Proposing Disaster Management System based on Vehicular Ad hoc Networks

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Proposing Disaster Management System based on Vehicular Ad hoc Networks

Propuesta de sistema de gestión de desastres basado en redes vehiculares ad hoc

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ABSTRACT/ Disaster Management System (DMS) demands fast and timely response for roaming relief teams to save human lives and property. To mitigate the effects of disasters, the installation and restoration of proper communication infrastructure is highly required to facilitate and coordinate the exchange of information among the relief teams working in the area. This paper proposes a data collection system based on the Vehicular Cloud Network services, which uses Vehicle Ad hoc Network (VANETs) infrastructure with Cloud to form Vehicular Cloud Network (VCNs) to perform this task. In the proposed system, vehicles play roles based upon their locations, and directions e.g. monitoring environment, collecting data, and relaying data to operation center. Proposed system introduces hybrid wireless networking: central network and ad hoc network to establish disaster management system. The implementation results confirm that the proposed system is more reliable and efficient; in terms of the reachability with few hops improvement is achieved even in light density. Furthermore, end-to-end delay and packet delivery ratio assure high performance for the proposed system in comparison with the traditional system. Keywords: Vehicle as a resource, Relaying vehicle, Sensor vehicle, smart vehicle, Reachability, End-to-end, and Packet Delivery Ratio. RESUMEN/ El Sistema de Gestión de Desastres (DMS) exige una respuesta rápida y oportuna para que los equipos de ayuda itinerantes salven vidas y propiedades humanas. Para mitigar los efectos de los desastres, es muy necesaria la instalación y restauración de una infraestructura de comunicación adecuada para facilitar y coordinar el intercambio de información entre los equipos de ayuda que trabajan en el área. Este documento propone un sistema de recopilación de datos basado en los servicios de la red de vehículos en la nube, que utiliza la infraestructura de la red ad hoc del vehículo (VANET) con Cloud para formar la red de vehículos en la nube (VCN) para realizar esta tarea. En el sistema propuesto, los vehículos desempeñan roles basados en su ubicación e instrucciones, p. Monitoreo del entorno, recopilación de datos y transmisión de datos al centro de operaciones. El sistema propuesto introduce redes inalámbricas híbridas: red central y red ad hoc para establecer un sistema de gestión de desastres. Los resultados de la implementación confirman que el sistema propuesto es más confiable y eficiente; En términos de accesibilidad con pocos saltos, la mejora se logra incluso en la densidad de la luz. Además, el retraso de extremo a extremo y la relación de entrega de paquetes aseguran un alto rendimiento para el sistema propuesto en comparación con el sistema tradicional. Palabras clave: Vehículo como recurso, vehículo de retransmisión, vehículo sensor, vehículo inteligente, accesibilidad, extremo a extremo y relación de entrega de paquetes.

1. Introduction:

The world is facing a big challenge every year when many times were stricken various catastrophic natural disasters, such as tsunami, typhoon, hurricane, and earthquake. Those regions hit by natural disaster are destroyed completely or partly became dangerous area for human lives. In these cases great economic and human losses are reported, which needed to minimize the impact on both of them (economic, human). The recent Japan earthquake and tsunami estimated in cost about 300 billion USD alone [1]. Though, many countries have started to adopt a system that handles these situations. For instance, in such scenarios, the people and authorities need to communicate with each other for different reasons ranging from looking for saving shelter to find the safe streets. However, since due to the damage of communication system, the rescue and other operations are suspended and affected. Furthermore, this breakage of communication causes the lack of communication among peoples, authorities, and disaster rescue teams [2].

