Mobile Coordinated Wireless Sensor Networks with Fault-Tolerance for Structural Health Monitoring

Dr. K. Shyamala
Associate Professor PG and Research Department of Computer Science, Dr. Ambedkar Government Arts College, Chennai - 600 039, India.
e-mail: Shyamalakannan2000@gmail.com

R. Parvathi
Research Scholar PG and Research Department of Computer Science, Dr. Ambedkar Government Arts College, Chennai - 600 039, India.
e-mail: rkparvathi90@gmail.com

Abstract— This paper introduces the Structural health monitoring (SHM) using Mobile Access Coordinated Wireless Sensor Network (MA-WSN) energy - efficient scheme for time sensitive applications. In Sensor Networks with Mobile Access points (SENMA), the mobile access points (MAs) traverse the network to collect information directly from each sensor. To organize disjoint nodes forming into small groups in high energy level, sensors are used in clustering methods, where each cluster has a coordinator referred as Cluster Head (CH). Early detection of failure CHs will reduce the data loss and provide possible minimal recovery efforts. Failure CHs are unable to connect to automatically organized another cluster head of access node and this access node collect and transfer data directly. So a new technique has been proposed in this paper which improves the life time of sensor nodes or it minimizes the maximum energy used by the sensor for transmitting data to the base station and also ensures monitoring quality. The performance of the proposed placement method has been tested by NS2 simulations and the result is compared with the sensor placement using effective independence method. This method obtains almost the same placement quality as that provided by using effective independence method, but with improvement in system life time.

Keywords- *Wireless sensor networks, mobile access coordinator, Structural Health Monitoring, throughput, Backup Sensor.*

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I. Introduction

In recently, there has been a great deal of communication in ad hoc networks for wireless transmission sensor networks. This network node is dynamically organized into network without requiring any infrastructure. In ad- hoc networks, each node acts as a router not as an end node. To initialize energy level at each node, some types of information communicate and delivered the information to set of designated gateway nodes. The energy consumption becomes a primary concern in a WSN, as it is crucial for the network to functionally operate for an expected period of time. To reduce the data, threshold values are forwarded to the data sink via backup sensors. The routing decision and the transmission node energy level selection are connected and checked in these energy controlled structural health monitoring system for wireless sensor network. Due to the advantage of easy deployment and cheap cost, wireless sensor network has many applications and structural health monitoring (SHM) is one of the main applications.

II. Related Work

The Efficient and reliable communication over large - scale networks, sensor network with mobile access points (SENMA) was proposed in [1] SENMA, the mobile access points (MAs) traverse the network to collect the sensing information directly from the sensor nodes [1]. In addition to SENMA, ad hoc networks with mobile sinks have also been explored by other researchers. In [2], a mobile sink is utilized for data collection, where it visits a limited number of pre-defined collection points in the network. Evaluate the average per node throughput and compare it with that of SENMA. It is observed that the throughput of MC-WSN is independent of the physical speed of the MA [1].

Similar approach has been considered in [6], the case of the conventional SENMA, the main limitation of these approaches is that data transmission depends on the physical speed of the access point, which is not desirable for time-sensitive applications.

Structural Health Monitoring (SHM) systems are implemented for these structures to monitor their operations and health status. WSNs are becoming an enabling technology for SHM that are more prevalent and more easily deployable than current wired systems [8].

The objectives of SHM are to determine health status (i.e., damage, which is a remarkable change around a sensor location) of a structure, and provides both long term monitoring and rapid analysis in response to unusual incidents [2].

This paper focuses on two important challenges for Sensor deployment and decentralized computing.

- To present an approach, called FTSHM (Fault-Tolerance in SHM)
- To repair the network before it starts operations, so as to guarantee a specified degree of fault-tolerance.

The fault types occur in WSNs problems are:

- How to continue data transfer between one sensors to another sensors obtaining monitoring information?
- How to find energy level to exchange information for each node? and
- How to avoid sensors fault tolerance in SHM?

Without these answers, we are unable to know at some moment [6] maintaining.

In Fig 1 shows the FTSHM searches the repairing node points or locations in clusters of node, and places a set of backup sensors at those points of node by satisfying engineering requirements. In fact, searching the RPs is a prediction of future network failure points (e.g., separable points, isolated points, and critical middle points), which is a promising idea (to search such points and tackle them in advance).

