International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 03 Issue: 01 | Jan-2016 www.irjet.net p-ISSN: 2395-0072

A Comparative Review on Reliability and Fault Tolerance Enhancement Protocols in Wireless Sensor Networks

Abhinav Sharma[1], Sandeep Sharma[2]

[1] M.Tech Scholar, Computer Engineering and Technology Department, Guru Nanak Dev University, Punjab, India
[2] Asst Prof, Computer Engineering and Technology Department, Guru Nanak Dev University, Punjab, India

---***---

Abstract - ***Fault Tolerance of Wireless Sensor Networks (WSN) is a very significant and central issue in current research topics related to WSN. It is of critical importance because these nodes are deployed in harsh environmental conditions which make them prone to failure and simultaneously their sensed data is very precious for various applications and hence it is desired to lose this precious data because of fatal failures. Since the working environment of WSN is Presented with many challenges and deployment issues that affect the operation of WSN so a need for a fault tolerant technique becomes essential for good quality sensor data since the quality of sensed data is proportional to the amount data sensed and a number of sensing nodes. The fault tolerant technique should satisfy all the characteristics of WSN operations and must have minimum deployment and operational overheads because node's energy and computation power of nodes are the scarcest resources of any WSN which should be kept in mind while designing a fault tolerant technique for the WSN. In this paper, we recapitulate and compared some of the existing and widely used fault tolerant techniques and protocols of WSN for encountering faults. The paper compares the various characteristics of some existing techniques and provides us a picture for the comparative analysis of various recent fault tolerance protocols and techniques. From the findings of the comparison we highlighted the issues challenges and faced in achieving fault tolerance and give some description for systematic investigation in order to provide enhancement to fault tolerance and reliability techniques.***

Key Words: *Wireless sensor network, Fault tolerance, reliability protocols.*

1. INTRODUCTION

WSN consists of interconnected Sensor nodes (SNs) which are deployed in a very large number and are capable of sensing, gathering, processing and transmitting the data. SNs collect data by sensing the target surroundings and send the sensed data to base station (BS) by using wireless transmission techniques.

Key Characteristics of Wireless Sensor Networks are:

- Limited Power constraints for nodes because of usage of either batteries or energy harvesting
- Mobility of nodes
- Ability to withstand after node failures
- Network topology's dynamic nature
- Ability to cope with Communication failures
- Deployment Scalability to large scale and wide geographical area
- Ease of use
- Ability to resist failure in harsh environmental conditions
- Continuous operation
- Power consumption
- Heterogeneity of nodes

The communication topology and geographical positions of nodes of an SN must be in such a way that all the above characteristics of the WSN are satisfied. During operation SN can be down for several reasons and most common of them are, running out of energy, harsh environmental conditions and sometimes the activities of any intruder can also be the cause of failure. In the case of failure of SN's, naturally, the overall quality of the sensor network suffers, as the nodes which are down are not able to contribute their sensed data to provide the overall accurate picture of the environment. The sensing quality also diminishes proportionally with the increasing number of down nodes. Since there is an enormous number of an event which can lead to failure of a WSN so a fault tolerance mechanism must be employed so that system can meet all the above characteristics.

The remaining sections of the paper are organized in the following manner. In Section II the basic concepts of fault tolerance are described, Section III is the summary of the related works & it also contains an analytical comparison among different fault tolerance models and protocols, and finally Section IV describes the conclusion.

2. WSN'S FAULT TOLERANCE – AN OVERVIEW

In any normal system, Fault Tolerance (FT) deals with quick identification, repair and replacement of faulty components to keep the system functional. Whereas in WSN, fault tolerance is the capability of the WSN to confront the abrupt modifications of network environment such as network bottlenecking, hardware failures and software faults that may lead to failure of a single node or of the whole network.

In other words, the fault tolerance is the ability of the network itself to maintain its functionality to an acceptable level even with the presence of interruptions caused by the failures of SNs.

Harsh environments in which WSNs are deployed are the primary cause of failure of some components of the SNs and sometimes even of the whole network. So the deployment environment and characteristics of WSNs raise the need to provide some mechanisms that overcome these issues and help the WSN to provide service to an accepted level, even in the presence of a fault. Since all the factors (Harsh environmental conditions, battery life, interrupts caused by humans) are not easily determinable so WSN should have a robust fault tolerant mechanism in order to deal with every possible failure and provide best sensor readings possible.

