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Improved QoS Routing performance in Hybrid Networks for Disaster Management

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Abstract: Wireless technologies play a vital role for disaster management and Military applications. Mobile Ad hoc Network's (MANET) provides more flexibility, highly dynamic and reliable network in disaster areas. Satellite network's covers huge area and make communication quickly and efficiently. In existing we implemented communication networks like MANET and satellite network separately for its applications. In order to improve the routing performance and flexible communication in disaster sites we combine both MANET and satellite networks. In comparison with existing AODV and AOMDV, the proposed hybrid network could achieve high throughput, greatest packet delivery ratio, and low utilization of bandwidth, lower delay and control overhead; for the meantime it also provides load balancing in terms of traffics at gateways to maximum satellite links' utilization.

Keywords: *Hybrid networks; satellite links; QoS; load balancing, disaster management.*

1. INTRODUCTION

Disasters like floods and earthquakes are serious disruption cause environmental losses and impacts of huge damage to buildings and human lives in addition of affecting economic losses. For example, the 126 earthquakes have been observed at the magnitude of 6.0-6.9 all over the world at the year of 2016 and ranked first death toll 676 at Ecuador [1]. In 2004 on 26 December, the earthquake named as tsunami occurred at Indian Ocean killing 230,000-280,000. In 2015 on 25th April Nepal earthquake named Gorkha earthquake, which killed nearly 9,000 people and injured about 22,000.Recently on Dec 2015 Chennai affected heavy flood causes more than 500 peoples killed [2].

In most of the situations, the disaster management teams and independent rescue peoples would go to the affected area immediately as soon as possible to rescue peoples and save economic losses. Due to the sudden disaster either it may be natural or artificial disasters, infrastructures based network like mobile base stations and antennas could be completely damaged. Hence, the lack of communication problem due to failure of infrastructure based network, the rescuers would slow down rescue operation, which might losses more human lives and economic loss.

Due to the basic characteristics of flexibility and infrastructure less, the Mobile Ad hoc Network (MANET) and satellite networks are suitable for disaster areas to establish communication. In wireless network MANET does not require infrastructures, like an Access Point (AP) or Base Station (BS), to perform communication. Mobile nodes in the MANET act as both router and transceiver to form self-organized wireless network and they communicates directly to each other [3]. Another potential characteristic of mobility in MANET helps to create dynamic topology using this deploy different range of mobile nodes in disaster areas. So, MANET is well suited for disaster affected area to perform rescue operation by using communication. Normally, a Satellite networks cover a wide area and many satellites provides global coverage area.

Based on the location of the orbits satellites are divided into three broad categories, named as Low Earth Orbit (LEO) which works < 2*k* km from earth surface, Medium Earth Orbit (MEO)which works 5-15*k* km above earth surface and Geostationary Earth Orbit (GEO)which lies on 35786 km from earth surface[4]. In Existing the hybrid network of mobile networks and satellite networks for commercial applications like connecting different mobile base stations, point of sale,VoIP,Broadband internet access etc..

In our research, we propose a new hybrid network with the combination of Mobile Adhoc Network-satellite networks with the advantage of global coverage, flexibility and high reliable for disaster management to fulfil Quality of Service (QoS) requirements. The new hybrid network performance is analyzed and compared with popular reactive routing protocols, *i.e*. Ad hoc On-demand Distance Vector routing (AODV) and Ad hoc On-demand Multipath Distance Vector routing (AOMDV). In our previous research, we implemented hybrid networks with proactive routing protocols like DSR, OLSR could not achieve agreeable performance. The performance of the hybrid networks are evaluated based on throughput, Packet Delivery Ratio (PDR), and average end-to-end delay. Finally the best result achieved compare to the existing routing protocols and load balancing also improved through global coverage of satellite. This paper has the following sections: Section 1 consist of analysis of disasters and its causes, satellite network basis and its types based on orbit range and implementation of hybrid network. Sections 2 consist of proposed hybrid network architecture. Section 3 describes methodology of the proposed routing scheme .The performance of proposed routing scheme evaluated in Section 4. Finally, conclusion of the proposed work and thoughts to extend future work are added in Section 5.

2. HYBRID NETWORK ARCHITECTURE

To provide high mobility with MANET and global coverage with satellite network formed hybrid network, the combination of MANET-Satellite Networks provides well suited communication to disaster areas on earth. The most advantage of this hybrid network is infrastructure less and easy to deploy network in affected areas with absence of mobile networks. The proposed hybrid network is shown in Figure 1.