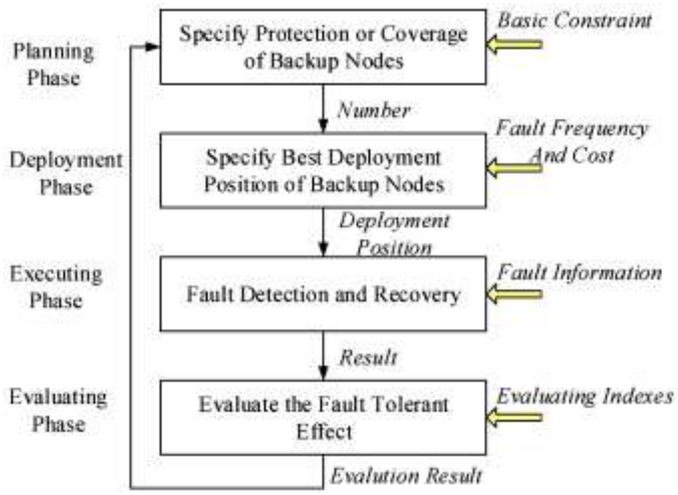

Fig. 1 Fault Tolerance Mechanism

To search highly possible RPs, we think of this searching in a distributed manner: it involves only local communication between neighbors in a cluster, and limits searching to clusters (i.e., cluster by cluster). To present an energy-efficient SHM algorithm, called BSP (Back Sensor Placement) Algorithm. This runs on each sensor and then provides a light-weighted indication of damage in a cluster in a decentralized manner.

The major contributions of this paper are as follows:

- The proposed model is a reliable and efficient MC-WSN energy efficient scheme for time sensitive information exchange mechanism. The energy efficient of each individual senor node is maximized as they are not involved in the routing process, and do not need to receive signals from the MA.
- The WSN average number of node between a sensor and its nearest node is minimized, and show that the number of node to any sensor placement to the MA can be limited to a pre-specified number.
- To initialize the value of energy efficient level for each node and calculate throughput of mobile coordinate wireless sensor network considering both single path and multipath routing between each source and its corresponding position.
- The information exchange to each node, if occur collision and irregular communication distance – transmitting data from a sensor to another sensor, or the BS over large structures and low energy of correspondent sink.
- To formulate the problem of placing a small set of backup sensors with threshold value into a deployed WSN with primary sensors, and design the FTSHM to address the problem, which is no easy task, as it incorporates multi-domain knowledge.
- To make the WSN resilient to the faults, we propose a backup sensor placement (BSP) algorithm.
- To make the resource-constrained WSN easier to use for SHM, we propose an SHM algorithm, Damage-Indicator, showing how a traditional centralized SHM framework can be transformed into a decentralized one.
- To conduct a comprehensive evaluation of FTSHM. In simulation studies, to use data sets collected from the GNTVT system (a SHM project of Hong Kong PolyU) . In a real-world deployment, to utilize integrated Imote2 sensors that run on TinyOS. The effectiveness of FTSHM is compared with that of existing approaches [9].

III. METHODOLOGY

A. *Clustering design*

In Fig 2 and Fig 3 shows that clustering design grouping formation is an important issue in a wireless sensor network. Performance parameters such as energy consumption, network lifetime, data delivery delay, sensor field coverage depend on the network topology. Distances between nodes, physical interconnections, transmission rates, or signal types may differ between two networks, yet their topologies may be identical.

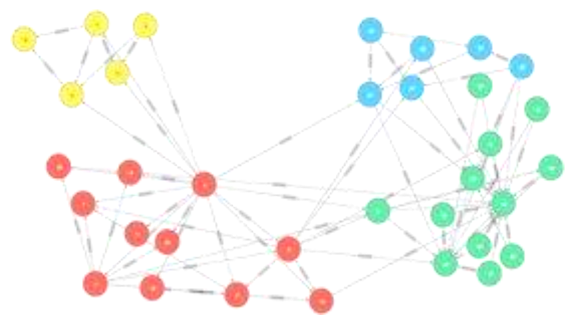

Fig. 2 Clustering Design

Wireless sensor network mainly used for monitoring the events such as disaster tactical in military surveillance. It can be placed in two different manners 1) Regular manner and 2) Irregular manner. Mostly in irregular manner we are deploying sensors in irregularly is the chance for create a fault in sensor networks. It is considered that the sensors are moving randomly over a large target region node and designed to detect specified events. Each every one of sensors can sense specified events in its sensing range, and communicate with others in its transmission range.

