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Quality of Service Routing for MANET and Internet Hybrid Network to Support Communication Restoration Teams in Disaster Situations

JAMAL MUAFAQ HAMEED AL-BAYATI
Faculty of Mathematics
University of Belgrade
11000 Belgrade, Serbia
E-mail: jamrafab@yahoo.com

This paper proposes a novel scheme to support communication teams in emergency and disaster situations. First, the multicast ad hoc on-demand vector (MAODV) routing protocol is modified to integrate a wireless MANET into a wired network. The modified routing protocol is called wired MAODV (WRD-MAODV). Second, we implemented proactive, reactive, and hybrid approaches for internet gateway discovery in a multicast environment based on the proposed WRD-MAODV routing protocol. Third, we implemented a hybrid gateway discovery approach that combines the proactive and reactive approaches, and compared with the previous similar solutions proposed in the literature; the positive results show a considerable improvement in routing overhead, packet delivery ratio, and end-to-end delay.

Keywords: integration technology, MANET, hybrid gateway discovery, MAODV, QoS

1. INTRODUCTION

Integration technology is the backbone of large-scale rescue operations in situations such as fires, earthquakes, and floods. This technology has a crucial role in disaster situations especially during the first 24-48 hours to help restore vital communication links that guarantee the flow of vital information to government agencies and other parties involved in rescue operations.

The integration technology is superior to the other solutions in many ways, most important of which is the speedy formation and swift establishment in a disaster environment, despite the loss of telecommunications infrastructure.

Fig. 1 shows the proposed structure scheme for the integration of a wireless MANET and wired network.

Mobile ad hoc networks (MANETs) consist of many autonomous mobile nodes that can communicate with each other over a wireless connection, which are thus highly flexible and do not require any additional infrastructure to assist in the network, such as base stations (BS) or access points (AP).

In the same context, the routing protocols in MANETs are designed to perform a vital core function to specify how mobile nodes communicate data packets with each other, and distributing information that enables them to select routes between any two nodes in a wireless MANET.

On the other hand, wired networks transfer data using wire-based communication

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technology, and have advantages of high-speed data transfer and maintaining signal integrity for longer distances. These are typically connected to external networks to provide internet access.

An important part of the integration structure known as an internet gateway device is shown in Fig. 1.

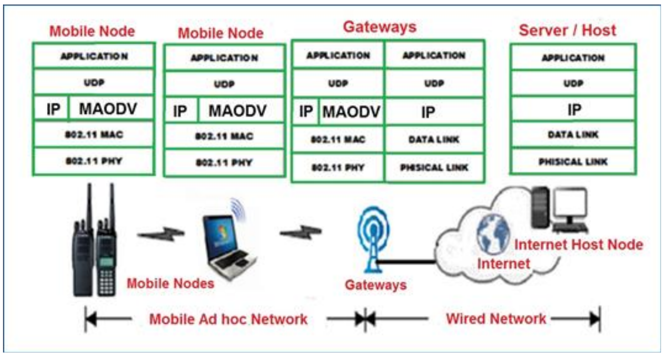


Fig. 1. MANET-Internet integration structure.

In telecommunications, the term internet gateway device refers to a part of networking hardware for interfacing with another network that uses different protocols, which is the focal point between an internet wired network and a wireless MANET. A gateway is often connected with both an internet host device and router.

Consequently, the routing protocol in a MANET should be modified in order to perform the integration between mobile nodes in a MANET and internet host in a wired network through gateways.

Furthermore, such a protocol should also be able to distinguish among different kinds of nodes, such as the internet host node (IHN) and internet gateway node (IGW).

Gateway discovery processes can be performed by selecting one of the known standard approaches (reactive, proactive, and hybrid) based on the initiator of the discovery process (whether by the mobile nodes, the gateway itself, or through both).