3. RELATED WORKS

In this section, the basic emphasis is given to the fault detection, recovery techniques, and their comparison.

Many researchers have proposed different algorithms to make WSN more faults tolerable. Monia Bellalouna et al. (2010) [1] describes that the WSNs are prone to various forms of failures which indeed have an adverse effect on their reliability. They classified various causes of failures of SNs and explain the different methods to assure the acceptable level of functioning of WSN. Furthermore, they suggested that optimal reliability of WSN should be there to ensure the data transmission's success with low energy overheads.

Some distributed approaches for making WSN more fault tolerant were explored by Tsang-Yi Wang et al (2005) [2] they proposed a distributed in nature multiclass classification by making use of a fault-tolerant fusion rule for WSN. In the case of occurrence of faults, binary decisions from local SNs are forwarded to the fusion center for improving fault-tolerance capability and to reduce the time for computation and to use less memory at the fusion center.

Samira Chouikhi et al (2015) [3] also gave an overview of WSN mechanisms that improve the fault tolerance property of WSN. They included each and every mechanism that allows the prevention of fault occurrences such as data aggregation, energy aware routing, and compression, according to the tasks they target (flow management, data management). Furthermore, a new classification supported on network size was proposed. As the functioning of the majority of mechanisms is dependent on the node count and geographical distribution of the SNs. Thus, they concluded that a well-functioning protocol conceived for small networks may be incapable for large networks and vice versa.

There is another approach for fault tolerance in WSNs put forward by Saad Ahmad Khan et al. (2014) [4] they suggested a bridge protection algorithm (BPA) that suggests to change the role of a set of significant (topologically) SNs in the network as a reactive measure in case of a catastrophic event. The motive is to prevent the failure of significant bridge nodes by allowing few SNs to share some of the responsibilities of the sink. Simultaneously, they relieve other nodes which are overwhelmed, by sharing the load and thus prevent the disjoint partition of the network.

Sookyoung Lee et al. (2014) [5] presented their ideas focused on regaining stable functioning state after a catastrophic event. They suggest the deployment of an inter-partition bi-connected topology which minimizes the maximum path length between all pairs for partitions and deploys the least possible optimal count of relay sensor nodes (optimal number and position of RN's were found by using heuristics) for assuring connectivity after any disastrous event.

Meenakshi Panda et al. (2015) [6] proposed a distributed fault detection mechanism to find a soft faulty sensor node in distributed WSN. In addition, in order to minimize communication overheads, each and every sensor node gathers the information entirely from the neighboring nodes. It is a self-detectable distributed fault detection algorithm to detect the faulty sensor nodes.

Prasenjit Chanak et al. (2015) [7] also propose a fuzzy rule-based faulty node identification, classification, and management scheme for WSNs that can detect and reuse faulty sensor nodes according to their fault status. In order to overcome uncertainties that are inherited in the WSN environment, a fuzzy logic based method is utilized, in addition, a routing scheme is applied that reuses the retrieved faulty nodes during the data routing process.

4. COMPARATIVE ANALYSIS OF VARIOUS FAULT TOLERANT AND RELIABILITY IMPROVEMENT PROTOCOLS

[8]E²SRT protocol provides reliability based on the fact that reliability of the event detected at the sink node is a factor of reports of several source nodes rather than the report of a single node. It tries to provide the feature of desired reliability level with energy conservation.

[9]GARUDA protocol provides a reliable data delivery in point to multipoint fashion from a sink node to various SNs. It is a reliable protocol for message delivery of small size messages, also, it suggests having a virtual infrastructure termed as the core for optical assignment of locally designated servers, it supports a bi-stage negative acknowledgment (also known as NACK scheme) based process for recovery.

[10]RCRT stands for Rate-Controlled Reliable Transport and there are four major components of RCRT which are for detection of congestion in the network, adaptation in transmission rate, allocation of transmission rate and for end-to-end retransmission. RCRT also implements a NACK scheme for recovery in case of an end to end the loss of data.

ZigBee Acknowledgement based Reliable Broadcast (ZARB) [11] protocol It utilizes the acknowledgment mechanism in multicast and broadcast transmission for reliable transmission by smartly managing the broadcasted acknowledgments for reliable data broadcast in WSN.

