Review of Wireless Technology Based Accident Reporting System: A Nigerian Perspective

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***Abstract*- Accident constitutes a very serious threat to human life. The rate at which accident occurs on our road has become so alarming and calls for urgent attention. To curb the menace of road traffic crash, there is need for timely reporting of accident occurrence to the rescue station. The major means of reporting road accident is through wireless technology assisted solution. Wireless technology technique commonly employed in the reporting of road accident is Vehicular Ad-hoc Network (VANET) or Global System for Mobile communication (GSM) or combination of both. VANET is an ad-hoc network that allows vehicle to vehicle and vehicle to infrastructure communication provided they are within communication range. Whereas, GSM is a communication standard based on wireless technology used to transfer voice on cell phone networks and also provides other services such as text messages, picture messages and MMS (multimedia messages). Prompt reporting of accident to the rescuing team will lead to quick response to accident victims, which invariably will result to decline in the number of deaths and loss of property. This paper seeks to survey accident reporting systems that are based on wireless technology (VANET or GSM). We provided a brief overview of wireless network, VANET and GSM wireless technology. We equally considered weaknesses of VANET-based reporting system and GSM-based reporting system and suggested the integration of Internet of Things as the best accident reporting option for Nigeria.**

***Keyword*- Accident Reporting, wireless technology, VANET, GSM**

I. INTRODUCTION

The increasing number of accidents across the globe has been attributed to high population and high level of vehicle utilization on the road. Accident is more prevalent in developing countries like Nigeria where road infrastructures development is not proportional to automobile population. In Nigeria, there is no single day that will pass without the record of accident, resulting to high mortality, morbidity and great financial loss [1].

According to World Health Organization (WHO), the number of people that looses their lives on yearly basis because road accident is estimated to be over 1.3 million and about 50 million people suffer injuries. World Health Organization also predicts that the number will increase to 1.9 million if no concrete action is taken by the end of 2020, especially in developing country such as Nigeria [2].

Therefore, the use of an efficient wireless communication technology approach that enables quick and reliable transmission of accident information will be a very good strategy to minimize the magnitude of lives and properties that are lost due to road accidents. Solutions proposed by different authors for accident detection and reporting use sensors to determine accident occurrence [3]. The reporting of accident to the concerned agency when it is detected is achieved by sending an alert message via GSM, VANET, or a combination of both.

VANETs supports vehicle that are fitted with computing devices, wireless communication devices, Global Positioning System (GPS) and sensors for reporting vehicle condition [4][5]. In this paper, the authors carried out a review of the existing wireless based technology used globally for accident reporting and recommended the best approach for Nigerian situation. In Nigeria, the means of detecting and reporting accident is not yet automated and has resulted to high loss of lives and property during accident.

A. *Motivation*

The magnitude of lives and property lost as a result of automobile mishap in Nigeria is highly disturbing. In Nigeria, serious injuries and deaths arising from road accident are rapidly increasing as a result of poor traffic infrastructure, bad road network, inadequate enforcement of traffic rules, rise in population and high number of road users [6]. Fatalities, physical disability, and morbidity from road accidents predominantly affect the young and the economically productive age groups [7]. According to road traffic safety experts, the actual number of casualties may be higher than what is documented, as many traffic accidents go unreported, hence detection will be helpful here [8]. Information and communication technologies in symbiosis with vehicles provides priceless opportunity to enhance assistance to people injured in road traffic accidents through the provision of information about the incident to reduce the response time of emergency services.

B. *Problem Definition*

In Nigeria, despite heavy loss due to accident, little or no effort has been made in provision of automatic means of detection and reporting of accident. Moreover, VANET and GSM wireless technology that are widely used globally as means of reporting accident may have limitation for efficient message delivery in Nigeria. In the case of GSM, most of our highways and local roads do not have network coverage. In

the same hand, VANET infrastructures are grossly lacking in our roads. These, therefore call for the need to review the existing accident reporting system.

