Survey of Deploying Wireless Sensor Networks with Fault-Tolerance for Structural Health Monitoring

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Abstract- *A wireless sensor network (WSN) has important applications such as remote environmental monitoring and target tracking. This has been enabled by the availability, particularly in recent years, of sensors that are smaller, cheaper, and intelligent. These sensors are equipped with wireless interfaces with which they can communicate with one another to form a network. Method: Wireless sensor network has been identified as a key technology in green communications, due to its indispensable role in both civilian and military applications, such as reconnaissance, surveillance, environmental monitoring, emergency response, smart transportation, and target tracking. Along with recent advances in remote control technologies, Unmanned Aerial Vehicles have been utilized in wireless sensor networks for data collection as well as for sensor management and network coordination. Findings: The group of Wireless sensors (WS) installed in a structure could provide sufficient amounts of pragmatic data for monitoring structural health. SHM brings new challenges to WSNs: engineering-driven optimal deployment, a large volume of data, sophisticated computing, and so forth. The faults caused by sensors are communication errors, unstable connectivity; battery down due to large usage of the sensors without any placement Planning may greatly affect the performance of sensors while monitoring. Improvements: Along with recent advances in remote control technologies, Unmanned Aerial Vehicles have been utilized in wireless sensor networks for data collection as well as for sensor management and network coordination.*

Keywords- Energy-Efficient, sensor placement, Structural Health Monitoring, Wireless sensor networks, Backup sensors

I. INTRODUCTION

Recent years have witnessed the emergence of WSNs as a new information-gathering paradigm, in which a large number of sensors scatter over a surveillance field and extract data of interests by reading real-world phenomena from the physical environment. 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 packets are forwarded to the data sink via multi-hop relays among sensors.

A network is a group or two or more computer systems linked together. There are two types of computer networks. They are wired and wireless networks. The topology, protocol and architecture are the important characteristics of the networks. In wireless networks, the computers or any wireless devices are connected to form a network without wires. A wireless network is any type of computer network that uses wireless data connections for connecting network nodes. Each system may also acts as nodes or as sensors. Here comes a sensor networks. When sensor devices form a network is called a sensor networks.

Wireless Sensor Network (WSN) are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, vibration, etc. and to pass their data through the network to base station. Wireless Sensor Networks (WSN) consists of a large number of sensor nodes. The sensor nodes can be deployed either inside or very close to the sensed phenomenon. A sensor is the device which converts a physical phenomenon and also sound phenomenon to the electric signals e.g. Heat, light, motion, vibration etc. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, structural health monitoring, and so on. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network.

Some of the characteristics of the sensor networks are:

- Requirements: small size, large number, tether-less, and low cost.
- Constrained by Energy, computation, and communication
- Small size implies small battery
- Low cost & energy implies low power CPU, radio with minimum bandwidth and range
- Ad-hoc deployment implies no maintenance or battery replacement

The authors observed that training of SHM is to monitor the health status (i.e., damage) of a structure, and supply both long-term monitoring and immediate response to unusual incidents, e.g., earthquakes. In real, it is often difficult to achieve these objectives in WSN-based SHM, due to requirements of SHM.

II. II.LITERATURE REVIEW

The authors focused on High performance requirements of wireless sensors intended for structural monitoring are more. First, the wireless sensors must be inexpensive in order to make economically reasonable dense arrays of sensing units, perhaps hundreds of nodes in a single structure.

Because wireless sensors have a narrowed power supply, usually an on-board battery pack, they must be able to operate with low power consumption and be equipped with efficient power management techniques. More effective computing methods for damage detection can be achieved using wireless sensing nodes capable of distributed in-network computation.

Limitations:

To be power efficient, such a device requires the minimization of communication between sensors as, generally, the radio is the greatest consumer of power within the unit. The wireless monitoring systems must be completely scalable, not restricted in terms of size or number of wireless sensor nodes.

The author considers the connectivity restoration problem subject to path length constraints. Basically, in some applications, such as combat robotic networks and search-and-rescue operation, timely coordination among the actors is required, and extending the shortest path between two actors as a side effect of the recovery process would not be acceptable.

The authors addressed the problem of placing sensors in a target field to maximize the sensing coverage. Although the centralized approach may minimize the sensor movement, central server architecture may not be feasible in some applications.

