Efficient Multimedia Content Transmission Model for Disaster Management using Delay Tolerant Mobile Adhoc Networks

Sushant Mangasuli, Mahesh Kaluti
Dept. of Computer Science and Engineering, PES College of Engineering, Mandya, India

***Abstract*—Natural and manmade disasters such as earthquakes, floods, unprecedented rainfall, etc. pose several threats to our society. The citizens upload disaster information in the form of multimedia content such as pictures, audio, and videos. Efficient information and communication framework are critical for disaster management. Mobile Adhoc Networks (MANET) have been used effectively for disaster management. However, Disaster management prerequisites following Quality of Service (QoS) requirements such as bandwidth, high delivery ratio, low overhead, and minimal latency; however, the existing data transmission scheme induces high latency and overhead among intermediate devices; In order to meet the QoS requirement of disaster management applications in this paper, High Delivery Efficiency and Low Latency Multimedia Content Transmission (HDELL-MCT) scheme for MANETs is presented. Then, an improved buffer management scheme is presented for meeting disaster management performance and latency prerequisites. The experiment is conducted using ONE Simulator, the outcome shows the HDELL-MCT scheme achieves very good performance considering different QoS metrics such as improving delivery ratio by 38.02%, reducing latency by 7.53% and minimizing hop communication overhead by 65.1% in comparison with existing multimedia content transmission model.**

Keywords*—Buffer management; disaster management; Mobile Adhoc Network; opportunistic routing; Quality of Service

I. Introduction

Disaster management is unpredictable as the disasters can be caused by humans or can be a natural calamity. In the disaster, many man-made things are damaged or destroyed such as buildings, cellular towers, power grids, network infrastructure, etc. [1], [2]. Due to these damages, there is no proper communication if a person is stuck in a disaster. Moreover, there is congestion in the communication channel due to the data traffic as the people try to contact their family or friends seeking help. The disaster management teams are deployed to rescue the people, and resources and many people use an online platform to share the condition of that area by posting videos and pictures [3]. Due to this, there is more traffic and congestion in the communication networks [4]. Despite having massive technologies, there are many communication problems which include system overload, system failure, and incompatibility between communication systems used by different agencies. These communication problems can be resolved by providing a redundant communication channel or by providing a separate communication network for disaster management [5], [6].

In disaster management, the Mobile Ad-hoc Networks (MANETs) can play an important role by providing the person's information when the rescue team cannot find the person who is stuck in a disaster [7], [8]. The MANETs contain various mobile nodes that are deployed randomly which can join or leave the given network when it moves. The mobile nodes can communicate opportunistically [9] with other nodes using the wireless link to share the information. Mobile Ad-hoc Networks can add various new devices rapidly. All the devices which are in the network can move freely in any direction. Some examples of MANETs that are currently being used are in military operations, a small conference room, recuse operations on the battlefield, ad-hoc networks, and emergency operations [9].

During the transmission of the nodes from the source to the destination, many challenges are faced by the MANETs [10], [11], & [12]. Some of the challenges include the delivery ratio, multihop, congestion control, and latency. Thus, designing a network in MANETs is a challenging task as there are many problems in its design. Every node in the network acts like a router that can send the packets (i.e., images, videos, etc.) from the source to the destination in an opportunistic manner [13]. The nodes can be of any device like mobiles, laptops, personal computers, etc. Mobile Ad-hoc Networks can range from small networks to very large dynamic networks for provisioning multimedia applications [14]. The nodes communicate with the other nodes in a multihop manner. When the transmitter sends a packet to a given destination node, an intermediate node is used for communication in the network. Hence, every node plays a vital role in sending the packets from the source to the destination [3], [15], [16]. An extensive survey shows existing data transmission scheme induces memory overhead among intermediate for provisioning disaster management applications; thus, inducing poor delivery ratio and latency. This motivated the research to develop an improved multimedia content delivery model namely HDELL-MCT for provisioning disaster management applications. The HDELL-MCT incorporates the location feature into the actual packet and predicts whether the current device will go toward destined groups or not; further, each packet is composed of time validity within which the data has to be delivered to the destined group. Then, an improved buffer management scheme is presented for meeting disaster management performance and latency prerequisites. The significance of HDELL-MCT is as follows.

