Faulty Link Detection in Wireless Sensor Network: A Survey

Anjila Deheriya
M.Tech Scholar,
SSSIST, sehore
anjila_cse@rediffmail.com

Kailash Patidar
HOD CSE/IT
SSSIST, sehore
kailashPatidar123@gmail.com

Megha Jain
Asst. Prof. CSE
SSSIST, sehore
06meghajain@gmail.com

Abstract- A wireless sensor network (WSN) contains of numerous small sized sensor nodes that have computation power. Wireless sensor networks have recently received increased attention for a broad array of applications such as surveillance, environment monitoring, medical diagnostics, and industrial control. In WSNs serious incident data collected by the sensor nodes necessity to be reliably delivered to the sink for successful monitoring of an environment. Associated to the wired networks, it seems considerable more important to sense link faults rather than node responsibilities in WSNs. The reliability of individual links' performance is crucial in these applications, e.g., in a surveillance network, the transmissions must be reliable to avoid false alarms and missed detections. In large-scale wireless sensor networks, faulty link detection plays a critical role in network diagnosis and management. In this paper we provides the survey of faulty link detection.

Keywords-Faulty Link, Routing,Route Discovery, Security, Wireless Sensor Network

1 INTRODUCTION

A wireless sensor network (WSN)[1] consists of many tiny sized sensor nodes that have computation power, communication capability, and sensing functions. Each sensor node[1] can sense physical phenomena, like temperature, vibration, light, electromagnetic strength, humidity, and so on, and transmit the sensed data to the sink node through a chain of multiple intermediate nodes that help forward the data.Wireless sensor networks (WSNs) have received significant attention in recent years due to their potential applications in military sensing, wildlife tracking, traffic surveillance, health care, environment monitoring, building structures monitoring, etc. The most significant benefit of sensor networks is that they extend the computation capability to physical environment where human beings cannot reach. They can operate for prolonged periods in habitats that are hostile, challenging or ecologically too sensitive for human visitation, Moreover it has the potential to provide wealth of data about theenvironment in which they are deployed and send their results across the network to the end-users. Wireless Sensor Networks (WSNs) have been the preferred choice for the design and deployment of next generation monitoring and control systems. It has now become feasible to deploy massive amounts of low-cost sensors to monitor large regions over ground surface, underwater, or atmosphere. WSNs can be treated as a special family of wireless ad hoc networks. A WSN is a self-organized network[2] that consists of a large number of low-cost and low powered sensor devices, which can be deployed on the ground, in the air, in vehicles, on bodies, under water, and inside buildings. Each sensor node is equipped with a sensing unit, which is used to capture events of interest, and a wireless transceiver, which is used to transform the captured events back to the base station, called sink node. Sensor nodes collaborate with each other to perform tasks of data sensing, data communication, and data processing.

Compared to the wired networks, it seems much more essential to detect link faults[2] rather than node faults in WSNs. A wireless link itself virtually exists, which means we can't directly observe and assess whether it performs well or not. It proves difficult to localize[3] the faulty links under a dynamic mal-condition in the wild, for the link quality will be significantly impacted by the natural environment like trees in the forest and flow in the ocean. Faulty link detection becomes more difficult in the multi-hop networks due to topology features. Faulty link detection plays an important role in network failure detection and network management. Link failure is one of the problem against wireless sensor networks and can affect the whole sensor network communication. The variety of technique against fault link detection is overwhelming.

Organization of paperthe rest of the paper is organized as follows. Section 2 provides a background of wireless sensor network, routing protocols used in wireless sensor network. Section 3 concentrates on the literature survey.Finally, Section4 provides concluding remarks, limitation discussion.

