Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI: 10.21474/IJAR01/12197
DOI URL: http://dx.doi.org/10.21474/IJAR01/12197

RESEARCH ARTICLE

A SURVEY ON VARIOUS FAULT TOLERANCE DEPLOYMENT MECHANISMS IN WIRELESS SENSOR NETWORKS

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Manuscript Info

Manuscript History
Received: 20 October 2020
Final Accepted: 24 November 2020
Published: December 2020

Key words:-
Wireless Sensor Networks, Fault Tolerance, Deployment

Abstract

Wireless Sensor Networks (WSN) is different from other wireless networks due to power consumption, size, cost and their trade offs. One of the major issues in design and performance of WSNs is fault tolerance deployment of sensor nodes and base stations in WSN to achieve increase network lifetime, energy consumption, data reliability, accuracy and reduce failure of components. Deployment strategy poses different research challenges. This paper presents an analysis of fault tolerance deployment mechanisms in WSN to identify the strengths and weaknesses of each one of these mechanisms. This paper presents the scope of research directions in order to help researchers who are working in this field.

Introduction:-

A Wireless Sensor Network (WSN) is a network formed by a large number of sensor nodes, each equipped with sensor(s) to detect physical phenomena such as heat, light, motion, or sound. Using different sensors, WSNs can be implemented to support many applications including security, entertainment, automation, industrial monitoring, public utilities, and asset management. However, many WSN devices have severe resource constraints in terms of energy, computation, and memory caused by a need to limit the cost of the large number of devices required for many applications and by deployment scenarios that prevent easy access to the devices. Such resource limitations lead to many open issues. In a sensor network, many tiny computing nodes called sensors are scattered in an area for the purpose of sensing some data and transmitting data to nearby base stations for further processing. A sensor node, also known as a mote, is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. The transmission between the sensors is done by short range radio communications. The base station is assumed to be computationally well-equipped whereas the sensor nodes are resource- starved.

Deployment of nodes in Wireless Sensor Networks (WSNs) is a basic issue to be addressed as it can influence the performance metrics of WSNs connectivity, resilience and storage requirements. Many deployment schemes have been proposed for wireless sensor networks.

In WSNs, two specific factors arise; i) the envisioned applications and the operation of the protocol layers are usually driven by the physical variables measured by the sensors. Therefore, the dynamics of the physical parameters sensed by the network govern the network traffic, and even the topology. (ii) The energy is a primary

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concern in WSN. Usually, nodes run on non-rechargeable batteries. Therefore, the expected node lifetime is a fundamental element that must be taken into account.

Recent technological advances have made it possible to have various deployment strategies for wireless sensor networks consisting of a large number of low-cost, low power, and multifunctional sensor nodes that communicate at short distances through wireless links. In our study, we illustrate various node deployment strategies for wireless sensor networks: a random, a grid, a group and a grid-group. We analyze three performance metrics: connectivity, resilience and low memory usage.

Fault tolerance and Deployment Schemes:

Various schemes have been proposed by the researchers for the deployment of Base stations (BSs), which claims reliable operation with optimal utilization of time taken for deployment. WSNs are mostly deployed in hostile environments such as volcanoes, flooded regions, and deep oceans, where human intervention is not possible for post deployment maintenance, so efforts are being made to enhance its efficiency and durability. Deployment can be classified as manual or random. Among these, random deployment from the sky (using aerial vehicle/robot) is most suited for unreachable, hazardous or large-scale open environments.

Techniques of sensor node deployment can be classified on the basis of the placement strategy, usage and deployment domain as shown in Fig.1. However, existing state of art models of deployment can be categorized under multiple classes.

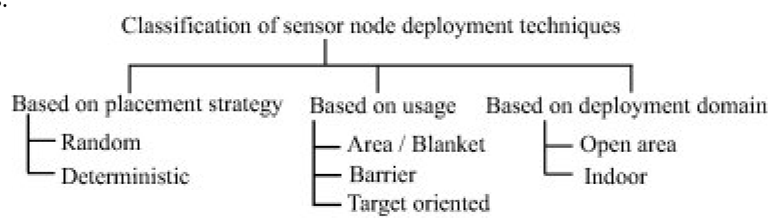

Fig 1:- Classification of sensor node deployment techniques.

In sensor networks, the data transport model is such that a base station, typically located at the boundary of or beyond the area in which sensors are distributed, collects data from the sensor nodes. That is, the sensor nodes are the data sources and the base station is the data sink. Typically, the sensor nodes, in addition to behaving as source nodes in generating data to be passed on to the base station, act as intermediate relay nodes as well to relay data from other source nodes towards the base station on a multichip basis. Deployment of multiple base stations as data sinks can reduce the average number of hops between the source nodes and their corresponding data sinks.

Fault tolerance is a critical issue for reliable data delivery in WSN applications. It should ensure that a system is available for use during any interruption or presence of fault. Therefore, fault tolerance enhances the availability, reliability also dependability of the wireless network Sensor node failures can be classified into single node failure, which indicates the loss time and multi-node failures, which indicates failures at a time.

Related Work:

Careful deployment of SNs in WSNs can lead to effective design goals. There are different strategies of deployment of SNs, which are; pre deployment of SNs that is called design of the network, during deployment of SNs and after deployment of SNs. After deployment of nodes, topology control mechanism is needed; network topology may changes due to dislocation of SNs, sensor nodes failure, or other conditions. Moreover, connectivity of SNs may also change due to noise, interference, etc. Therefore, topology control algorithms are required to increase the network lifetime. Moreover, topology control methods in fact decrease the degree of routing redundancy by decreasing the number of communication links in the WSN.

