Wireless Sensor Networks: Applications and challenges

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Abstract

This paper describes the concept of sensor networks which has been made viable by the convergence of micro-electro-mechanical systems technology, wireless communications and digital electronics. First, the sensing tasks and the potential sensor networks applications are explored, and a review of factors influencing the design of sensor networks is provided. Then, the communication architecture for sensor networks is outlined, and the algorithms and protocols developed for each layer in the literature are explored. Open research issues for the realization of sensor networks are also discussed.

Keywords

Wireless sensor networks, Ad hoc networks, Application layer, Transport layer, Networking layer, Routing Data link layer, Medium access control, Error control, Physical layer, Power aware protocols

Introduction to Wireless Networks

A Wireless sensor network can be defined as a network of devices that can communicate the information gathered from a monitored field through wireless links. The data is forwarded through multiple nodes, and with a gateway, the data is connected to other networks like wireless Ethernet.WSN is a wireless network that consists of base stations and numbers of nodes (wireless sensors).These networks are used to monitor physical or environmental conditions like sound, pressure, temperature and co-operatively pass data through the network to a main location .

A wireless network is any sort of computer network that uses wireless data connections to plug network nodes. Wireless networks are computer networks who are not connected by cables regardless of the sort. The use of a wireless network enables enterprises to prevent the costly means of introducing cables into buildings or as a connection between different equipment locations. The cornerstone of wireless systems is radio waves, an implementation that occurs at the physical higher level of network structure. Wireless technologies differ in a number of dimensions, most notably in just how much bandwidth they provide and how far apart communicating nodes can be. Other important differences include which perhaps the electromagnetic spectrums they choose and exactly how much power them consume

A Wireless Sensor Network (WSN) is by hundreds of small, low-cost nodes that are fitted with limitations in memory, energy, and processing capacity. In this particular form of networks, several problems is to learn each node. Recent advances in wireless communications and electronics have enabled the roll-out of low-cost, low-power and multi-functional sensors that are small in dimensions and communicate in a nutshell distances. Cheap, smart sensors, networked through wireless links

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and deployed in vast quantities, provide unprecedented opportunities for monitoring and controlling homes, cities, along with the environment. Furthermore, networked sensors use a broad spectrum of applications within the defense area, generating new capabilities for reconnaissance and surveillance and various Tactical applications. Self-localization capability can be a highly desirable sign of wireless sensor networks. In environmental monitoring applications for example bush fire surveillance, water quality monitoring and precision agriculture, the measurement data are meaningless lacking the knowledge of the placement from the location where the data are obtained. Moreover, location estimation may enable many applications for example inventory management, transport, intrusion detection, road traffic monitoring, health monitoring, reconnaissance and surveillance. With all the advances inside the miniaturization and integration of sensing and communication Technologies, large-scale wireless sensor networks using a large number of low-cost and low-power sensors are already developed. Within a wireless sensor network, lots of money of tiny, battery-powered sensor nodes are scattered throughout a physical area. Each sensor in the sensor network collects data, as an example, sensing vibration, temperature, radiation along with other environmental factors .A wireless sensor network (WSN) includes hundreds to a large number of low-power multi-functional sensor nodes, operating within the unattended environment, and having sensing, computation and communication capabilities. The essential the different parts of a node undoubtedly are a sensor unit, an ADC (Analog to Digital Converter), a CPU (C.P.U.), an electrical unit as well as a communication unit. Sensor nodes are microelectro-mechanical systems (MEMS) that develop a measurable a reaction to a general change in some fitness like temperature and pressure. Sensor nodes sense or measure physical data in the area being monitored. The continual analog signal sensed through the sensors is digitized by an analog-to-digital converter and sent to controllers for more processing. Sensor nodes are of small size, consume extremely low energy, are operated in high volumetric densities, and will be autonomous and adaptive towards the environment.

Types of Wireless Networks

Basically, there are five types of wireless networks:

1. Wireless PAN
2. Wireless LAN
3. Wireless MAN
4. Wireless WAN
5. Global Area Network

Ad-hoc Networks

Ad-hoc networks are multi-hop wireless networks that can operate minus the services of the established backbone infrastructure. While such networks have obvious applications from the military and disaster relief environments, more modern works that contain motivated their use even in regular wireless packet data networks have raised their significance. The main objective on this paper should be to study the performance with the TCP transport layer protocol over ad-hoc networks thinking about an ad hoc network is normally unfamiliar to finish users with only seen small residential or business networks that use a standard router to send wireless signals to individual computers. However, the ad hoc network will be used a great deal in new sorts of wireless engineering, although until recently it turned out a rather esoteric idea. One example is a mobile

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random network involves mobile devices communicating directly with each other. A different type of random network, the vehicular random network, involves placing communication devices in cars. Both these are examples of ad hoc networks designed to use a large variety of individual devices to freely communicate with no sort of top-down or hierarchical communication structure.