As the communication infrastructure considers as a corner stone of the connection system to facilitate the rescue operations. The most vital task for such networks is to prepare essential information for locating and rescue survivors. The potential survivors location, and the planned subjected to recover the trapped people in any region is evaluated to provide the resources efficiently. Both of them represent key issues in any rescuing survivors. To maintain the network connectivity to perform the collecting useful information and the location is not guaranteed through or after catastrophic. Worst of all, the network connectivity is unpredictable due to unexpected destruction in the infrastructure caused by the disaster. So it’s a crucial to search for a communication network that still operates in such areas. Based on our observations, we identified the following issues [3] that motivates our research:

1. The solution needs to deploy and cover all the emergency zones without human intervention.
2. The new solution should be easy and uncostly to develop, and it should work for at least for 72 hours until other communication network services are installed or restored.
3. Since, it is hard to use the Internet access for disaster rescue network and we can mitigate the dependable on connectivity by seeking for another resources.

We assume a large disastrous scenario, where existing terrestrial communication infrastructure is destroyed and disabled completely. In the literature, many researchers have proposed various solutions to address this issue, but all of them assume that a telecommunication operator as an essential part of their systems to manage emergency environments. To fill this gap, we propose that a Vehicular Ad hoc Network (VANET) can play a vital role to overcome this challenge. VANETs combined with the cloud computing initiates a Vehicular Cloud Networks (VCN) that supports a connection between vehicles and share resources through a cloud platform. The last decade has seen a tremendous interest in VCN applications especially when a new advance technology supported this direction [4]. These facilities start from safety, interesting, economical, and other applications. Smart vehicle is one of these new emergency technologies that are equipped with a high applicable resources like computation, storage, and processing. Such vehicles will be used in different aspects that need VCN applications increasingly. Though, we consider a smart vehicle as mobile cloud server[4] in our proposed system. Our view to proposed Disaster Management System is shown in figure 1. DMS configured with VCN which include hybrid wireless networks; cellular network and ad hoc network. Cellular mode is used inside each zone to collect data while ad hoc mode is used to route data to operation center (Authority Management).

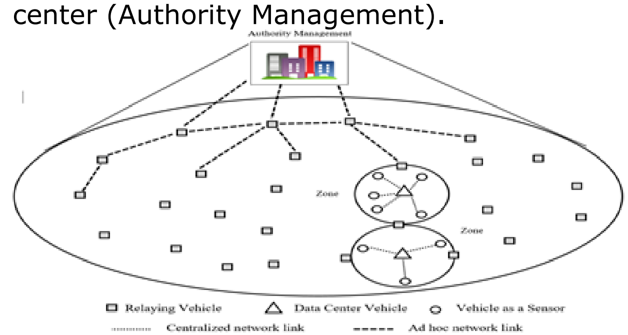

Figure 1: Outline Disaster Management System

2. Related Works

A critical issue for emergency situation is to aggregate urgent information in a manner securely and quickly in order to mitigate damage and survive the victims. The major target for data collection systems is to prohibit the damage hits main requirement lifeline facilities excessively. Mobile networks, water supply, and electric power supply are an examples of lifeline facilities that should take care in such situations. Unfortunately, sever catastrophes in the whole world have continuously indicate limitation in data collection systems that should provide reliable communication among rescue response (emergency teams and relief agencies). Many studies has been done in this area.

Ahmed et al. [5] with other authors proposed SAFIRE system that addressed the interoperability and flexibility in communication systems in emergency circumstances. SAFIRE provide a novel multi-hop architecture expedite exchanging information fastly and reliably information among first responder. The major features of SAFIRE are decentralized platform, publish-subscribe for exchange data, and flexible multi-layer architectures. The main task of this paper is achieving interoperability among various communication systems but no guarantee that those system keep working in such environment which is considers a as drawback.

Some authors highlighted situations related to pre- and post-disaster circumferences. In this context, Sun et al. [6] suggested RescueME system which is integrated with another existing infrastructure communication systems to provide the way and entities to save the locations of users. Many duties and roles are established for entities before and after catastrophic occurrence. As an example, proposed system considers users as drivers when natural situations are presented but when disaster occur becomes a potential survivors. Privacy and security are involved in proposed system to protect locations data by Public Key infrastructure. This study does not mentioned and cover the intermitting in communication systems when disaster have been happen.