In Figure 1 shows, MANET implemented in disaster area, and satellite radio links carries information packets between the disaster area and the main network gateway at the HeadQuarter. The dotted lines symbolize for wireless communication links. Every disaster management team peoples uses a hand-hold device for transmitting data; consequently these hand-hold devices perform as the mobile nodes in MANET coverage area.

As explained above, in MANET all the mobile nodes transmitting information to the Headquarter (HQ) through satellite radio links. The Headquarter placed distance far away from the disaster area. Due to the lack of energy consumption and cost reason the mobile devices in the MANET could not be directly connected to satellites. Basically, the rescue operation peoples having vehicles to integrate information from mobile devices in disaster areas. Satellite antennas or dishes fitted on the vehicles, so these vehicles might operate as gateways (GW). By using these gateways mobile nodes are connected with satellites and information passes to HQ. One or two of the mobile devices in the MANET directly connected to satellites with special interface. Hence, the gateways (GW) act as a part of the terrestrial Mobile Adhoc network; Information packets are passed between mobile devices and gateways using ad hoc method.

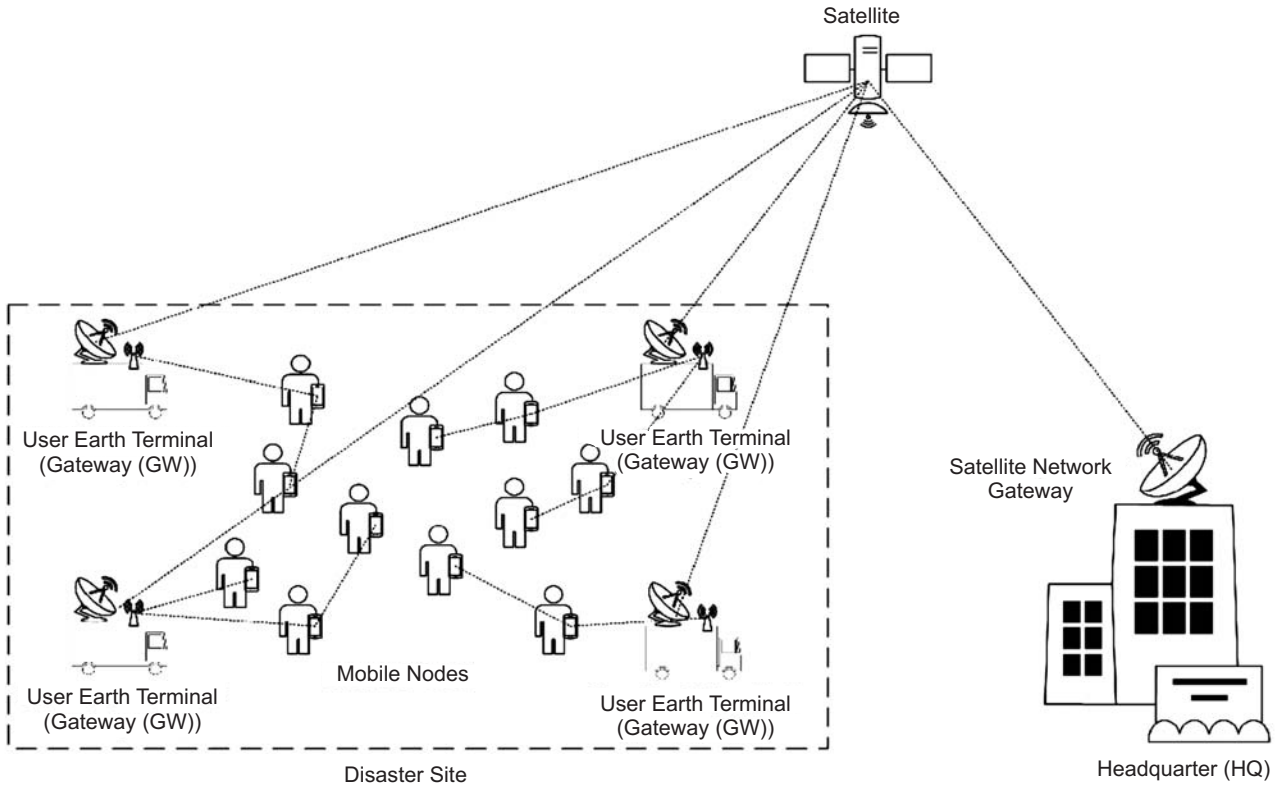

Figure 1: Hybrid Network Architecture

3. PROPOSED METHODOLOGY

In disaster management, the rescue people collect information about survey of disaster and transmit in the form of packets to gateways (GW). By comparing the end-to-end delay of a packet could be less important as long as the delay is not dramatic; for instance, with a reduction of a few seconds delay achieved and it could not direct to considerably result variation in life time saving. Based on assumption above, we focusing the performance of routing protocol on PDR, and achieved the result metrics will be less weighted.

In a proposed hybrid network, gateways act as a bridge which is used to connect both MANET and Satellite network. But the gateway performance would be the bottlenecks of network's performance compared with the performance of mobile nodes [5]. Normally in hybrid network consists of more number of gateways, so detection and selection of gateway among several is critical one.

3.1. Detection of Gateway (GW)

As explained above, gateways in the hybrid network are considered as mobile nodes in MANET. So, the efficient MANET routing protocols also used to detect gateways in hybrid network.