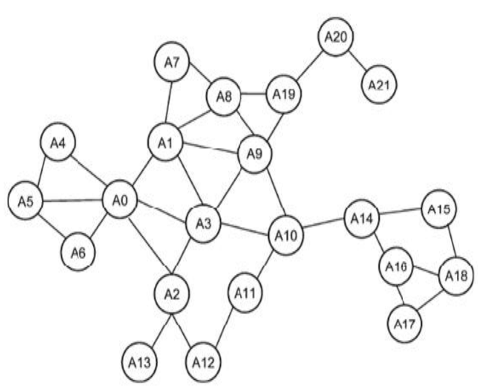

Fig. 1 Example one –connected inter actor network, Nodes A0, A10, A14 and A19 are cut vertices whose failure levels the network partitioned into two or multiple disjoint blocks.

The author focused their attention on Power Efficient Event Detection Scheme in Wireless Sensor Networks for Railway Bridge Health Monitoring System. A power efficient, low delay and non-ambiguous event detection scheme which is the first step in any health monitoring scheme. On one hand, to achieving low power consumption, while on the other, we are improving our system's tolerability to false event.

Limitation:

A simple but robust event detection algorithm is proposed which maintains both accuracy as well as low delay and also ensures less battery consumption by keeping the nodes in operation only when a train is on the bridge.

Drawbacks:

- Doesn't give priority for emergency signal
- Doesn't check connectivity before transmitting
- Fault tolerance value is high

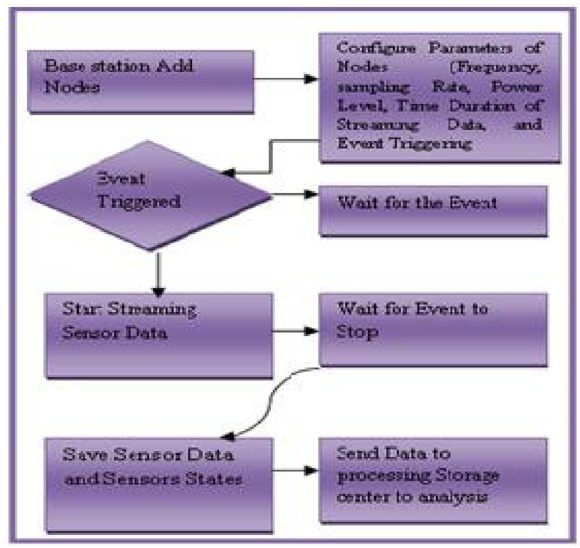

Fig 2 workflow of sensor Networking

Authors designed and evaluated distributed self-deployment protocols for mobile sensors. After discovering a coverage hole, the proposed protocols calculate the target positions of the sensors where they should move.

Author problem statement is given the target area, how to maximize the sensor coverage with less time, movement distance and message complexity. Given an area to the monitored, Author distributed self-deployment protocols first discover the existence of coverage holes (that are not covered by any sensor) in the target area based on the sensing service required by the application. After discovering a coverage hole, the proposed protocols calculate the target positions of these sensors, where they should move.

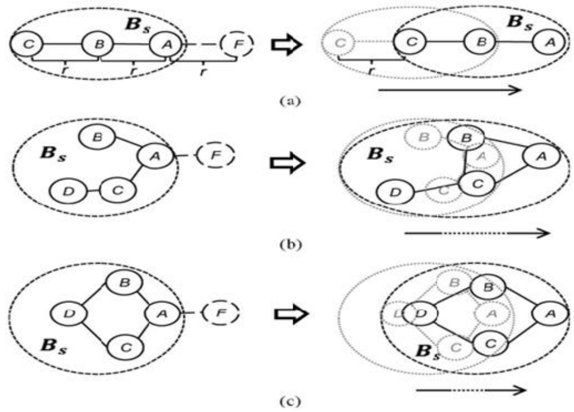

Fig. 3 workflow of sensor Node any pair of affected nodes is extended relative to its pre-failure status

Authors use VORonoi diagrams to discover the coverage holes and design three movement-assisted sensor deployment protocols, VEC(VECtor-based), VOR (VORonoi-based), and Mini-max based on the principle of moving sensors from densely deployed areas to sparsely deployed areas. By intensive simulations, authors evaluate Author protocols from various aspects: coverage, deployment time, moving distance, and scalability to initial deployment and communication range, etc, and show that Author protocols are very effective in terms of coverage, deployment time, and moving distance.

