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Software Architecture of Wireless Sensor Networks in Structural Health Monitoring

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Abstract

Structural health monitoring has become a famous application in wireless sensor networks since years. But it has some limitations such as scalability, visual impact and installation/maintenance cost. Wireless sensor networks are having wide area of application in SHM. In this paper we proposed a placement algorithm for SHM. SHM is a wide area of interest. SHM is the way by which we can make the structures smart. It is a new and advanced way to make non-damaging evaluation. SHM consists of a lot of sensors, smart materials and processing abilities in its structure. Conventional monitoring systems which were used for this application involve a large number of wires and an acquisition system having remote connections [7] Wireless sensor network has many applications. SHM is one of them in which WSN is used for health monitoring of buildings, bridges and many more structures.

Keywords: *Component, Formatting, Style, Styling, Insert.*

I. Introduction

Wireless sensor networks are the combination of small sensor nodes which are used to monitor the conditions of environment. These nodes sense the events from the sensing events (temperature, pressure, humidity etc.) and pass the information so collected to the centralized base station [8]. MEMS (micro electro mechanical systems) have increased the popularity of WSN. WSN is based on a simple equation i.e sensing event + processor + transceivers = hundreds of applications [3].

WSNs systems are far much better than the wired sensing systems because these are easily installed, reconfigured and deployable. Also the maintenance cost is less as compared to wired sensing systems. These sensing nodes form a backbone network so that the information is passed to other nodes to reach the base station [12]. Also these sensor nodes communicate with other nodes to make a global decision for an event [12]. Structural health monitoring is used for buildings [6], bridges [10], tunnels [1], wind turbines [11], and coal mines [5] etc. The structure is monitored by measuring the behavior i.e displacement, vibrations etc.

Fig. 1 shows the different applications area of SHM. Buildings, bridges are the main parts of our society for making structures.

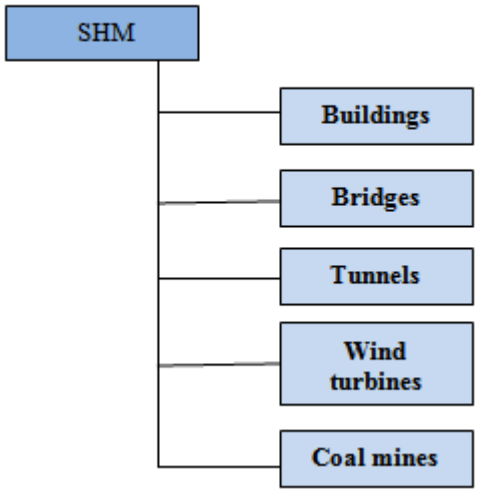

Fig. 1 Applications of SHM

In this paper we will proposed an algorithm based on SHM applications with different parameters. The main goal of it is to increase the lifetime of the network.

II. Why to Perform Structural Health Monitoring??

SHM is the most emerging applications of WSN. It is a wide area of interest. It mainly focused on the monitoring of structures, integration and applications of sensors, processing of signals and technology involved in communications. Following are the main cause's fir performing structural health monitoring:

A. Detection of damages

The most obvious cause is the damage detection. It continuously monitors the behavior or structures such as in earth quakes without inspection of expensive manual [1,9].

B. Long term monitoring for degradation

The structure is continuously monitored over a long period of time. The main aim is to find the continuous values on normal conditions [1, 9].

C. Structural properties

The actual dynamic properties of a structure can be determined by long term monitoring of system. And the design assumptions can be verified by these values. These properties can be determined at different level of motions by using forced vibrations [1,9].

III. Key Problems for SHM

The key problems using WSN are defined as follows [4]:

A. Transmission Bandwidth

In general WSNs are used for those applications which require low power. But in some of the applications like vibrations measurements and image acquisition higher transmission bandwidth is required.

B. Compatibility with Different Sensors, Operational Modes and their Sampling Frequencies:

In the SHM applications, various types of sensors are used like resistance strain, pizeo electric vibrations, accelerometer, acoustic emission, optical fiber strain, dip angle and stress measurements sensor. Before doing any operation it is necessary to choose the sensor network frequency from Hz to several KHz, their operational modes and the compatibility with each other.

C. Synchronisation

The signals which are ti be sampled must be synchronized with each other otherwise there will be incorrect information due to the grouping of samples which are coming from different time of vibrations and phase and results in wrong judgment vibration model.

D. Energy

Each function of WSN like transmission, reception, data sampling, signal processing, signal transmission, signal fusion etc. requires energy. Energy consumption varies with application area.

E. Topology and data fusion

For an efficient wireless network, the topology should be constructed efficiently. An efficient network topology not only decreases the consumption and increase the network's lifetime but also increase the capacity of the network. And also reduce the MAC contention.

