A Survey of Recovery Techniques in Wireless Mesh Networks

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ABSTRACT
As communication services turns very important in disaster affected areas, the recovery of the remaining infrastructure becomes very much necessary. Wireless Mesh Network (WMN) serves as a cost effective technology that provides backbone infrastructure to yield city-wide network access. Due to the self-recovery characteristics of Wireless Mesh Network (WMN), it has been used as an appropriate solution for network access in disaster areas. Several techniques have been proposed by many researchers for efficient recovery of WMN. In this survey, we particularly focus on such techniques and provide conclusion on the advantages of these techniques.

Keywords
Wireless Mesh Networks, Mesh Gateway (MG), Access points, Movable and Deployable Resource Unit (MDRU), Virtual Access Point (VAP)

1. INTRODUCTION
The recent advancements in mobile devices such as web-browsing, powerful processing and large storage capacity have changed their use from simple communicating units into powerful handy computers. This requires a ubiquitous broadband Internet access. Wireless Mesh Networks (WMN) is a next generation of wireless network which provides better services. WMN comprises of nodes which serves as mesh router and mesh clients. Every node works as a host as well as a router. It performs the operation of forwarding packets on the side of other nodes which may or may not be within transmission range of their destination.Efficient and reliable communication is very necessary during recovery after natural or manmade disasters.For rescue operations, safety information such as number of victims, ocation and safety status is essential.

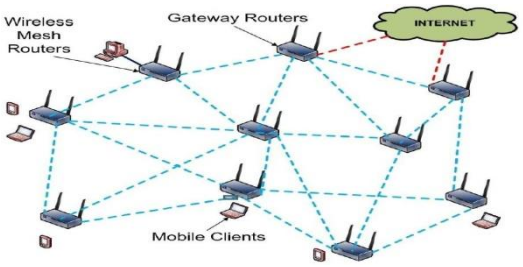

Fig 1. Basic Wireless Mesh Network infrastructure.

Communication also plays an important role for people to access the network so that they can convey their safety status to the rescuer. So a momentary communication infrastructure is vital to ensure required communication services.

When most of the part of a WMN is destroyed, the remaining network elements should be able to provide the network services. A number of still-active access points (AP) are always present which can be used for network recovery. These APs are generally located across the disaster area. The APs must be able to quickly connect to nearby Internet access services. This network establishment should be quick and transparent to the victims. This is because the victims cannot be presumed to execute setup operations [4].In order to achieve this, there are two challenges that must be overcome:

- Building up a network that holds the user devices without requirement of any efforts from the users.
- Configuration of addressing, routing and designating the nodes in the network in an automated and simple way.

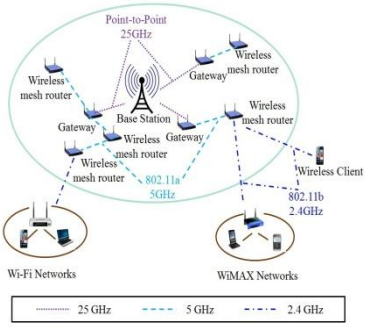

Fig 2. Internetworking Wireless Mesh Network

In a certain area, method to choose a mesh router as the gateway to provide maximum available system throughput has been a key issue in recent years. The goal is to easily and quickly find the candidate gateways that maximize the system throughput. Using this gateway the devastated network can be connected to the external network.The rest of this paper is grouped as follows. In section II, a brief explanation of WMN deployment is given. Section III presents the different approaches for recovery process of WMN. Finally, we conclude the paper in section IV giving a comparative description of these technologies.

2. WIRELESS MESH NETWORK DEPLOYMENT

A wireless mesh network (WMN) is a mesh topology of radio nodes organized to form a communication network. WMN is a type of ad hoc network. Wireless mesh network generally comprise mesh routers, mesh clients and gateways. The mesh clients can be wireless devices such as cell phones, laptops, etc. The mesh routers are used to forward traffic which passes from the gateways.

The nodes not only act as an end user but also perform function of a router.