Ad-hoc Networks Characteristics

1. Multihopping: A multihop network is a network the spot that the path from source to destination traverses other nodes. Random nets often exhibit multiple hops for obstacle negotiation, spectrum reuse, and conservation. Battlefield covert operations also favour a sequence of short hops to scale back detection by the enemy.

2. Self-organization: The ad hoc network must autonomously determine its very own configuration parameters including: addressing, routing, clustering, position identification, power control, etc. Sometimes, special nodes can coordinate their motion and dynamically distribute from the geographic area to supply coverage of disconnected islands.

3. Energy conservation: Most ad hoc nodes (e.g., laptops, PDAs, sensors, etc.) have limited power supply no power to generate their particular power (e.g., solar power systems). High efficiency protocol design (e.g., MAC, routing, resource discovery, etc) is important for longevity with the mission.

4. Scalability: In certain applications (e.g., large environmental sensor fabrics, battlefield deployments, urban vehicle grids, etc) the random network can grow to thousand nodes. For wireless "infrastructure" networks scalability is actually handled by a hierarchical construction.

Applications of Wireless Sensor Networks

The applications for WSNs involve tracking, monitoring and controlling. WSNs are mainly utilized for habitat monitoring, object tracking, nuclear reactor control, fire detection, and traffic monitoring. Area monitoring is a very common application of WSNs, in which the WSN is deployed over a region where some incident might be monitored. E.g., a substantial variety of sensor nodes may very well be deployed over the battlefield to detect enemy intrusions rather than using landmines. When the sensors detect case being monitored (heat, pressure, sound, light, electro-magnetic flux, vibration, etc.), the big event needs to be reported to at least one in the base stations, which often can than take some appropriate action (e.g., send some text online or even a satellite). Wireless sensor networks are utilized extensively within the water/wastewater industries. Facilities not wired for power or data transmission can be monitored using industrial wireless I/O devices and sensor nodes powered by solar panels or battery packs. Wireless sensor networks are able to use numerous sensors to detect the existence of vehicles for vehicles detection. Wireless sensor networks may also be employed to control the temperature and humidity levels inside commercial greenhouses. If the temperature and humidity drops below specific levels, the greenhouse manager might be notified via e-mail or a cellular telephone text, or host systems can trigger misting systems, open vents, first turn on fans, or control a multitude of system responses. Because some wireless sensor networks are super easy to install, they've also been simple move if the needs with the application change.

There are lots of applications of WSN:

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1. Process Management: Area monitoring is a very common using WSNs. In area monitoring, the WSN is deployed spanning a region where some phenomenon is usually to be monitored. A military example may be the use of sensors detect enemy intrusion; a civilian example would be the geo-fencing of gas or oil pipelines. Area monitoring is most important part.

2. Healthcare monitoring: The medical applications might be of two sorts: wearable and implanted. Wearable devices are applied to the body surface of the human or maybe at close proximity from the user. The implantable medical devices are the ones that are inserted inside your body. There are numerous other applications too e.g. body position measurement and of the person, overall monitoring of ill patients in hospitals and also at homes.

3. Environmental/Earth sensing: There are numerous applications in monitoring environmental parameters samples of which are given below. They share any additional challenges of harsh environments and reduced power supply.

4. Polluting of the environment monitoring: Wireless sensor networks have been deployed in lots of cities (Stockholm, London and Brisbane) to monitor the power of dangerous gases for citizens. These can leverage the random wireless links instead of wired installations that also make them more mobile for testing readings
in several areas.

5. Forest fire detection: A network of Sensor Nodes is usually positioned in a forest to detect every time a fire has begun. The nodes is usually with sensors to measure temperature, humidity and gases which are produced by fire within the trees or vegetation. The first detection is necessary to get a successful action of the fire fighters; As a result of Wireless as Sensor Networks, the fire brigade are able to know when a fire begins you bet it can be spreading.

6. Landslide detection: A landslide detection system uses a wireless sensor network to detect the slight movements of soil and modifications to various parameters that will occur before or throughout a landslide. With the data gathered it may be possible to know the appearance of landslides before it genuinely happens.

7. Water quality monitoring: Water quality monitoring involves analyzing water properties in dams, rivers, lakes & oceans, and also underground water reserves. The application of many wireless distributed sensors enables the creation of a accurate map on the water status, and allows the permanent deployment of monitoring stations in locations of difficult access, while not manual data retrieval.

8. Natural disaster prevention: Wireless sensor networks can effectively act to avoid the results of disasters, like floods .Wireless nodes have successfully been deployed in rivers where changes in the water levels have to be monitored in realtime.