II. WIRELESS NETWORK OVERVIEW

The technology that permits two or more devices to exchange information without wire but through the use of standard network protocols is referred to as wireless networking. In wireless networks, data are transmitted over air either through the use of infrared or radio frequencies. Two approaches are involved in wireless communication, infrastructure-base and infrastructure-less (ad-hoc).

A. Infrastructure-Base Mode

In infrastructure-base mode, wireless network could either be Wireless Local Area Network (WLAN) or cellular network.

In WLAN, network devices are connected via an access point which is a device that receives and transmits data from devices that have wireless interface cards (NICS). Access point can be taken as a hub that links wireless network together.

Cellular network on the other hand is a single hop network mode which supports communication in wireless network by installing base stations as an access points. Two communicating nodes within communication radius of fixed base stations in cellular networks rely on the wired backbone [9]. Through handoff process, a node that goes out of range of one base station can connect to a new base station and begin to communicate through it. The figure below shows infrastructure-based network.

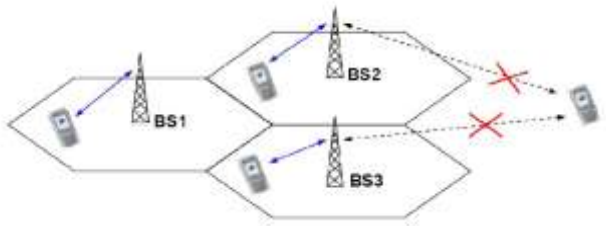

Fig.1 Infrastructure-based wireless network [10]

B. Infrastructure-Less Mode

Infrastructure-less type of wireless network also referred to peer-to-peer allows two or more device to receive and transmit data without centralized administration provided they have network interface card installed on them. Since two nodes that are not within a communication range cannot communicate, neighbouring nodes within the communication range can be employed to send packets from source to the destination [11]. This type of message forwarding is known as multi-hop relay. Every participating node in the network serves as router and is involve in routes discovery as well as maintenance.

Three emerging and promising areas within infrastructure less wireless networks include, MANETs, VANETs and WSNs (Wireless Sensor Networks). The figure below depicts infrastructure less wireless network.

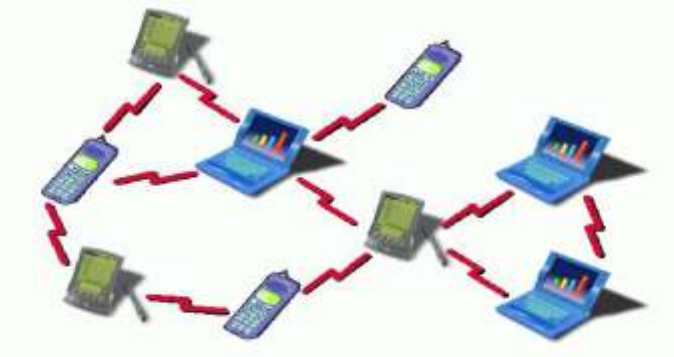

Fig.2 Infrastructural wireless network [12]

III. VEHICULAR AD HOC NETWORKS (VANETs)

VANET is a subclass of Mobile Ad hoc Network (MANET) that interconnect vehicles on road using wireless links. Every vehicle in VANET serves as a wireless router or node, allowing cars that are approximately 100 to 300 meters away from each other to connect and communicate within the network. Vehicles that are equipped with computing devices, event data recorders, antennas, and Global Positioning System (GPS) receivers make VANETs realizable.

The VANET architecture in fig.3 shows that communication could be Vehicle-to-vehicle (V2V), where one car can communicate with another car using Dedicated Short Range Communication DSRC (5.9 GHz), for range up to 1 KM. Communication between vehicle and Road Side Unit (RSU) which is referred as vehicle-to-infrastructure communication can also take place. The On Board Unit (OBU) of the vehicle connects the vehicle with RSU via DSRC radios. The RSU serves as a router that connects vehicles moving on the road and other network devices. The communication of vehicle or RSU with other nodes is either in single hop or multi hop.