Advantage:

This algorithm is based on the belief that a sensor should not be too far away from any of its Voronoi vertices when the sensors are evenly distributed.

Authors to approach new method of Local Monitoring and Maintenance for a WSN, which combines monitoring operations for the WSN with the operations of a mobile event monitoring, in a manner that is both energy and latency-efficient. The two important issues are monitoring probable anomalies/faults of the nodes, and link failures.

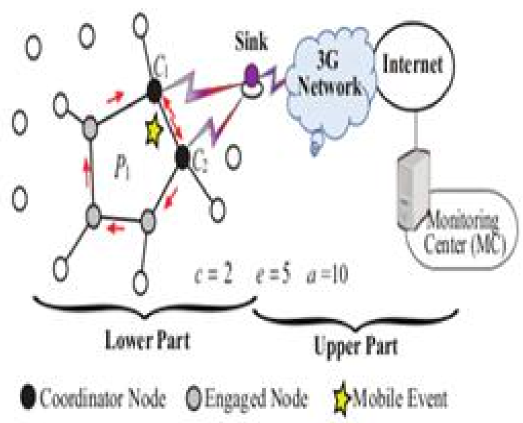

Fig. 4 The two part monitoring architecture for WSNs, where the sensor nodes around a mobile event are monitored locally

The authors focus on the very first problem in the SHM applications: where the sensors to be placed, that can best capture the structure properties and is suitable for efficient system design. In previous studies, one common assumption in the computer science community is that the sensor placement should be determined by civil engineering.

Limitation:

To discussed here, what kind of problem facing in sensor locating in health monitoring structure. To release SPEM this can provide valuable placement quality information in a step by step manner. In showed how topology control, data routing and energy efficiency can be integrated with the SHM framework.

Drawbacks:

- Bottleneck problem will be created
- Interference and collusion may disturb signal
- Signal consumption consume more energy Packet delivery rate will be lower

Finally, the survey on the placement of the wireless sensors networks without affecting in the monitoring process of the structure. The group of Wireless sensors (WS) installed in a structure could provide rich amounts of empirical data for monitoring structural health.

S.no	Authors Name	Problem discussed and Technique Used	Advantages	Limitations
1	N. Xu, S. Rangwala al.[4]	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.	The best expedite is reduce the data packets are forwarded to the data sink via multi-hop relays among sensors shows the best result.	Time taken to switching from one sensor to another is very high in case of using more than cost level of sensor node, such that energy efficiency of parallelization is considerably low.
2	Prashant Tiwari1 et al.[5]	The Coverage Problem in a Wireless Sensor Network proposed solutions to two versions of the coverage problem, namely k-UC and k-NC, in a WSN.	Sensing of regions are irregular. Connectivity issues are more.	To checking the perimeter of each sensor's sensing range. Although the problem seems to be very difficult.
3	Soumendu Kumar Ghosh al.[1]	Power Efficient Event Detection Scheme in Wireless Sensor Networks for Railway Bridge Health Monitoring System	To connected inter actor network, Nodes A0, A10, A14 and A19 are cut vertices whose failure levels the network partitioned into two or multiple disjoint blocks.	A simple but robust event detection algorithm is proposed which maintains both accuracy as well as low delay and also ensures less battery consumption by keeping the nodes in operation only when a train is on the bridge.
4	M. Hedley al.[15]	To focus on detecting and characterizing damage from high-velocity impacts in the skin of aerospace structures.	The use of SHM offers a number of technological challenges to be overcome before SHM systems are ready to be deployed in many applications.	A sensor network for the collection and distributed processing of data from a large number of acoustic emission sensors attached to multi-agent algorithms for providing the network intelligence that is robust to failures in part of the sensor network.
5	Gregory Hackmann al.[18]	Structural health monitoring of civil infrastructure rep-resents an important application domain of cyber-physical systems.	To propose a novel cyber-physical co-design approach to structural health monitoring based on wireless sensor networks.	The results illus-trade the promise of cyber-physical approach which consider both the architecture of the cyber (WSN) system and the characteristics of the physical (structural engineering) methods.
6	Adam B. Noel al.[12]	Background information relating to structural health monitoring such as common sensors	The sensor placement optimization and data processing were presented and solutions to these problems discussed and compared.	To performed in the lab and on real-world structures was presented and discussed. Finally, future research directions for SHM systems using WSNs were presented.