In proposed scheme, due to the mobility features of mobile Ad hoc network the movements of mobile node patterns in every mobile node moving at random within the disaster area with normal speed. The proactive routing protocols could not provide reliable connection between for all nodes in MANET and it is proved already in our previous research [6]. Due to the reason, we implement reactive routing protocols in hybrid network for disaster management. During Route discovery process source node flooding control packets like Route Request (RREQ) and get Reply (RREP) from destination node for route discovery using the reactive routing protocols, like as AODV or AOMDV [7].

3.2. Selection of Gateway

In usual mobile networks, each mobile nodes are connected to the Access Point (AP). The mobile node before transmitting data to others it should try to connect with AP.After connection made with AP the mobile nodes transfer data to destination. But the main disadvantage of this mechanism is if a mobile node has located faraway from its connected AP, its data transfer could involve relaying with many other nodes in which it would achieve to more delay, more bandwidth utilization and infrequent low PDR.

In our proposed methodology, the concept of multipath routing used in AOMDV which is also used in the selection gateway process [8]. Based on the following three metrics like available bandwidth, Delay and Reliability, every node monitors the status of gateways (GW) and specific location connected to the mobile nodes. Three metrics are:

1. **Available bandwidth:** The residual bandwidth available along the path from source node to gateway. Hence, bandwidth BW from source node n_{sr} to gateway node n_{gw} is

$$\text{BW}\ (n_i, n_{gw}) \quad = \quad \min\ bn_i\ n_{i+1} \tag{1}$$

Where i ranges from 0 to $n-1$ and n is the number of hop count in a path, n_i is the i^{th} node from source mobile node n_{sr}, $bn_i\ n_{i+1}$ is the residual bandwidth between from node n_i to node $n_{i+1.}$

2. **Delay :**The overall variation of the delay in data transmission from source node n_{sr} to gateway node n_{gw} is :

$$\text{L}\ (n_{sr\ ,}\ n_{gw}) \quad = \quad \sum_{i=0}^{n=1} dn_i\ n_{i+1} \tag{2}$$

Where $dn_i\ n_{i+1}$ is the variation of delay from node n_i to node $n_{i+1.}$

3. **Reliability:** Ratio of total number of packets successfully received by receiver from overall packets sent from sender. It is denoted R from source mobile node n_{sr} to gateway node n_{gw} is :

$$\text{R}(n_{sr\ ,}\ n_{gw}) \quad = \quad \prod_{i=0}^{n=1} rn_i\ n_{i+1} \tag{3}$$

Where $rn_i\ n_{i+1}$ is the reliability from node n_i to node $n_{i+1.}$

The Normal AOMDV routing protocol finds two routes with least cost metrics to reach destination node. The first route based on low cost and second one used when first route fails [9].