This paper proposes a novel scheme to support communications for emergency telecommunications team in disaster situations by integrating a wireless MANET with a wired network in a multicast environment. The multicast ad hoc on-demand vector (MAODV) routing protocol is modified to integrate a wireless MANET into a wired network. The modified routing protocol, called wired MAODV (WRD_MAODV), contains reactive, proactive, and hybrid approaches for the discovery of gateways according to the initiator of the process. To demonstrate this information as accurately as possible, our hybrid gateway discovery approach that combines the advantages of both approaches (reactive and proactive), is compared with similar solutions proposed in the literature. The results of comparison indicate that our proposed routing protocol WRD_MAODV yielded impressive results and superior accuracy over conventional approaches, particularly in terms of average end-to-end delay, routing overhead, and packet delivery ratio.

The remainder of this paper is organized as follows: In Section 2, we briefly discuss related work by various researchers, their contributions, and the mechanisms to advance issues related to the integration of the MANET-Internet. In Section 3, we give an overview of the MAODV routing protocol. Our proposed modified routing protocol is presented in Section 4 along with the three gateway discovery strategies. Section 5 describes our simulations to test the proposed method, and we offer our conclusions in Section 6.

2. RELATED WORK

In the literature, there is significant work related to the integration of wireless MANET and wired internet networks. These are mainly focused on expanding traditional routing protocols, which is the only major factor of integration, as well as implementation the proactive, reactive and hybrid gateway discovery mechanisms, or to improve these previously proposed mechanisms. Our summary is clearly intended to highlight that most of the previously proposed routing protocols for the implementation of integration strategies, including gateway discovery approaches, are only extended versions of the traditional AODV and DSDV routing protocol methods. Consequently, they will only support the unicast transfer mode.

Sharma *et al.* [1] reviewed several approaches to discovering and selecting an internet gateway to establish integration between mobile nodes in a MANET and the internet. They also provided a critical study of all these approaches (proactive, reactive, and hybrid) with reference to their advantages, disadvantages, and future trends. Furthermore, they focused on the various proposed technical solutions to improve the performance of internet gateway discovery mechanisms.

Thongthavorn *et al.* [2] proposed a new gateway discovery protocol using a location-aided directional flooding algorithm and solicitation technique to reduce the overhead of the hybrid gateway detection mechanism. The proposed protocol has been implemented and simulated based on the extended version of AODV named AODV+ proposed by Hamidian *et al.* [8]. The proposed protocol was compared with the traditional hybrid protocol and previous location-aided gateway route-discovery protocol. Their protocol achieved better performance in packet delivery rate, end-to-end delay, Gateway discovery time, and especially in routing overhead.

Pandey *et al.* [3] proposed an effective mechanism to discover and select a proactive gateway using fuzzy logic to combine latency and hop count metrics, which leads to selection of a less congested and shorter path between mobile nodes and gateways. Results of simulations showed improvements in terms of average end-to-end delay and throughput with increasing mobility and traffic load. Further, it outperformed the method proposed by Hamidian *et al.* [8] to support the mechanism of discovery and selection of the gateways.

Majumder *et al.* [4] proposed a novel hybrid gateway discovery approach by using an adaptive value for broadcast range that ensures proper utilization of the hybrid method. In this method, after receiving replies from several mobile nodes in response to an initial advertisement message, the gateway sets its range for the next broadcast based on the mean distance of all mobile nodes that have replied. This variable range allows the gateway to send the advertisement message over a long distance. The simulation result showed improvements in packet delivery ratio and packet drop, and also decreases delay in different speed for mobility model.

Saluja *et al.* [5] proposed to expand a reactive AODV routing protocol to design internet connectivity for MANETs. They evaluated the performance characteristics of the three gateways discovery approaches under a number of different mobile nodes and different scenarios by using Ns2 simulation.

Iqbal *et al.* [6] proposed a novel gateway discovery mechanism for connecting nodes in an ad hoc network to the internet. The gateway broadcasts a separate reply to the requestor (mobile node) for each request message having the same broadcast ID (BID) that it receives from that source instead of broadcasting only one unicast reply to the requestor. The AODV routing protocol has been used for routing in the MANET domain. Their findings suggest a lower delay and fewer packets dropped [7]. The authors proposed an approach for integrating MANETs with the Internet by the extended DSDV protocol named efficient DSDV (Eff-DSDV) that has been applied to provide bi-directional connectivity between ad hoc mobile nodes and the hosts node in infrastructure-based networks.