9. Industrial monitoring:

a. Machine health monitoring: Wireless sensor networks happen to be developed for machinery condition based maintenance (CBM) as they offer significant personal savings and enable new functionality .In wired
systems, installing enough sensors can often be tied to the price of wiring. Previously inaccessible locations, rotating machinery, hazardous or restricted areas, and mobile assets can now be reached with wireless sensors.

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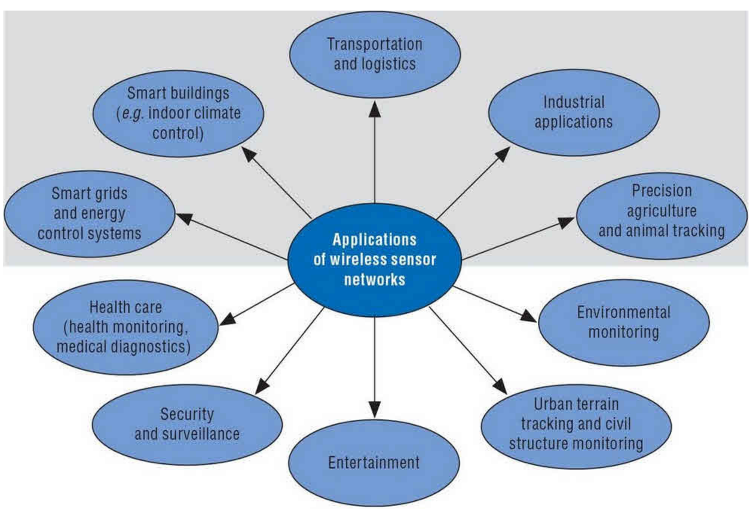
b. Data logging: Wireless sensor networks are also employed for the gathering of web data for monitoring of environmental information; this is often as easy as the monitoring from the temperature in a very fridge to the level of water in overflow tanks in nuclear power plants. The statistical information will then be employed to show how systems have been working. The main benefit of WSNs over conventional loggers is the "live" data feed which is possible.

c. Water/Waste water monitoring: Monitoring the high quality and level of water includes many activities including checking the quality of underground or surface water and ensuring a country's water infrastructure for your benefit of both human and animal .It may be helpful to protect the wastage of water.

d. Structural Health Monitoring: Wireless sensor networks enables you to monitor the fitness of civil infrastructure and related geophysical processes all around real time, and more than very long stretches through data logging, using appropriately interfaced sensors



Wireless Sensor Networks Applications

- These networks are used in environmental tracking, such as forest detection, animal tracking, flood detection, forecasting and weather prediction, and also in commercial applications like seismic activities prediction and monitoring.
- applications, such as tracking and environment monitoring surveillance applications use these networks. The sensor nodes from sensor networks are dropped to the field of interest and are remotely controlled by a user. Enemy tracking, security detections are also performed by using these networks.
- Health applications, such as Tracking and monitoring of patients and doctors use these networks.

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- The most frequently used wireless sensor networks applications in the field of Transport systems such as monitoring of traffic, dynamic routing management and monitoring of parking lots, etc., use these networks.
- Rapid emergency response, industrial process monitoring, automated building climate control, ecosystem and habitat monitoring, civil structural health monitoring, etc., use these networks.

This is all about the wireless sensors networks and their applications. We believe that the information about all the different types of networks will help you to know them better for your practical requirements. Apart from this, for additional information about wireless SCADA, queries, and doubts regarding this topic or electrical and electronic projects, and for any suggestions, please comment or write to us in the comment section below.

Research Challenges in Wireless Sensor Networks

A brief history on the research in SN, but more interesting may be the overview within the technical challenges and issues is presented, from where we could cite several relevant items: WSN working in a harsh environment; the ability with the network (leastways the neighbors); the network control and routing; querying and tasking (should be as simple and intuitive as it can be); plus security issues (low latency, survivable, low probability of detecting communications, high reliability)..

1. Security: Security is often a broadly used term encompassing the characteristics of authentication, integrity, privacy, non repudiation, and anti-playback. The greater the dependency on the info supplied by the networks may be increased, the more potential risk of secure transmission of information in the networks has increased. To the secure transmission of numerous kinds of information over that happen to be renowned. In this section, we discuss the network security fundamentals you bet the techniques are meant for wireless sensor networks .

2. Cryptography: The encryption-decryption techniques devised for your traditional wired networks usually are not feasible to be employed directly for the wireless networks in particular for wireless sensor networks. WSNs include things like tiny sensors which really suffer from the possible lack of processing, memory and battery Applying the security mechanisms for instance encryption could also increase delay, jitter and packet loss in wireless sensor networks when applying encryption schemes to WSNs like, what sort of keys are generated or disseminated. How a keys are managed, revoked, assigned to your new sensor put into the network or renewed for ensuring robust to protect the network Adoption of pre-loaded keys or embedded keys could hardly be an efficient solution.