II. BACKGROUND

A. WIRELESS SENSOR NETWORK

A wireless sensor network is which organized itself according to the situation. It is a collection of nodes. The nodes are low cost and low battery power sensor devices. WSN can be positioned on the ground, in the air. It can be positioned in vehicles, on bodies of the human or animals. It can be deployed under water, and inside the houses. The main components of wireless sensor networks are sensing unit, and a wireless transceiver. The function of sensing unit is capture events of attention. The main function of wireless transceiver is transform the captured events back to the base station. The base station is called sink node. Sensor nodes cooperate with every other to achieve tasks of data identifying, data communication, and data processing. In WSNs serious incident data collected[4] by the sensor nodes necessity to be reliably delivered to the sink for successful monitoring of an environment. The greatest noteworthy advantage of sensor networks is that they increased the computation ability to physical atmosphere where human beings cannot reach. They can work for lengthy periods in locales that are antagonistic, challenging or environmentally too sensitive for human examination. Moreover it has the probable to send prosperity of data about the setting in which they are organized and send their outcomes across the network to the users. A sensor node is a tiny component that is proficient of computation, sensing and communication competences. Sensor node is the main component of WSN. Sensor nodes can be used to sense moisture and temperature. It is also used to sense temp. and light. Since a single sensor transports only limited information; a system of these devices is used to achieve huge surroundings. The communication component in sensor nodes is used to transfer information.

It has now become possible to install enormous quantities of low cost sensors to monitor big regions over ground underwater, surfce, or atmosphere. WSNs have received noteworthy consideration in current years due to their potential applications in wildlife tracking, armed sensing, traffic investigation, fitness care, atmosphere monitoring, building constructions monitoring, etc. Nodes in WSNs are disposed to letdown due to hardware letdown, energy reduction, communication link faults, mischievous attack, and so on. The main WSN objectives are low node cost, small node size, low power consumption, scalability, self configurability, better channel utilization, fault tolerance, adaptability, Qos[4] support and security.

B. ROUTING PROTOCOLS IN WSN

Routing in wireless sensor networks differs from conventional routing in fixed networks in various ways. There is no infrastructure, wireless links are unreliable, sensor nodes may fail, and routing protocols have to meet strict energy saving requirements [5]. Many routing algorithms were developed for wireless networks in general.

Routing in wireless network is different from simple adhoc network. Wireless sensor network is infrastructure less. Wireless links are not reliable. All the routing protocols of wireless sensor network require good energy. Wireless sensor node may fail because of infrastructure. The wireless sensor network protocols are location based protocols, hierarchical protocols, data centric protocols, multipath based protocols, QoS based protocols, mobility based protocols, and heterogeneity based protocol.

Location based protocols are GAF, TBF, SMECH, GeRaF, MECN, GEAR, Span, BVGF.Hierarchical Protocols are APTEEN, LEACH, HEED, PEGASIS, TEEN.

Data-centric Protocols are Rumor Routing, ACQUIRE, Quorum-Based Information Dissemination, SPIN, EAD, Information-Directed Routing, HABID, GBR, EAR, IDR, COUGAR, DD.Heterogeneity-based Protocols are CHR, CADR, IDSQ.

Multipath-based Protocols are Braided Multipath, Sensor-Disjoint Multipath , N-to-1 Multipath Discovery.Mobility-based Protocols are TTDD, SEAD, Dynamic Proxy Tree-Base Data Dissemination, Joint Mobility and Routing, Data MULES.

QoS-based protocols are SPEED, Energy-aware routing, SAR.All major routing protocols proposed for WSNs may be divided into seven categories and as summarized in Table 1.

Category	Representative Protocols
Hierarchical Protocols	APTEEN, LEACH, HEED, PEGASIS, TEEN
Data-centric Protocols	Rumor Routing, ACQUIRE, Quorum-Based Information Dissemination, SPIN, EAD, Information-Directed Routing, HABID, GBR, EAR, IDR, COUGAR, DD
Location-based Protocols	GAF, TBF, SMECN, GeRaF, MECN, GEAR, Span, BVGF
Heterogeneity-based Protocols	CHR, CADR, IDSQ
Multipath-based Protocols	Braided Multipath, Sensor-Disjoint Multipath , N-to-1 Multipath Discovery
Mobility-based Protocols	TTDD, SEAD, Dynamic Proxy Tree-Base Data Dissemination, Joint Mobility and Routing, Data MULES
QoS-based protocols	SPEED, Energy-aware routing, SAR