ALGORITHM: Gateway Selection in Hybrid network

1. Initialize N number of nodes with the condition
   for($n = 0$; $n <$ node ; n ++) {
2. If (routing table is empty or not updated list) { then
3. Update }
4. Endif
5. Else {
6. for ($i = 0$; $i < gw$, i ++)
7. Q_i = Bandwidth(BW) + latency(L_i) + Reliability(R_i)
8. }
9. Sorting Qi from decending order
10. }
11. Select gateway(gw) with highest Q value
12. Select next node based on routing information gateway is selected in routing table
13. }

The AOMDV routing mechanism provides more flexible compare to AODV routing protocol. Such the way of routing doesn't include other quality of service metrics such that security, control overhead etc. During implementing the two types of routes in data transmission it affect the packet ratio. Due to that the selected route among all possible routes is not efficient for data transmission. In proposed hybrid network the variation of delay considered for selecting shortest path route with less hop count from source node to destination node. The other parameters available bandwidth and reliability is used to balancing the gateways in hybrid network. Because, mostly we use large coverage area with more number of nodes and deploy network in disaster area. Ultimately we use more number of gateways to reduce traffic in network. In order to balancing gateways use satellite links for carry data to satellite gateways.

In discussion with Gateway Selection Algorithm, initialize all required nodes with coverage limits and check for routing table updating required if any. Calculate link quality (Q) based on available bandwidth and reliability of network. The quality value increasing based on the coefficient value α. Perform sorting link quality value Q from highest to lowest value and select gateway with highest link quality Q value. Finally select next node based on gateway selected information available in routing table.

4. SIMULATION RESULT

In order to evaluate the performance of the proposed hybrid network, compare the reactive protocols AODV and AOMDV with proposed scheme using network simulator-3.Simulation experimented in two types of network such as normal mobile ad hoc network (MANET) with terrestrial gateways and satellite links. Considered as a square shape disaster area in which consists of gateways at each corner. Using vehicles we carry satellite dishes and through that pass the signal to satellite. The size of the simulation area is selected as 600 m x 600 m. Based on the real number value 62 mobile nodes are used. (*i.e.*) 62 rescue operation peoples. The mobile nodes randomly move anywhere within the coverage area. Normally satellite radio links could not disturb mobile ad hoc network performance so Geosynchronous Earth Orbit (GEO) used in simulation. The simulation runs after 4200 s with 720 s for successful delivery of data packets from satellite to Headquarter (HQ).

Table 1
Simulation Parameters

Parameters	*Metrics*
Area Size	600 m x 600 m
Number of Gateways	4
Number of Nodes	64
Upper limit Moving Speed	1.5 m/s
Type of Satellite	GEO
Simulation Duration	4200 s

TCP is a most reliable protocol to provide guarantee packet delivery and UDP used for real time video and audio packet transmission hence both TCP and UDP used in disaster area to perform rescue operation. Hence we evaluate performances like PDR and throughput and end-to-end delay of both AODV and AOMDV with proposed hybrid network.

