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Fault Detection in WSN and MANET

Amanpreet Kaur [1] and Gaurav Banga [2]
[1] Research Scholar, Master of Technology, ECE Department, GIMT, KKR, India
E-mail: amanpreet.kp@gmail.com
[2] Assistant Professor, ECE Department, GIMT, KKR, India
E-mail: gauravbanga86@gmail.com

***Abstract*—A wireless communication system to operate efficiently in the industrial/factory floor environment has to guarantee low and probable delay of data transfer (typically, less than 10 ms) for actual time applications. Faults occurring in sensor nodes are familiar due to the sensor device itself and the unkind environment where the sensor nodes are deployed. WSNs are mainly affected by the crash of sensor nodes. MANET nodes may experience two types of faults that would direct to the degradation of performance. First type is function fault, which normally stops the working of individual nodes, packet failure, routing failure or network separation. The other type of error is data fault, in which a node behaves normally in all aspects except giving its sensing results, leading to either major inclined or random errors.**

***Index Terms*— WSN, MANET, Fault Model, Fault Diagnosis.**

I. INTRODUCTION

A. Mobile Ad Hoc Network

Ad hoc is a Latin Phrase importance "for this". It mainly denote a solution designed for a precise problem or task, not proposed to be able to be modified to other purposes , non-generalizable [8]. Common examples are administrations, committees, and commissions formed at the national or international level for a specific task. The term ad hoc networking usually refers to a system of network elements that combine to practice a network requiring little or no planning. The growing use wireless movable devices such as phones and laptops is important to the possibility for natural or ad hoc wireless communication known as (MANET).

A mobile Ad hoc network (MANET) is a self-configuring network that does not require any pre-existent (static) Infrastructure, which decrease their deployment time and cost also. As each node in this network is able to move which makes the network to change its topology constantly. The infrastructure-less mobile nodes in ad hoc networks lethargically form routes among themselves to make own wireless network on that instant as shown in Figure 1. With the improvements in wireless technologies and growth of mobile devices, ad hoc networks will play an vital position in enabling present and future communication. For together video and data communication, mobile radio technologies have practiced a rapid growth.

To simplify the explanation of a MANET, the MANET model is commonly explained as shown in Figure 1. Nodes *i*, *j*, and *k* are mobile nodes in the network. The region shown by circles in the figure denotes the radio coverage areas of nodes. In wireless networks, node *i* can hear node *j* if *i* is within the radio range of *j*. Node *i* is a neighbour of node *j* if node *j* can also hear node *i*. This is also known as a bi-directional connection. Two nodes are separated if one node is not in the radio range of the other. For example, nodes *j* and *k* are disconnected.

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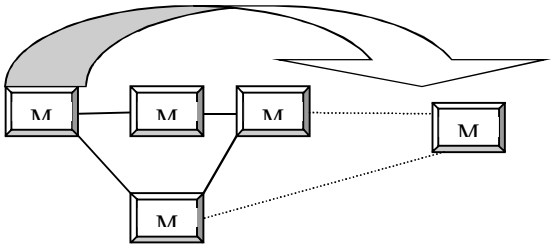

Figure 1. Mobile Ad-hoc Networks

B. WSN

A wired network depends on physical cables to transfer data. As it is assumed that in a wireless network, the communication amongst different network modules can be either wired or wireless. As wireless communication does not have the control of physical cables, it allows a explicit freedom for the hosts and/or routers in the wireless network to move. This is one of the advantages of a wireless network [2]. Wireless LANs contemporaneous the following productivity, accessibility, and cost advantages over the wired networks [3].

C. Applications Of Wireless Sensor Networks

The structures of WSN provide a wide range of applications for WSNs. A number of applications containing sensed data collection and spreading are shown in Figure 2.

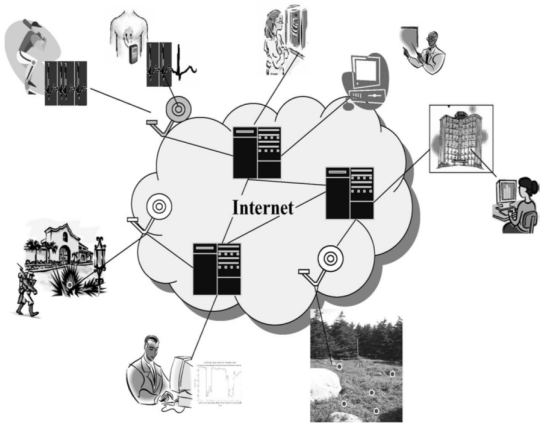

Figure 2. Wireless sensor network applications

Temperature control: One fundamental controller controls the air conditioning or heating systems of the mainstream buildings centrally. But this one important control is not suitable to control the airflow evenly in gigantic apartment; coldness or heat is not equally distributed. The airflow and temperature can be matched by combining the WSN in the large room, so proper turning on and off air conditioning or heating unit can save energy.