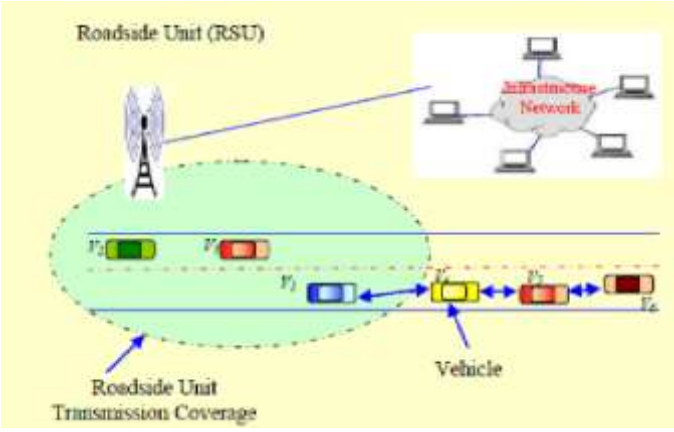

Fig.3 VANET Architecture [13]

IV. GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)

GSM (Global System for Mobile Communications) is a communication standard based on wireless technology developed by the European Telecommunications Standards Institute (ETSI) to provide a system that would enable greater capacity to be achieved than the previous first generation analogue systems. GSM, popularly known as second-generation (2G) technology is primarily used to carry your voice on cell phone networks that uses that type of technology and also provides other services such as text messages, picture messages and MMS (multimedia messages).

GSM network operates on a technology known as circuit switching which means that a dedicated communication channel must be established between two points before any data is transmitted and this channel remains active for the entire duration of the transfer with no one having to use the circuit, even when it not carrying any data.GSM network consists of Mobile station, Base station subsystem and Network and operation subsystem.

IV. REVIEW OF LITERATURE

Various works have been proposed by different researchers on accident detection and reporting approaches. Below is a review of some of the approaches.

In [14], an efficient accident and rescue system that employs an algorithm based on Vehicular Ad hoc Network (VANET) to deliver accident message to the rescue station was proposed. The system automatically provides alert on accident and also guides the rescue team to the spot. Accident is detected with the help of the crash sensor of the Air Bag System installed in the car. If the crash signal is above the set threshold, message is triggered by the controller to inform the rescue agency. The main aim of the work is to propose an automatic system for accident detection, alerting the rescue services with aid of VANET and also assists them to reach the accident spot.

Authors in [15] proposed an Emergency Services and Accident Detection system that is based on VANET. This system uses RF module to transmit the message which is received by the moving vehicle having this system to another enabled vehicle within the range of RF module. It will continue to send the message to the next moving vehicle until the vehicle in GSM network area receives this message. The message will then be transmitted through GSM to the service centre as soon as the message gets to a vehicle in network area. The system failed to consider any routing approach that will minimize delay in the message routing within the VANET.

Authors in [16] proposed a Sensor Based Accident Detection and Prevention Technology. This system employs multiple sensors for accident prevention and detection. In the prevention system, alcohol sensor and ultrasonic sensor are used to sense the alcohol content in the breath of the driver and to detect when a vehicle is much closer to an object or another vehicle respectively. If the driver is drunk, the vehicle is lock automatically so that the driver cannot even start the car. Also, the car automatically slows down the speed of the vehicle using the automatic speed controller fixed to the vehicle engine. In the detection system, the ultrasonic sensor, vibration sensor and glass break sensor are used to detect head displacement of the driver, collision of vehicle and glass breakage respectively. The outputs of the sensors are given as input to the microcontroller which processes the output and initiates the GSM to send emergency message to the rescue team if accident is detected.

