A Study on Various Types of Sensor Networks

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ABSTRACT

Wireless sensor network is emerging field because of its wide applications and least cost. Wireless sensor network is different from other popular wireless networks like cellular networks, wireless LAN and Bluetooth in many ways. Wireless Sensor networks are distributed networks made up of small sensing devices equipped with processors, memory and short-range wireless communication. It is a wireless network which consist a group of small sensor nodes which communicate through radio interface. These sensor nodes are composed of sensing, computation, communication and power as four basic elements. But limited energy, communication capability, storage and bandwidth are the main resource constraints. In this paper, comparison of traditional wireless network and Wireless Sensor Network and also various types of Wireless sensor networks and their applications are discussed.

I. Introduction:

With the advances in micro-electro-mechanical system technologies, embedding system technology and wireless communication with low power consumption, it is now possible to produce micro wireless sensors for sensing, wireless communication and information processing. This inexpensive and power-efficient sensor nodes work together to form a network for monitoring the target region. Through the cooperation of sensor nodes, the WSNs collect and send various kinds of message about the monitored environment (e.g. temperature, humidity, etc.) to the sink node, which processes the information and reports it to the user. Sensor networks have a wide variety of applications and systems with vastly varying requirements and characteristics. The sensor networks can be used in Military environment, Disaster management, Habitat monitoring, Medical and health care, Industrial fields, Home networks, detecting chemical, Biological, radiological, nuclear, and explosive material etc. Deployment of a sensor network in these applications can be in random fashion (e.g., dropped from an airplane) or can be Planted manually (e.g., fire alarm sensors in a facility). For example, in a disaster management application, a large number of sensors can be dropped from a helicopter. Networking these sensors can assist rescue operations by locating survivors, identifying risky areas, and making the rescue team more aware of the overall situation in the disaster area .

II. Comparison of WSN with traditional wireless network

- Number of sensor nodes in WSN is much larger than any of traditional wireless networks.
- A major difference between WSN and other traditional networks computing devices including PC's, PDA's and other embedded devices is that in WSN main emphasize is on power management.
- WSN is a data centric approach but traditional wireless networks are address centric because of large number of nodes in WSN.
- Sensor nodes are much cheaper than nodes in other wireless networks.
- WSN uses broadcast communication approach but traditional wireless networks use point-to-point communication.
- Traditional wireless network like Mobile ad hoc Networks are designed for distributed computing while WSN are designed to gather information.
- A unique characteristic of WSN is that data collected by adjacent nodes and some consecutive readings sensed by sensors are highly correlated which gives opportunity to develop efficient protocols.

III. Types of Sensor Networks

1. Underwater Wireless Sensor Network

Wireless information transmission through the ocean is one of the enabling technologies for the development of future ocean-observation systems and sensor networks. Applications of underwater sensing range from oil industry to aquaculture, and include instrument monitoring, pollution control, climate recording, and prediction of natural disturbances, search and survey missions, and study of marine life. Underwater wireless sensing systems are envisioned for stand-alone applications and control of autonomous underwater vehicles (AUVs), and as an addition to cabled systems. For example, cabled ocean observatories are being built on submarine cables to deploy an extensive fiber-optic network of sensors (cameras, wave sensors and seismometers) covering miles of ocean floor. These cables can support communication access points, very much as cellular base stations are connected to the telephone network, allowing users to move and communicate from places where cables cannot reach.

Underwater communication systems today mostly use acoustic technology. Acoustic communications offer longer ranges, but are constrained by three factors: limited and distance-dependent bandwidth, time-varying multi-path propagation and low speed of sound.

Applications

Applications of underwater networks fall into similar categories as for terrestrial sensor networks.

- Scientific applications observe the environment: from geological processes on the ocean floor, to water characteristics (temperature, salinity, oxygen levels, bacterial and other pollutant content, dissolved matter, etc.) to counting or imaging animal life (micro-organisms, fish or mammals).
- Industrial applications monitor and control commercial activities, such as underwater equipment related to oil or mineral extraction, underwater pipelines or commercial fisheries. Industrial applications often involve control and actuation components as well.
- Military and homeland security applications involve securing or monitoring port facilities or ships in foreign harbors, de-mining and communication with submarines and divers.