Chenji et al. [7] proposed a DistressNet system, this system focusing on the requirements of search-and-rescue workers after disaster occurred in urban environment. The system relay on incorporated various devices like smart phones and low power sensors into easy-to-deploy infrastructure. The simple deployment of these devices at certain optimal locations close to catastrophic area could be enhanced the overall efficiency of proposed system. Although, the authors carried out an evaluation for various components of the system separately, the TestBed was executed with no comprehensive implementation. Furthermore, DistressNet system used IEEE802.11a/b/g/n as a backbone networking stack with Independent Basic Service Set (IBSS) phase. Moreover, many hardware motes were used in system but IEEE 802.11 does not support them like Explicitly Parallel Instruction Computing (EPIC).

Another study Bai et al. [8] which mixed wireless sensor network with Mobile Ad hoc networks (MANETs) to build an Integrated Emergency Communication System (IECM) for catastrophic area. The proposed system provides various emergency management services for involved people in rescue team based on Integrated Emergency Service System (IESS). Mesh access points and Mesh clients were configured MANETs using wireless mash networks IEEE 802.11s. According to service requirements and network conditions the end user select a connection route through MANETs or cellular network or satellite network if available. In this context, it seems that this mechanism is not feasible in practical work.

Alazawi et al. [9] proposed an intelligent evacuation system to find the optimal evacuation strategies. The main target is to update the transport management response and as a result enhance vehicular DMS. The authors focusing on the evaluation proposed tool which is assumed in dynamic decision in effectiveness evacuation characteristics. But this paper does not deal with communication in worse catastrophic situation where communication systems were collapsed which is considers as a corner stone of any DMS.

Raw et. al. and others in [10] create an Intelligent Vehicular Cloud Disaster Management System(IVCDM) model that support multi-mode communication to maintain the connectivity among vehicles. Vehicle-to-infrastructure (V-I), Vehicle-to-Pedestrian (V-P), and Vehicle-to-Vehicle (V-V) are multi-mode communication approach that used to message propagation. Two scenarios are used to evaluate proposed system city and highway environment. The results highlight that connectivity for V-P communication mode is more efficient than V-V mode. The paper does not cover city environment connectivity actually. Paper assumes communication systems keep working in disaster situations where connectivity is not guaranteed in this mode V-P.

Finally, Khaliq et al. [11] designed an emergency response system that supported a TestBed implementation rely on the VANETs communications. The authors focusing on the communication among rescue teams where no system can be used in such circumstances for communication. For this purpose, TestBed is an application that used to relay vital information through deployment over VANETs environments. TestBed is supplied with onboard units with credit card microcomputer called Raspberry Pi in addition to Global Positioning System were embedded to participate vehicles in proposing system. Furthermore, pre-defined code according to urgency level used to deploy messages through multiple hops in the way to central control unit. Consequently, the authority take appropriate action based on received message code from client. The system examined according to various factors, delay and reliability of the network with respect to number of hops which was proved its applicability. Finally, the system does not mentioned the configuration of the vehicles within the scenario or area of interest.

In all above papers the researchers were dealt with fatality situations where the environment required to handle and manage, but no pure studying focusing on the cover intermitting problems for communication networks. So, this paper try to fill this gap by proposing a new system.

The rest of the paper is organized as follows. Section 3 presented the background information about the requirements of catastrophic environment. In section 4, the network model and communication paradigm which supported proposed system are described in detailed. Section 5 covers the evaluation of the proposed system by simulation, finally the conclusion of the paper and future work in section 6 are presented.