The research work presented in [17] is a design of an accident detection system that informs the police control room or any other emergency calling system about the accident. An accelerometer based sensor was employed in detecting abrupt change in g-forces in the vehicle when accident occurs. If the g-forces range comes under the accident severity, then the microcontroller triggers the GSM modem interfaced to it and message (pre-stored SMS) is sent to a predefined phone number. Also implemented in the system is a buzzer which is switched on when accident occurs. The product design was tested in various conditions. The test result of the system confirmed its stability and reliability.

An Accident Management System Based on Vehicular Network for an Intelligent Transportation System in Urban Environments was developed in [18]. The management system makes use of vehicular ad hoc network together with a system that uses cellular technology in public transport. This system provides real-time communication among vehicles, ambulances, road side units and central server. Also, an optimal route planning algorithm (ORPA) was proposed in this system to improve aggregate spatial use of road network and bring down the travel cost of operating a vehicle. The accident management system comprises of five units namely, vehicular, central server, road side unit, ambulance and hospital. The vehicular unit takes care of the accident detection and message alert to the road side unit and the central server. The central server is responsible for the management of traffic. The ambulance unit identifies the best route using the accident information and optimal route information provided by the vehicular unit and the central server unit respectively. Through the connection between the ambulance unit and the hospital unit, the updates of the patients' health conditions are transmitted to the hospital unit.

In [19], an accident notification system in VANETs using Improved Location aided Cluster based Routing Protocol (ILCRP) was proposed. In the proposed system, each vehicle (node) has position monitoring system which monitors the vehicle position. When accident takes place, the mobile communication terminal receives the signal and informs the nearest hospital about the accident so that the victims can be rescued and treated immediately. The system involves cluster

formation in which every node in the VANET relies on the other vehicles for routing their packets. VANET is organized in groups called clusters and all the vehicles in a particular cluster move in the same direction with relative speed and having a cluster head. Packets are continuously transmitted between the nodes and the cluster head monitors all the member nodes. When there is packet loss or accident occurs, the cluster head will send information about the accident to the nearest hospital node for prompt rescue of the occupants. The Improved location aided Cluster based Routing Protocol is the algorithm proposed for VANETs to improve packet delivery ratio, reduce control overhead and reduce end to end delay. The system uses GPS for detecting location and speed of vehicle and GSM modem for forwarding of message by the cluster head.

A Road Accident Prevention (RAP) with instant emergency warning message dissemination in vehicular ad hoc network was proposed in [20]. RAP was proposed to prevent highway traffic crash and thereby minimizing death and injury rates. Once there is an advanced predication of road accident, RAP will initiate highway traffic accident prevention. The activities of the scheme include the following:

i. Prediction Report (PR) on the vehicles and traffic condition on the highway is constructed by the road side unit.
ii. An Emergency Warning Message (EWM) based on abnormal PR is generated by the road side unit.
iii. VBN structure is formed by the road side unit.
iv. The road side unit transmits the EWM to all the vehicles with high risk factors and travelling in high risk zone.

The RAP scheme reduces cost by formulating and deploying VBN structures to minimize the number of road side units.

A. Analysis of Reviewed Works

In the various papers on accident detection and reporting system, sensors play a major role of detecting accident while GPS detects the location of the vehicle under the control of a programmed microcontroller. In the aspect of reporting of the accident to the rescue centre when detected, GSM, VANET or a combination of both is used. This reporting approach has some weakness. There are certain points along the road that are not covered by GSM network and when accident occurs at these points, emergency alert may not be delivered to the rescue centre. On the other hand, VANET may not be so reliable because of high mobility of vehicles on the highways and VANET under certain climatic conditions may not function well. Also, because of high cost of VANET infrastructures, adequate installation may not be provided to guarantee effective communication among vehicles and Road Side Units (RSUs).

