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Need to Change focus from Link Failures to Backbone Failures in WMN

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Abstract- As we know the wireless mesh network is playing a vital role in today's network infrastructure. Wireless mesh networks (WMNs) have achieved significant development because of fast deployment, easy maintenance and low investment compared with traditional wireless networks. The structure of WMN consists of base stations, distribution system (backbone), links and the mobile stations. The issue is to manage the radio coverage [85] in between all the nodes whether they are base stations or mobile nodes. The need for the system is to achieve the stability or fault tolerance [86] in radio coverage failures.

However, to the best of our knowledge, no systematic approach exists for base station planning for wireless mesh networks with respect to fault tolerance requirements of industrial automation networks.

Keywords- **wireless, network, fault, tolerance, failure, base station.**

I. Introduction

In the current scenario, when everything is connected throughout the world by a network, Wireless network communication has gained much popularity last decades. Wireless networks do not need a wired backbone because of this they become a good option for latest network situations. Wireless Mesh network [1] is one of the significant parts of this wireless communication spanned all over the world. Wireless mesh network is made up of much number of nodes which are interconnected to each other but the interconnection is in such a way that the nodes in the WMN are connected in a random fashion i.e. there is no defined structure for it. Now some of the nodes are taken as immobile for being the base station, which creates cells and interconnect the other mobile nodes. The base station nodes have a defined range of area to cover the mobile nodes. In WMN architecture the base stations are generally the mesh routers and the mobile nodes are mesh clients. There is a backbone network [6] in between all the base stations to manage the connectivity. It is a type of ad-hoc network. The mesh clients i.e. the mobile stations are connected to the base stations for creating a link among them. A link exists when two wireless devices can communicate through the wireless medium with some quality parameters. With the movement of mobile stations, the links are modified according to the range of base stations. It simply means the mobile station will be connected to that base station of which the coverage area is. It will dynamically create the connection and loses the connection with the movement in different coverage areas. In this way, the mobile stations remain always connected to the network and do not perform roaming as in the classic infrastructure networks [2]. The routing is served by the base stations.

II. Why Fault Tolerance

Engineering automation networks have classically been inaccessible single-cell networks or classic infrastructure networks with multiple cells. This means that coverage set up is obligatory only for the 'last mile', i.e. the connection between a base station and a mobile station, e.g. [9]. In multi-hop wireless mesh networks, the coverage planning of the backbone network is not focused much. Maximum researchers on radio network planning think about network throughput as a main planning goal, e.g. [4]. The need of the hour in the requirement of engineering networks is availability.

As the new technologies are coming into the market (e.g. Zigbee, Wireless HART), the challenge is to make base station planning. Some of the papers [13] are presenting confronts for developing a planning tool for wireless sensor networks and also signifies that base station planning is an important requirement. But still a systematic approach is missing in planning multi-hop wireless networks with respect to fault tolerance requirements of industrial automation networks.

III. Fault Tolerance Approaches In Context

Link failure[11] can be classified into two categories in terms of the number of broken links: single-link failure and multiple-link failure. Moreover, according to the recovery time from the link failure, they can be classified as permanent failure and transient failure. When a failure does not recover automatically within a short time, we call it a permanent failure. While a failure lasts for a very short duration, we call it a transient failure. Temporary failures are more frequent than permanent ones.

One of the authors [3] takes multiple link failures into account. They state that it is hard for the previous routing approaches and failure insensitive routing approach, to resolve multiple link failures. Hence, they present a new scheme called BAF, in which the trade-offs of its reliability, optimality and scalability is balanced, to deal with multiple link failures. Based on the BAF, the authors propose other two routing schemes called BAFL and FBAF.

In paper [10], the author indicate that there are some problems in the previous channel related research of WMNs, which are: overhead is high and scalability is limited, difficulty in obtaining accurate information in dynamic networks, QoS failures may be caused when failure is repaired, more resources compared with the reconfiguration are requited when some fault-tolerance routing protocols such as local re-routing [3] and multi-path are used. Therefore, they propose an algorithm called LEGO to overcome the above-mentioned problems. There are three phases in LEGO: monitoring, reconfiguration and planning, which make the multi-radio of WMN to recover from the local link failures available.

One of the researchers [15] provides the solution for the fault tolerance in wireless ad-hoc network. It shows a scenario for determining the probability that a backbone network graph is k-connected, based on the transmission range. But the basic assumption of the method is that the network can be modeled as a union disk graph, where all nodes within a given transmission range are perfectly reachable and all nodes outside this range are not reachable at all. It has been shown that this network model in the general case does not comply with real networks.

Many papers cover the problem of fault-tolerant communication in mobile multi-hop ad-hoc networks (MANET) and in wireless sensors networks. Papers allowing for fault-tolerant routing, for instance [16], have as a prerequisite at least biconnected backbone network, but still the base station planning problem is out of their scope. Some scientific works consider the topological properties of the networks, for instance bi connectivity testing and topology control. [18] Proposes a distributed algorithm for testing a given wireless multi-hop network for bi connectivity under uncertainty caused by message losses. Topology management algorithms (e.g. [19, 20]) determine the sleep transitions and transmit power levels of the nodes, such that the network topology is connected and the total power consumption minimum. Node placement algorithms generate multi-hop network topologies for the purpose of simulation. The goal of these algorithms is to resemble the real network properties as much as possible [18] and they generate topologies which are not bi connected.

However, the base station planning problem has been little addressed in the MANET and sensors networks research domains. This is because in these scenarios the number and position of the nodes is considered uncontrolled or hardly controlled: the nodes are typically autonomous or randomly deployed. In automation scenarios, however, the networks are typically planned to provide service in some predefined geographical area (e.g. production hall). This requires careful base station planning for ensuring high availability of the radio coverage.