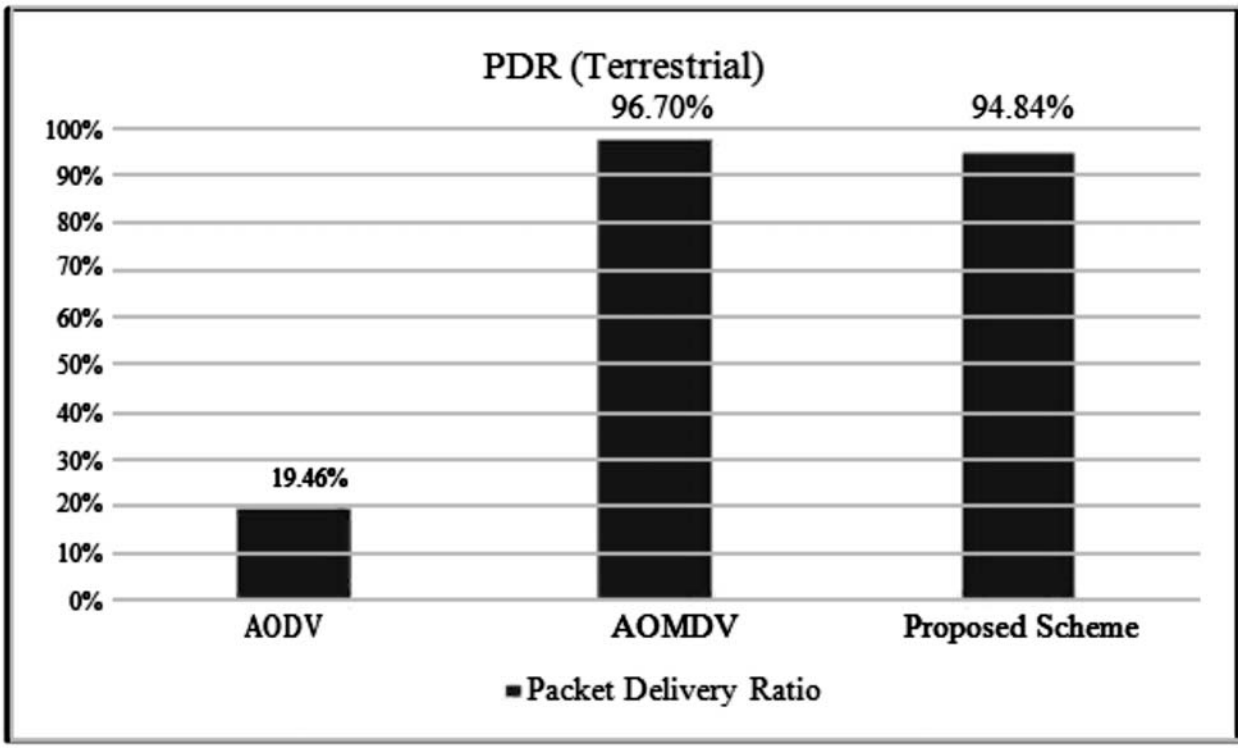

Figure 2: Packet delivery ratio (terrestrial part)

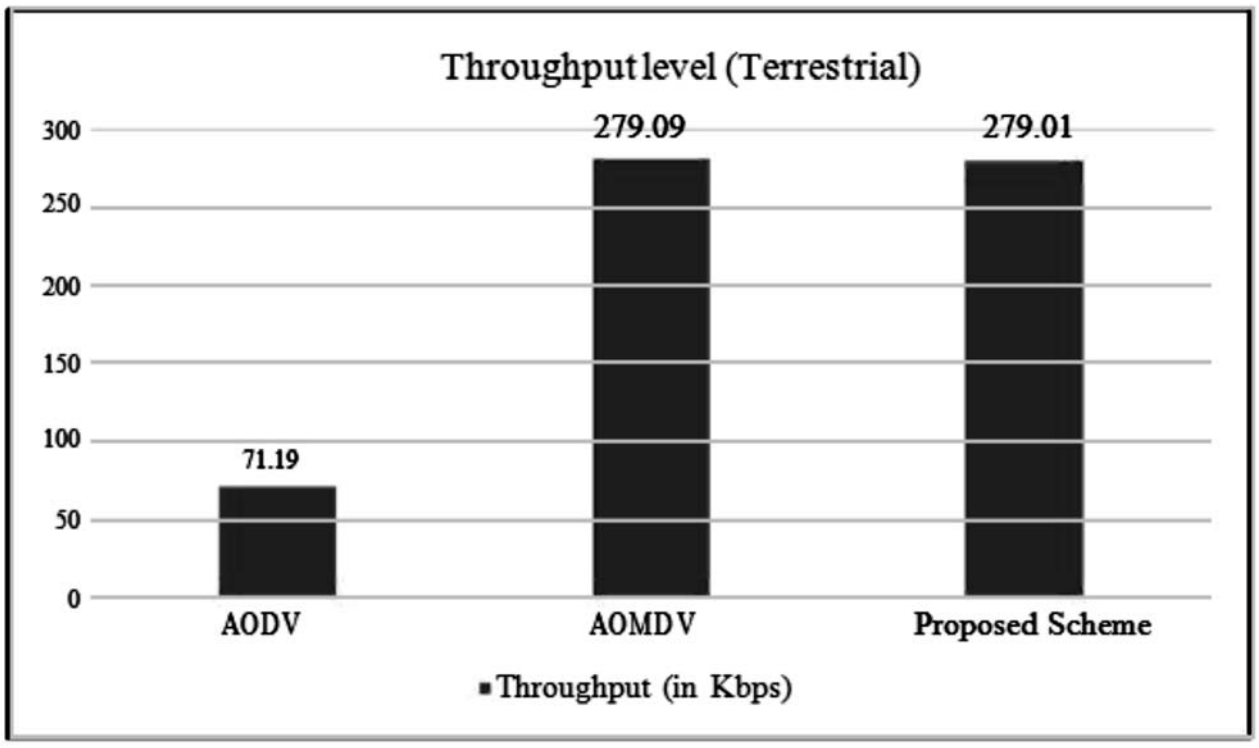

Figure 3: Average throughput (terrestrial part)