- The HDELL-MCT employs a two-level multimedia data transmission model for MANETs.
- The HDELL-MCT model can meet the delivery ratio and latency requirement of disaster management applications.
- The HDELL-MCT improves delivery ratio, and intermediate hop overhead, and reduces latency in comparison with the existing multimedia data transmission model.

The manuscript is arranged as follows. In section II, various existing data transmission model for wireless and Mobile Adhoc networks is discussed, and also identified research issues for developing an improved multimedia content transmission model. In section III, the proposed high delivery efficiency and low latency multimedia content transmission model have been presented for disaster management using Mobile Adhoc networks. In section IV, the simulation outcome of HDELL-MCT and existing MCT through The One simulator is validated. In the last section, the result is concluded with a future research direction.

II. Literature Survey

Here are various existing data transmission schemes for provisioning disaster management applications for wireless and Mobile Adhoc networks. In [5], a routing protocol, TA-AOMDV has been proposed which can adjust to the movement of the node at high speed to achieve a good quality of service. In this protocol, an algorithm is used which takes the node resources for the selection of the path and also to connect the stability probability between any two nodes. This protocol uses a technique that constantly brings up-to-date routing strategies using the evaluation of the link stability of the nodes. In [6], a routing scheme known as BARS has been presented which can avoid the overcrowding of the bandwidth problems in network paths and make space in the queues to store the information in the cache. The available storage of the cache must be evaluated before the transmission of the data takes place. This model uses a technique of feedback through which it can identify the traffic source to adjust the data rate using the bandwidth and hold the data in a queue so it can be sent to the routing path. In [7], a study on MANET has been evaluated using the AODV protocol, which evaluates the outcome of the route requesting parameters. This protocol was compared with the OLSR protocol using the performance metrics such as energy consumption, latency, and other metrics. The comparison tells that the OLSR model has some latency when compared with the AODV model.

In [8], a routing protocol has been proposed using the delay-tolerant MANET, in which the virtual nodes are carefully chosen based on the delivery to the destination node, only if the node is not delivered using the MANET protocol. The transmission of the node is done from the source node to the destination node. In [10], a routing protocol has been proposed opportunistic network, which generates a data forwarding model in the communication of the data where it evaluates the rules of transferring data in a partition scheme for node activity. To achieve the trade-off between the transmission efficiency and system overhead a different approach has been used. A free movement degree model is developed depending on which a utility capacity is concluded to pick nodes for transmission of the information [11]. In [12], focused on addressing the congestion at the node and link-level adopting reactive routing mechanism using random early detection and expanding ring searching models to improve packet delivery ratio with minimal latency. In [13], an energy-efficient version of the FCSG, EFCSG has been proposed for the OppNets. This protocol uses the fuzzy controller with fuzzy features to check the nodes that can be considered for the routing process.

In [15], a technique, TBSMR is used to improve the Quality of Service in MANETs performance. This technique uses different factors like malicious detection of nodes, control of congestion, packet loss reduction, etc. to strengthen the Mobile Ad-hoc Networks quality of service. In [3], a method, namely MMDSR (multipath multimedia dynamic source routing) has been modified from the previous version to include the tie strength in the decision which is done using the forwarding algorithm; where the model finds a trade-off between the QoS and the reputation between the users who arrange the path in the MANET. This method increases the reputation metric without affecting the QoS. However, the major drawback of the existing data transmission scheme is that they achieve poor data delivery ratio and induce memory management overhead considering delay-tolerant disaster management application; For overcoming research issues an improved multimedia data transmission scheme for provisioning disaster management through Mobile Adhoc Network.

III. High Delivery Efficiency and Low Latency Multimedia Content Transmission Model for Disaster Management using Mobile adhoc Networks

This section presents high delivery efficiency and low latency multimedia content transmission model for disaster management using Mobile Adhoc networks. In traditional MANETs, the messages are generally broadcasted to every neighboring device available leading to high congestion in the network. In addressing this work employ group-casting-based communication where groups represent a location that can provide services; Any MANET device that resides within a group will become a possible receiver. In group-casting, all information's are addressed to a respective group and each MANET device that resides within that group will receive the data packets; thus, it is important to outline groups in MANETs. Further, information should incorporate the group's information; thus, every MANET device that resides within groups will receive packets.