Table 1 Wireless routing protocols

C. LINK FAILURE DETECTION

The reliability of individual links' performance is crucial in these applications, e.g., in a surveillance network, the transmissions must be reliable to avoid false alarms and missed detections. Compared to the wired networks, it seems much more essential to detect link faults rather than node faults in WSNs. A wireless link[6] itself virtually exists, which means we can't directly observe and assess whether it performs well or not. It proves difficult to localize the faulty links under a dynamic mal-condition in the wild, for the link quality will be significantly impacted by the natural environment like trees in the forest and flow in the ocean. Multi-hop networks suffer more harm than single- hop networks due to link failures. Accordingly, compared to single-hop networks, faulty link detection becomes more difficult in the multi-hop networks due to topology features. Therefore, faulty link detection becomes one of the most critical issues in multi-hop network diagnosis. One of the most peculiar routing characteristics of WSN is routing dynamics. It is not surprising that a sensor node frequently changes its parent to forward packets. Unfortunately, many existing approaches just aim to detect the faulty links which had been behaving badly, but fail to offer an inspection on other unused ones, thus have no guidance to reroute when the current routing strategy is less than satisfactory. The object of link scanner is to provide a blacklist containing all possible faulty links. With such a blacklist, further analysis and recovery processes become possible, including exploring the root causes of observed symptoms in the network, adjusting routing strategy for the related nodes, offering the spare list of links for every node.

III.LITERATURE SURVEY

Wireless sensor networks (WSNs) have been widely used in many application areas such as infrastructure protection, environment monitoring and habitat tracing. The reliability of individual links' performance is crucial in these applications, e.g., in a surveillance network, the transmissions must be reliable to avoid false alarms and missed detections. Compared to the wired networks, it seems much more essential to detect link faults rather than node faults in WSNs. A wireless link itself virtually exists, which means we can't directly observe and assess whether it performs well or not. It proves difficult to localize the faulty links under a dynamic mal-condition in the wild, for the link quality will be significantly impacted by the natural environment like trees in the forest and flow in the ocean. Multi-hop networks suffer more harm than single- hop networks due to link failures. For example, a critical link may cause a large area of partition, or significantly interfere with routing protocol among the nodes, producing problems such as routing cycle and even network partition. Accordingly, compared to single-hop networks, faulty link detection becomes more difficult in the multi-hop networks due to topology features. A packet has to traverse multiple links to the sink, it is for this reason that exactly localizing a faulty link becomes really hard if only on the basis of whether the packet arrives at the sink or not. Therefore, faulty link detection becomes one of the most critical issues in multi-hop network diagnosis. According to the status of a link, packet loss failure, routing failure, partition can be found easily. Notably, link performance actually reflects a network's reliability and bottleneck if exist.

Although single link failures are more common, multiple link failures occur due to shared risks such as failure of a link while another link is under maintenance, or natural disasters that cause links traversing a region to fail. In [7], the authors use monitoring paths and cycles to localize single link and Shared Risk Link Group (SRLG) failures. They also prove that (k+ 2) - edge connectivity was necessary and sufficient to uniquely localize all

SRLG failures involving up to k links with one monitor. In practice, however, not all sensor networks can satisfy this strict condition, especially in the cases we spread the sensor nodes randomly in the area of interest. In addition, in most cases we are not allowed to set any more monitors after the deployment. What we expect is to utilize the rule-free probes (i.e., without computing the exact probing paths) to achieve link scan. One of the most peculiar routing characteristics of WSN is routing dynamics. It is not surprising that a sensor node frequently changes its parent to forward packets. Unfortunately, many existing approaches just aim to detect the faulty links which had been behaving badly, but fail to offer an inspection on other unused ones, thus have no guidance to reroute when the current routing strategy is less than satisfactory. To solve the above problems, in this work we propose Link Scanner (LS)[4], a passive and rule-free detection approach for discovering faulty links in sensor networks. The object of LS is to provide a blacklist containing all possible faulty links. With such a blacklist, further analysis and recovery processes become possible, including (i) exploring the root causes of observed symptoms in the network, (ii) adjusting routing strategy for the related nodes, (iii) offering the spare list of links for every node. As a result, we not only achieve the goal of diagnosis, but also take a big picture of wholly link performance.