Inventory management: Sensor node can be devoted to each point of inventory, walls, ceiling or gates in a warehouse. These sensor nodes can localize the position of the item existing in the inventory all the time. The warehouse engineer can find out the location of the item when he/she wants to do so, therefore items can be located by the WSNs and can be known to the end users. Any sudden large-scale activities of items or major changes in inventory levels are alarmed to the administrator or supervisor of the warehouse. In this way, WSNs based systems will reject manual scanning and offer further efficient way of locating the items without spending far money on manpower. Inventory can be transformed automatically by binding the sensors to the different arrived items in the warehouse.

Physiological monitoring: WSNs can be used to collect and save the physiological adjustable of the patients such as blood pressure, heart rate, etc. for a extended period of time. Doctors can control these data remotely

for medical examination through the use of WSNs. This is actually more suitable for the patient as they enable a better quality of life in comparison to the medical hospitals. Even in the hospital, WSN can be used very competently. Small sensor nodes of WSN can be devoted to each patient body to do their allotted tasks such as measuring different parameters such as blood pressure, heart rate and brain activities and so on. Smart sensor can be used to determine these parameters at transformed times.

Habitat monitoring: Habitat monitoring offers a inclusive collection of sensing modalities and environmental conditions (Cerpa et al 2001). Think the objective of supportive data collecting and model development of complex ecosystems. Environmental authorities and scientist would like to control soil and air chemistry, as well as animal species and plant populations and activities. The main modalities are video (imaging) and audio (acoustics) to track species or occurrences based on video or sound information. The sensor nodes for this task must be set up in remote areas that absence the power and the communication facilities, arise the necessity for low-energy wireless communication.

Precision agriculture: WSNs can also be used to intellect the air pollution, pesticides level in the water, the level of soil erosion. Extraordinary smart sensor nodes can help to recognize the variation, concentration, and location of pollutants. Basically, WSNs will deliver the end users a superior understanding of the agriculture environment.

Forest fire detection: WSNs may be set up accidentally, and densely in a forest, sensor nodes can broadcast the source of the fire to the fire release team or fire fighting department before the fire is increase over other area. Plenty of sensor nodes can be set up and networked using today's transmission technologies.

D. Applications of MANETS

With the rise of transportable devices in addition to development in wireless communication, ad hoc networking is gaining importance with the growing number of well-known applications. Ad hoc networking can be beneficial anywhere where there is little or no infrastructure for communication or the present infrastructure is costly or not convenient to use. Ad hoc networking allows the devices to preserve connections to the network as well as simply adding and eliminating devices to and from the network. MANET's applications [10] are different, ranging from large-scale, mobile, greatly dynamic networks, to small, fixed networks which are controlled by power sources. Separately from the legacy applications that move from old-fashioned infrastructure environment into the ad-hoc context , various new services can and will be made for the new environment. It includes [10]:

Military battlefields: Military equipment now normally contains some sort of computer equipment. Ad hoc networking permits the military to take gain of common place network technology to keep an information network among the soldiers, vehicles, and military information head quarters. The important techniques of ad hoc network came from this field.

Commercial Sector: Ad hoc can be used in emergency/release operations for adversity relief efforts like for example in fire, flood, or earthquake. Emergency save operations should take place where non-existing or smashed communications infrastructure and fast deployment of a communication network is preferred. Information is conveyed from one rescue team member to another over a small handheld. A small number of more commercial circumstances include for example ship-to-ship ad hoc mobile communication, law enforcement, etc.

Local level : Ad hoc networks can separately link an instant and temporary multimedia network by notebook computers or palmtop computers to extent and distribute information amongst participants for example at a session or a classroom. Another suitable local level application might be in home networks where devices can communicate openly to exchange information. Similarly, in other civilian environments like boat, sports stadium, small aircraft and taxicab mobile ad hoc communications will have various applications.

Personal Area Network (PAN): Network Short-range MANET can create simpler the intercommunication between various mobile devices such as PDA, a laptop, and a cellular phone. Tedious wired cables are exchanged with wireless connections. This type of ad hoc network can also spread the access to the Internet or additional networks by mechanisms e.g. Wireless LAN (WLAN), UMTS and GPRS also. The PAN is a encouraging application field of MANET in the future universal computing environment.