A. MANET Device Group Classification

Here we define the groups for MANETs considering delay-tolerant prerequisite of disaster management applications. The groups define MANET devices that reside in the same region and have coverage to communicate the data packets. In disaster management applications the groups are represented through two-dimensional geographical coordinates. Here the MANET devices randomly transmit information to destined groups; thus, aiding in reducing broadcasting overhead by preventing unwanted message transmission. Most of the existing group-casting-based data transmission scheme assumes groups through circular pair, these models generally increase their circular radius for reaching faraway MANET devices; thus, resulting in bandwidth wastage. In a standard group-casting-based data transmission model the groups must be predefined; however, in this work, the message caries coordinates information which is the address of the destined device. In MANETs, the device is highly mobile and is aware of adjacent device locations; however, each device can share information among them through intermediate nodes. Therefore, every information must have information about destined groups. Along with the data transmission scheme must be in a position to communicate information to a destined group. The data transmission scheme should be in a position to establish MANET device is within the group or not in a reliable manner. The step involved in establishing whether a destined MANET device is within-group or not is described in Algorithm 1.

Algorithm 1. MANET Device Group Classification	
Step 1	**For each** collected data with respective MANETs, the device **do**
Step 2	**Obtain** the MANETs device location (x, y)
Step 3	**Compute** vertical segment of network with x-coordinate of respective MANETs device's location
Step 4	**Establish** intersected array among the vertical segment and the receiver's group of MANETs.
Step 5	**For each** intersected region within the array **do**
Step 6	**If** y-coordinate of the intersected region is lesser when compared with y-coordinate of the destination's region **then**
Step 7	**Eliminate it** within the array
Step 8	**End if**
Step 9	**End for each**
Step 10	**If** the intersected number is not odd, **then**
Step 11	**get** 0 (i.e., MANETs device is not the receiver of corresponding data and is outside the group)
Step 12	**Else**
Step 13	**get** 1 (i.e., the current MANETs device is the receiver of corresponding data)
Step 14	**End if**
Step 15	**End for each**

B. *Multimedia Data Transmission Scheme*

The objective of HDELL-MCT is to effectively convey the group-casting information to all the MANET nodes that reside within the destined group considering a certain session period. As the MANET device are mobile, they frequently dynamically change groups, thus, incorporating session information is very important. As a result, the HDELL-MCT model delivers to the device that can reach the destination group within the stipulated time. On the other side, the existing routing strategy delivers the packet to detained group according to the device ID defined. However, group association is dependent on MANET device coordinates which vary according to their mobility. Thus, every MANET device must obtain session validity and group address information for routing to be successful to deliver to the intended destination. The main challenge of incorporating session validity into HDELL-MCT, here the session validity is obtained based on message creation time and its maximum time limit i.e., content validity (CV).

The HDELL-MCT model is composed of two-level. In level 1, an effective carry-forward mechanism toward the destined group. In level 2, message delivery to all MANET device that resides within the region/group. The graphical representation of the two-level HDELL-MCT model is shown in Fig. 1.

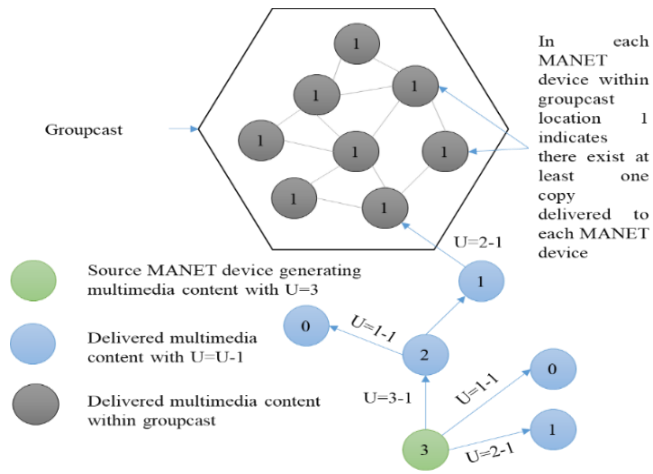

Fig. 1. Graphical representation of HDELL-MDC scheme.