3. Background

3.1 Impact of Disaster on Communication System

When a natural disaster hits any city in the world, the vast damage in the government infrastructure and transportation system will occur as a consequence. Notably, the communication system is failed and highly affected. Cellular networks which many people think are highly dependable are also affected by these emergency situations as well. Added to this, there are many other related issued and things noticed in a disastrous situations like:

- Rescue squads, police, army, and fire fighter are all need to response adequately to decrease the losses as possible as. Blocked in transportation systems prevent external assistance to reach damaged area in certain time.
- Rescue teams resources for relief operation were inaccurate and misplaced because they were blind and difficult to assessment the zone of damage.
- Ambulance for sensitive rescue operation imposed to find the shortest way to save the human lives and avoid blocked streets as much as possible.

In all of the above cases, a working or a standby communication system in place can highly reduce the impact of catastrophic situation.

3.2 System Requirements and Challenges

The major system requirements and challenges that need to take an account to establish network connections for sharing information for disaster rescue system are listed below:

Intermittent connectivity: the damages in the infrastructure are unforeseeable and the connectivity is not predictable. The delivery of the information is not reliable and not guaranteed. The intermittent faculty in connectivity or communication may occur partially or totally, sometimes the region is isolated. In such situation more reasonable turn form end-to-end delivery to continual storage and redundancy storage. This approach of storing requires saving the sharing information in available resources so that it will be later reach the rescue network. Redundancy storage requires storing the information in a distribution fashion.

Minimal and rapid deployment effort: The desirable objective of disaster rescue network is to establish this network from the existing infrastructure. This meaning that building dedicated disaster rescue network is costly and rarely used. So reliance on the infrastructure that is previously built is more beneficial and cheaper. Wide deployment of such system is crucial and vital without human intervention. Furthermore, such system is required to be self-organizing and discover other member nodes without manual human intervention.

Robustness and Resilience: The disaster rescue network is imposing robust and resilience network characteristics. As mentioned previously, end-to-end service is not viable, so the system should offer a store and forward approach when no neighbouring nodes are exist.

3.3 Vehicular Cloud Network (VCN)

VCN is a new paradigm that emerging by combing the VANETs with the cloud computing resources. The goal of this model is to create virtual vehicle cloud and prompt cooperation among members of cloud to provide vehicular services that an induvial vehicle cannot support alone. VCN is formed temporarily when the idle resources available in the

vehicles are interconnecting, though a network of resources that working in a shared virtual infrastructure on which the efficiency of cooperation is maximized VCN [12].
Consuming idle vehicle resources in VANETs platform is the basic idea behind the concept of VCN. Vehicle resources are leveraged and the capabilities of the vehicles like sensing, data storage, relaying information, computing, and other facilities allow the vehicle to perform as mobile service provider. With these added new components, a vehicle represents as an intelligent vehicle which support many services. The author in [13] introduces Vehicle as a Resource (VaaR) which adopted various vehicular potential services. According to author s point of view vehicle can provide a various instances of VaaR.

4. The Proposed System

When an unplanned disaster hits a specific region many assumptions need to suggest in proposed system to handle this crisis. One of the most significant assumptions is to divide the cities region in to small zones that can be easily manageable and handled. Every zone surrounding by a neighbour zones that separated by a boundary line. We consider a digital map that involved these zones as a virtual map (digital map) that stores implicitly in every smart (intelligent) vehicle that roaming in the city. However, in the event that a disaster happens these smart vehicles are deployed randomly in the city and assumed the collapse hits all the communication network. As mentioned above the most suitable communication infrastructure is one which is stay working as long as possible. VANETs is the one that least significant platform damaged in comparison with other telecommunication networks when disaster occurs. So, in a chaotic environment the connection among all the smart vehicles play a vital role to keep the communication system working as possible as. In this manner, we select three types of VaaR to serve in our proposed system. VaaR-data storage and computing (VaaR-Storage), VaaR-data relaying (VaaR-Relaying), and VaaR-Sensing. Each of them has different task to act in our system: starting from monitoring the zone environment then collecting monitoring information, and finally forwarding data to surrounding zones by VaaR-Relaying nodes. Proposed system adopt the diversified VaaR and below the description of each of them in details:

- **VaaR-Sensing**: various sensors are included in smart vehicles the most significant one is environment monitoring. Vehicles that monitor the surrounding vicinity for further relaying to search data of interest. Number of VaaR-Sensing vehicles within each zone proportional to size of zone. Big size of zone required large number of VaaR-Sensing vehicles and vice versa. And they are distributed randomly through zones. More specifically, the role of VaaR-Sensing vehicle is monitoring and sending data to data center which explained below.
- **VaaR-Storage** (Data center): data aggregated within each zone by this type of vehicles. This type act as a data server that collected the information from neighbouring VaaR-Sensing vehicles. The task of VaaR-Storage vehicle imposes the central occupancy in each zone. The number of VaaR-storage in each zone at least one which selected according to their location. In turn VaaR-Storage forwarded the collected data to the relaying node which is working as a gateway to other zones.
- **VaaR-Relaying** (gateway): this type of vehicles is responsible for relaying a data to other zones. Relaying data to out of coverage area of zone is substantial and should support by our suggested scheme. To ensure that all sensed data reach furthest destination (Authority Management), VaaR-Relaying vehicle can achieve this goal. Our system involved at least one vehicle that play the gateway vehicle, and the best location encountered to accomplish this task is the border of the zone.

4.1 Network Model

Figure 2 illustrates the proposed vehicular cloud network layered approach. Each layer has specific task which is related to a type of vehicle cloud service provider. The components of each layer has distinct task and their locations so the role of them is different as well. The system suggested that the wireless communication technology Dedicated Shorted-Range Communications [14] is a medium between any two layers with one-hop distance is separate between them.

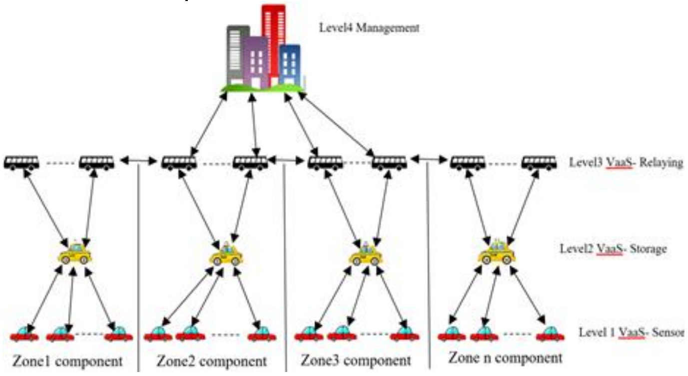

Figure 2: proposed Network Model

As mentioned previously city is classified into various zones, each zone involved network of roads and intersections. All these information are stored in the digital map which is saved in all smart vehicles. The most significant coordinates are the center and boundary of zones. Through these coordinate the smart vehicle will play the VaaR-Storage and VaaR-Relaying node role.

4.2 Communication Paradigm

This section concerned with how the proposed system layers are communicating among them. In this context, system is divide in two phases: the first is concerned with the preparation phase; the second is focusing on the how the data is flow.

4.2.1 Preparation phase

In this phase, in case the emergency occurs all smart vehicles (VaaR) have built in virtual map of the city. According to proposed network model of system, VaaR are randomly distributed in city and assumed equipped with Global Positioning System [15]. Every VaaR can play different role according to their location, VaaR close the zone center play as a VaaR-Storage, while near the zone border play VaaR-Relaying node, between center and border zone the VaaR-Sensing are disseminated randomly through zone. To identify the location of each VaaR in zone below strategy is used:

Each vehicle will send a message to advertise their location to all one-hop neighbour. This message contains VaaR location and direction. Figure 2 depicted the content of message. All vehicles issue a neighbour list and update it periodically and save it as a history of movement. Thus, VaaR can calculate its direction using (1).

$$\beta = \tan^{-1}\frac{Y2-Y1}{X2-X1} \qquad (1)$$

Where (X2, Y2) is the current coordinates of the VaaR at t2 time, (X1, Y2) is the previous coordinates at time t1, and β is the VaaR heading angle which represent the direction of the VaaR. The information of message in this step shown in figure 3.