To maintain a sensor network running in a normal condition, many applications in flooding manner are necessary, such as time synchronization, reprogramming, protocol update, etc. In the flooding process, each node is expected to receive multiple probe messages through different paths. By embedding lightweight data into the flooding packet, LS passively collects hop counts of received probe messages at sensor nodes. Since faulty links may cause probes dropped, there must be mismatches between the received hop counts in sensor nodes and our expectations according to the topology. With a probabilistic and heuristics based inference model, LS analyzes the mismatches and deduces the faulty links.

A wireless network often contains a large number of links which virtually exist in the air, but can never directly observe whether they perform well or not. Proposes a passive and low-cost link scanning scheme LS for faulty link detection. LS infers all links statuses on the basis of data collection from a prior probe flooding process, in which leverage hop count to reflect the in/out-going link performances. In the inference model, use to describe the inner relationship among the links, and finally output the optimal fault report with some constraints, which reversely generates a feedback for DLP's next computation. The algorithm through a testbed consisting of 60 TelosB sensor motes and an extensive simulation study, while a real outdoor system is deployed to links including those potential but not used ones in sensor networks. Item According to the exceptional features of sensor networks, develop an efficient investigation marking scheme that exposes the innermost dependencies of sensor networks. Link scanner proposes characterized implication models to get the multi-level dependences between the network elements and accomplish great precision. Further introduce a learning-based inference scheme which increases the inspection accuracy and is thus scalable for large scale networks. A field study on a real outdoor deployment is also presented to verify that LS is practical to surveillance networks.

Network diagnosis has been extensively studied in recent years. Existing approaches can be broadly divided into two categories: debugging tools and inference schemes. This work belongs to the later category. [8] is a notable tool which focuses on debugging sensor nodes at the source-level, and enables developers to wirelessly connect to a remote sensor and execute debugging commands. Declarative Tracepoints [9] allows the developers to insert a group of action-associated checkpoints at runtime, which are programmed in an SQL-like declarative language. Existing inference-based diagnosis schemes for WSNs like [10] trust deeply on an add in procedure that occasionally reports a big amount of network information from separate sensor nodes to the sink, announcing enormous overhead to the resource forced and traffic sensitive sensor network. In order to minimize the overhead, some researchers propose to establish inference models by marking the data packets [11] and then parse the results at the sink to infer the network status, or conduct the diagnosis process in local areas [12]. [13]apply Belief Network with the bipartite graph to represent dependencies among links and end to end connections, then the root causes can be deduced by conducting inference on the Belief Network. [14] explores the bottleneck nodes in a WSN, and [15] enhances the network visibility by analyzing the events and status in history.

Besides, most approaches actively design their probes to fetch desired information for faulty link detection [9], especially in the managed enterprise WLANs and wireless mesh networks, where the monitors are easy to deploy. For each cycle, a node is required to monitor the cycle's performance. [7] develops a non-adaptive fault diagnosis through a set of probes where all the probes are employed in advance. The authors in [15] propose a failure detection scheme, in which monitors are assigned to each optical multiplexing and transmission section. These approaches usually compute the probe paths according to different network symptoms, so as to combine the network topology to infer the link status. For a large scale sensor network, however, deploying monitors in the wild not only increases the cost, but also needs to guarantee sustainable management. Sniffers can be used to collect the information.

IV. CONCLUSION

Wireless sensor networks have recently received increased attention for a broad array of applications such as surveillance, environment monitoring, medical diagnostics, and industrial control. Compared to the wired networks, it seems much more essential to detect link faults [2] rather than node faults in WSNs. In large-scale wireless sensor networks, damaged link detection plays a critical role in network diagnosis and management. In this survey we discussed faulty link detection and different links used to detect and report about faulty link detection.

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