1) Level 1- Forwarding Multimedia Content toward the destination group: In this work, a similar multi-copy spray and wait (MCSW) technique [17] is used. The adoption of MCSW aid in reducing communication overhead and improves message delivery; thus, aids in providing an efficient manner of reaching the destination group. Here every time a message is created a token U is attested to the message. The parameter U will act as an identifier for representing the size of message replication considered. The parameter U will be reduced by 1 every time it encounters a MANET device. Once U reaches to0, the message will be no longer communicated defining the message as expired, and the message will be deleted from the local memory.

2) Level 2- Deliver Multimedia Content to all MANET devices within the group: Here the message is communicated to all the MANET devices within the group by employing an efficient flooding mechanism. The HDELL-MCT model first flood the information to all MANET device and every device keep a copy of the content (as described in line 14-16 and line 21-24 of Algorithm 2). In HDELL-MCT, if a replicated multimedia content goes beyond the destined group, the multimedia content is forwarded back to the MANET device that resides within the group (this step is described in line 20 of HDELL-MCT Algorithm 2); until U becomes 0 i.e., expires. Finally, the message is removed from the memory (as described in line number 4 of HDELL-MCT Algorithm 2). This aids in reducing memory and network overhead by preventing information exchange beyond the destined group. The two-level HDELL-MCT is described in Algorithm 2. In HDELL-MCT the value of U can be pre-configured according to disaster and safety-related application prerequisites such as operating environment, mobility, density, and so on. However, in this work, the U is configured dynamically and device density impacting delivery ratio and latency is a major focus for HDELL-MCT.

Algorithm 2. Multimedia Data Transmission Scheme	
Step 1	**For each** interaction among two MANET devices within the network **do**
Step 2	One device becomes the sender T_1 and other becomes the receiver T_2
Step 3	**If** the MANET device is the sender T_1 **then**
Step 4	Remove valid multimedia content from the memory
Step 5	Apply memory optimization scheme
Step 6	**For each** multimedia content within the memory **do**
Step 7	**If** multimedia content is already present within T_2 memory
Step 8	Move on to the next multimedia content present within the for loop
Step 9	**End if**
Step 10	**If** $(U > 0)$ **then**
Step 11	$U \leftarrow U - 1$
Step 12	Send a replicated multimedia content to T_2
Step 13	**Else if** $(U = 0)$ **then**
Step 14	**If** T_1 is within the receiver group (see algorithm 1) **then**
Step 15	Send a replicated multimedia content to T_2
Step 16	**End if**
Step 17	**End if**
Step 18	**End for each**
Step 19	**Else if** the MANET device is the receiver T_1 **then**
Step 20	**For each** received content **do**
Step 21	**If** T_2 is within the receiver group (use algorithm 1) **then**
Step 22	Transmit the multimedia content to the application layer
Step 23	Keep a replicated multimedia content in the memory
Step 24	$U \leftarrow 0$
Step 25	**Else if** T_2 is outside the receiver group (use algorithm 1) **then**
Step 26	Keep multimedia content in the memory
Step 27	$U \leftarrow U - 1$
Step 28	**End if**
Step 29	**End for each**
Step 30	**End if**
Step 31	Change scenario (sender T_1 and receiver T_2) and **return** to **step 3** at least once
Step 32	**End for each**

C. Memory Optimization Model

Algorithm 2 encompasses the memory optimization problem in line 5. The parameter U has been used for delivery efficiency considering limited bandwidth availability, the memory optimization is done using priority optimization. Here we route the packet based on First Come First Serve (FCFS) with Minimal Content Validity (MCV). The HDELL-MCT scheme uses very less resources with a high delivery ratio and less latency when compared with the recent standard data transmission scheme which is experimentally proven next section below.

