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Various Routing Parameters in SHM using WSN

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***Abstract-** This paper gives attention to the particular application of Wireless Sensor Network. Since the Wireless sensors network nodes are typically battery equipped, the primary goal is to optimize the available resources. These resources can be utilized by the various parameters in every layer of the WSN. Wireless sensor networks are now used in many applications including military, environmental, healthcare, home and in traffic control. In this paper Structural Health Monitoring application with the help of WSN along with various routing parameters have been discussed.*

***Keywords:** Wireless Sensors Network (WSN), Routing Protocols, Structural Health Monitoring*

I. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices that use sensors to monitor physical or environmental conditions. These autonomous devices, or nodes, combine with routers and a gateway to create a typical WSN system. The distributed measurement nodes communicate wirelessly to a central gateway, which provides a connection to the wired world where you can collect, process, analyze, and present your measurement data. To extend distance and reliability in a wireless sensor network, you can use routers to gain an additional communication link between end nodes and the gateway [1-4].

National Instruments Wireless Sensor Networks offer reliable, low-power measurement nodes that operate for up to three years on 4 AA batteries and can be deployed for long-term, remote operation. The NI WSN protocol based on IEEE 802.15.4 and ZigBee technology provides a low-power communication standard that offers mesh routing capabilities to extend network distance and reliability. The wireless protocol you select for your network depends on your application requirements.

Energy consumption issues in wireless sensor network- Energy consumption is the most important factor to determine the life of a sensor network because usually sensor nodes are driven by battery. Sometimes energy optimization is more complicated in sensor networks because it involved not only reduction of energy consumption but also prolonging the life of the network as much as possible. The optimization can be done by having energy awareness in every aspect of design and operation. This ensures that energy awareness is also incorporated into groups of communicating sensor nodes and the entire network and not only in the individual nodes.

SHM is another important domain for sensor network application. The combined US and Canada Civil infrastructure assets have an estimate value of US$25 trillion, SHM applications, serving as precaution measure, can have great social and economic impact. The widely accepted goals of SHM system include detecting damage, localizing damage, estimating the extent of the damage and predicting the residual life of the structure. SHM has been an evolving technology since it was first proposed in 1990's, the latest approach, wireless sensor network based approach, is promising because it has many advantages: low deployment and maintenance cost, large physical coverage, high special resolution etc. One of the barriers is that damage detection is very difficult even for sophisticated sensors, thus breakthrough in damage detection using small MEMS sensors is much needed. So far, a SHM system using wireless sensor network technology is yet to emerge [5-9].

II. ADVANTAGES AND DISADVANTAGES OF WIRELESS SENSOR NETWORK

Recent developments in the area of micro-sensor devices have accelerated advances in the sensor networks field leading to many new protocols specifically designed for wireless sensor networks (WSNs). Wireless sensor networks with hundreds to thousands of sensor nodes can gather information from an unattended location and transmit the gathered data to a particular user, depending on the application. These sensor nodes have some constraints due to their limited energy, storage capacity and computing power. Data are routed from one node to other using different routing protocols. There are a number of routing protocols for wireless sensor networks. In case of wireless sensor networks dynamic routing is employed because nodes may frequently change their position and die at any moment. The advantages and disadvantages of wireless sensor networks can be summarized as follows [1-4]:

Advantages:

a) Network setups can be done without fixed infrastructure.
b) Ideal for the non-reachable places such as across the sea, mountains, rural areas or deep forests.
c) Flexible if there is ad hoc situation when additional workstation is required.
d) Implementation cost is cheap.

Disadvantages:

a) Less secure because hackers can enter the access point and get all the information.
b) Lower speed compared to a wired network.
c) More complex to configure than a wired network.
d) Easily affected by surroundings (walls, microwave, large distances due to signal attenuation, etc.)

III. WIRELESS SENSOR NETWORK FORSTRUCTURAL HEALTH MONITORING

WSN is an application specific network. There is no general solution for WSN problems. It depends upon application, budget (cost) & resource availability. Structural health monitoring (SHM) using wireless sensor networks has drawn considerable attention in recent years. It is an active area of research that can autonomously and proactively assess the structural integrity of buildings, bridges, coal mines, tunnels and turbines using Wireless Sensor Network. Recent technological advances promise the eventual ability to cover a large civil structure with low-cost wireless sensors that can continuously monitor a building's structural health [10-11].

WSN suits the application requirements in comparison with wired sensing systems, since it is easily deployable and reconfigurable even in an inaccessible areas and reduces the system installation and condition monitoring cost in general. Wireless sensor network enables low-cost sensing of environment. Structure monitoring is one example of such applications. Wireless sensor networks are well suited for the structural health monitoring for buildings, wind turbines, coal mines, tunnels and bridges. To monitor a structure, we measure behavior (e.g. vibration, displacement) of structure, and analyze health of the structure based on measured data. SHM is an emerging research area and is focused on the field of infrastructure mainly on the integration and application of sensors, signal processing, and communication technologies. It also focuses on complex engineering systems and infrastructure to prevent structural failure and disaster.

Large civil structures such as buildings and bridges form the backbone of our society and are critical to its daily operation. Inspectors typically assess them manually, but a networked computer system that could automatically assess structural integrity and pinpoint the existence and location of any damage could measurably lengthen a structure's lifetime, reduce its operational cost, and improve overall public safety.