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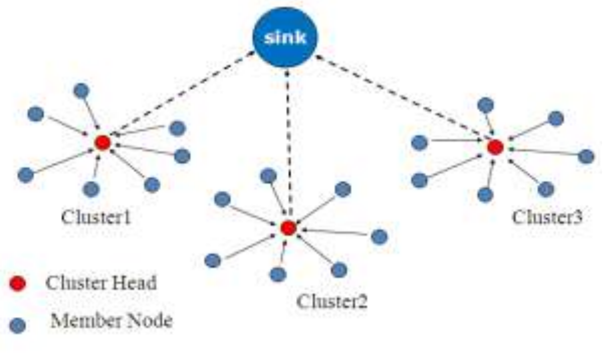

Fig. 3 Cluster and Member node

B. Backup Sensors

The RP's identified are provided with the backup sensors of similar configuration as primary sensors. It improves the stability of the network by making system fault tolerant. The search for repair points runs continuously through all the clusters till all the RP's are provided with backup sensors.

IV. IMPLEMENTATION

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A. The Backup Sensor Placement with Thershold Value

Middle point sensors also called Cluster Head node or Access node and a cluster is an Repair points (RP) which is with the longest and irregular transmission distance and the link between r1 and r2 is vulnerable.

In Backup Sensor placement,

1. Where to place Backup sensors?
2. How many Backup sensors are there available?
3. How to find the locations for the backup sensors?

Find Critical midpoint, Search node placement algorithms as follows implement to placement backup sensor with threshold in a network. Fig 4 shows the repair points to place Backup sensor a lot of unused locations available in a structures (M (locations) - N (sensors)) [Q1].The RP's identified are provided with the backup sensors of similar configuration as primary sensors. It improves the stability of the network by making system fault tolerant. The search for repair points runs continuously through all the clusters till all the RP's are provided with backup sensors (RP(<N), N-RP? N+RP?) [Q2].

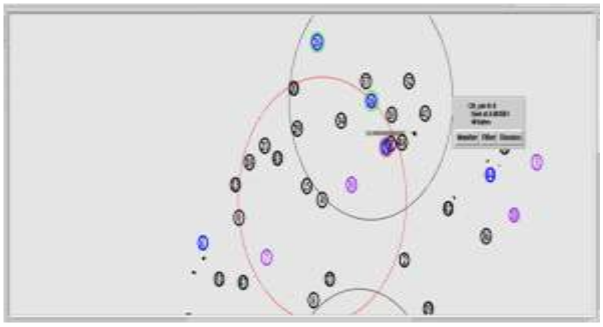

Fig. 4 Repair points to Place Backup sensor

B. Backup Sensor placement with Thershold value Mechanism

- The whole cluster head reach at threshold value RP>40, to reduce energy level at replace the backup sensor placed. The Backup Sensor placed to base station.
- Threshold level maintain to reach>40, it will once again go to rendezvous point mechanism elect re-cluster head.
- In both of major points find this local position rendezvous point placements of each sensor placement at repairing points. (RP)
- Fig 5 shows the Backup sensor placement in between time interval and conditions in threshold level.

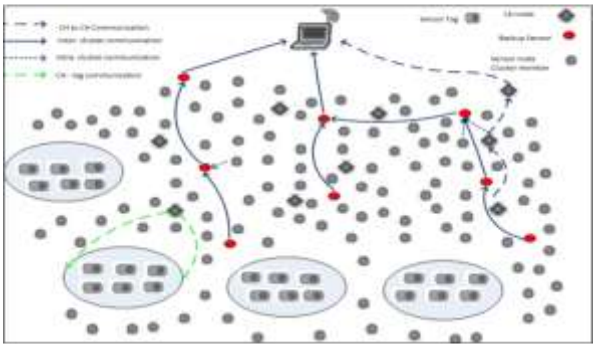

Fig. 5 Backup sensor Placement

C. Proposed Algorithm for Sensor Placement

The below algorithm node placement and MA detection in network, each node sends 'hello' message to check update position information. When the message received and the node position is updated. It forms grouping by cluster method, create the head node which is high energy level.