IV. Simulation Result and Analysis

Here experiment is conducted for validating the performance of the proposed High Delivery efficiency and low latencies multimedia content transmission (HDELL-MCT) scheme and standard data transmission [3]. The delivery ratio, intermedia hop forwarding overhead, and latencies by varying network density size are performance metrics considered for validating models. To validate the performance of HDELL-MCT over existing MCT schemes, simulation is conducted using real-time scenarios through The One simulator [18]. This work uses QSMVM (QoS-based Socio-Aware Multi-metric) routing scheme as an existing MCT scheme for comparison because it performed significantly well with better packet delivery and reasonable latency in comparison with various existing baseline data transmission models such as Social aware Content-based Opportunistic Routing Protocol (SCORP) [19], Prophet [20], Epidemic [21], and other data transmission protocol [11].

A. Simulation Parameter Configuration

The scenario namely, Helsinki comprised of synthetic traces, is based on the one presented in [3], where nodes are placed on the map of Helsinki city (see Fig. 2). We considered a variable number of MANET devices (i.e., 20, 40, and 80), to assess the performance for different densities. During the simulated 12 h time-period, the MANET device moves on the map roads at an average speed of 50 km/h, between random locations, and with random pause times between 5 and 15 minutes. Each MANET device randomly generates many posts (i.e., to grant the participation of all the MANET devices in the network, every MANET device generates at least one message per day) and generates a message depending on its location at that moment. The parameters taken in this work are based on [3] and Table I shows the main parameters used in the simulated safety-related (disaster management) application scenarios.

Fig. 2. The traffic pattern of devices placed across the map of Helsinki [8].

TABLE I. Simulation Parameter Considered

Parameters	Configured
Message Generation Rate	1000 messages per simulation
Message Size	[12] MB
TTL	12 h
Network Interface	$IEEE$ 802.11 a, b, g, n, p
Transmission Range	200 $meters$

B. Latency Performance

Fig. 3 shows the latency induced for transmitting data in the network using QSMVM and HDELL_MCT scheme considering varied MANET device sizes of 20, 40, and 80. From the result, we can see the HDELL_MCT model achieves much lesser latency for transmitting packets when compared with the QSMVM scheme. A latency reduction of 7.53% is achieved using HDELL_MCT over the QSMVM multimedia data transmission scheme.

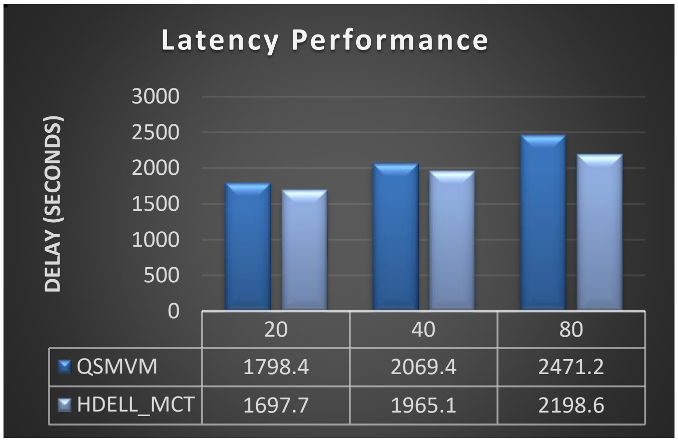

Fig. 3. Multimedia content transmission latency performance for varied MANETs devices.

C. Delivery Ratio Performance

Fig. 4 shows the delivery ratio performance for transmitting data in the network using QSMVM and HDELL_MCT scheme considering varied MANET device sizes of 20, 40, and 80. From the result, we can see the HDELL_MCT model achieves much superior delivery ratio performance when compared with the QSMVM scheme. A delivery ratio performance improvement of 38.02% is achieved using HDELL_MCT over the QSMVM multimedia data transmission scheme.