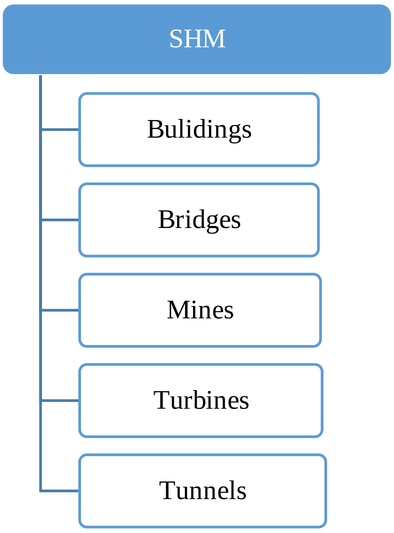

Fig.1: SHM for various applications

IV. REASONS FOR PERFORMING STRUCTURAL HEALTH MONITORING

A. Damage Detection

Obviously damage detection is the most common reason. The main aim is continuously monitoring of a structure following an event, such as an earthquake, without requiring a dangerous and expensive manual inspection.

B. Long Term Monitoring for Deterioration

Structure is detected over a long period of time. The aim here is to be assured of the structural performance and continued value of the asset under “normal” conditions.

V. TRADITIONAL METHODS OF STRUCTURAL HEALTH MONITORING

SHM projects can be divided into those undertaken over a short term for research purposes, and those performed over a long period for long term health monitoring. The short-term projects typically involve a relatively large number of sensors, many hundreds of meters of cable and a multi-channel recording system. This can take many days to set up. For long term monitoring projects, typically from one to three accelerometers are installed at key points within the structure and possibly cabled together [11-15]. The reason for this small number of sensors is the cost of the equipment and its installation and operation.

Figure 2: Traditional method

Data from these sensors is usually collected manually, following an event of interest, and taken back to a laboratory for analysis. In some more recent installations a modem is connected to the recorder so that the data may be transmitted to the laboratory, thus removing one of the steps.

VI. KEY PROBLEMS FOR SHM

The key problems for developing the SHM system in conjunction with WSN are summarized [10-15]as follows:

A. Compatibility between different sensors, their sampling frequencies and operational modes

In the field of SHM, various types of sensors are used like accelerometer, resistance strain, piezoelectric vibration, optical fiber strain, dip angle, acoustic emission, and stress measurement sensors. All these sensors have different physical mechanisms. Thus the choices of the sensor network sampling frequency, from several Hz to several hundreds of kHz, working mode, and compatibility must be considered when choosing each node.

B. Transmission Bandwidth

Generally WSNs are used for low-bandwidth applications. But in some applications, the data from vibration measurements as well as those resulting from image acquisition require a higher transmission bandwidth.

C. Synchronization

The signals must be sampled synchronously by the nodes; otherwise there will be incorrect information, due to samples grouped together coming from different times of the vibration phase, resulting in an incorrect vibration model judgment.

D. Energy Issues

Each function of a WSN, such as self-organize ability, adaptability, signal sampling, information fusion, signal processing and signal transmission requires energy consumption. Energy consumption issues various with application scenarios.

E. Topology and Data Fusion

WSNs need different topologies to meet the needs of different application characteristics in SHM. Typical topologies include star, cluster tree, and mesh networks.

VII. CLASSIFICATION OF VARIOUS ROUTING PARAMETERS

This section describes the various routing parameters along with the routing protocols. These are summarized [12-15] with the help of a table.

Routing Protocols	Routing Parameters
WEAR,GPSR, GEAR	• Energy consumption • Network life time • Load imbalance factor • No. Of Failed sensors • Path length extension rate • Hole extension • Query/reply success delivery rate
LEACH,TEEN, APTEEN	• Power consumption in transmission • Network life time • Life time of a node • Time taken in cluster formation • Average lifetime of nodes • Average delay per packet
EAGRP,DSR, AODV	• Throughput • Packet delivery ratio • End-to-end delay of data packets • Energy consumption
DD,Flooding	• Remaining energy • Route load

DD,SPIN	• Energy efficiency • Average packet received by a node
AODV,DSR, DSDV	• Total energy consumption • Coverage area • Network lifetime • Random deployment
Flooding, Gossiping, Multi-hop LEACH	• Latency • Battery usage • Success rate • Connectivity
EAR,SPEED, AODV	• Average energy consumption • Data delivery ratio • Average end-to-end delay

From the above table we have a large no of routing parameters. But all these are not energy efficient. The energy efficient parameters are Energy Consumption per Node, Total energy consumption, Network Lifetime, Battery Usage, Average Energy Consumption, Power consumption in transmission, Average lifetime of nodes, remaining energy.

VIII. CONCLUSION

Wireless technologies are constantly improving and many different applications are already successfully implemented in different application scenarios. Structural health monitoring is a typical area amongst the many possible applications of wireless sensor networks. Recent advances in electronic components, MEMS sensors and wireless communications have created the opportunity to monitor structures in ways that were not previously possible. Performing Structural Health Monitoring with energy efficiency is a great task. For this purpose a lot of routing protocols along with their respective routing parameters have been summarized in a table. Out of these routing protocols the energy efficient parameters have been pointed out.

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