HERO [12] is a routing protocol which exploits hierarchical structural design by allowing an effective, robust and multi-hop communication in both directions among nodes which are arranged in multiple tiers, to give developers the advantage to organize a Wireless Sensor Ad-hoc Network with as many tiers as needed.

Table -1: Comparison of Reliability and Fault Tolerance improvement techniques

Name of the protocol	Reliability enhanced	Constrains satisfied	Performance improved	Technique used
[8]E²SRT	Event-to-sink reliability	Dynamic topology, unreliable link	Energy efficiency	Including congestion control and reducing convergence time
[9]GARUDA	Multiple reliability semantics	Packet size, retransmission overhead	Latency, energy efficiency	Loss recovery through minimum recovery set
[10]RCRT	End-to-end reliability	Asymmetric link, hardware constraints	Network efficiency and flexibility	Implementing NACK based end-to-end loss recovery scheme
[11]ZARB	Packet reliability	More broadcast coverage time	Network Efficiency	Active and Passive ACK packets broadcasting
[12]HERO	Bi-directional packet delivery	Node and network constraints	Energy efficiency and life time	Efficient clustering techniques
[13]Data fusion with desired reliability	Transmission and information reliability	Unreliable data fusion structure	Energy efficiency	Fusion depends upon amount of information weight
[14]Improved CICADA	End-to -end	Mobility	Throughput, reduced retransmission, delay, energy efficiency	Randomization and overhearing
[15]Simple CRT based packet forwarding	Packet forwarding	Unreliable channels, dynamic topology changes and MAC overhead	Power saving, simplicity and fair distribution of energy consumption	Packet-splitting algorithm Based on Chinese Remainder Theorem(CRT)
[16]EIRDA	Clustering	Security	Energy efficiency, life time, fault tolerance	Functional reputations for sensing, aggregation and routing implemented using beta-distribution function to evaluate trustworthiness
[17]CAP	Event reporting	Node constraint	Fault tolerance	Collaborative aggregation
[18]Collaborative distributed detection	Information reliability	Faulty nodes	Energy efficiency, life time, fault tolerance	Coefficients of a regression polynomial, aggregation the median information and judges the final state of the event-region

[13]Data fusion with desired reliability protocol is preferred for less energy consumption and reliable transmission of sensed data in WSN.The in-network processing techniques used by this algorithm, such as data fusion are efficient but it may often lead to unbalancing of information between nodes in the data fusion hierarchy.

[14]CICADA which stands for Cascading Information Retrieval by Controlling Access with Dynamic Slot Assignment is a cross-layered protocol which is deployed on mobile body area in multi-hop environment networks.

[15]Simple CRT based packet forwarding is a protocol which functions on a packet splitting done by using the Chinese Remainder Theorem (CRT). The splitting procedure helps the forwarding nodes which cannot process or forward heavy packets. It is the responsibility of the sink node to recombine all sub-packets (called CRT components) and to reconstruct the original message provided they are received correctly.

(EIRDA)[16] Stands for Energy Efficient Interest based Reliable Data Aggregation and this protocol consists of a static nature scheme for making clusters in the appropriate manner and to distribute SNs uniformly in each cluster.

In the Contention Access Period protocol (CAP)[17], data can be transmitted by any device only after a slotted CSMA/CA mechanism is executed successfully. There are two types of models defined in the CAP for data transfer. One suggests that the downlink data should be sent through indirect transmission and other goes for the uplink data to be transmitted directly.

[18] Collaborative distributed detection diminishes the risk of network node failures, reduces the communication overhead of the network, and prevents the fusion center of data from being overwhelmed by the immense amount of raw data from the sensor node.

5. CONCLUSIONS

In this paper various aspects of fault tolerance techniques in WSN are discussed also various fault tolerance protocols are compared and by comparing all the major reliability improvement techniques, it is clear that no one technique or protocol can provide a completely reliable solution for the fault tolerance problem of Wireless Sensor Networks. So we have to go for a Hybrid approach which should utilize the best features of various protocols and can provide a better solution in terms of reliability, fault tolerance and energy efficiency.

REFERENCES

[1] M. Bellalouna and A. Ghabri. 'A priori methods for fault tolerance in wireless sensor networks.' unpublished.

[2] Tsang-Yi Wang, Yunghsiang S. Han, Pramod K. Varshney and Po-Ning Chen. 'Distributed fault-tolerant classification in wireless sensor networks.' IEEE journal on selected areas in communications, vol 23, 2005.

