

A Review on Energy Harvesting in Wireless Sensor Networks

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ABSTRACT: Wireless sensor networks (WSN) are generally distributed independent sensors which work mutually to monitor all or some physical or ecological conditions, such as temperature sound, pressure, moisture, humidity etc. They are sometimes called as Wireless Sensors and Actuators Networks (WSAN) as well. Wireless Sensor Networks work thoughtfully to pass their information through the network by capable routing to a main location or base station. The more recent networks are generally bi-directional; also enable the control of sensor activity. The development of wireless sensor networks was primarily aggravated by military applications such as Warfield surveillance, battlefield surveillance; today such wireless sensor networks are used in several industrial, consumer and medical applications, such as machine health monitoring and control, industrial process machine monitoring and control, , and so on. In this paper, concise review is presented of protocols in wireless sensor network for energy harvesting.

KEYWORDS: WSN, Routing Protocol.

I. INTRODUCTION

The WSN is generally a combination of "nodes" which can vary from few numbers of nodes to several hundreds or thousands of nodes. It works in a very complex topology where each node is associated to at least one (or sometimes several) sensor [1]. Such Sensor Network require several parts to complete the network which include a radio transmitter and radio receiver with generally an inside antenna or it employs a connection to an outside antenna, a minimum 8-bit microcontroller. A repeater circuit and electronic noise cancelling for interfacing with the particular sensor and a constant energy source, generally 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 energy and size depending on the usage of the nodes in several applications, even though functioning "speck" of genuine microscopic dimensions have yet to be formed. The cost of sensor nodes is variable, ranging from a few to hundreds of dollars to thousands of dollars, depending on the complexity of the network and the individual sensor nodes as well. Size and cost of the sensor node is highly dependent on the application it is going to be employed and is the driving factor for the computational speed, transmission speed, energy, and memory and communication bandwidth. There are number of WSNs available which vary from simple bus or star network to an advanced multi-hop wireless mesh network. The communication technique among the sensor nodes in the network can be routing or flooding of the information. [2][3]

II. APPLICATION OF WSN

- **Area monitoring:** Out of the Applications of WSNs, Area Monitoring can be considered as one of the most common applications of WSN. In this case, The Wireless Sensor Nodes are installed throughout a region/zone to capture an instance of actions or any phenomenon. Ex. - Military example consists of detecting Enemy Intrusion and Civil example consists of locating boundaries for Oil/Gas pipelines. [4]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

- **Health care monitoring:** Health Care Monitoring is also common application of WSNs. It can be used in Health Care as Wearable and/or Implanted types. In the First case, device is used touching the body surface or used just at defined close proximity of the human. The latter case requires the device to be inserted inside human body. Health care industries use WSNs to monitor overall health of ill patients at hospitals and at homes and collect information about one's health, BMI, Energy consumption etc.
- **Environmental/Earth sensing:** WSNs are majorly used to detect Environmental Problems well in advance so that it can be prevented or can be taken care of in a better way. Some of the examples of Environmental/Earth Sensing Applications are as follows:

Air Pollution Monitoring
Fire Detection in Forests
Landslide Detection
Natural Disaster Prevention
Rain Water Quality Monitoring etc. [5]

- **Air Pollution Monitoring:** WSNs have already been deployed in most of the developed cities like London, Chicago, and Paris to save mankind from dangerous gases or pollution. These devices are helpful in detecting the intensity of these dangerous gases in advance and signal the corresponding team so that required action can be taken in time. E These devices take advantage over the conventional methods because of the capabilities they carry. They can be used in different areas as and when required and are mobile in nature.
- **Forest Fire Detection:** This is the most important area where these networks are very useful. WSNs can be installed in Forests, dense areas to detect the fire early. These devices can be configured in such a way that they can early detect the increase in temperature, humidity, and gases over a defined limit and can signal the Fire Brigade to take the corrective action. These devices can also help in determining the intensity, location of the fire attack so that successful action can be taken in one goes.
- **Landslide Detection:** WSNs play a very important role to detect the Landslide or Soil Movement by defining certain parameters. They pass on the information to the destination as soon as they detect variation in the parameters that may occur before or during the landslide. By collecting the data constantly, once can be able to know the impending occurrence of Soil Movements long in advance before it actually happens.
- **Water Quality Monitoring:** Water is considered as the most important resource in the World and is used in several ways in mankind. The sources of water to satisfy all the requirements are Dams, Rivers, Lakes, Oceans, underground water etc. WSNs can be deployed under the water or at the surface to detect the quality of the water and create a more accurate map of the Water status from all of the above mentioned sources. WSN reduces the manual retrieval of the data and encourages the team to help identifying the locations which are facing difficulties to access the right quality of water.
- **Natural disaster prevention:** Wireless sensor networks can sense the level of the ground water and can be very useful to prevent the consequences of natural disaster like floods. There are many industries/agencies which have successfully deployed such WSNs in the rivers or dams where real time monitoring of water level is monitored frequently.
- **Machine health monitoring:** Wireless Sensor Networks have been developed to check the health of a machine which requires conditional based servicing. Enabling such WSNs for these machines offer significant cost saving and new functionalities. The main advantage of the WSN over conventional or wired network is the flexibility to

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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Vol. 6, Issue 4, April 2017

place the WSN in the area where it is impossible to reach with the wired system like rotating machinery or untethered vehicles.