2. Underground Wireless Sensor Network

Wireless Underground Sensor Networks (WUSNs) constitute one of the promising application areas of the recently developed wireless sensor networking techniques. WUSN is a specialized kind of WSN that mainly focuses on the use of sensors at the subsurface region of the soil. For a long time, this region has been used to bury sensors, usually targeting irrigation and environment monitoring applications, although without wireless communication capability. WUSNs promise to fill this gap and to provide the infrastructure for novel applications. The main difference between WUSNs and the terrestrial WSNs is the communication medium. In fact, the differences between the propagation of electromagnetic (EM) waves in soil and in air are so significant that a complete characterization of the underground wireless channel was only available recently.

Although its deployment is mainly based on underground sensor nodes, a WUSN still requires aboveground devices for data retrieval, management, and relay functionalities. Accordingly, three different communication links exist in WUSNs based on the locations of the transmitter and the receiver:

- **Underground-to-underground (UG2UG) Link**: Both the sender and the receiver are buried underground and communicate through soil. This type of communication is employed for multi-hop information delivery.
- **Underground-to-aboveground (UG2AG) Link**: The sender is buried and the receiver is above the ground. Monitoring data is transferred to aboveground relays or sinks through these links.
- **Aboveground-to-underground (AG2UG) Link**: Aboveground sender node sends messages to underground nodes. This link is used for management information delivery to the underground sensors.

Applications

- Environmental monitoring
- Earthquake and landslide monitoring
- Precision agriculture
- Security (intruder detection)
- Assisted navigation
- Sports field maintenance
- Infrastructure monitoring

Despite its potential advantages, the realization of WUSN is challenging and several open research problems exist. The main challenge is the realization of efficient and reliable underground wireless communication between buried sensors. To this end, underground communication is one of the few fields where the environment has a significant and direct impact on the communication performance.

3. Mobile Wireless Sensor Networks

Mobile wireless sensor networks (MWSNs) can simply be defined as a wireless sensor network (WSN) in which the sensor nodes are mobile. MWSNs are a smaller, emerging field of research in contrast to their well-established predecessor. MWSNs are much more versatile than static sensor networks as they can be deployed in any scenario and cope with rapid topology changes. However, many of their applications are similar, such as environment monitoring or surveillance. Commonly the nodes consist of a radio transceiver and a microcontroller powered by a battery. As well as some kind of sensor for detecting light, heat, humidity, temperature, etc.

There are two sets of **challenges** in MWSNs; hardware and environment. The main hardware constraints are limited battery power and low cost requirements. The limited power means that it's important for the nodes to be energy efficient. Price limitations often demand low complexity algorithms for simpler microcontrollers and use of only a simplex radio. The major environmental factors are the shared medium and varying topology. The shared medium dictates that channel access must be regulated in some way. This is often done using a medium access control (MAC) scheme, such as carrier sense multiple access (CSMA), frequency division multiple access (FDMA) or code division multiple access (CDMA). The varying topology of the network comes from the mobility of nodes, which means that multihop paths from the sensors to the sink are not stable.

Since there is no fixed topology in these networks, one of the greatest challenges is **routing** data from its source to the destination. Generally these routing protocols draw inspiration from two fields; **WSN**s and **Mobile ad hoc networks** (MANETs).

- **Wireless Sensor Network** routing protocols provide the required functionality but cannot handle the high frequency of topology changes.

  WSN are of spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location.

- **MANET** routing protocols are, can deal with mobility in the network but they are designed for two way communication, which in sensor networks is often not required.

A **mobile ad hoc network** (**MANET**) is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires.

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently.

MANETs consist of a peer-to-peer, self-forming, self-healing network in contrast to a mesh network has a central controller (to determine, optimize, and distribute the routing table).

Protocols designed specifically for MWSNs are almost always multi hop and sometimes adaptations of existing protocols. For example, Angle-based Dynamic Source Routing (ADSR), is an adaptation of the wireless mesh network protocol Dynamic Source Routing (DSR) for MWSNs. ADSR uses location information to work out the angle between the node intending to transmit, potential forwarding nodes and the sink.

Another popular routing technique is to utilise location information from a GPS module attached to the nodes. This can be seen in protocols such as Zone Based Routing (ZBR), which defines clusters geographically and uses the location information to keep nodes updated with the cluster they're in. In comparison, Geographically Opportunistic Routing (GOR), is a flat protocol that divides the network area into grids and then uses the location information to opportunistically forward data as far as possible in each hop.

Multipath protocols provide a robust mechanism for routing and therefore seem like a promising direction for MWSN routing protocols. One such protocol is the query based Data Centric Braided Multipath (DCBM).