II. MANET ARCHITECTURE

The nodes in a MANET can be confidential by their capabilities. A Client or Small Mobile Host (SMH) is a node having reduced processing, storage, message, and power resources. A Server or Large Mobile Host

(LMH) is a node that has a large share of resources. Servers, due to their larger competence contain the complete DBMS and bear the main responsibility for data broadcast and satisfying client query. In a MANET, each node has an influencing area. This is the area over which its transmission can be heard.. Network nodes may operate in any of following modes that are designed to facilitate the reduction in power used:

Active Mode: This is the mode using the most power. It allows both the transmission as well as reception of messages.

Receive Mode: The CPU is capable of processing information and is also able of receiving notification of messages from additional nodes and listening to broadcasts.

Standby Mode: The CPU does no processing and the node has no capability to send/receive messages. The node is inactive. This mode allows a node to turn itself off for short periods of time lacking require power-up or re-initialization.

A node with zero remaining power, or one that is off, is not at present a part of the network and is not reachable by any other node. Nodes can become disconnected from the entire network. When stirring back in range of other nodes, they will become re-connected. Conversely, a node may be reachable by several LMHs or SMH.

III. Fault Diagnosis

Fault diagnosis put extra burden on the sensor node besides with their standard task and it will also consume more energy of the sensor nodes. Various techniques have been suggested to solve this difficulty, but they still cannot satisfy the specific need of WSN Fault identification is one of the significant parts in many protocols. When any changed behaviour is shown by system or nodes of the network, a diagnosis function is on the go to find out which node(s) has (have) shown irregular behaviour. This is called as Diagnosis; diagnosis is categorized based on the existence of fault. It is basically classified as static diagnosis and dynamic diagnosis.

1) In static diagnosis, the faults are not happening during the diagnosis session.

2) In dynamic diagnosis, the faults can arise during the diagnosis session, which is challenging to handle because node can be faulty after it has been diagnosed as fault-free by other node.

The Heartbeat Approach: The best universal method for monitoring crash faults is the heartbeat mechanism. The classical heartbeat method [14] is based on the constant monitoring of a node to know whether it is alive or not. Thus, each mobile transfers periodically an "*I Am Alive*" message to mobiles that monitor its state. After the running out of a timeout, if a mobile *x* does not accept such a message from one of the neighbours, say *y*, it is in charge of identifying its failure, then it starts questioning it as being faulty. Mobile *x* adds *y* to a list of supposed nodes, and will eliminate it from this list once it receives later *y's* with "*I Am Alive*" message. The two chief parameters by which the heartbeat mechanism can be considered are as follows:

• *The heartbeat period* Δ that signifies the time between two successive "*I Am Alive*" messages.

• *The timeout delay* Δ *to* which denotes to the time between the last reception of an "*I Am Alive*" message from *v*, and the time where *u* starts distrusting *v*, until *u* starts receiving again *vs.* "*I am Alive*" messages.

The classical heartbeat approach has two chief weaknesses. The first one is that the finding time depends on the last heartbeat. This weakness may have a negative influence on the accuracy of the failure detector since untimely timeouts may occur. The second weakness is that it depends on a fixed timeout delay that does not take into account the network and system's load. That is, a node may be incorrectly supposed as faulty if it slows down because of heavy workload or if the network agonizes from links failure that may delay the delivery of "*I Am Alive*" messages.

A Notations and Terminologies

Let n mobile hosts communicating via radio networks and every mobile host is having a distinctive identifier. The topology of a network at any specific instant t is signified by a directed graph S(t)=(W,L(t)), where W is the set of nodes or mobiles extant in the network and L(t) is the set of logical links between two nodes i.e. if two nodes u, v are connected in the network then L(u; v) $\in$ L(t). In new words we can say, u is in the transmission range of v. For the sake of easiness we can assume the communication graph to be undirected. Hence for any instantaneous of time t, if L(u; v) $\in$ L(t) then L(v; u) $\in$ L(t) i.e. both u and v can interchange information among themselves. Some of the facts that are being considered here are as follows:

I) Each mobile has a distinctive identity, ID, and it knows the IDs of its neighbours.