V. PROPOSED WORK

As a result of limitations associated with GSM and VANET, we suggest the integration of Internet of Things (IoTs) approach to the existing GSM/VANET approach to ensure the delivery of accident alert message. Internet of Things simply refers to an application performing with the help of internet access [21]. Internet of Things worldwide implementation is feasible with cloud centric vision. Incorporating Wireless Fidelity (Wi-Fi) into an embedded system will guarantee worldwide monitoring, control and data storage [21]. Therefore, our proposed approach comprises sensors and GPS for accident detection and location tracking respectively. The reporting aspect of the proposed system involves GSM, VANET and IoTs approaches to guarantee efficient message delivery to the rescue centre. With the help of Raspberry-pi 3 which has an inbuilt Wi-Fi module, accident information obtained from sensors will be forwarded to cloud server using Wi-Fi module. Server is used to store data and also provide all information concerning the accident on a web page. In addition to GSM and VANET, Internet of Things technique is used to provide network among vehicles and central server. The proposed work provides multiple options for emergency message delivery, thereby enhancing performance of the system. Even though, the practical implementation of the proposed work may be costly, the authors of this paper believe that nothing is costlier than life. The above mentioned components are connected as shown in fig.4.

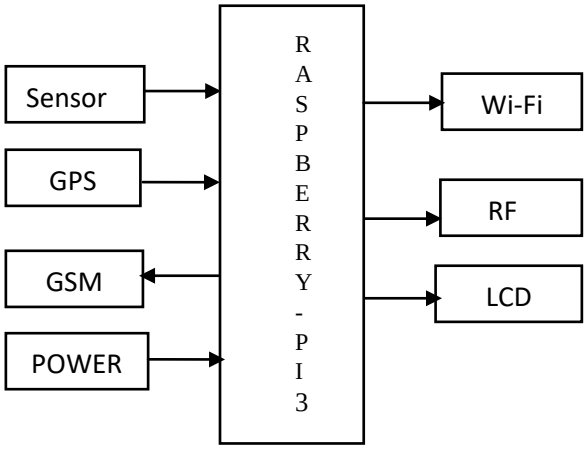

Fig.4 Architecture of Proposed Work

A. Raspberry-pi 3

The Raspberry-pi 3 is the controller of the system which is programmed to take urgent decision based on the information it receives from the sensor. It triggers any of the components interfaced to it when the service of the component is needed. The Raspberry-pi 3 comes with an inbuilt Wi-Fi module.

B. Sensors

Sensors play sensing role in the system. The main function of sensors in the system is to detect accident and send information to the raspberry-pi 3.

C. Wi-Fi Module

Wi-Fi stands for Wireless Fidelity. Raspberry-pi 3 triggers the Wi-Fi module when accident occurs and accident information acquired for the controller is transmitted to the cloud server. The information about the accident is displayed on the web enabled device in the rescue station.

D. RF Module

Radio Frequency module component of the system that is interfaced to the raspberry-pi 3 is for VANET. It is responsible for vehicle to vehicle and vehicle to RSUs communication

E. GSM Module

GSM stands for Global System for Mobile communication. This module is used for sending accident alert message to the designated number of the rescue agency so that vehicle occupants can be saved.

F. GPS Module

This functions as the location tracking module. The location of the accident scene is detected the GPS module. This information is very important to the rescue team for easy tracking of the victims.

G. LCD

Liquid Crystal Display is a display unit in the vehicle. The events taking place in the vehicle are display here for the driver to see and take necessary precautions.

H. Power Supply Unit

This is the source of power to the system. The system can only function if there is a means of supplying energy to it. The system can derive its power from the vehicle or through an inbuilt power unit.

VI. CONCLUSION

In this paper, we carried out a review of some research works done in the area of accident detection and reporting system taking Nigeria situation into consideration. Weaknesses in the commonly used approach for accident reporting were identified. And the paper concludes by proposing the integration of Internet of Things (IoTs) technique to enhance the delivery of message in such system.

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