[3] Samira Chouikhi, InèsElKorbi, Yacine Ghamri-Doudane and Leila Azouz Saidane. 'A survey on fault tolerance in small and large scale wireless sensor networks.' Elsevier, pp 22-27, 2015.

[4] Saad Ahmad Khan, Ladislau Bölöni and Damla Turgut. 'Bridge protection algorithms – A technique for fault-tolerance in sensor networks.' Elsevier, pp 186-199, 2014.

[5] Sookyoung Lee, Mohamed Younis and Meejeong Lee. 'Connectivity restoration in a partitioned wireless sensor network with assured fault tolerance.' Elsevier, pp 1-19, 2015.

[6] Meenakshi Panda and P.M. Khilar. 'Distributed Byzantine fault detection technique in wireless sensor networks based on hypothesis testing.' Elsevier, 2015.

[7] Prasenjit Chanak and Indrajit Banerjee. 'Fuzzy rule-based faulty node classification and management scheme for large-scale wireless sensor networks.' Expert Systems with Applications, 2015

[8] S. Kumar, Z. Feng, F. Hu, and Y. Xiao. 'E2SRT: Enhanced event-to-sink reliable transport for wireless sensor networks.' Journal of Wireless Communications and Mobile Computing, Vol 9, pp 1301-1311, 2009.

[9] S.-J. Park, R. Vedantham, R. Sivakumar and I. F. Akyildiz. 'GARUDA: Achieving effective reliability for down- stream communication in wireless sensor networks.' IEEE Transactions on Mobile Computing, Vol 7, pp 214-230, 2008, doi:10.1109/TMC.2007.70707.

[10] J. Paek and R. Govindan. 'RCRT: Rate-controlled reliable transport for wireless sensor networks.' ACM Transactions on Sensor Networks, Vol 7, pp 305-317, 2010, doi:10.1145/1807048.1807049.

[11] T.-W. Sung, T.-T. Wu, C.-S. Yang and Y.-M. Huang. 'Reliable data broadcast for zigbee wireless sensor networks.' International Journal on Smart Sensing and Intelligent Systems, Vol 3, pp 504-520, 2010.

[12] E. Cañete, M. Díaz, L. Llopis and B. Rubio. 'HERO: A hierarchical, efficient and reliable routing protocol for wireless sensor and actor networks.' Computer Communications, Vol 35, pp 1392-1409, 2012. doi:10.1016/j.comcom.2012.04.003

[13] H. Luo, H. Tao, H. Ma and S. K. D. 'Desired reliability in wireless sensor networks.' IEEE Transactions on Parallel and Distributed Systems, Vol 22, pp 501-512, 2011.

[14] B. L. Braem, B. Blondia, C. Moerman and I. Demeester. 'Improving reliability in multi-hop body sensor networks.' Second in Technologies and Applications, August, pp. 342- 347, 2008.

[15] G. Campobello, A. Leonardi, and S. Palazzo. 'Improving energy saving and reliability in wireless

sensor net- works using a simple CRT-based packet-forwarding solution.' EEE/ACM Transaction Networking, Vol 20, pp 191-205, 2012.

[16] H. Sethi, D. Prasad and R. B. Patel. 'EIRDA: an energy efficient interest based reliable data aggregation protocol for wireless sensor networks.' International Journal of Computer Applications, Vol 22, pp 20-25, 2011.

[17] W. Yuan, S. V. Krishnamurthy, and S. K. Tripathi. 'Improving the reliability of event reports in wireless sensor networks.' Proceedings of the 9th International Symposium on Computers and Communications, Vol 1, pp 220-225, 2004.

[18] Z. ShuKui, G. ShengRong, C. ZhiMing and F. J. Xi. 'A reliable collaborative detection scheme of event-region in wireless sensor networks.' Proceedings of the International Symposium on Information Processing, pp 021-024, 2009.

BIOGRAPHIES

Abhinav Sharma pursuing M. Tech in Computer Science & Engineering from Department of Computer Engineering & Technology, Guru Nanak Dev University, Amritsar, Punjab, India. His research interests include Wireless Sensor Networks.

Dr. Sandeep Sharma is working as a professor in the Department of Computer Engineering & Technology, GNDU, Amritsar, Punjab, India. He has published many research articles in the National/International conferences. His research interests include Cloud Computing and Parallel Processing.