Protocols designed for MWSNs are usually validated with the use of either analytical, simulation or experimental results. Detailed analytical results are mathematical in nature and can provide good approximations of protocol behavior. Simulations can be performed using software such as OPNET, NetSim and NS2 and is the most common method of validation.

Applications:

The advantages of mobile wireless sensor network over static wireless sensor networks include better energy efficiency, improved coverage, enhanced target tracking, and superior channel capacity.

The advantage of allowing the sensors to be mobile increases the number of applications beyond those for which static WSNs are used. Sensors can be attached to people for health monitoring, which may include heart rate, blood pressure etc. Animals can have sensors attached to them in order to track their movements for migration patterns, feeding habits or other research purposes. Sensors may also be attached to unmanned aerial vehicles (UAVs) for surveillance or environment mapping.

4. Earthbound Wireless Sensor Networks

Terrestrial WSNs typically consist of hundreds to thousands of inexpensive wireless sensor nodes deployed in a given area, either in an ad hoc or in a pre-planned manner. In adhoc deployment, sensor nodes can be dropped from a plane and randomly placed into the target area. In pre-planned deployment, there is grid placement, optimal placement, 2-d and 3-d placement models. In a terrestrial WSN, reliable communication in a dense environment is very important. Terrestrial sensor nodes must be able to effectively communicate data back to the base station. While battery power is limited and may not be rechargeable, terrestrial sensor nodes however can be equipped with a secondary power source such as solar cells. In any case, it is important for sensor nodes to conserve energy. For a terrestrial WSN, energy can be conserved with multi-hop optimal routing, short transmission range, in-network data aggregation, eliminating data redundancy, minimizing delays, and using low duty-cycle operations.

5. Multimedia Wireless Sensor Network

The availability of inexpensive hardware such as CMOS cameras and microphones has fostered the development of Wireless Multimedia Sensor Networks (WMSNs), i.e., networks of wirelessly interconnected devices that are able to ubiquitously retrieve multimedia content such as video and audio streams, still images, and scalar sensor data from the environment.

The first step in creating a WMSN is equipping a single sensor device with audio and visual information collection modules. As an example, the Cyclops image capturing and inference module, is designed for extremely light-weight imaging and can be interfaced with a host mote such as Crossbow's MICA2 or MICAz. In addition to the ability to retrieve multimedia data, WMSNs will also be able to store, process in real time, correlate and fuse multimedia data originated from heterogeneous sources.

Applications

- **Multimedia Surveillance Sensor Networks**: Video and audio sensors will be used to enhance and complement existing surveillance systems against crime and terrorist attacks. Large scale networks of video sensors can extend the ability of law enforcement agencies to monitor areas, public events, private properties and borders.
- **Traffic Congestion Avoidance Systems:** It will be possible to monitor car traffic in big cities or highways and deploy services that offer traffic routing advice to avoid congestion. Automated parking assistance is another possible related application.
- **Advanced Health Care Delivery:** Telemedicine sensor networks can be integrated with 3G multimedia networks to provide ubiquitous health care services. Patients will carry medical sensors to monitor parameters such as body temperature, blood pressure, pulse oximetry, ECG, breathing activity. Similarly, elderly and family monitors will help in providing timely and essential support to the less able sections of society.
- **Industrial Process Control:** Multimedia content such as imaging, temperature, or pressure amongst others, may be used for time-critical industrial process control. The integration of machine vision systems with WMSNs can simplify and add flexibility to systems for visual inspections and automated actions that require high-speed, high-magnification, and continuous operation.

Many of the above applications require the sensor network paradigm to be re-thought in view of the need for mechanisms to deliver multimedia content with a certain level of quality of service (QoS). Since the need to minimize the energy consumption has driven most of the research in sensor networks so far, mechanisms to efficiently deliver application-level QoS, and to map these requirements to network-layer metrics such as latency and jitter, have not been primary concerns in mainstream research on sensor networks.

IV. Conclusion

Wireless Sensor Network is one of the emerging fields in research area. Wireless sensor network has a remarkable feature to monitor environmental and physical conditions. In this paper we discussed various aspects of wireless sensor networks and also discussed various types of WSNs and their applications. In the future, the wide range of application areas will make sensor networks an integral part of our lives. We also discussed how it is differ from traditional wireless networks. Wireless sensor network has bright future in the field of networking because it continuingly providing us solutions for many monitoring problems.

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