Hamidian *et al.* [8] extended the unicast AODV routing protocol to achieve interconnection between a MANET and the Internet. Reactive, proactive and hybrid gateway discovery approaches for the mobile node to access the Internet were implemented based on the initiator of the discovery process.

The goal in [2] is to reduce the routing overhead for hybrid gateway discovery protocol. The main drawback of this work focuses on two key points:

First: The proposed "location-aided" algorithm uses a purely mathematical mobility model, we can see this clearly from its inability to fulfillment work with the reactive approach within the hybrid approach, while the hybrid gateway discovery approach consists of two approaches (reactive and proactive). Second: the mechanism used for this algorithm depends on unleashing the intermediate nodes by broadcasting an RREQ message; in this case, the sender (mobile node) can determine that the destination that is accessible through the intermediate node is a mobile node and it is not a wired internet host. This problem will be addressed with an example of the protocol proposed by us.

The most important features that differentiates our work from existing research is that to the best of our knowledge, there are no prior applications of multicast routing protocol to integrated wireless MANET-Wired networks, taking into accounts the representation of gateway discovery approaches in a multicast environment. This in turn reflects our desire to improve QoS provision for the whole network.

3. BACKGROUND: DESCRIPTION OF THE STANDARD MAODV PROTOCOL

The MAODV is an extension of the AODV protocol designed to facilitate communication among multicast groups. It is dynamic, self-starting, and permits multihop communication among mobile nodes that want to join or participate in a multicast group on an ad hoc network. The MAODV operates on the principle of tree navigation, by linking multicast groups using trees and updating the tree sequence according to node behavior. Multicast groups in such a setup are allocated unique sequence numbers, which are assigned to a group leader and incremented for the participating nodes. These sequence numbers are used to establish the fastest route to any node.

The basic components of the MAODV are inherited from the AODV, such the

RREQ and the RREP. However, to implement a multicast on a group of nodes, the protocol introduces a multicast activation message (MACT) and group hellos (GRPH). The details of the protocol are given in [37].

4. NEW PROTOCOL DESIGN AND IMPLEMENTATION (WRD_MAODV)

In this section, the design of the proposed routing protocol WRD_MAODV is discussed in detail. The different design phases for integrating a wireless MANET and a wired network in a multicast environment are also explained to highlight the approach.

4.1 Problem Statement and Solutions

The main problem represents the inability of the wireless node to discover the gateways device along routes through a series of traditional RREQ messages due to heterogeneity.

Accordingly, we first propose a new solution to identify the gateway by expanding the Format transmitted RREQ messages algorithm between the gateways and the mobile node by entering a definition field for the gateway address called “GWMADV” message (as shown in Fig. 2).

Type	R	A	I	Reserved	Prefix Sz	Hop Count
GWMADV						
Destination IP Address						
Destination Sequence Number						
Originator IP Address						
Lifetime						

Fig. 2. The format of GWMADV message.

Secondly, we insert a “GWMDV_ID” field into the advertisement message format, similar to the “RREQ_ID” field in the RREQ message format. To ensure that all mobile nodes within the MANET receive the advertisement message of the gateways. In addition, this modification enables the mobile node to remain connected to a gateway while searching for a new gateway position.

Thirdly, the RREQ_IFLAG messages are modified to the IP address of the groups of gateways connected to the MANET and these requests are received and processed through gateways only. When a gateway receives an RREQ_IFLAG, it sends back as reply an RREP_IFLAG. When they are received by intermediate nodes, RREQ_IFLAG are rebroadcast to the nearby mobile nodes.

4.2 New Mechanism: Internet Integration for MANETs

The proposed WRD_MAODV routing protocol uses a multicast route discovery mechanism. When a group of mobile nodes or a member of a multicast group desires to communicate with an IHN, it first checks its multicast routing table for a route to the destination. If a path is found, communication is established; otherwise, the mobile node starts the route discovery process by broadcasting an RREQ message across the network.

The destination address of the RREQ is set to the IP address of the desired IHN, and the destination sequence number is set to the last known sequence number for that group.

