVS scheme varies the power levels within the sensor node depending on the non-deterministic workload. By varying the voltage along with the frequency, it is possible to obtain quadratic reduction in power consumption.

5) Sensors

Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored. The continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing. A sensor node should be small in size, consume extremely low energy, operate in high volumetric densities, be autonomous and operate unattended, and be adaptive to the environment. As wireless sensor nodes are typically very small electronic devices, they can only be equipped with a limited power source of less than 0.5-2 ampere-hour and 1.2-3.7 volts. Sensors are classified into three categories: passive, omni-directional sensors; passive, narrow-beam sensors; and active sensors. Passive sensors sense the data without actually manipulating the environment by active probing. They are self powered; that is, energy is needed only to amplify their analog signal. Active sensors actively probe the environment, for example, a sonar or radar sensor, and they require continuous energy from a power source. Narrow-beam sensors have a well-defined notion of direction of measurement, similar to a camera. Omni-directional sensors have no notion of direction involved in their measurements. The overall theoretical work on WSNs works with passive, omni-directional sensors. Each sensor node has a certain area of coverage for which it can reliably and accurately report the particular quantity that it is observing. Several sources of power consumption in sensors are: signal sampling and conversion of physical signals to electrical ones, signal conditioning, and analog-to-digital conversion. Spatial density of sensor nodes in the field may be as high as 20 nodes per cubic meter.

V. WIRELESS SENSOR NETWORK APPLICATIONS

Wireless sensor network has lots of applications such as Environmental data collection, Military applications, Security monitoring, sensor node tracking, health application, home application, and hybrid networks.
1. Environmental Data Collection

Environmental data collection application, are used to collect various sensor data in a period of time. If a data to be meaningful so collecting sensor data at regular interval and the nodes would remain at known locations. In the environmental data collection application, a large number of nodes continuously sensing and transmitting data back to a set of base stations that store the data using traditional methods. In typical usage scenario, the nodes will be evenly distributed over an outdoor environment. In environmental monitoring applications, it is not essential that the nodes develop the optimal routing strategies on their own. Instead, it may be possible to calculate the optimal routing topology outside of the network and then communicate the necessary sensor data to the nodes as required. This is possible because the physical topology of the network is relatively constant. While the time variant nature of RF communication may cause connectivity between two nodes to be intermittent, the overall topology of the network will be relatively stable.

2. Military Applications

Most of the elemental knowledge of sensor networks is basic on the defense application at the beginning, especially two important programs the Distributed Sensor Networks (DSN) and the Sensor Information Technology form the Defence Advanced Research Project Agency (DARPA), sensor networks are applied very successfully in the military sensing. Now wireless sensor networks can be an integral part of military command, control, communications, surveillance, reconnaissance and targeting systems. In the battlefield context, rapid deployment, self-organization, fault tolerance security of the network should be required. The sensor devices or nodes should provide following services: like Monitoring friendly forces, equipment and ammunition, Battlefield surveillance, Reconnaissance of opposing forces, Targeting, Battle damage assessment Nuclear, biological and chemical attack detection reconnaissance.

3. Security Monitoring

Security monitoring networks are collected of nodes that are placed at fixed locations throughout an environment that continually monitor one or more sensors to detect any anomaly. A key difference between security monitoring and environmental monitoring is that security networks are not actually collecting any data. This has a significant impact on the optimal network architecture. Each node has to frequently check the status of its sensors but it only has to transmit a data report when there is a security violation. The immediate and reliable communication of alarm messages is the primary system requirement. These are “report by exception” networks. It is confirmed that each node is still present and functioning. If a node were to be disabled or fail, it would represent a security violation that should be reported. For security monitoring applications, the network must be configured so that nodes are responsible for confirming the status of each other. One approach is to have each node be assigned to peer that will report if a node is not functioning. The optimal topology of a security monitoring network will look quite different from that of a data collection network. In a collection tree, each node must transmit the data of all of its decedents. The accepted norm for security systems today is that each sensor should be checked approximately once per hour. Combined with the ability to evenly distribute the load of checking nodes, the energy cost of performing this check becomes minimal. A majority of the energy consumption in a security network is spent on meeting the strict latency requirements associated with the signaling the alarm when a security violation occurs. In security networks, a vast majority of the energy will be spend on confirming the functionality of neighbouring nodes and in being prepared to instantly forward alarm announcements. Actual data transmission will consume a small fraction of the network energy.

4. Health Applications

Sensor networks are also widely used in health care area. In some modern hospital sensor networks are constructed to monitor patient physiological data, to control the drug administration track and monitor patients and doctors and inside a hospital. In spring 2004 some hospital in Taiwan even use RFID basic of above named applications to get the situation at first hand. Long-term nursing home: this application is focus on nursing of old people. In the town farm cameras, pressure sensors, orientation sensors and sensors for detection of muscle activity construct a complex network. They support fall detection, unconsciousness detection, vital sign monitoring and dietary/exercise monitoring. These applications reduce personnel cost and rapid the reaction of emergency situation.

5. Home Application

Along with developing commercial application of sensor network it is no so hard to image that Home application will step into our normal life in the future. Many concepts are already designed by researcher and architects, like “Smart Environment: Some are even realized. Let’s see the concept “the intelligent home” After one day hard work you come back home. At the front door the sensor detects you are opening the door, then it will tell the electric kettle to boil some water and the air condition to be turned on. You sit in the sofa lazily. The light on the table and is automatically on because the pressure sensor under the cushion has detected your weight. The TV is also on. One sensor has monitored that you are sitting in front of it. “I’m simply roasting. The summer time in Asia is really painful.” You think and turn down the temperature of the air condition. At the sometime five sensors in every corner in the room are measuring the temperature. Originally there is also sensor in the air condition. But it can only get the temperature at the edge of the machine not the real temperature in the room. So the sensors in the room will be detecting the...
environment. The air condition will turn to sleep mode until all the sensors get the right temperature. The light on the corridor, in the washing groom and balcony are all installed with sensor and they can be turned on or turn out automatically. Even the windows are also attached with vibratory sensors connected to police to against thief. How nice! You become nurse and bodyguard at the same time.

VI. ADVANTAGES

1. It avoids a lot of wiring.
2. It can accommodate new devices at any time.
3. It's flexible to go through physical partitions.
4. It can be accessed through a centralized monitor.

VII. DISADVANTAGES

1. It's easy for hackers to hack it as we cant control propagation of waves.
2. Comparatively low speed of communication.
3. Gets distracted by various elements like Blue-tooth.
4. Still Costly at large.

VIII. FUTURE SCOPE

The most general and versatile deployments of wireless sensing networks demand that batteries be deployed. Future work is being performed on systems that exploit piezoelectric materials to harvest ambient strain energy for energy storage in capacitors and/or rechargeable batteries. By combining smart, energy saving electronics with advanced thin film battery chemistries that permit infinite recharge cycles, these systems could provide a long term, maintenance free, wireless monitoring solution.

REFERENCES


AUTHOR’S PROFILE

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