<u>Node placement</u>

1) *Deploy the nodes in same/random place.*
2) *For each node*
   - *Update own position information*
   - *Send the hello message with the position information*
3) *Receive hello message*

- *Update own position*
- *Check the dist from hello sender (dist)*
- *If less then Th*
    - *Calc future position*
        - *Set temp_pos = current pos*
        - *Set future_pos = temp_pos+/- (dist/2)*
        - *Start the node movement to future_pos*

Failure detection Algorithm

If the ma is failure in network due to low energy, next nodes which have high level energy is detected and replaced as cluster head.

1) *Initialize the Htimer and Neigh_timer*
2) *If timer expire*
    - *generate the hello message*
        - *Attach*
            - *node id*
            - *Position info*
    - *Broadcast Hello message*
    - *Set new schedule for next hello*
3) *If hello received*
    - *Check in neigh_table*
        - *If sender info already found*
            - *Increase the expire time*
        - *Else*
            - *Create new entry*
4) *If neigh_timer expires*
    - *If neigh_info expire*
        - *Delete*
        - *Set as failed neighbor*
        - *Share the info to next neighbors*
    - *Set new schedule for next verification*
5) *If failure sharing receive*
    - *Make confirmation of node failure*

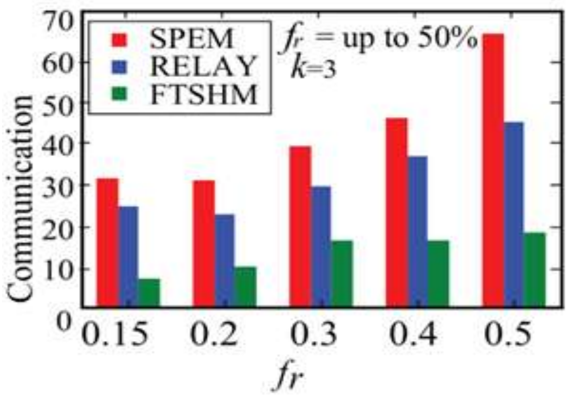

Fig. 6 Frequency of Clustering and communication

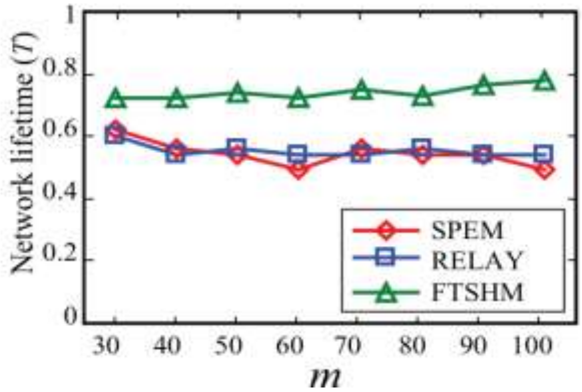

Fig. 7 Network lifetime if m sensor placement

Figure 6 shows the placement of many sensor nodes to form locations using SPEM and proposed method. In this node communication performances is high efficient.

V. CONCLUSION AND FUTURE WORK

In this paper, A Mobile Access Coordinated Wireless Sensor Networks (MC-WSN) architecture was proposed for reliable, efficient, time-sensitive information ex- change and discussed sensor placement problem in structural health monitoring for fault tolerance. In this technique, we placed sensor nodes by maximizing information matrix and minimizing the maximum energy consumed by sensor. MC-WSN exploits the MAs to coordinate the network through deploying, replacing, and recharging nodes. In case, there is no issue in the route connectivity of disconnected group then the extra backup sensor will be moved towards nearest position which sensor had low energy and in case, there is a problem in route of disconnected group the extra sensor will be moved to the place which will be effective to connect the disconnected group and connected group.

In future, Backup sensor mobility network should be improved in security and if any malicious, backup all information from cluster it's vulnerable to network.

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