N. Li and J. Hou in [10] proposed a topology control algorithm; the main objectives of this algorithm are to keep network connectivity, enhancing power efficiency and increasing capacity of the network. The derived topology was more prone to SN failures. The authors resolved this problem in the topology construction process by enforcing k-vertex connectivity. A localized method named Fault-tolerant Local Spanning Sub graph (FLSS) was proposed, that could preserve k-vertex connectivity and was min-max optimal between other methods. Results revealed that, compared with previous localized and distributed fault-tolerant topology control methods; FLSS yields better energy efficiency as well as higher network capacity. Furthermore, FLSS is robust with respect to position estimation errors.

Chen et al. in [9] presented a fault tolerance and energy efficient topology control protocol (P-CDS). The presented mechanism scheduled active sensor nodes and backup sensor nodes in the backbone to tolerate failures. To recover network connectivity, the P-CDS protocol could adapt the radio ranges of coordinators. When SN failure was identified, both active and backup SNs adjusted their transmission ranges to keep network connectivity. Simulation results showed that P-CDS created a smaller connected dominating set than the existing fault tolerant topology control method. The P-CDS method also provided effective broadcast with relatively less power consumption.

Sitanayah in [3] designed Emergency Response Medium Access Control (ER-MAC) which is a hybrid protocol for emergency response WSNs. The proposed protocol is able to switch from energy efficient operation in normal periodic monitoring to reliable and fast delivery for emergency monitoring, and vice versa. In addition, the author provided solutions for topology planning problems using redundancy method. Additional Relay Placement, Additional Backup Placement, Multiple Sink Placement, and Multiple Sink and Relay Placement were used to support FT by ensuring that there are alternative acceptable routes to data sinks when failure occurred. The ER-MAC protocol was used to evaluate the FT of each deployment resulted in multi-hop data gathering. In this work, the author mentioned that MAC protocols and topology planning algorithms can be used together to create fault tolerant WSNs for volatile environment. The proposed strategy could only guarantee robustness against single failure.

Rong et al. in [4] introduced a novel fault-tolerant method named “Adaptively Fault-tolerant Topology Control (AFTC)” to assign network resources reasonably. The SNs with greater fault-tolerant degree were elected as backbone nodes, and every backbone node had the backup nodes for advance performances of WSNs, containing fault-tolerant capability and power efficiency. Results showed that the method is effective and reliable to fabricate and keep the fault-tolerant topology for WSNs.

Rehena et al. in [5] presented a robust recovery mechanism of nodes failure in a certain area of the network during data transmission to achieve FT. This recovery mechanism was concentrated on multiple-sink partitioned network. The proposed technique dynamically discovered new node to route data from source to sink. In addition, authors presented an area handling mechanism. Results demonstrated that the data delivery to sink was still possible, when all nodes in a particular geographical area were dead. In addition, the proposed mechanism considered the active nodes in a specific partition when they are unable to transfer data to the sink. Therefore, the active nodes tried to be attached with other partitions. The outcomes revealed that proposed technique has better tolerability and energy efficiency for area failure.

Sun et al. in [6] proposed a trust framework for data aggregation with FT in wireless multimedia sensor networks. In this approach, multilayer data aggregation structure is used which divide the network into different layers or levels. In the proposed framework, nodes are classified as SNs and data aggregators, which they play different roles in the data aggregation process. To increase the correctness and trustworthiness of gathered information jointly considered data aggregation, FT and information trust. The proposed framework could evaluate both continuous media streams and discrete data in a wireless multimedia sensor networks. Results revealed the proposed scheme could meaningfully enhance the quality of multimedia data as well as reliability of gathered data.

Paul et al. in[11] proposed a new optimal location of base station using geometrical approach for maximum lifetime of the sensor network. Most of the algorithms use power minimization has been considered along with geometry as well as the path loss exponent of the medium. Akkaya et al. showed that dynamic positioning of the BS is an effective means for boosting the network dependability.

Bashher et al. proposed delaunay refinement based suboptimal receiver placement technique which reduces the dilution of localization accuracy. Efrat et al. used approximation schemes for optimally locating a base station. Wong et al. proposed a novel binary integer programming formulation of base station placement algorithm. So the main issues in BS deployment are i).Deployment of base stations to use maximum network lifetime. ii). Dynamic and multiple base station positioning iii)Base station deployment for minimal energy consumption.

Conclusion and future directions:

This paper presents a review of various fault tolerant algorithms designed for WSN. After reviewing, it has been observed that the different strategies of deployment schemes used in different applications with respect to the level of FT requirement. Importance given to the deployment phase can drastically save the energy, increase the lifetime and enhance the reliability of the network. Some future research directions are listed below.

Most of the research has done by considering only one base station in the network where in large-scale WSNs, we need to consider multiple BSs in order to save energy and to increase fault tolerant against BS failure. Moreover, the deployment of BSs should be done based on some significant parameters such as geographical area of the network, the average ratio of SNs subsequent to failure of BS, which represent the FT of the network, the average delay of the network due to congestion.

A WSN can be interrupted by malicious attacks. In order to achieve security goals for WSNs, there is a need to design and develop specific mechanism with respect to FT.

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