3. Steganography: While cryptography aims at hiding necessary of a message, steganography aims at hiding a good the message. Steganography is the art of covert communication by embedding a note in to the multimedia data (image, sound, video, etc.). The leading objective of steganography is to modify the carrier in a fashion that is just not perceptible and hence, it looks the same as ordinary.

4. Physical Layer Secure Access: Physical layer secure access in wireless sensor networks may very well be offered by using frequency hopping. A dynamic mixture of the parameters like hopping set (available frequencies for hopping), well time (interval per hop) and hopping pattern (the sequence in which the frequencies in the available hopping set is used) could be combined with a little expense of memory, processing and resources. Important points in physical layer secure access

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will be the efficient design in order that the hopping sequence is modified in less time than is required to discover it and for employing this both sender and receiver should maintain a synchronized clock. A scheme as proposed in may be utilized which introduces secure physical layer access employing the singular vectors while using channel synthesized modulation. Attacks against wireless sensor networks may very well be broadly considered from two different levels of views. One is the attack from the security mechanisms and this band are brilliant from the basic mechanisms (like routing mechanisms).Ideas signalize the most important attacks in wireless sensor networks.

5. Localization: It is amongst the key techniques in wireless sensor network. The place estimation method is usually classified into Target / source localization and node self-localization. In target localization, we mainly introduce the energy-based method. Then we investigate the node self-localization methods. Considering that the widespread adoption on the wireless sensor network, the localization methods are wide and varied in several applications. There are some challenges using some special scenarios. With this paper, we present a wide survey these challenges: localization in non-line-of-sight, node selection criteria for localization in energy-constrained network, scheduling the sensor node to optimize the tradeoff between localization performance and energy consumption, cooperative node localization, and localization algorithm in heterogeneous network. Finally, we introduce the evaluation criteria for localization in wireless sensor network. The entire process of estimating the unknown node position inside the network is known as node self-localization. And WSN comprises a large number of inexpensive nodes which are densely deployed in a very region of interests to measure certain phenomenon. The leading objective would be to determine the location of the target. Localization is significant travelers have an uncertainty with the exact location of some fixed or mobile devices. One example has been in the supervision of humidity and temperature in forests and/or fields, where thousands of sensors are deployed by way of plane, giving the operator minimal possible ways to influence may location of node. An efficient localization algorithm might utilize all the free information from the wireless sensor nodes to infer the positioning of the individual devices. Another application will be the positioning of an mobile robot determined by received signal strength from your number of radio beacons placed at known locations around the factory floor. The primary function of an location estimation method to calculate the geographic coordinates of network nodes with unknown position in the deployment area. Localization in wireless sensor networks is the process of determining the geographical positions
of sensors. Only a number of the sensors (anchors) inside the networks have prior knowledge about their geographical positions. Localization algorithms utilize location information of anchors and estimates of distances between neighboring nodes to discover the positions in the rest of the sensors.

6. Power-Consumption: A wireless sensor node can be a popular solution when it is difficult or impossible to perform a mains supply towards sensor node. However, because the wireless sensor node is normally positioned in a hard to reach location, changing the battery regularly will not be free and inconvenient. An essential take into account the introduction of a wireless sensor node is making sure that there's always adequate energy accessible to power the system .The facility consumption rate for sensors in the wireless sensor network varies greatly good protocols the sensors use for communications. The Gossip-Based Sleep Protocol (GSP) implements routing and many MAC functions in a energy conserving manner. The effectiveness of GSP has already been

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demonstrated via simulation. However, no prototype system has become previously developed.GSP was implemented for the Mica2 platform and measurements were conducted to discover the improvement in network lifetime. Results for energy consumption, transmitted and received power, minimum voltage supply necessary for operation, effect of transmission power on energy consumption, and different methods for measuring time of a sensor node are presented. The behavior of sensor nodes when they're all around their end of lifetime is described and analyzed.

7. Deployment: Sensor networks provide capability to monitor real-world phenomena in more detail and also at large scale by embedding wireless network of sensor nodes in the environment. Here, deployment is anxious with establishing an operational sensor network inside a real-world environment. On many occasions, deployment is often a labor-intensive and cumbersome task as environmental influences trigger bugs or degrade performance in a way that is not observed during pre-deployment testing within a lab. The real reason for this really is that the real life features a strong influence for the function of your sensor network by governing the output of sensors, by influencing the existence and excellence of wireless communication links, and also by putting physical strain on sensor nodes. These influences is only able to be modeled to your very restricted extent in simulators and lab testbeds. Home the typical problems encountered during deployment is rare. You can only speculate for the grounds for this. On one side, a paper which only describes what actually transpired during a deployment seldom constitutes novel research and could possibly be hard to get published. However, people might often hide or ignore problems that are not directly related to their field of research. It is additionally often tough to discriminate desired and non desired functional effects for the different layers or levels of detail.

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