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Energy Harvesting in Wireless Sensor Network: A Review Paper

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Abstract: Wireless sensor networks (WSN), sometimes also referred as wireless sensors and actuators networks (WSAN), are generally spatially distributed autonomous sensors to monitor all or some physical or environmental conditions, such as temperature, humidity, sound, pressure, moisture, etc. and to cooperatively pass their data through the network by efficient routing to a main location or base station. The more modern networks are generally bi-directional, also enabling the control of sensor activity. The development of wireless sensor networks was initially motivated by military applications such as battlefield surveillance, Warfield surveillance; today such wireless sensor networks are used in many industrial, medical and consumer applications, such as industrial process machine monitoring and control, machine health monitoring and control, and so on. In this paper, brief review of protocols in wireless sensor network for energy harvesting is presented.

Keywords: WSN, Routing Protocols

1. Introduction

The WSN is generally a built of "nodes" – from a few number of nodes to several hundreds or even thousands, where each node is connected to at least one (or sometimes several) sensor. [1]

Each such desired sensor network node has typically several parts: a radio transmitter and radio receiver with generally an internal antenna or it employs a connection to an external antenna, a minimum 8-bit microcontroller. An electronic noise cancelling and repeater circuit for interfacing with the particular sensor and a constant energy source, usually a good battery or an embedded form of energy harvesting or maybe a renewable energy source like solar power, wind energy. A sensor node might vary in size and energy from that of a box down to the size of a grain of salt, although functioning "speck" 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 communications 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. [2][3]

2. Application of WSN

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. A military example is the uses of sensors detect enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines.[4]

Health care monitoring: The medical applications can be of two types: wearable and implanted. Wearable devices are used on the body surface of a human or just at close proximity of the user. The implantable medical devices are those that are inserted inside human body. There are many other applications too e.g. body position measurement and location of the person, overall monitoring of ill patients in hospitals and at homes. Body-area networks can collect information about an individual's health, fitness, and energy expenditure.

Environmental/Earth sensing: There are many applications in monitoring environmental parameters, examples of which are given below. They share the extra challenges of harsh environments and reduced power supply.[5]

Air pollution monitoring: Wireless sensor networks have been deployed in several cities (Stockholm, London, and Brisbane) to monitor the concentration of dangerous gases for citizens. These can take advantage of the ad hoc wireless links rather than wired installations, which also make them more mobile for testing readings in different areas.

Forest fire detection: A network of Sensor Nodes can be installed in a forest to detect when a fire has started. The nodes can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation. The early detection is crucial for a successful action of the firefighters; thanks to Wireless Sensor Networks, the fire brigade will be able to know when a fire is started and how it is spreading.

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. Through the data gathered it may be possible to know the impending occurrence of landslides long before it actually happens.

Water quality monitoring: Water quality monitoring involves analyzing water properties in dams, rivers, lakes & oceans, as well as underground water reserves. The use of many wireless distributed sensors enables the creation of a more accurate map of the water status, and allows the permanent deployment of monitoring stations in locations of difficult access, without the need of manual data retrieval.

Natural disaster prevention: Wireless sensor networks can effectively act to prevent the consequences of natural disasters, like floods. Wireless nodes have successfully been deployed in rivers where changes of the water levels have to be monitored in real time.

Machine health monitoring: Wireless sensor networks have been developed for machinery condition-based maintenance (CBM) as they offer significant cost savings and enable new functionality. Wireless sensors can be placed in locations difficult or impossible to reach with a wired system, such as rotating machinery and untethered vehicles.

Data logging: Wireless sensor networks are also used for the collection of data for monitoring of environmental information, this can be as simple as the monitoring of the temperature in a fridge to the level of water in overflow tanks in nuclear power plants. The statistical information can then be used to show how systems have been working. The advantage of WSNs over conventional loggers is the "live" data feed that is possible.

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

Structural health monitoring: Wireless sensor networks can be used to monitor the condition of civil infrastructure and related geo-physical processes close to real time, and over long periods through data logging, using appropriately interfaced sensors.

Wine production: Wireless sensor networks are used to monitor wine production, both in the field and the cellar.

3. Network Design Challenges:

Node deployment: Node deployment is dependent on the application and effect the performance of WSNs. The deployment can be either deterministic or randomized. In deterministic deployment, the sensing elements are manually identified and data is routed through pre-defined routes.[6] However, in random node deployment, the sensor nodes are

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spotted randomly creating WSNs. If the consequent distribution of sensor node is not uniform, optimally clustering becomes necessary to allow connectivity and enable energy efficient network performance. Inter-sensor communication is normally within short communication ranges due to energy and bandwidth restrictions. Thus, it is most probable that a route will consist of multiple wireless hops.