When an intermediate node receives an RREQ from a multicast group that contains a path for an IHN in their routing table, the RREQ message is rebroadcast to its neighbors. As the RREQ is broadcast across the network, nodes set up pointers to establish the reverse route in their multicast routing tables. A mobile node receiving an RREQ first updates its multicast routing table to record the sequence number and information concerning the next hop for the source node. If the routing table of the intermediate node contains the next-hop address for the IHN, under normal conditions, the intermediate node responds to the origin of the RREQ message by rebroadcasting an RREP message. However, this presents a problem because the group multicast believes that the destination that is accessible through the intermediate node is the mobile node and not an IHN.

To solve this problem; firstly, we prevent any intermediate node from rebroadcasting an RREP message to a multicast group if their routing table indicates that an internet host is the next-hop address. Secondly, a new function is added by modifying the "Route Handling Functions" in the MAODV source file. The new function is responsible for reprinting the routing table, searching for the path to which the packet can be sent, and returning if the destination is not an IHN. Table 2 shows the routing table status of the intermediate node that receives an RREQ message. If the next-hop address field is for the destination pointing to the default path, the destination is an IHN; otherwise, the destination is a gateway or mobile node. More specifically, suppose that a mobile node (MN1) has a routing table with destination address 192.192.1.3, destination address for the IGW of192.168.1.1, IHN of 255.255.255.0, and mobile node (MN2) with destination address 192.192.1.2. When MN1needs to communicate with IHN, the next-hop address of IHN is pointed to as Default. The function searching for "Default" will get a "Next-hop address" of 192.168.1.1and assign this next-hop address of 192.168.1.1 to 192.192.1.2. Subsequently, packets can be sent to the destination address for MN2 at 192.192.1.2.

Table 1. Routing table of wireless mobile nodes after creating a "route entry" for a wired Internet host.

Destination Address	Next-Hop Address
255.255.255.0	Default
Default	192.186.1.1
192.186.1.1	192.186.1.2

This sequence of actions makes it impossible for the mobile node to send the RREP message back to the originator of the RREQ message when the destination address is the IHN. Thus, the RREQ message will rebroadcast until the value of the TTL becomes zero. When the timer expires, a new RREQ message is sent with a larger TTL value.

4.3 The New Role of Gateway Correspondence

When the gateway receives an RREQ message from the multicast group, it checks its routing table for the field "Destination IP Address" included in the message. If the gateway finds the destination address in its routing table, it sends an RREP_IFLAG message to the originator of the message in the multicast group. This sent message contains a flag that provides a default route for the mobile node to establish communication. Otherwise, if the gateway does not find the destination IP address, it sends an RREP_IFLAG message to the sender RREQ message.

4.4 Solve the Broken Link Problem between Gateway and MANET

There is a worrying problem when the mobile node loses connection with all the gateways during communication owing to its mobility. In such a case, the failure to try the mobile nodes to rejoin with the gateways again will lead to increased collisions and congestion in the entire network.

This problem is solved by adding a new function in the MAODV source code that carries out the following procedure when a valid path has expired: (1) drop all packets from the send buffer in the IHN, (2) invalidate the path and do not call the path again when the path expires (maximum timeout for TTL value for RREQ_I message).

4.5 New Methods to Discover Gateway

Fig. 2 describes the design of the new hybrid gateway discovery method to achieve the integration process in multicast environments based on the WRD_MAODV routing protocol.

4.5.1 A novel proactive to discover a proactive gateway in a multicast environment

The proactive gateway discovery process is started by the gateway itself. The gateway discovers the routes toward to the multicast groups for mobile nodes in a MANET by periodically broadcasting gateway advertisement interval (GWMDV) messages in order to establish contact with them when it does not have a route to those groups. The destination address of each GWMDV message is set to the IP address of the desired multicast group, and the "destination sequence number" is set to the last known sequence number for that group. As these gateway advertisements are an important part of network traffic, the optimal time to send the advertisement is specified by the "double interval" parameter and must be carefully selected to prevent unnecessary flooding in the network. On receiving a GWMDV message, any mobile node that is a member of a multicast group updates its multicast route table with the sequence number and net hop information (it is not activated unless the route is specified to be part of the multicast tree). Then, it sends a response message to the gateway. The GWMDV message may be either broadcast or unicast depending on the information available at the gateway. If the gateway does not receive a response before timing out, it broadcasts another GWMDV message with BID increased by one. In this context, we review some of the main advantages and disadvantages of this proposed approach:

Advantages

– Excellent connectivity between a multicast group of mobile nodes and the gateway.
– Predefined routes to the gateway nodes are available by any mobile nodes in a multicast group, which results in faster routing.
– Minimum end-to-end delay in broadcasting multicast packets to an optimal gateway.
– Decrease in overhead and low consumption of existing resources in the network.
– Allows for easy and soft handoff.