- **Data logging:** Wireless Sensor Networks are also designed considering the requirement of monitoring environmental information like temperature, humidity etc. This can be explained as simple as measuring the temperature in a fridge but can be used in Power industries to monitor the level of water in overflows tanks in Nuclear Power Plants. The information collected can be converted to statistical data and can be studied to understand the overall performance of the system in real time.
- **Water/Waste water monitoring:** Wireless Sensor Networks are designed to bless the mankind by measuring the quality of the water based on the usage like drinking or waste water. There are instances when quality of the water becomes bottleneck for many industries where water is classified based on the usage. Using WSNs to monitor the waste water can be very advantageous over the conventional systems.
- **Structural health monitoring:** Wireless sensor networks can be used to monitor the situation of civil infrastructure and related geo-physical processes very close to real time, and over long span of time 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.

IV. NETWORK DESIGN CHALLENGES

- **Node deployment:** Node consumption is mainly dependent on WSN's use and it is responsible to affect the performance of WSNs. The consumption can be randomized or deterministic. In deterministic deployment, the sensing node fundamentals are manually identified and data is routed through already existing routes. [6] Though, in random node exploitation, the sensor nodes are marked randomly creating WSNs.
- If equality is not maintained in consequent distribution of sensor node, optimally clustering becomes compulsory to allow connectivity and enable energy efficient constant network performance. Inter-sensor communication is normally.

Within short domain of communication due to bandwidth and energy restrictions. Thus, it is most achievable that a route will consist of several wireless hops.

- **Energy consumption:** The primary task of the routing protocols is efficient delivery of data from source to destination. Efficient consumption of Energy is the major concern in the development of routing protocols for WSNs. Sensor node has limited resources of energy and information or data are required 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 identifying the neighborhood node and aggregation of the data.
- **Scalability:** A large number of sensor nodes are scattered in the application network, i.e. thousand or more numbers of WSN node. There is heavy involvement of Routing protocols to work with 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 energy, outside damage, or natural interference. The crash of sensor nodes must not affect other nodes and shouldn't influence the overall task of the WSNs. In case of damage or crush to large number of nodes, Routing Protocols and MAC should be capable enough to lodge the information or data packets and should be able to transmit it over new links and routes over the communication

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 4, April 2017

network. This might require a complex routing protocol script and more power might be required to form a new connection. Therefore it must be taken care that several level of duplication are employed in the Wireless Sensor Networks to deal with the fault tolerance and system has enough power/energy to handle such situations.

- **Data Aggregation:** Another challenge in Wireless Sensor Network is to handle the duplicate data which can come from Sensor nodes deployed in different regions. An efficient data aggregation technique must be introduced in the network so that redundant data coming from different nodes can be filtered and transmitted over the network. Data Aggregation technique generally deals with duplicates repression, average, minima and maxima. Data aggregation is used to gain energy efficiency and data transfer optimization in all routing protocols.
- **Quality of Service:** In many applications, data must be delivered in very less defined 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 compromise with the performance.

V. ROUTING PROTOCOLS

There is several numbers of Routing Protocols for Wireless Sensor Networks proposed by many researchers. In general, all the routing protocol for WSNs can be divided into:

Data centric protocols
Hierarchical Protocols
Location based protocol
Opportunistic routing protocols [7]

- **Data Centric Protocols:** Data Centric Routing Protocols are generally used to eliminate the redundancy of the data in the network. There are scenarios where sensors nodes do not have any global identification recognition which helps them identified uniquely thus these sensor nodes can transmit redundant information. Data Centric Routing functions in a way that destination node or system demands for the data by sending the questions to the nearby sensor node and gets the reply relating to the query. SPIN is the first Data Centric Protocol which considers network nodes in order to eliminate the redundant data and preserve energy of the overall system. Later, Directed diffusion has been enhanced and has become a breakthrough in data-centric routing.
- **Hierarchical Routing Protocols:** Hierarchical Routing Protocols work like standard Cellular Phone Network and use hub process wherein sensor nodes send the corresponding information to a key cluster head and then the cluster head forwards this information to the desired receiver. The primary purpose of hierarchical routing is to maintain the energy consumption of sensor nodes efficiently by taking them in multi-hop network communication within a defined cluster and by performing data collection and combination in order to lessen the number of communicating messages to the goal. Even though there are several hierarchical routing protocols existing, but the frequently used protocols are LEACH and PEGASIS.
- **Location Based Routing Protocol:** The assessment of location-based protocols is using a scrupulous region instead of a node identifier as the purpose of a packet transmission. Any node that is identified within the given area will be considered as a destination node and can obtain and process the information or data packets. Such Location based routing becomes important to request data from any region in the perception of the sensor network. Provided that Sensor networks don't have any addressing method like IP address routing, they are distributed in a given region so that location information can be used in routing the data in energy efficient manner. For Example, if the region to be sensed or monitored is identified, the corresponding sensor node implemented in the same region can be used to transmit the information by disseminating the question to that particular region only. This

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Vol. 6, Issue 4, April 2017

way number of transmission will be eliminated significantly and overall task of the network will be optimized. The location-based routing protocols obtain into report the mobility of sensor nodes and execute very well where density of network is the requirement. Simply, the execution is very contemptible when the network deployment is sparse and there is no data aggregation and further handing out of the header node. For example, GEAR is one of the location-based protocols.

- **Opportunistic Routing in WSNs:** Optimistic Routing is a challenged network where network contacts are intermittent or where link performance is highly unbalanced and there is no complete path from source to destination for most of the time. The path can be highly unbalanced and may change rapidly. To make communication achievable intermediate nodes may take keeping of data during the faint and forward it when the connectivity resumes. Opportunistic Routing used broadcast transmission to send packets during multiple transmit. Opportunistic routing archives higher throughput than conventional routing.

VI. 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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