Vehicle Adhoc Sensor Network Framework to Provide Green Communication for Urban Operation Rescue

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***Abstract*—The use of wireless technology based on vehicle ad hoc network and wireless sensor network may give opportunity to the operational rescue team for emergency cases. Information transmitted using the vehicular and sensor technologies may improve the rescue communication. In this paper, a green communication framework is proposed to support the operation rescue together with green communication requirements. The proposed model is validated using two parameters which are average packet delivery ratio and level of congestion messages. The results are promising since we are using the 802.11Ext (extension for vehicle ad hoc protocol) to allow vehicle-to-vehicle communications.**

***Index Terms*—Vehicle adhoc network, wireless sensor network, green communications, mobile networks, simulation, operation rescue**

I. Introduction

Integrated software-based intelligence in cars can increase the passengers' safety and travelling experience. Vehicle Adhoc Networks (VANETs) pave way to research due to its mobility patterns which present unique challenges for discovering routes in the network layer. Such challenges are further enhanced due to several VANET applications having exclusive requirements at each layer for performance efficiency. The demand for more dependable, consistent and safer vehicular network standards is increasing due to emerging commercial applications such as ITS [1] and infotainment. The main goal of VANETs is to provide the drivers and passengers a safe and comfortable journey by minimizing the risks of accident and by introducing applications that notifies a vehicle about collision warnings, road signal alarms, infotainment [2] and file sharing procedures. VANETs are ad-hoc networks formed by moving vehicles and stationary Road Side Units (RSUs). In comparison with other conventional ad-hoc networks, the computational equipment in VANETs are not resource-constrained as well as distinct in their movement and also much more communication oriented. The most important characteristic of VANETs is the high mobility of the nodes, which is the fundamental cause of a series of VANET-specific attributes requiring the expansion of applicable solutions. In these circumstances nodes can move with certain mobility pattern on roads i.e. restricted by streets, traffic and traffic rules. In Urban areas the traffic density is high during rush hours, whereas roads experience recurring network fragmentation in rural areas.

Integration of Wireless Sensor Networks (WSNs) and VANETs provide sensing technology in future green communication. The road side unit (RSU) may sense the vehicles on the road to create a wireless sensor network. During the communications, the vehicle may sense the incident happen on the road and disseminate the information to the other vehicles for safe driving. Ad hoc networks (e.g. WSN, WMN, and VANET) propose a quick and efficient way for information dissemination. Thus, recently they have been used for accurate real-time data dissemination in traffic light management systems. Hewer and Nekovee in [3] have proposed a method to adapt the car following and Intelligent Driver Model (IDM) for decreasing traffic congestion on the roads by using the message dissemination based on vehicular networks. Another algorithm was offered in [4] for improving traffic management systems at intersections by utilizing vehicular networks. In [5], a Vehicular Grid (VGrid) framework was proposed based on V2X communications. Wireless Sensor Networks (WSNs) are used to estimate the number of vehicles at specific intersection as discussed in [6], [7], [8] for designing an adaptive traffic management systems. Using these approaches, drivers consume lesser fuel for their trips.

This paper is organized as follows: in Section II, we discuss the green communication in mobile networks. In Section III, we discuss the proposed framework of Vehicle Ad Hoc Sensor network and green communication requirements. The experiments and results are presented in Section IV. Section V concludes the article.

II. Green Communications: Related Work

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Nowadays, the whole world of telecommunications and information communities is facing more and more serious challenges, namely on one side the transmitted multimedia-rich data are exploding at an astonishing speed and on the other side the total energy consumption by the communication and networking devices and the relevant global CO2 emission are increasing terribly. According to report in [9], 3% of the world-wide energy is consumed by the Information and Communications Technology (ICT) infrastructure. This contributes about 2% of the world-wide CO2 emissions, which is comparable to the world-wide CO2 emissions by airplanes and cars". The energy costs account for as much as half of a mobile operators operating expenses. Therefore, telecommunications applications can have a direct, tangible impact on lowering greenhouse gas emissions, power consumption, and achieve efficient recycling of equipment waste. Networking provides solution to improve energy efficiency as well as resource efficiency that can benefit the global environment and society [10].