Energy consumption: The main task of the routing protocols is efficient delivery of data from source to destination. Energy consumption is the major concern in the development of routing protocols for WSNs. Sensor node has limited energy resources and information or data want to be delivered in an energy efficient way without compromising the correctness of the information. The main reason of energy consumption for routing in WSNs is neighborhood discovery and data aggregation.

Scalability: A large number of sensor nodes are scattered in the application area, i.e. thousand or more numbers of node. Routing protocols work with large number of sensor nodes. WSN routing protocols must be an adequate amount of scalable to act in response to events in the network. If an event occurs, then sensor nodes are responsible or handle that event.

Fault Tolerance: A few sensor nodes can crash due to lack of power, physical damage, or environmental interference. The crash of sensor nodes must not influence the overall task of the WSNs. If a large number of nodes crash, MAC and routing protocols must lodge formation of new links and routes for communication in the network. This may need more power for new link formation and route these new links in the sensor network. Therefore, several levels duplication can be needed in a fault tolerant sensor network.

Data Aggregation: Sensor nodes can produce duplicate data from different regions. Data aggregation techniques combine data from various nodes, according to a definite aggregation function, e.g., duplicate repression, minima, maxima and average. Data aggregation is used to meet energy efficiency and data transfer optimization in all routing protocols.

Quality of Service: In many applications, data must be delivered in a definite period of time from the instant it is sensed, otherwise the data will be of no use. Therefore, restricted latency for data delivery is another situation for time-constrained applications. Since, the energy gets exhausted, the network has to degrade the performance.

4. Routing Protocols:

Many researchers proposed routing protocols for WSN. In general, all the routing protocol for WSNs can be divided into data centric protocols, Hierarchical Protocols, location based protocol and opportunistic routing protocols.[7]

Data Centric Protocols: Data Centric routing protocols are used to manage the redundancy of data; it happens for the reason that sensor nodes do not have global identification, which identifies them uniquely. Therefore, data sent to every node is having significant redundancy. In data centric routing, the destination demand for data by sending the question then the nearby sensor node sends the data selected relating to the query. SPIN is the first data-centric protocol, which considers between nodes in order to eliminate redundant data and maintain energy. Later, Directed diffusion has been modernized and has become a breakthrough in data-centric routing. **Hierarchical Routing Protocols:** Standardized to a cellular phone network, sensor nodes in a hierarchical routing approach send their information to a key cluster-head and the cluster head then forwards the information to the desired receiver. The primary purpose of hierarchical routing is to efficiently maintain the energy consumption of sensor nodes by taking them in multi-hop communication within a particular cluster and by performing data collection and fusion in order to lessen the number of communicating messages to the destination. Among numerous of hierarchical routing protocols LEACH and PEGASIS are mostly used protocols.

Location Based Routing Protocol: The estimation of location-based protocols is using an arena instead of a node identifier as the object of a packet. Any node that positions within the given area will be acceptable as a destination node and can obtain and process a message. From the perspective of sensor networks, such location-based routing is important to request sensor data from any region. Since there is no addressing method for sensor networks like IP-addresses and they are spatially deployed in a neighborhood, location information can be used in routing data in an energy-efficient manner. For example, if the region to be sensed is identified, using the location of sensor nodes, the question can be disseminated only to that particular region which will eradicate the number of transmission significantly. The location-based routing protocols obtain into report the mobility of sensor nodes and execute very well when the density of the network increases. Merely, the execution is very pitiful when the network deployment is sparse and there is no data aggregation and further dealing out of the header node. For example, GEAR is one of the location-based protocols.

Opportunistic Routing in WSNS: Challenged networks where network contacts are intermittent or where link performance is highly variable and there is no complete path from source to destination for most of the time. The path can be highly unstable and may change or break quickly. To make communication possible intermediate nodes may take keeping of data during the blackout and forward it when the connectivity resumes. Opportunistic Routing used broadcast transmission to send packets through multiple relays. Opportunistic routing archives higher throughput than traditional routing.

5. Conclusion

Wireless sensor networks are not always homogeneous, they may be heterogeneous too. The lifetime and reliability of the network can be improved by heterogeneity in wireless sensor networks. In this paper, we studied a brief review on wireless sensor networks.

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