Generally three types of topology are used that are:

1. Star topology
2. Cluster tree topology
3. Mesh or peer-to-peer topology

i. Star topology: In this topology a coordinator and several nodes (end stations) are connected with one another. Whenever there is any packet exchange between two devices then it must go through the coordinator. The limitation of this device is that network will not work if coordinator will not work because all the packets have to go through the coordinator.

ii. Cluster tree topology: In this topology a child node is connected with its parent node and forms a cluster. It consists of many routers, end devices and a coordinator. Routers are used to increase the coverage area of network. The limitation of this network is that if two nodes are very close to each other then they cannot communicate directly.

iii. Mesh or peer-to-peer topology: It consists of a no. of routers, a coordinator and end station. In this topology packets pass from more than two hops so called as multihop network topology.

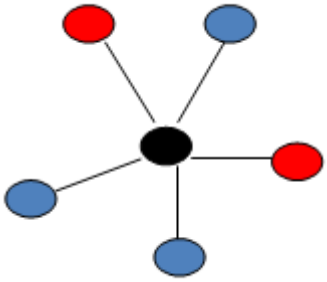

Fig. 2 Star topology

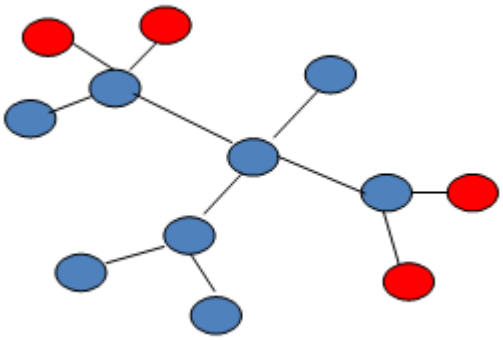

Fig. 3 Cluster tree topology

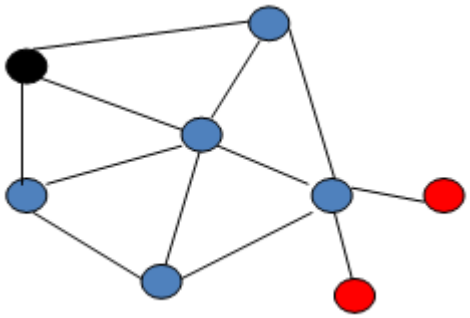

Fig. 4 Mesh topology

IV. Software Architecture of WSN

(A) Basic Service Oriented Architecture: In this type architecture, the network receives request from the client application about the structural conditions in a specific area which is to be monitored. For this the client application sends request to the proxy server for the specific information. Then the proxy server communicates with the appropriate node. The sensing node evaluates the data from the monitored event and gives the relevant information to the proxy server which translates it and sends back to the client.

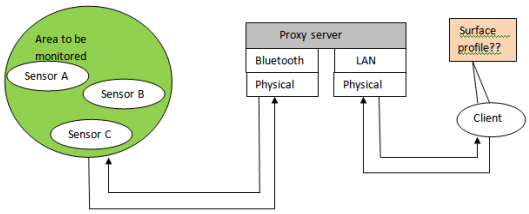

Fig. 5 Sensor Node Network Architecture

(B) A Cluster Base Service Oriented Architecture: Clustering is the most favorable architecture of WSN. A cluster is a bunch of sensor nodes which interact with the rest of network via a gateway i.e CH [8T]. Gateways or CHs are the nodes having higher energy that managed the network in the cluster aggregate the data and manage the sensors. Clusters are modified on the basis of conditions and availability of nodes [8T]. When cluster is formed, one node having the highest energy is selected as CH. A node can not belong to multiple clusters however cluster can be overlapped spatially. Cluster act as base in the software architecture of sensor network.

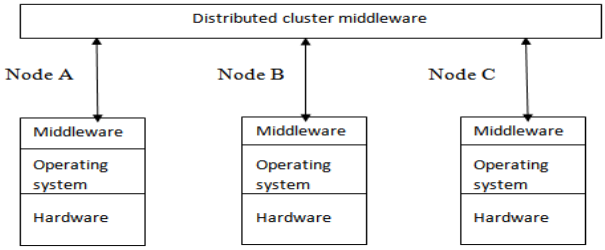

Fig. 6 Cluster Based Software Architecture

V. Proposed Algorithm for SHM

In this algorithm we will consider the nodes of homogeneous nature in a predefined area. The maximum and minimum transmission range of a sensor node is $r_{max.}$ And $r_{min.}$ Respectively as shown in fig. 7.