The increased number of vehicles nowadays has a significant impact on the environment. They are the biggest contributors to global warming [11]. In Malaysia, the number of registered vehicles by the end of 2011 was 21,401,269 according to the Road Transport Department [12]. This rapid increase of vehicles posts serious threats to the environment in terms of CO2 emissions as well as noise pollution. It also contributes to road congestion which worsens the issue of air pollution. According to [13], road congestion increases emissions and thus, there is a need to find a solution that can reduce the travel time in order to minimize such emissions. Many solutions have been proposed to mitigate the issue of road congestion and emissions. Some of the reviewed solutions included traffic signals coordination to achieve a green wave where possible as in [14] and [15]. Achieving a green wave according to these studies would reduce the overall travel time as well as the stop and delay related emissions while waiting in front of the traffic signals. Manipulating the control settings for the traffic signals such as cycle lengths and offsets was used in [16]. Results suggested that the cycle length did not have a significant relationship to emissions. However, the platoon arrival pattern had a significant impact on the emissions ratio. Early platoon arrival scenario forced vehicles to wait longer in front of the traffic signal. Late platoon arrival on the other hand did not bring vehicles to a complete stop and thus, vehicles produced less emission as compared to the former scenario of the early platoon arrival. Moreover, the difference between coordinated and non-coordinated traffic signals scenarios as well as the traffic demand was studied in [17]. Results showed that signals coordination and traffic demand considerations could reduce the emission ratios significantly.

Other studies have suggested the regulations of speeds such as in [18] and [15] and the engine idling as in [19] and [20]. Regulating the speed of vehicles on the roads did not have a significant impact on emissions in [18]. However, imposing speed limitations within residential areas had a significant effect as reported in [15]. Engine idling on the other hand was found to cause unnecessary pollution through fuel burning. This has led many countries to count engine idling as a road offence. Other advanced solutions that include the vehicles as part of the solution is the use of VANET as in [21], [22], and [23]. The use of geocast protocol to detect congestion combined with the Dijkstra-based method to compute the best route was used in [21]. The use of Received Message Dependent Protocol (RMDP) where a vehicle broadcasts its traffic information to vehicles in its surroundings as well as vehicles on the opposite lane was proposed in [22]. Another method was proposed in [23] where vehicles construct their own maps depending on the speeds they experience along their journeys. Lower speeds over specific areas over those maps would indicate congestion. Vehicles then can share these maps through VANET.

To improve the traffic flow and reduce congestion further, a hybrid solution of VANET and traffic signals control was proposed in [24]. The system relies on VANET to determine the intensity of vehicles in front of the traffic signal. It then adjusts the traffic signal cycle length for a better waiting time. Another proposed method suggests the elimination of traffic signals use [25]. The proposed method relies on Vehicle to Vehicle Communications (V2V). It uses a temporarily elected vehicle at roads intersections to broadcast the usual traffic instructions. Those instructions would be displayed to other vehicles through a built-in display. The approach is believed to deliver a better traffic control at intersections.

The study of green communications will require investigation in several areas such as power efficient radio frequency hardware, energy efficient operations scenarios, efficient MAC protocols, networking, and integration of renewable energy with communications equipment, frequency reuse deployment strategies, spectrum policy, and many more.

III. OPERATION RESCUE USING VASNET

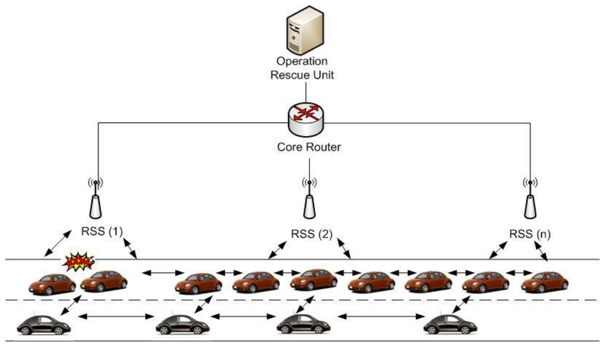

Figure 1. VASNet mobility architecture.

Vehicle Adhoc Sensor Network (VASNet) inherits its characteristics from both Wireless Sensor Networks (WSN) and Vehicular Ad Hoc Networks (VANET). There is no infrastructure for VANET; therefore the vehicular nodes do perform data transmission and packet routing. In this paper the integration of WSN and VANET functionalities to provide better solution in green communications. Fig. 1 shows the architecture of WSN and Vehicular to Infrastructure (V2I) for urban operation rescue.

The architecture is divided into two levels which are the infrastructure level and ad hoc level. The infrastructure level consists of operation rescue unit which located in the cities, a core router and several Road Side Sensors (RSSs) where they are connected by either fiber optic cables or the backbone from the service provider. The ad hoc level creates the connectivity among vehicular nodes. The onboard sensors which are carried by the vehicles provide a short-range wireless communications. The functionality of the sensor is to disseminate the information from other vehicles to the base stations via RSS. The RSSs are deployed along the road where it acts as an edge router to the infrastructure level. RSS sends and receives the traffic from the vehicular nodes to the base stations of rescue operation unit.