WMNs have received increasing attention due to their various attractive advantages [1], like low up-front cost, easy network deployment, stable topology, robust-ness, reliable coverage, and so forth. Since WMNs can be easily deployed without wire lines among wireless mesh routers, they allow fast recovery for network access services in disaster areas even if the existing network infrastructures have been enormously destroyed by terrible earthquake, tsunami, and so on. WMNs inherit the useful characteristics from the ad hoc network paradigm, with the power of self-evolution, self-restoration, and self-management [12]. In particular, these characteristics are widely applicable for the disaster recovery application.

As shown in Fig.2 an example of WMN infrastructure designed for an actual disaster area is considered. Here, the network is divided into three hierarchies. The top hierarchy is deploying a base station located at the center of the wireless mesh network to take charge of the whole area, choosing a certain number of wireless mesh routersas gateways, and establishing a connection with each of them by point-to-point with 25GHz band. The middle hierarchy consists of wireless mesh routers that make up the network backbone with one or more of these nodes directly connected to the base station as the gateway, in which the standard, 802.11a with high frequency band (5 GHz), is used in the network backbone. The bottom hierarchy consists of mesh clients that are deployed at the edge to communicate with the mesh routers by using 802.11b with 2.4 GHz.

3. RECOVERY TECHNIQUES

WMN being a classification of wireless communication network provides various advantages such as self-forming, self-healing and self-organisation.Many factors affect the performance of wireless mesh networks e.g., location of wireless mesh routers, channel assignment, scheduling transmission, etc.Selection of different mesh routers as the gateway, results into different network performances. Throughput is one of the major criteria to evaluate network performance.

There are various techniques as described below for network recovery:

3.1 MDRU Based Network Architecture

In this technique a Movable and Deployable Resource Unit (MDRU) is transported to the affected area [8]. This can be done by either air or ground transportation like truck or helicopter. The MDRUs are huge communication device composed of various communication equipments which has connectivity to outside network infrastructure like Internet through fiber optic or any other techniques.After MDRU arrives at the affected area, it will commence an initialization signal which can propogate through a large distance. Any still-working AP which receives this initialization signal and it will switch its working mode from normal AP to Mesh Router. these MRs will then construct a backbone network with a Mesh Gateway in that area. Multiple MDRU can coexist in a specific area to provide better coverage and system performance. The MDRU based WMN technology has two main advantages:

1. Coverage enhancement:

Performance of the mesh network is improved by the number of MRDUs availabe. The coverage can be improved by incresing the number of MRDUs, ensuring that they are not allocated for exactly the same location.

2. Capacity improvement:

Optimum channel allocation results into ni interference among each MRDU cell. The overall capacity is given by

$$C_{n\,f\,t} = C_{channel} \times num(MDRUs)$$

where num(MDRUs) stands for the total number of MDRUs used [8]. The equition shows that the capacity of the network increases with the increase in number of MDRUs deployed.

3.2 OEMAN Design Approach

The approach is to on-the-fly establishment of multihop wireless access networks (OEMAN). OEMAN expands Internet connectivity using remaining APs to the victims with the use of their own devices [4].

The formation of extended network connectivity is shown in Fig 3. After the distruction of all main components of the infrastructure such as routers, basre stations, etc. the Internet access for any user in the affected area has been disconnected (Fig 3a). The closest mobile node to the still-alive AP, such as MN1, will attempt to associate with this AP (Fig 3b). This would result in initialization of OEMAN. The required softwares are downloaded at MN1. This will lead to conversion of MN1 into Virtual Access Point (VAP). This results in extension of the network access to further nodes (Fig 3c).