IV. BACKBONE COVERAGE AND FAULT TOLERANCE

The important issue to be focused in WMN is radio coverage [4], which may be either backbone coverage as well as last mile coverage. The main role of the last mile coverage is to provide the network connectivity to the mobile stations moving within some pre-defined service area while the backbone coverage in WMN provides connectivity among the base stations within the distribution system. Backbone coverage has to provide a path in between every two base stations exists. Now in case of base station failures, the nodes should be covered by some other base stations. It should be done for more than one base station failure, so that the network can be managed without any interruption. In our paper we made the survey for link failures and the base station failures research. The first is link failure in which the nodes will move out of the coverage area and there is no link left in between the mesh points. The second is base station failure which includes two major areas: last mile coverage fault tolerance and backbone coverage fault tolerance [12]. For achieving a fault tolerant WMN, we need such a backbone coverage that can deal with n number of faults.

The previously defined algorithms [12, 14] have provided a backbone coverage design which includes minimum number of base stations and lead to the connected backbone graph but do not provide fault tolerance. The approach is to transform the planning problem into a linear optimization problem, which is a combination of a set covering problem and a network flow problem. As a result the backbone is a connected graph, but there is no fault-tolerance. Because of this one more drawbacks arises that is the intractability of the proposed approaches.

Paper [14] addresses this issue by a decomposition method, but still the algorithm takes about 22 hours for a scenario with 58 nodes. This is acceptable for the mentioned scenarios, but for network reconfiguration in automation scenarios a faster algorithm is required. Extending these algorithms to fault-tolerance would mean an additional increase in the complexity.

V. BASE STATION FAILURE APPROACH

S. Ivanov et al papers [17] approach is to extend the existing methods from infrastructure network planning to plan the multi-hop wireless mesh networks with fault-tolerance aspects. The base station planning algorithm provides coverage in a predefined area by adjusting the number and the position of the base stations. But this approach also works for limited number of faults that is can work only for one base station failure.

In the paper [16], the author proposed an approach for fault-tolerant base station planning in wireless mesh networks that manages sufficient amount of fault tolerance in link failures as well as backbone failures in a cost- effective manner. It will help to get an efficient and cost-effective mechanism for fault tolerant connectivity among different base stations and clients. This approach works for a configurable amount of fault tolerance, i.e. the radio coverage remains correct if k base stations fail and/or l links fail. They provided the concept of using antenna arrays at base stations for improving the performance of base stations.

Chandra et al. [5] addressed the gateway placement problem aiming to minimize the number of gateways while satisfying bandwidth requirements of all clients. They defined three wireless link models, and developed gateway placement algorithms for each model. The gateway placement problem was formulated as a network flow problem, and a max-flow min-cut based algorithm was developed for gateway selection.

VI. RECOVERY MECHANISMS

Failure recovery mechanism [6] [7] tries to mitigate system-level failures such as loss of a network link by placing sufficient diversity and capacity in the network topology and also by designing the topology and determining the capacity of links in a backbone network so that the network can carry the projected demand even if any one link is lost due to a failure. The dynamic fault recovery routing algorithm works such that failure has minimum impact when it occurs and that connections disrupted by failure are restored while maintaining network stability. There are broadly three type of schemes recovering from the failure:

(i) Protection Scheme
(ii) Restoration Scheme
(iii) Hybrid Scheme

(i) In the protection scheme, such as [Srinivas and Modiano 2003], [Li and Hou 2004], [Zhao et al. 2006], [Al-Kofashi and Kamal 2007] and [Zhao et al. 2007], two (or more) link-disjoint paths are selected between a source and a destination node.

The source node forwards the data on all of the selected paths. If there is a link on one of the paths which is broken, the destination can still receive the data for the other path. Currently, most mentioned protection schemes are referred to as 1+1 protection schemes. The protection schemes can be classified into two categories: proactive protection and reaction protection. The most difference between these two classifications is that data is forwarded to the destination along the selected paths at the same time in the former one, hence it needs at least twice as many resource which is hard to realize; while in reaction protection, there are primary path and the backup path, the backup path is not used until a failure happens.

(ii) Restoration schemes are more capacity-efficient, which are used in [Lumetta and Medard 2001], [Wu et al. 2003], and [Dong et al. 2005]. When a failure is detected, it switches the failed path to a backup path dynamically. Many connections can share the fibers used in the backup route. However, since restoration introduces some delay in the recovery process, it should balance capacity-efficiency and speed. There are two kinds of restoration algorithm: one is a dynamic algorithm in which plentiful message flooding is needed to recompute the route, hence, it is fast enough to address frequent failures but introduces delay; the other one is a pre-planned algorithm which can recover from the failure more quickly.

(iii) Hybrid schemes resort to restoration when the protection fails.

VII. CONCLUSION AND FUTURE WORK

With the increasing need of WMN, recovering from link failures and base station failures has become one of the most significant issues. In this survey, we have reviewed the WMNs, link failures in WMNs, base station failures and the solutions for them.

We would like to mention that the fault-tolerance field in WMNs is still active and many new approaches are being proposed. It is high time to improve the efficiency of fault tolerance in WMN for base station and link failures. More solutions are required to achieve a fault tolerant WMN by the researchers. The backbone coverage can be improved further as stated in [16] and [17]. We need new technologies, algorithms and implementations in this field. The papers providing the solution of backbone coverage can be implemented for achieving a better connected WMN.

As it is the major issue in current state of WMN. We can't negotiate on the fault tolerance strategies for WMN failures. So, it has become a necessity to get a complete approach about the base station failures for the researchers so that the appropriate steps can be taken further for managing it. It will be showing a brief story of the approaches taken till now and the further modifications required for handling base station failures.

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