A. Green Communications Requirements for Urban Operation Rescue

An operation rescue is planned activity involving people to perform various activities to free from danger or confinement. Search and Rescue (SAR) is about searching and provision of aid to people who are in distress or imminent danger. The general field of search and rescue includes many specialty sub-fields, such as mountain rescue, ground search and rescue, search and rescue dogs, urban search and rescue in cities, combat search and rescue on the battlefield and air-sea rescue over water.

Green Communications must integrate system modeling across the multiple layers of a wireless networking in order to develop an environment for developing new ideas for improving energy efficiency. The model must be capable of performing a sensitivity analysis of each component within the overall system and how changes in those components affect performance including capacity, Quality of Service (QoS), and energy efficiency, as well as how changes in a single component affect other peripheral aspects such as cooling requirements. This can be deployed either in wired or wireless infrastructure to set up energy efficiency that uses the lowest resource consumptions. Therefore, it offers QoS guarantees.

In providing operation rescue research in green communication, there are several metrics used for evaluation. In network communications perspective, physical layer performance and QoS may use Bit Error Rate (BER), Frame Error Rate (FER), and latency to measure the efficiency of power and energy. However, in our research perspective, we have identified three evaluation metrics in providing green communications.

- Reduce Time Travel: Time travel is the cost of time spent on vehicle including waiting as well as actual travel. To reduce time travel, the vehicle may avoid traffic congestion after receiving an alert message from a neighboring vehicle.
- Travel Time Reliability: This is involving with unpredictable travel conditions and congested road. A metric is used to increase high reliability and estimate the travel time.
- Frequency Level of Congestion: The frequency of congestion message exceeds a defined threshold. Therefore the vehicle does not performance accordingly. It is defined as the percentage of packet transmitted during time travel period.

B. Stepwise Approach

High mobility of the vehicles creates a barrier for developing an efficient communication. A path between source and destination node may have multiple hops, this condition is more complicated in the city area. Intermediate vehicles can act as routers to determine the optimal path along the way. Traffic is disseminated using the optimal path in providing green communications. However, in real life scenarios, such as urban area or rural area, it has great influence by the road structures, traffic lights, big buildings and many more. In VASNet, vehicles move independently by changing their positions restricted to the road structure, connect with each other in a highly dynamic network topology and disseminate information via RSS. To deploy our idea, a stepwise approach is designed for VASNet as follows:

- Step 1: Set a coordinate or position of the neighboring vehicle to collect the information. The information is required for the source in forwarding the packet efficiently.
- Step 2: Identify packet transmission rate between vehicles. A number of packets forwarded may be increased due to disconnection of vehicles communication
- Step 3: Position of neighboring node is used to calculate the vehicles density (hop count). The vehicles may be too close especially during the congestion or accident occurs.
- Step 4: Choose the next hop node that is closer to the destination. The chosen next hop node is considered as a successor. There are three metrics to consider when choosing the successor, i.e. distance d_s, traffic load l_n, and expected successor connectivity e_c.
- Step 5: Identify transmission threshold value if messages are congested during time travel period.
- Step 6: Calculate traffic reliability and frequency level of congestion.

IV. Experiment and Result

An operation rescue is a challenging experience in helping any incidents involved in urban areas and rural areas. The rescue team requires efficient and reliable communications for each operational rescue involved. The operation rescue team would be able to share an incident location, share the incident cases via video or voice streaming, and forward medical information. Urban traffic has increased dramatically, making driving more stressful, costly, and unhealthy. For urban operation rescue team, it may affect their operation because of the high traffic density. Our aim is to use VASNet to support urban operation rescue in providing green vehicular communications.

We used the NS-2 simulator [26] to measure the performance of the VASNet. There are five different scenarios which consists of 10, 20, 30, 40 and 50 vehicles. The context is about simulating vehicle traffic in urban area during the rescue operation. Hence, the speed is considered 20 m/s, a vehicular traffic flow was deployed using IEEE 802.11Ext with transmission range of 80 meters. Various parameters were considered for establishing the communication among vehicles (see Table 1).