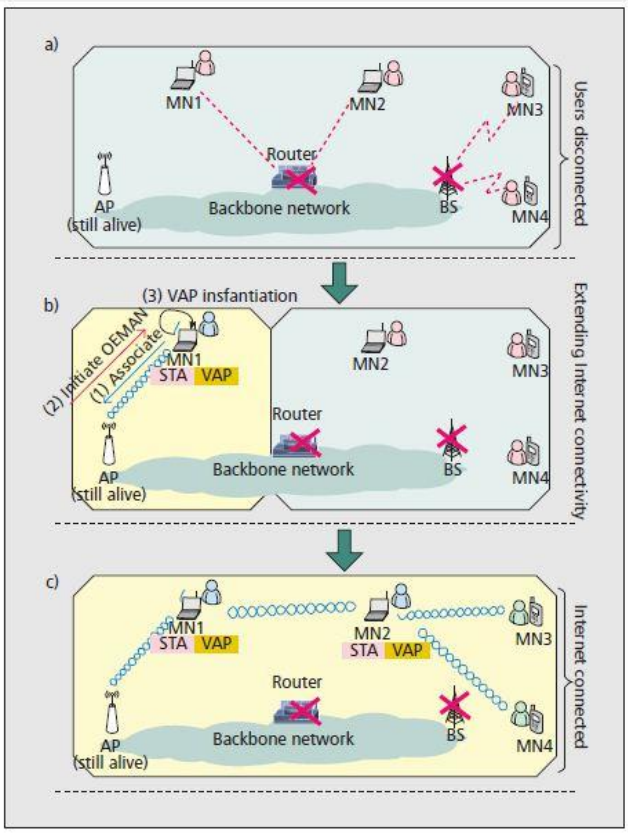

Fig 3. OEMAN establishment: a) Failure of Infrastructure; b) Extending the Internet; c) Wireless access network

Thus the configuration software for OEMAN will be transferred and installed to all the nodes which associates with the VAP. After connection all the intermediate nodes becomes VAP and provides connectivity in its proximity (Fig 3c). This technique utilizes the on site assets to provide on demand wireless networks, it is cost effective as well as fast. This approach satisfy the demand of quick emergency response.

3.3 Selection a Wireless Mesh Router as Gateway

The WMN can be easily and quickly recovered by selecting a gateway that connects the network to external network. Thus they allow us to quickly recover network access services in disaster areas even if the existing network infrastructures have been enormously destroyed.

In a certain area, how to choose a mesh router as the gateway to provide maximum available system throughput has been a key issue in recent years. The goal is to easily and quickly and the candidate gateways that maximize the system throughput. Using this gateway the devastated network can be connected to the external network [12].The goal is to easily and quickly find the candidate gateways that maximize the system throughput without solving a complex optimization problem which includes a large number of parameters and involves heavy computation load.

The base station can select a number of wireless mesh routers as gateways, and establish a connection with each of them. Particularly, due to the base station supports one channel,the mesh routers connect to each other by the single channel. Only one gateway is considered in a certain area. If there are multi-gateways, the problem can be solved by separating the nodes related to one gateway from nodes associated to other gateways.

In the disaster area, when we prepare to deploy a wireless mesh network to recover communications, it is inevitable situation that a number of mesh router nodes take on heavy loads and others are light. Under this case, the gateway cannot be deployed in the center of the network, since different nodes as the gateway will bring different system throughput. Therefore, we need to select an optimal node as the gateway to ensure the maximum throughput in the network. Furthermore, the throughput depends on the theoretical maximum throughput and the bottleneck collision domain. The maximum throughput can be exactly calculated as a constant value. In other words, the bottleneck collision domain is the key factor that affects the optimal throughput in the network. As a consequence, the mesh router node who has the smallest bottleneck collision domain should be choosen as gateway.

This approach of selecting a gateway has advantage of its simplicity and reduced computational load. This also utilizes the remaining infrastructure on site.

4. CONCLUSION

In this paper, we explained the different techniques that can be utilized for the recovery of WMN in disaster affected areas. All the approaches differ in some of the other parameter. The MDRU based network provides better network capacity and coverage, whereas it requires greater number of MDRUs. This would result in increase of resources needed. The remaining two techniques have an advantage over the first that it utilizes the remaining infrastructure for the recovery process. However the gateway selection method is more suitable for disaster areas as it is quick and does not require any installation process.

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