Disadvantages

– In superlative mobility for mobile nodes, it leads to an increase in the number of broken links. (This occurs in abnormal cases).

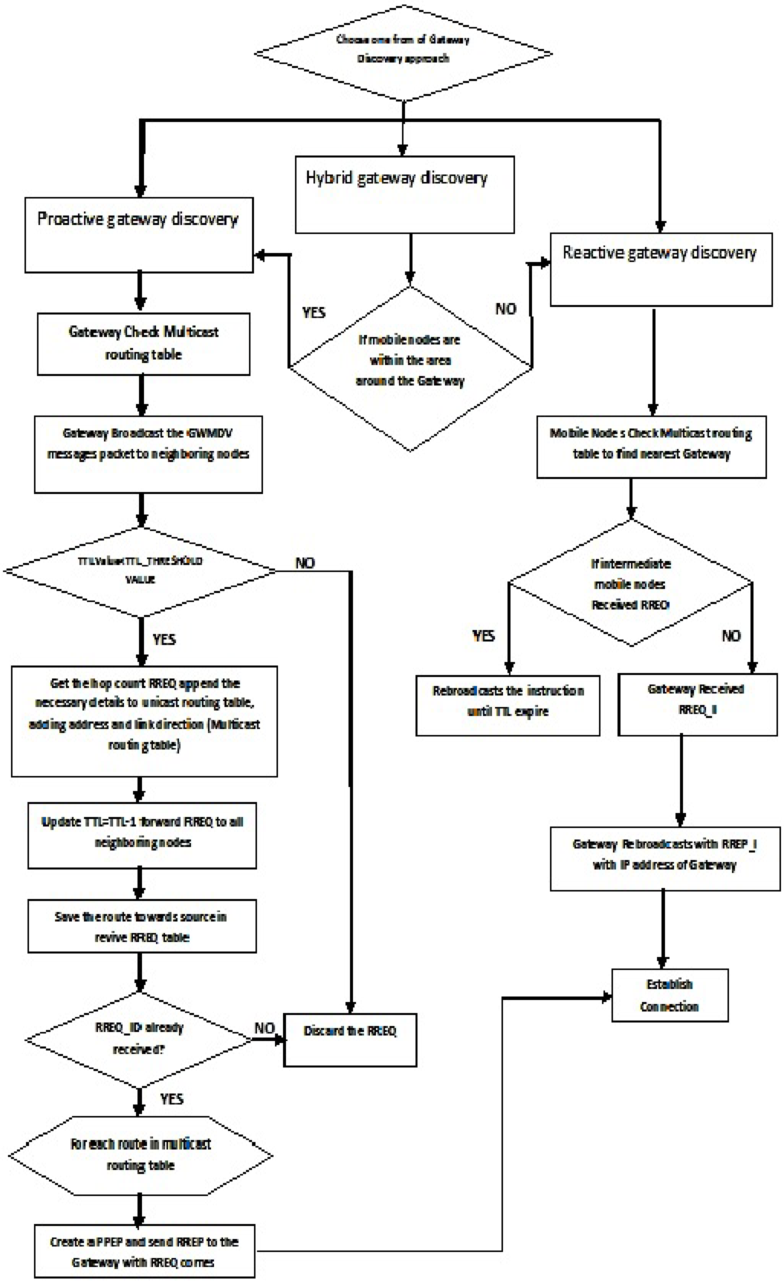


Fig. 3. Flowchart of the mechanism of the proactive gateway discovery in the WRD_MAODV routing protocol.