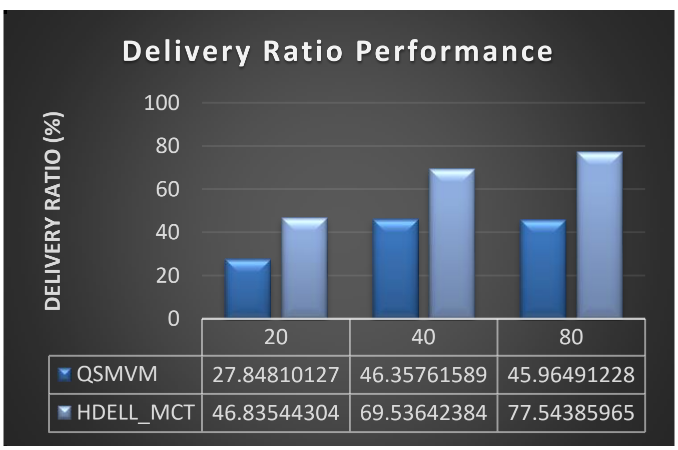

Fig. 4. Multimedia content transmission delivery ratio performance for varied MANETs devices.

D. Number of Hop-Count Performance

Fig. 5 shows the hop count performance for transmitting data in the network using QSMVM and HDELL_MCT scheme considering varied MANET device sizes of 20, 40, and 80. From the result, we can see the HDELL_MCT model uses less number of a forwarder for transmitting packets when compared with the QSMVM scheme; thus reducing the control channel computation overhead of the network. A computation overhead reduction of 65.19% is achieved using HDELL_MCT over the QSMVM multimedia data transmission scheme.

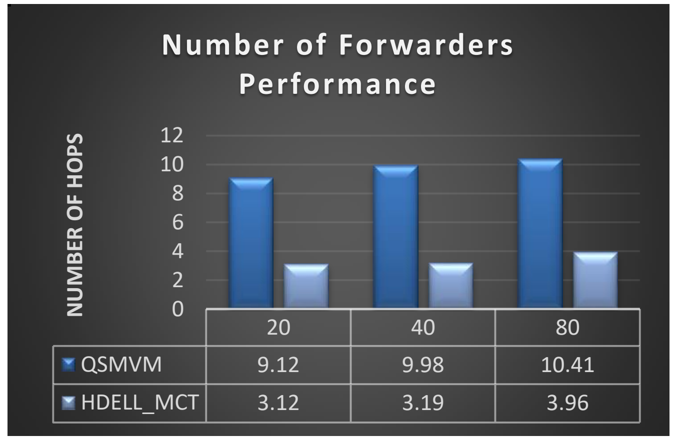

Fig. 5. Multimedia content transmission Hop count performance for varied MANETs devices.

From the overall result attained it can be seen the HDELL_MCT scheme achieves superior packet delivery ratio performance with fewer latencies and computation overhead under varied density; thus, are suitable for provisioning safety-related (disaster management) applications.

V. CONCLUSION

In this paper an effective MCT model namely the HDELL-MCT model is presented for provisioning disaster management applications. The MCT is designed considering improving delivery ratio and reducing latency. In order to meet the QoS requirement of disaster management applications in this paper, High Delivery Efficiency and Low Latency Multimedia Content Transmission (HDELL-MCT) scheme for MANETs is presented. Then, an improved buffer management scheme is presented for meeting disaster management performance and latency prerequisites. The HDELL-MCT employed a two-level multimedia content transmission algorithm for meeting the prerequisite of disaster management applications. Further, HDELL-MCT uses the location-aware feature, group-casting-based efficient flooding, and using priority-based memory optimization scheme balancing delivery ratio and latency reduction performance. The experiment is conducted using ONE Simulator, the outcome shows the HDELL-MCT scheme achieves very good performance considering different QoS metrics such as improving delivery ratio by 38.02%, reducing latency by 7.53% and minimizing hop communication overhead by 65.1% in comparison with existing multimedia content transmission model. Experiment outcome shows the HDELL-MCT model improves delivery ratio, uses less number of intermediate hop MANET devices, and reduces latency in transmitting multimedia data in comparison with the existing data transmission scheme for MANETs.

Future work would consider designing an adaptive propagation model for MCT considering diverse mobility patterns and the presence of obstacles in the line of sight along with, constructing an effective video encoding technique for improving storage and bandwidth efficiency of delay-tolerant MANETs.

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