Chapter 16
Load–Balanced Multiple Gateway Enabled Wireless Mesh Network for Applications in Emergency and Disaster Recovery

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ABSTRACT

A gateway node in a WMN acts as bridge between mesh nodes and the external network in order to exchange information between the wireless mesh network operating in a disaster stricken area and remotely located rescue headquarters and government agencies. Using a single gateway, WMN creates huge congestion on the routes to the gateway, as all the data traffic may travel in the same direction using longer routes to access the gateway node, causing channel contention between nodes that operate within carrier sensing range of each other. Therefore a multiple gateway environment is crucial during WMN application in emergency and disaster recovery. This paper presents the design and implementation of a Load-Balanced Gateway Discovery routing protocol called LBGD-AODV, which provides multiple gateway support in Wireless Mesh Network. LBGD-AODV is designed as an extension to the Ad hoc On-Demand Distance Vector (AODV) routing protocol and uses a periodic gateway advertisement scheme equipped with an efficient algorithm to avoid congestion by establishing load-balanced routes to the gateway nodes for Internet traffic. The evaluation tests show that the LBGD-AODV has not compromised the efficiency of basic AODV routing and has improved the performance of the network.

1. INTRODUCTION

Natural disasters such as earthquakes, tsunami, hurricanes and cyclones can affect large geographical areas resulting in significant impact on the network infrastructures, such as water, electricity, transport and communications. A quick response to provide the disaster rescue operation in affected areas is very critical to saving many lives. For example, people trapped under collapsed buildings and landslides in the disastrous stricken areas may have a greater chance of survival if they are rescued within 72 hours. As these disasters are increasingly becoming common threat facing mankind, ensuring effective disaster response, mitigation and recovery has become an important and growing topic for the research community worldwide. One of the major aftermaths of these disaster situations is the destruction of the traditional infrastructure of communications. The loss of communication systems makes rescue and relief operations extremely difficult which results in heavy loss of lives. Therefore establishing a temporary alternative communication network to support emergency communications is one of the most urgent tasks in a disaster rescue mission.

The nature of Wireless Mesh Network (WMN) makes them suitable to be deployed as an alternative communication network to facilitate an emergency and disaster recovery operation. WMN provides a useful and feasible solution for communication services in extreme emergency situations where the fast and effective deployment of a communication network infrastructure is impossible.

Rescue teams in each stricken area consist of a few trained professional squads: police, army, fire fighters, medical professionals and potentially many hundreds or thousands of disorganized volunteers. During large scale disasters these rescue teams have to work simultaneously at different disaster affected geographical locations as shown in the example scenario Figure 1. Therefore an emergency response usually requires a central control to coordinate the rescue efforts being carried by different teams at different locations. WMN provides that central control through gateway nodes which connect to the backbone external network, thus building a bridge between the WMN and external networks in order to share and exchange the critical information via www, email and FTP. It enables the command centers to learn about on-going situations to allocate and guide the rescue teams.

A mobile truck or van with satellite terminals can be used as an onsite command post at the scene of disaster to provide a gateway Internet connection for disaster areas and enable communication between the disaster site and headquarters. In a WMN, all the nodes on the network route packets destined for external networks to the gateway node, thus maintaining a good throughput to a gateway node becomes a primary goal for each mesh router to efficiently provide data services such as www, email and file transfer between the WMN and external network. Topology design and routing play a vital role when it comes to performance challenges such as maintaining an efficient throughput. Since the WMN is a multihop network, in order to reach a gateway node on the network the mesh nodes have to depend on routing protocols operating in the network layer.

Most of the routing protocols use the shortest path between source node and destination node as main routing criteria. The performance of data exchange between mesh routers and a single gateway node in a WMN decreases as the hop distance increases. A packet travelling on longer routes requires more intermediate nodes to forward the packet between the source and gateway nodes. This results in network congestion due to channel contention among the nodes operating within carrier-sensing range of each other. Application of WMN in disaster recovery may require the network to cover a larger stricken area. If a single gateway node is used to cover a larger network then all the traffic originated within the network

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