TABLE I. PARAMETERS OF IEEE 802.11P SPECIFICATIONS

Parameter	Value
Mobility Model	Mobility Random Waypoint
Propagation Model	Two ray Ground Model
MAC Type	802.11Ext
Antenna	Omni Antenna
Routing Protocol	AODV
Window Size	2000
Transport Protocol	TCP NewReno
Simulation Area	1000 m x 1000 m
Mobility Speed	20 m/s
No. of vehicles	10-20-30-40-50
Simulation Time	100 s
Maximum distance	100 m

The experiments are conducted to measure the proposed model using the two indicators which are Average Packet Delivery Ratio and Level of Congested Messages. In mobility random waypoint model, a vehicle moves toward it destination in randomly manner with a defined speed [0, V_{max}] where V_{max} is the maximum allowable speed for a vehicle. When the vehicle reached the destination, it stopped for duration ("pause time"). The process repeats until the simulation ends.

A. Average Packet Delivery Ratio

This is to evaluate reliability of travel time period for vehicular. Delivery ratio implies the ratio of number of packets successfully delivered to the number of packets sent. For calculating delivery ratio with respect to the number of vehicles, different traffic scenarios were simulated with varying number of vehicles in multiples of 10. For each scenario, delivery ratio was calculated for 5 simulation runs by changing the seed in multiples of 2. The average delivery ratio for each scenario was an average of 5 simulation runs and it is calculated as follows:

$$\text{Average Packet Received (APR)} = \left(\sum_{n=1}^{5} \text{Packet Received}\right)/5$$

$$\text{Average Packet Sent (APS)} = \left(\sum_{n=1}^{5} \text{Packet Sent}\right)/5$$

$$\text{Average Delivery Ratio (\%)} = (APR / APS) \times 100$$

Fig. 2 shows a comparison between five (5) scenarios on packet delivery ratio. Through the experiment, it is shows that the higher the number of traffic on the road, the lower packet delivery ratio. There are more messages are transmitted during the congestion period where the vehicles are sending acknowledgement message to their neighboring vehicle. The average packet delivery ratio is 95.65% for 10 vehicles on the road. The percentage is reducing when it is started to get congested to 50 vehicles, 49.02%. We could see more packets are dropped during the congestion period as it exceeds the threshold value.

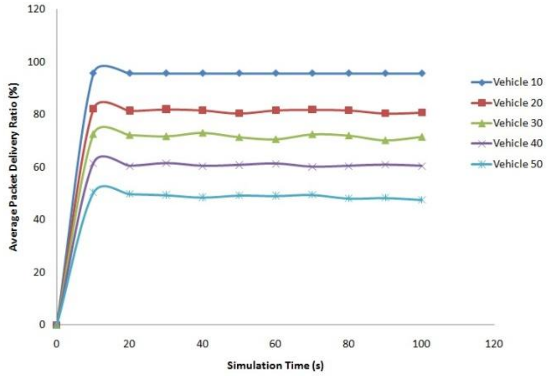

Figure 2. Average packet delivery ratio.

B. Level of Congested Messages

Fig. 3 shows the results for congested messages for five (5) different numbers of vehicles. At the beginning of the communication, the vehicle performs slow-start messages until it reaches fast transmission traffic until a time expired at 20 seconds. When the network is lightly congested and all vehicles lost their transmission signal, it starts to retransmit the message. This is happened continuously at 55 seconds and 80 seconds until the simulation finished.

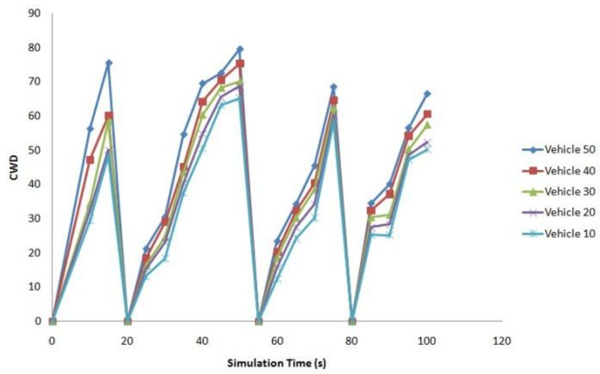

Figure 3. Congestion control messages.

V. CONCLUSION

This paper introduced architecture of vehicular ad hoc and wireless sensor networks to provide green vehicle communications. A simple communication in the mobility group is experimented using NS-2. The two parameters are used to evaluate five different scenarios, which are average packet delivery ratio and level of congestion message. With our work we want to contribute directly to the development of green communication at urban area using VASNet. Operation rescue communication provides the opportunity to integrate several technologies in one scenario as we have shown in here. Simulations and test-bed may require for future deployment to analyze the effectiveness of the system proposed in realistic environment.

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