4.5.2 A novel approach to discover a proactive gateway in a multicast environment

In this approach, a group of mobile nodes requests available gateways inside the MANET and updates its own multicast routing table to find the optimal path. Therefore, the mobile node broadcasts RREQ_IFLAG to the multicast address of the gateway in MANET.

RREQ_IFLAG messages are modified to the IP address of the groups of gateways connected to the MANET. These requests are received and processed through gateways only. When a gateway receives an RREQ_IFLAG, it sends back as reply RREP_IFLAG. In case of receiving intermediate nodes, RREQ_IFLAG rebroadcasts it to the nearby mobile nodes.

This approach preserves only the RREQ_IFLAG messages generated on demand and hence reduces overhead. Moreover, it avoids periodic flooding of the network with RREQ_IFLAG messages and periodic flooding with RREQ_IFLAG messages for better connection quality.

However, hand-offs are not possible with this approach, as the node must lose its connection to receive the RREP_IFLAG and reconnect to the gateway while possibly ignoring nearby gateways. The load on the neighboring mobile nodes of the gateway increases with increasing delivery time.

4.5.3 A novel approach to discover a proactive gateway in a multicast environment

To compensate for the disadvantages of the proactive and reactive approaches, and to combine their best features, a hybrid approach is created. The proactive gateway discovery approach is used when the mobile nodes are close to the gateway domain, whereas the reactive gateway discovery approach is used when the mobile node is beyond the range of the gateway. The gateway periodically multicasts GWMDV messages. On receiving the messages, the mobile nodes update their multicast routing table and rebroadcast them.

The value of the advertisement zone determines the zone used to calculate the number of mobile node hops. In case of a mobile node with hops that are equal or smaller than those of the advertisement zone, the proactive gateway discovery approach is used; otherwise, the reactive gateway discovery approach is employed. This approach allows for a soft hand-off while reducing congestion in the network and reduces the average end-to-end delay. However, it is difficult to identify the advertisement zone in this approach, and its performance suffers with increasing number of mobile nodes.

5. SIMULATION AND RESULTS

To examine the performance of the proposed WRD_MAODV routing protocol, including the proposed three new approaches, we decided to use a hybrid approach that combines the work of both approaches (proactive and reactive) simultaneously, as a candidate along with the hybrid approach in [2], in the same scenario.

5.1 Simulation Setup

We use Network Simulator 2 as a simulation tool with the proposed WRD_MA-

ODV routing protocol. This already provides a hybrid gateway discovery approach in a multicast environment based on the WRD_MAODV routing protocol. The simulated scenario is comprised of two parts: a wireless ad hoc network and a wired internet network. The two parts are connected via a gateway with a router connected to a host as shown in Fig. 4. A wireless adhoc network containing 50, 100, 150, 200, and 250 mobile nodes randomly distributed over the area of the network's topology. Each set consists of individual and groups that represent rescue teams. The disaster site is a rectangular area, and the gateway is located at center of the disaster site according to the scenario adopted in [2]. The simulation area size is selected as 1200m × 500m, which is similar to the size of a typical shopping center. The wired internet network consists of a gateway equipped with a router connected to the host. There are five source nodes which send 512 bytes of constant bit rate for 5 packets per second. The mobile node's speed is uniformly distributed in [1, 20] m/s with a random waypoint model (the mobile nodes move randomly at walking speed). The range of transmission for all mobile nodes was 250 m. For hybrid gateway discovery, a group of GWMDV messages was broadcast at intervals in each period, ADVERTISEMENT ZONE was utilized to locate the range within which proactive or reactive gateway discovery is used; the simulation parameters are shown in Table 3.

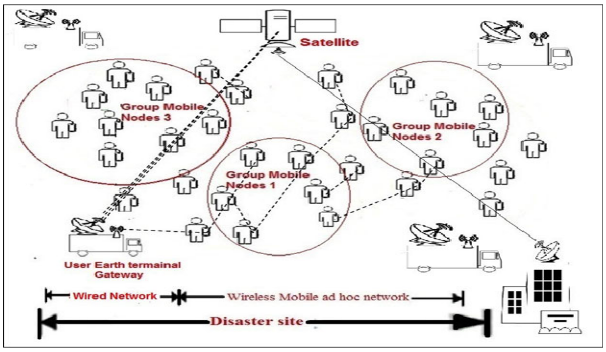


Fig. 4. Screenshot of the simulator.