II) Fault free mobiles can correctly recognize the sender of a message [13].
III) The message sent by a fault free mobile is properly received by all the fault free mobile nodes in the neighbourhood in a specific bounded time.
Common definitions used in this thesis:

- **Neighbourhood set N(u,t):** the nodes that are existing in the range of node u, that is, the nodes that can communicate with node u at a definite immediate of time t. Establish the neighbourhood set.
- **Stable mobile:** is theoretical to be either fixed or moving with a very slow speed so that it is not likely to leave the neighbourhood during the diagnosis session is called as a steady mobile.
- **Dynamic mobile:** is not fixed and may vary rapidly in positions during a diagnosis session is called a active mobile. A active mobile may receive a message from node u at time t and may account to other neighbour v, given that it has progressed away from u.
- **Connectivity k of graph S(t):** connectivity of a graph is well-defined as the minimum number of nodes which when detached results in a disconnected graph.
- **Permanent fault:** A fault that cannot be mended during a diagnosis session and has to be removed and/or repaired by some outside administrator [5]. It is basically of two type-

I) hard fault: the nodes that does not work at all and do not reply to any kind of stimulus.
II) soft fault : the nodes that respond to the stimulus and communicate with the network but with an changed behaviour.

IV. DIAGNOSING AND RESOLVING

Fault Diagnosis is a process that finds out the location of the fault and the type of. There are three types:
i) Analytical model-based method
ii)Signal processing-based method
iii) Knowledge based method.
Among these three methods used in the Diagnosis and resolving, the knowledge-based method is most widely used because of its self-rule and intelligence
Categorisation of Clustering Structure The clustering structure of MANETs may be classified according to various criteria such as cluster head-based clustering/non cluster head-based clustering with specific interest in the role of special function nodes (CHs), single-hop clustering/multi-hop clustering with focus on the distance between node pair hop distance; clustering protocols have different classifications also dependent on different criteria such as objectives that identify them characteristically into various categories.
Classifying the clustering protocols based on their objectives, the proposed MANET clustering schemes may be categorised into eight distinctive groups

- Dominating-Set-based (DS-based)
- Flooding-based clustering
- Channel-based clustering
- Low-maintenance clustering
- Mobility-aware clustering
- Energy-efficient clustering
- Load-balancing Clustering
- Combined-metrics based clustering

Dominating-Set-based (DS-based) clustering endeavours to determine the DS for a MANET where the number of mobile nodes participant in route search or routing table maintenance can be reduced as their function becomes 'familiar' and only DS mobile nodes are required to perform them.
Flooding-based clustering addresses MANETs' characterised by scant bandwidth, radio interference issues and no fixed infrastructure, circumventing the need for more
efficient (specified) techniques required of complex protocols. Flooding, as the term suggest, is the dissemination of information (overall and without explicit direction) that covers all the nodes in the network regardless. Each node redistributes the all of the information to all of its neighbours until there is inundation of the entire network without any computation requirements or maintenance of routing tables, thus avoiding network delay. For some, the 'flooding' may be based on specific, tailored criteria where it is perhaps limited to only a set of nodes instead of blanket network coverage.
Channel-based clustering segregates control channels and data channels for MANETs (that have no centralised control) as separate out-of-band signalling is preferential for these types of networks. The control

channel exchanges instructions and the data channel transmits information and by creating a bi-channel structure the mobile node can more efficiently schedule transmissions and reduce collisions overhead.

Low-maintenance clustering schemes aim to reduce cluster maintenance cost and 'greedy' resources consumption through the provision of stable cluster architecture for upper-layer protocols. This is achieved through prevention of re-clustering requirements and/or minimisation of explicit control messages for clustering.

Mobility-aware clustering will group like mobile nodes together according to their speed of movement – the chief reason for network topology changes. Similarly paced nodes are gathered into the same cluster allowing a tightening of intra-cluster links with corresponding stability realised in the presence of mobile nodes in motion.

Energy-efficient clustering manages battery energy of mobile nodes more sensitively in a MANET. Fine calibration of energy requirements through elimination of redundant energy consumption by mobile nodes or balance among different mobile nodes can greatly impact on the projected network lifetime.

Load-balancing clustering schemes attempt an even distribution of mobile nodes to each cluster to create similarly sized clusters thus sharing the load on the network by this arrangement.

Combined-metrics based clustering considers the multiple metrics in a cluster configuration with particular regard to cluster head decisions, weighting the parameters according to their attributes pertinent to a particular application requirement, allowing an adaptive response as justified by the needs. With the consideration of more parameters that might include mobility speed, node degree, cluster size or battery energy, cluster heads can be better selected without bias given to mobile nodes with specific attributes [4].

V. CONCLUSION

In this paper we provided a detailed study of faults that occurred in WSN and MANET. This concise study provides a valuable knowledge input for future application to prevent the same kind of issues from occurrence. In real wireless sensor networks and MANET, the sensor nodes use battery influence supplies and thus have incomplete energy resources. In adding to the routing, it is important to carry out the optimization of sensor node substitution, reducing the substitution cost, and reusing the most routing paths when some mobile nodes are non-functional.

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