VaaR ID	VaaR Location	VaaR Direction	Timestamp

Figure 3: Message format

After this step is complete its location with respect to zone coordinates, and according to the following algorithm 1 the VaaR plays either VaaR-Storage, VaaR-Relaying, or VaaR-Sensing. This phase involved cellular network formation mode when VaaR-Storage while VaaS-Relaying identification.

Algorithm (1):Selecting VaaR –Storage & VaaR-Relaying Vehicles

Input: all vehicle locations within zone

Output: Identify VaaR –Storage & VaaR-Relaying Vehicles

1. **Begin**
2. **Get** the position of vehicle
3. **For each** vehicle within zone
4. **IF** the vehicle direction towards the center of the zone
5. Calculates the distance between the vehicle and the zone center
6. **Select** a nearest vehicle to center to serve as VaaR-Storage and leave the others as a standby
7. **End IF**
8. **Else** The vehicle direction out of the zone center
9. Calculates the distance between the vehicle and the zone center
10. **Select** a furthest vehicle to center to serve as VaaR-Relaying within a coverage area and leave the others as a standby
11. **End for**
12. **End**

4.2.2 Emergency phase

When each member of zone are recognized: VaaR-Storage, VaaR-Relaying, and VaaR-

Sensing the second phase beginning. Reading the environment zone and flow information from VaaR-Sensing vehicle is starting. VaaR-Storage accept the data from all zone members' vicinity to aggregate and collect them. Furthermore, VaaR-Storage is ready to forward data to VaaR-Relaying node which in turn forward the data to other VaaR-Relaying node in other zones in the way to authority manager. In this way the ad hoc wireless network mode is established by distinguish the available route to authority management. The routing protocol IAODV as in [16] is used to deal with looking for route from VaaR-Relaying to another, and finally to authority management. The content of emergency message are: zone ID, first relayer ID, second relayer ID, emergency data, number of hops, and timestamp as shown in figure 4. Whether VaaR-relaying is the first relayer or the second one depend upon the format field of emergency message. In case of message is relaying twice the format field of emergency message assure the second relaying ID and so on. Each relayer node add its ID and increases the hop count by one.

First Relayer ID	Second Relayer ID	↔	*n* Relayer ID	Zone Sender ID	Emergency Data	No. of Hops	Timestamp

Figure 4: Emergency Message Format

4.2.3 Proposed System Characteristics

As mentioned previously in the catastrophic manner the taxi and bus vehicles are playing a vital role. These vehicles are deployed randomly in the city, and they are used to support communication infrastructure when the disaster occur in proposed system. Though, the drivers of those vehicles should calculate the time that the vehicles can stand for VaaR-Storage and VaaR-Relaying. At the same time the drivers also determine the amount of storage space that available in the vehicles to support the VaaR-Storage in the zone. The time spending in the vicinity and the size of storage identifies the vehicle that can serve as VaaR-Storage and VaaR-Relaying. Two remarkable conditions are noticed to choose vehicle as a temporary VaaR-Storage and VaaR-Relaying:

Observation1: The vehicle that moving towards zone center is a good candidate temporary to be VaaR-Storage. Our scenario proposes that all vehicles in vicinity are roaming, and the question is which of them highly likely meet the zone center is. Its logically nearest one is more suitable than others to serve as temporary VaaR-Storage. The stopping time for the VaaR-Storage vehicle is significantly based on the various parameters. As mentioned previously the amount of time that vehicle can serve as VaaR-Storage and the storage space are the two parameters identifies the vehicle in addition to its position to the zone center. We adopt approach mentioned in this paper [17] to calculate the spending time in zone.