Table 2. The simulation parameters.

Parameter	Value
Topology Area	1300m × 800m
Number of Mobile Nodes	50,100,150,200,250
Number of Traffic Sources	5
Number of Gateways	1
Packet Size	512 bytes
Speed	[1,20] m/s
Pause Time	5
Data Rate	2 Mbps
Transmission Range	250 m
Carrier Sense Range	550 m
Simulation Time	500 s
Advertisement_Interval	5 s
Advertisement_Zone	3 hops

5.2 Performance Metrics

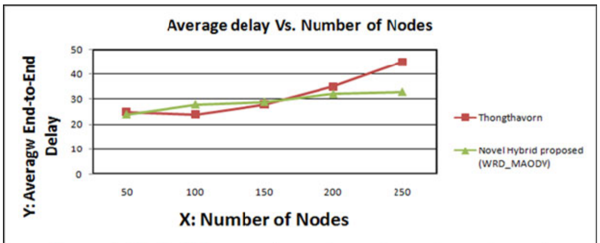
The hybrid gateway discovery method was evaluated using the following measures:

1. Packet delivery ratio: This is defined as the total number of data packets received divided by the total number of data packets sent by all the mobile nodes present in the simulation.
2. Average end-to-end delay: This can be defined as the delay for sending data packets from source mobile nodes to the fixed host.
3. Routing overhead: This was calculated as the total number of transmitted MAODV messages (in bytes) divided by the total number of transmitted MAODV messages and data packets.

5.3 Results and Discussion

The performance of WRD_MAODV was compared with the method proposed by Thongthavorn *et al.* [2] for the hybrid gateway discovery approach in the same scenario. The performance comparison was conducted in terms of average end-end delay, packet delivery ratio, and routing overhead, in which the impact of increased number of mobile nodes was taken into account.

Fig. 5 shows that the proposed WRD_MAODV routing protocol has lower average end-to-end delay than Thongthavorn *et al.*'s protocol.



Average End-to-End Delay					
No.of Nodes	50	100	150	200	250
Thongthavorn	25	24	28	35	45
Novel Hybrid proposed (WRD_MAODV)	24	28	29	32.2	33

Fig. 5. Average end-to-end delay of WRD_MAODV (Number of nodes).

In WRD_MAODV, the mobile node is characterized by a cohesive multicast routing table for the group tree structure because the table contains information related to the multicast group sequence number and the next hop. Therefore, the average end-to-end delay is decreased to transmit data packets because of a minimum of hop counts for selecting the best path between mobile nodes and gateways. Moreover, WRD_MAODV has reliable routes to minimize the time it takes to discover the route and repair the broken paths.

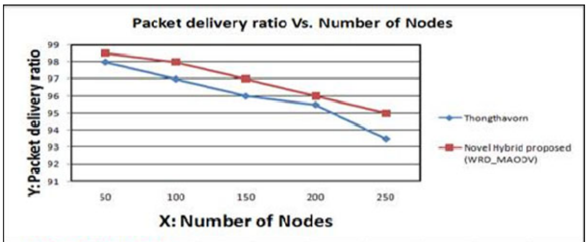
In Thongthavorn *et al.*'s results, on the other hand, higher average end-to-end delays arise owing to increased hop counts. Thus, more routing delays occur as the protocol recovers from broken routes and discover new ones. During a very short period numerous advertisements are broadcast, causing multiple collisions and increasing the average end-to-end delay.

The data delivery ratio of Thongthavorn *et al.*'s protocol is compared to that of the proposed routing protocol in Fig. 5. The results show that WRD_MAODV have high packet delivery ratios. This improvement occurs as a result the data sent through broken paths being minimized, hence increasing the number of data packets received at the destination. This advantage is a result of selecting the best path to update the multicast routing table for mobile nodes along the route.

In unicast data delivery methods methodology used by Thongthavorn *et al.*'s, the mobile nodes take a lot of time to rediscover the path as a result of broken routes or collisions, causing loss of data packets and no assurance of delivery.