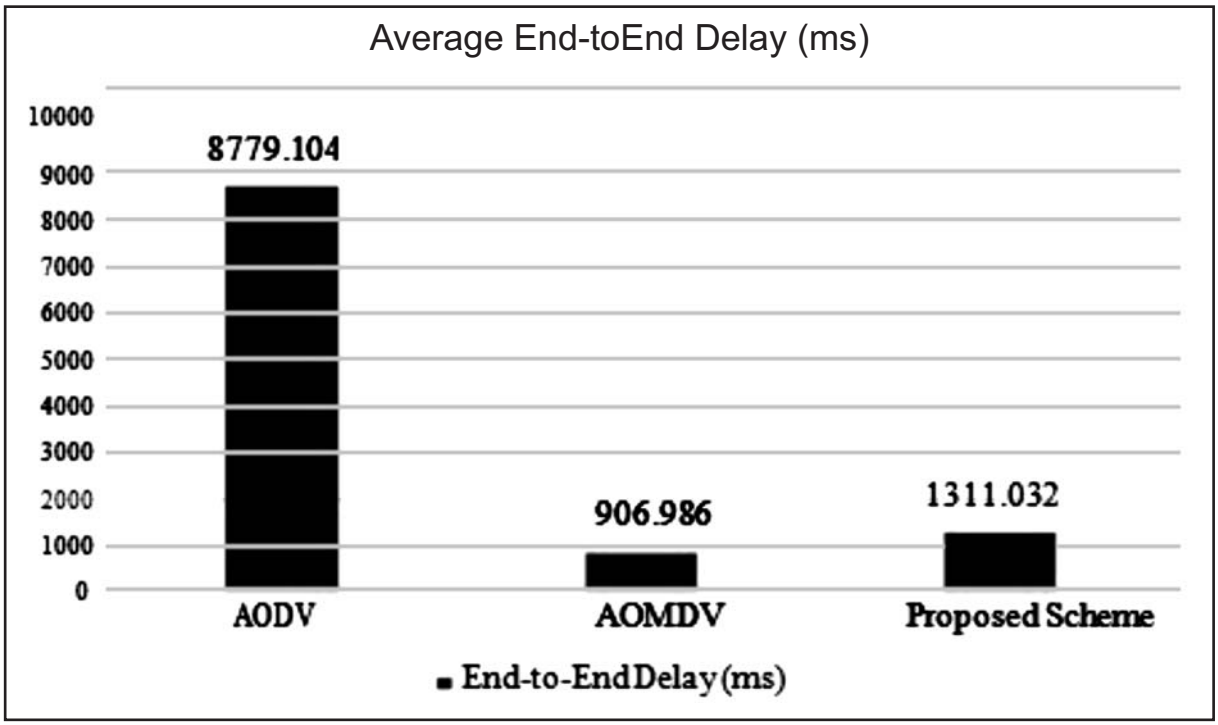

Figure 4: Overall average end-to-end delay

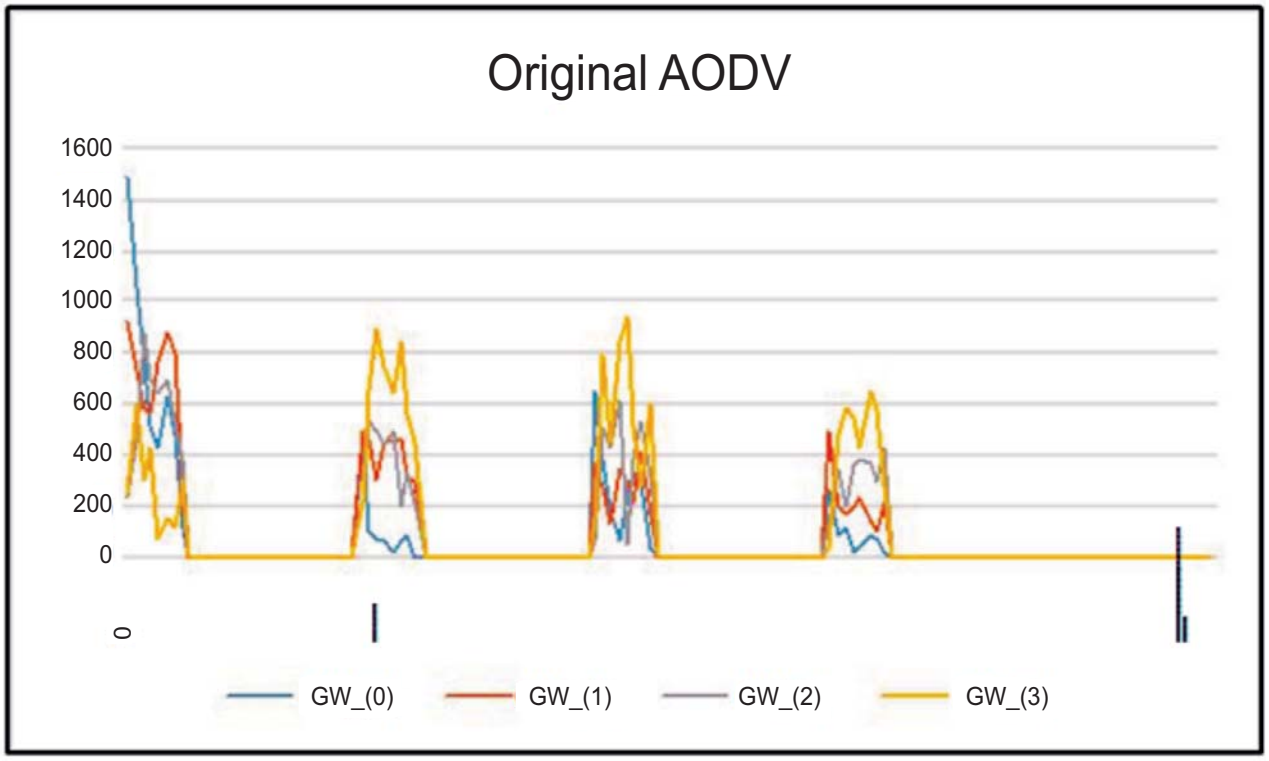

Figure 5: Normal AODV

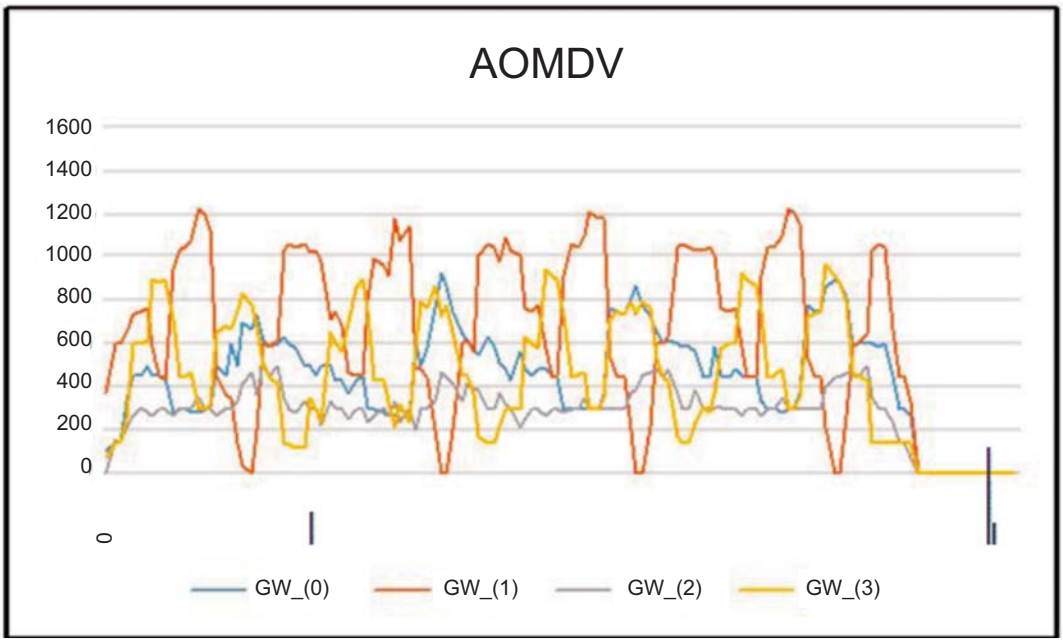

Figure 6: AOMDV

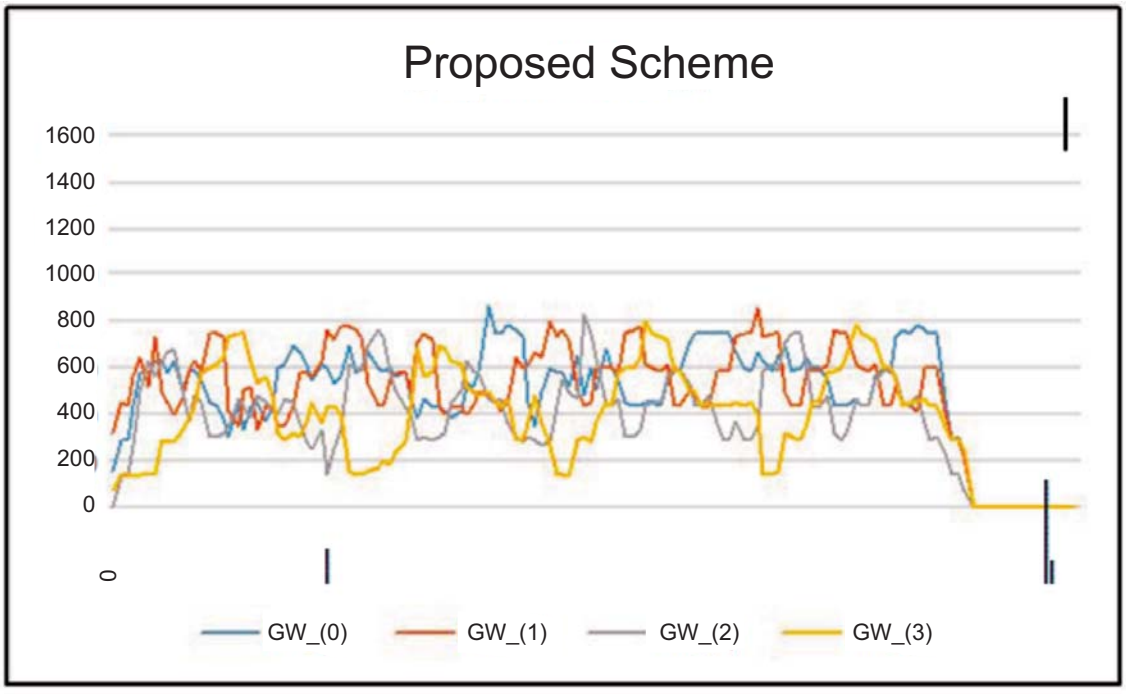

Figure 7: Gateway's (GW) traffic loads

In Figure 2,3 and 4 all mobile nodes are connected to terrestrial gateways for communicate satellite, so MANET performs lowest packet delivery ratio, normal throughput, and high end-to-end delay. Hence, the routing protocol AOMDV and the proposed hybrid scheme give similar performance. In proposed scheme information passing from MANET to HQ and it takes additional time compare to within MANET. So the

performance of Packet delivery ratio, throughput, and its delay is slightly lower than AOMDV. Moreover, such less amount of delay difference could not imply a considerable impact on disaster area communication scenarios. In