Observation 2: vehicles that travel across the zone boundary should serve as temporary VaaR-Relaying. To elect this vehicle the position and direction should be considered. Either the vehicle moving direction across the boundary region or its current location in boundary region is a candidate temporary VaaR-Relaying. Those vehicles should stop and perform duties as a VaaR-Relaying. Again the owner of the vehicle should compute the time that can perform this service, and not continue to travel outward the zone. It's crucial to keep the communication range with the VaaR-Storage and within the zone to avoid the interruption as possible as.

Observation 3: the proposed system starts when receive a message from the central authority which depicted the type of emergency and identify occurring emergency zone id.

Observation 4: for experimental implementation in low level the vehicles are embedded with onboard unit which involved a microcomputer that support a user interface for communication among derivers.

5. System Parameters and Evaluation

In this section proposed system is evaluated and the simulation parameters are presented. The evaluation process is dependent on the comparison between proposed system and the Traditional Disaster System (TDS) scenario. In this paper we adopt TDS where the vehicle play a vital role in communication but without exist a VaaR-storage and VaaR-Relaying nodes. We assumed that all vehicles participate in communications randomly in TDS scenario till the information reach authority management without zones existence. So, the dissemination data flow through different zones primarily rely on broadcast in all directions. In this way proposed system involved VCN infrastructure while TDS does not. The focusing in

comparison about the performance of two scenarios in communication measuring.
NS-2 [18] simulator is used to evaluate the two scenarios, the most significant factors is the parameters that used to run the simulator. These initial parameters are used to specify performance and behaviour of two scenarios in NS-2, which is summarized in table 1.
Table 1: Initial parameters for NS-2

Parameter	**Value**
Channel type	Wireless channel
Antenna model	Omni antenna
Network interface type	Wireless Phy
Interface queue type	Droptail
MAC type	Mac/802.11
Radio propagation model	Two ray ground
Number of nodes	5 …..35
Simulation area	40km *14km
Simulation time	400sec
Packet size	1500KByte
Speed	10-100km
Number of zones	15
Zone size	2km *2km
max packet interface queue	50
Transmission range	250 m

6. Results Analysis

To evaluate proposed system figure 5 shows the relation between the reachability as function to number of hops count. Reachability means the rate of VaaR-Sensor nodes data to reach authority of management. By doing this, the impact of No. of hops are clearly affect the behaviour of system. As No. of hops increases reachability decreases and this is because of multi-hoping where link breaking occurs. These links are vulnerable for many reasons due to deterioration or interference of the propagation model. Furthermore, in case No. of hops increases, the link connection may be degraded. As a result, the reliability of the network is break down when excessive hops are used in link establishment.
Three different densities are included in figure 1: low, moderate, and high density and their impact on reachability indicated obviously. When density is high reachability comes up to 100% especially for VaaR-Sensor nodes that are neighbour to authority of management (one hop count). For other nodes which they are needed to multi-hop to reach authority management reachability values achieve different ratio degradation.

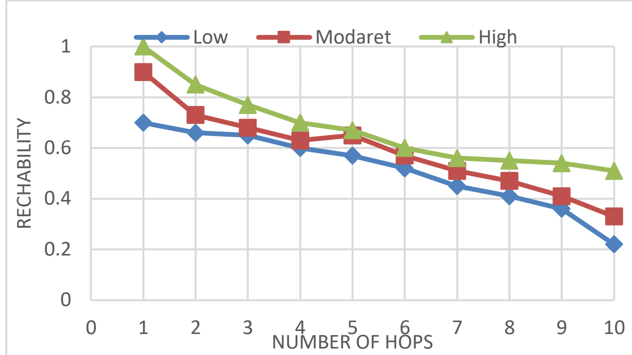

Figure 5: Reachability verses No. of Hops

In addition, two metrics are selected for performance evaluation of the two scenarios with Vehicular Cloud (with VC) and without Vehicular Cloud (without VC). The first one related to End-to-End (E-2-E) message delay time between the sender node and receiver authority management. While the second metrics is the ratio of the packet delivery (PDR) between the source and destination. The E2E delay and PDR both are represent as vital metrics that required to prove efficiency in such emergency situation. The main goal of proposed system is to transmit emergency data from the environment to the authority management quickly and stably. So, both metrics are selected to indicate the performance and resistance to harsh situations where data transition should manageable and handled carefully.
Figure 6, indicates relation between PDR verses simulation time. PDR means how much packets arrive authority management with respect to all sent packet. Proposed system (with VC) obtains good performance with 5 hops only, while traditional system (without VC) needs 10 hops or less with degradation in PDR. The reason behind that is the nature of traditional system where multi-hop link is required while proposed system does not.