Table 1 shows the summary of Deploying Wireless Sensor Networks with Fault-Tolerance for Structural Health Monitoring

III. CONCLUSION AND FUTURE WORK

There have been a several challenges in Wireless Sensor Networks for structural health monitoring. The placement of the wireless sensors on the structure is to collect the status of the health and to pass the status to the base station without any intervention in communication. Using wireless sensor networks, the communication among the sensors are efficient than wired sensor. The future work is to improve the wireless sensor efficient by handling the faults in wireless sensor

REFERENCES

[1] Soumendu Kumar Ghosh, Maroju Suman, Raja Datta, Prabir Kumar Biswas "Power Efficient Event Detection Scheme in Wireless Sensor Networks for Railway Bridge Health Monitoring System" ,2014

[2] Md Zakirul Alam Bhuiyan , Guojun Wang , Jiannong Cao , and Jie Wu,Local Monitoring and Maintenance for Operational Wireless Sensor Networks -- 2013

[3] Bo Li, Dan Wang, Feng Wang, and Yi Qing Ni High Quality Sensor Placement for SHM Systems: Refocusing on Application Demands --

[4] N. Xu, S. Rangwala, K. Chintalapudi, D. Ganesan, A. Broad, R. Govindan, D. Estrin, "A Wireless Sensor Network For structural Monitoring", in ACM SenSys, 2004.

[5] Prashant Tiwari1, Varun Prakash Saxena2, Raj Gaurav Mishra3, Devendra Bhavsar4 "Wireless Sensor Networks: Introduction, Advantages, Applications and Research Challenges" IJTIR Volume 14, April 2015

[6] David Clark, M.I.T., Pei Zheng, Feng Zhao, David Tipper, Jinmei Tatuya, Keiichi Shima, Yi Qian, Larry Peterson, Lionel Ni, D. Manjunath, Qing Li, Joy Kuri, Anurag Kumar, Prashant Krishnamurthy. Wireless Networking Complete The Morgan Kaufmann Series in Networking Series Editor

[7] David Clark, M.I.T., Feng Zhao, Leonidas J. Guibas Morgan Kaufmann Wireless Sensor Networks, The Morgan Kaufmann Series in Networking Series Editor, Publishers is an imprint of Elsevier

[8]]M. Hedley 1, N. Hoschke 2, M. Johnson 1, C. Lewis 2, A. Murdoch 1, D. Price 2, M. Prokopenko 1,A. Scott 2, P. Wang 1, and A. Farmer 2 Sensor Network for Structural Health Monitoring; IEEE 2004

[9] M. Hedley et al., "Testbed design for structural health monitoring network," Proc. Global Signal Processing Conference, Santa Clara, California, USA, Sept. 2004.

[10] Gregory Hackmann_, Weijun Guo_, Guirong Yany, Chenyang Lu_, Shirley Dykey . Cyber-Physical Codesign of Distributed Structural Health Monitoring With Wireless Sensor Networks, ICCPS'10 April 13–15, 2010

[11] J.-H. Weng, C.-H. Loh, J. P. Lynch, K.-C. Lu, P.-Y. Lin, and Y. Wang. Output-only modal identi_cation of a cable-stayed bridge using wireless monitoring systems. Engineering Structures, 30(7):1820{1830, 2008.

[12] Adam B. Noel, Abderrazak Abdaoui, Tarek Elfouly, Mohamed Hossam Ahmed, Ahmed Badawy, and Mohamed S. Shehata Structural Health Monitoring using Wireless Sensor Networks: A Comprehensive Survey,IEE 2017.

[13] S. Kim et al., "Health Monitoring of Civil Infrastructures Using Wireless Sensor Networks," in 2007 6th International Symposium on Information Processing in Sensor Networks, 2007, pp. 254-263.

[14] B. Aygün and V. Cagri Gungor, "Wireless sensor networks for structure health monitoring: recent advances and future research directions," Sensor Review, vol. 31, no. 3, pp. 261-276, 2011.

[15] R. Shaladi, F. Alatshan, and C. Yang, "An Overview on the Applications of Structural Health Monitoring Using Wireless Sensor Networks in Bridge Engineering."IEEE/ACM Trans. Netw., vol. 13, no. 3, pp. 934–947, 2010