order to show the performance in terms of load we compare the performance of MANET routing protocol AOMDV and our proposed hybrid network. Monitoring Gateways (GWs') load over time shown in figure 5,6 & 7.

In comparision with Figure 5,6&7,the traffic load of data packets at GWs in the propose hybrid method are high balanced than AODV and AOMDV protocols; the total numbers of packets received at each gateway move away less numbers in the proposed hybrid method than in AODV and AOMDV protocols as well. These actions increase maximum satellite links' utilization and avoiding unanticipated traffic bursts which may direct to communication failure [12].

5. SIMULATION RESULT

As explained above, our proposed hybrid network scheme could improve Quality of service requirements for disaster management. In normal routing protocol mobile nodes randomly choose gateways and there is no specific gateway assigned by routing protocols. But the proposed hybrid method dynamically monitors status of the gateways and selects the most appropriate one when a node wants to transmit packets.. This hybrid proposed scheme gives better QoS parameters than the terrestrial MANET routing protocols in the case of disaster relieves and management. We achieved the result of passing disaster information from disaster site to normal area without any base station using satellite networks.

1. Future work will concentrate on both satellite network and MANET part, which includes:
2. Analysis of performance difference on LEO, MEO and GEO satellite systems;
3. Evaluate, the satellite link quality of both uplink and downlink with hybrid network;
4. Design a new routing protocol for satellite networks with substantial LEO satellites;
5. Apply the hybrid network for various reactive routing protocols.

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