= Sensor node
r_{max} = Maximum transmission distance of a node
$r_{min.}$ = Minimum transmission distance of a node

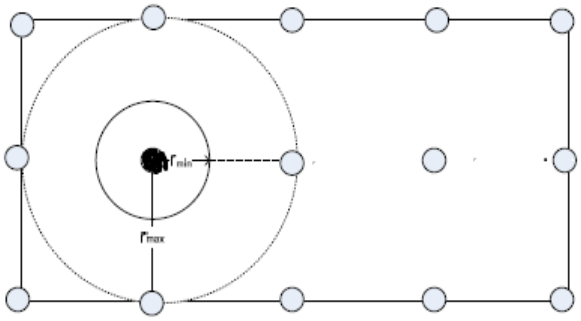

Fig. 7 Placement of nodes

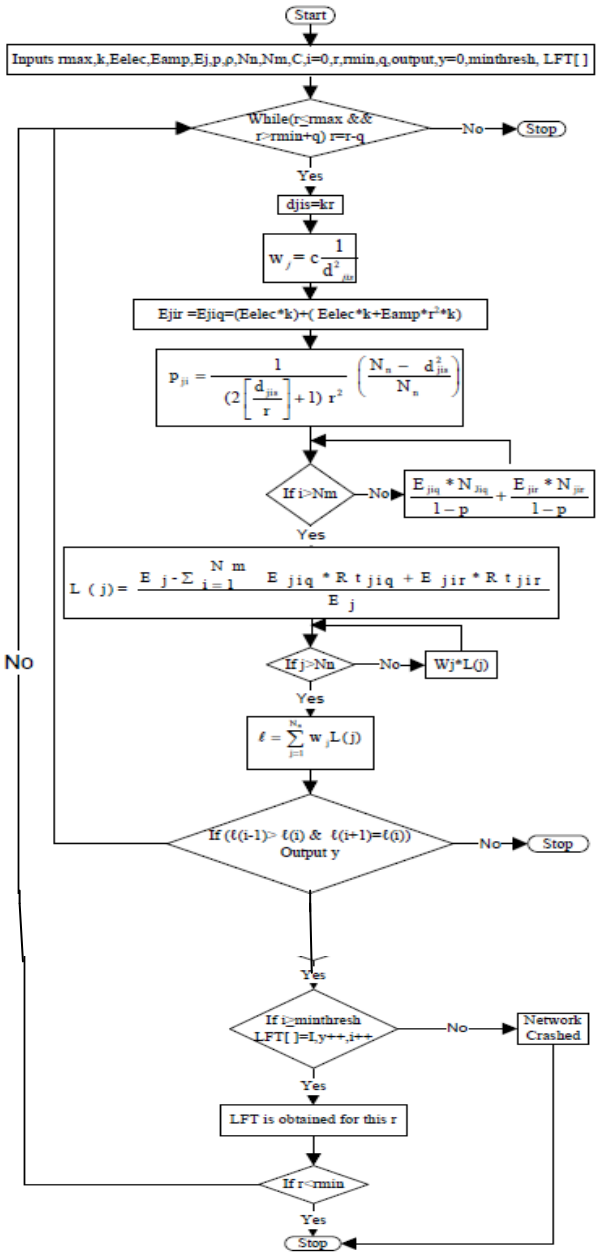

Fig. 8 Proposed Placement Algorithm

This algorithm makes energy efficient network by optimizing the radius between the nodes without altering the LFT (lifetime). Corresponding energy and LFTs of network are obtained at different distances and then we apply the sorting operation to arrange the LFTs in increasing order.

VI. Results and Future Work

The energy consumption and LFTs are determined at various distances for a sensor node in sensor network. The analysis for this is shown in fig. 7 which gives decrease in energy consumption and increase in LFTs by varying d parameter.

Table 1. Energy Consumed and LFTs at Various Distances

r=20m	*Energy Consumed*		*Lifetime of a Sensor Node (LFT)*
	$E_{jiq}(nJ)$	$E_{jir}(nJ)$	
d_{20}	33600	1,68,000	$\frac{1*10^6-15.9936Nm}{10^6}$
d_{15}	29400	1,47,000	$\frac{1.77*10^6-29.90Nm}{10^6}$
d_{12}	27456	1,37,280	$\frac{2.77*10^6-49.68Nm}{10^6}$
d_{10}	26,400	1,32,000	$\frac{4*10^6-75.588Nm}{10^6}$
d_{05}	24600	1,23,000	$\frac{16*10^6-375.96Nm}{10^6}$

Where d = k*r

d = distance between nodes, k = constant

N_m = no. of queries

E_{jiq} = energy consumed in the transmission of query Message

E_{jir} = Energy consumed in the reply message

In the future work the same can be done in the real time world for better operation.

VII. Conclusion

As we know the wireless technology is increasing day by day and it has made possible for most of applications to work efficiently. SHM is the typical area amongst those applications.

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