In the test of our approaches, we have seen that the mobile nodes have recaptured the shorter and newer routes despite the increase in the number of mobile nodes, thereby reducing the risk of loss of links and data packets.

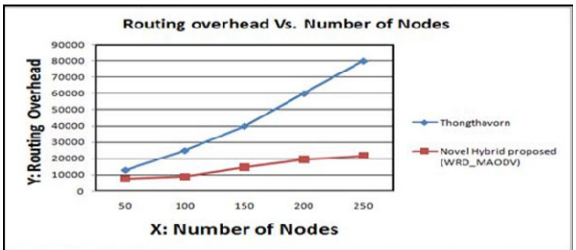
Our analysis leads us to believe that Thongthavorn *et al.*'s method's response to maintenance of broken links is its greatest limitation.



Packet Delivery Ratio

No.of Nodes	50	100	150	200	250
Thongthavorn	98	97	96	95.5	93.5
Proposed work	98.5	98	97	96	95

Fig. 6. Packet delivery ratio of WRD_MAODV (Number of nodes).



Routing Overhead

No.of Nodes	50	100	150	200	250
Thongthavorn	13000	25000	40000	60000	80000
Novel Hybrid proposed (WRD_MAODV)	7670	8890	14750	19560	21830

Fig. 7. WRD_MAODV Routing Overhead (Number of nodes).

Figs. 6 and 7 illustrate routing overhead as a function of increasing number of mobile nodes. Five different numbers of mobile nodes where tested: 50, 100, 150, 200, and 250 respectively. WRD_MAODV again outperformed Thongthavorn *et al.*'s method. This reduction is due to a significant decrease in the number of GWMDV messages used to control and recover the connection and the minimized loss of data packets resulting from broken paths. Moreover, there are fewer route recoveries, which improves the efficiency and scalability our protocol. Severe performance degradation occurs with increased number of mobile nodes for Thongthavorn *et al.*'s method owing to the higher data transmission overhead and the fact that most of the time is spent discovering routes to the gateway every time a request or a reply is sent. This leads to numerous broadcast advertisement messages over a short period and many collisions, causing increased overhead.

In summary, our proposed protocol and gateway discovery method result in superior QoS over the standard MAODV routing protocol when connecting MANETs to infrastructure networks, and thus to the internet. The performance increase is especially noticeable when the WRD_MAODV routing protocol is compared with Thongthavorn *et al.*'s protocol [2]. Thus, when considering QoS provisioning under MANET-Internet integration to support disaster rescue teams, the WRD_MAODV routing protocol is the method of choice using the hybrid gateway discovery method.

6. CONCLUSION

As already described above, our proposed scheme based on integrating a MANET and a wired network could fulfil QoS communication requirements for disaster sites. In this paper, we proposed a new protocol to integrate two heterogeneous networks in a multicast environment (wireless MANET and the wired network). The MANET routing protocol MAODV has been modified to the WRD_MAODV routing protocol to achieve the integration.

In this paper, three gateway discovery methods and selection schemes have been implemented and compared: proactive, reactive and hybrid gateway discovery. The proposed protocol was compared against the performance of the Location-Aided Gateway Discovery Protocol Thongthavorn [2]. Extensive simulations of these protocols, revealed the superiority of WRD_MAODV in terms of packet delivery ratio, end-to-end delay, and routing protocol overhead, as exhibited in the simulation results. In consequence, the multicast traffic created within the wired network-Internet can reach groups of disaster rescue teams located in the wireless Mobile ad hoc network.

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Jamal Muafaq Hameed Al-Bayati received his B.Sc. degree in Information System from AL-Rafidain University, Iraq, in 1997. He received his High Diploma degree in Software Engineering from the Iraqi Commission for Computers and Informatics, in 1999. He received his master degree in Computer Science from the Iraqi Commission for Computers and Informatics in 2006. Currently, he is a Ph.D. student and a Junior Researcher at the Department of Informatics in Belgrade University. His research interests include integrated networks, benchmarking of wireless networks and methodologies and optimization of gateway placement.