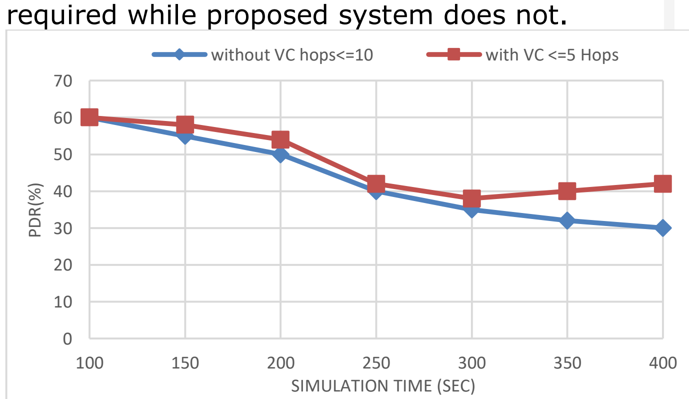

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Figure 6: PDR verses Simulation time

In rescue networks the real-time connections is vital where the humane live in danger. Delay in transportation environments information leads to lose a lot of people. So, to exhibit the behaviour of proposed and traditional system when transmit emergency data, figure 7 demonstrates the difference between them. Average E-2-E delay for proposed system is less than traditional system. As mentioned previously, links with many hops consume a time and prone to distortion, while links with few hops does not.

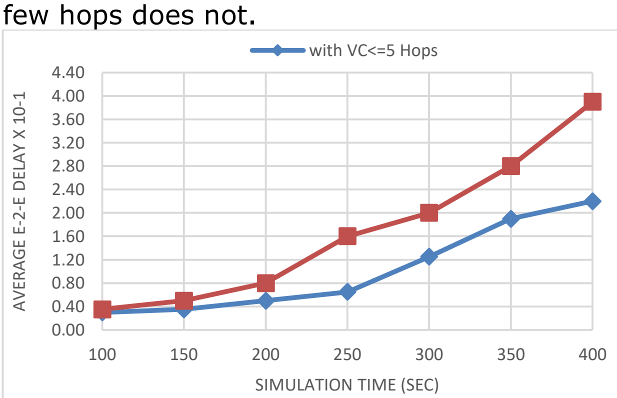

Figure 7: E-2-E delay verses Simulation time

Conclusion

This paper proposed a data aggregation system for catastrophic environments, which build mainly upon VANETs infrastructure. Where member nodes are deployed randomly in city, and those nodes are participating in establishing rescue network. Based on hybrid wireless networking proposed system is working; cellular network and ad hoc network. The connection inside zone rely on cellular networking while ad hoc wireless connection is used among relay nodes (gateway) in the way to authority management. Through this approach proposed system believe to cover the emergency situation monitoring environment. Simulations prove that reachability of proposed system is more efficient that traditional system with significant less in hops count. By 5 hops count proposed system feasible to achieve high reachability where traditional system required at least 10 hops to satisfy same reachability. Proposed system satisfied significant reachability with various densities but traditional does not. Furthermore, in case of average E-2-E delay and PDR metrics proposed system fulfil a perfect behaviour to serve the major target of establishment a rescue network.

Future work is required to enhancing proposed system through various aspects. Relay vehicle location play a vital role for routing the data to operation center this aspect need to study in details. Another aspect is the waiting time that both of VaaR-Storage and VaaR-Relaying should stay to accomplish their duties required studying carefully.

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