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Hazardous Vehicle Safety Control Application using WSN for 5G Network with Cyber Security

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***Abstract*: Hazardous substance carrying vehicle may create disaster for humans in case of any accident happen on highway road. This vehicle may carry hazardous substance, explosive material, gas, fuel etc. So these accidental event awareness to public, road traveler and respective highway authority can be achieved by WSN and effective implementation of this system can be achieved by 5G network.**

Accident of this vehicle can create disaster on road if material explodes, if gas , fuel leakage or fire on vehicle and it creates issues for road traveler and resident person also. Our aim is to detect such accidental event, its root cause and in vehicle control for before the event happens and informs to public and highway authority by wireless and we can use speed for data/information. 5G network use can trace vehicle to communicate and inform respective authority to vehicle track and also inform if any accident condition occur due to over speeding, leakage, over loaded vehicle, driver may be drunk and drive not following traffic rules. This information can be given to public on mobile internet those who are in the area of cell and suppose to enter in the cell. As these vehicles are connected over internet then there is risk for hack these vehicles for to create disaster or any terrorist activity. So this should be secure with help of cyber security.

Keywords: Wireless sensor network (WSN), Device to Device Communication(D2D), Software defined network (SDN).

I. INTRODUCTION

Every year Injuries in Global Crashes 50 million, Deaths in Global Crashes 1.3 million and still rising. Number of deaths due to road accidents, 85% of global crashes occur in low and middle income countries. In that India is rank 1 i.e. 1,10,000 people killed every year and China is at rank 2 i.e. 87,000 people killed every year. Various efforts are being made to improve road safety based on World report on Injury prevention and control. In spite of these global efforts, road crashes, fatalities and injuries in low and middle income group countries are not reducing. So to ensure that our efforts are successful it is important to first understand causes of accidents in developing countries, traffic in developed and developing countries is different. Hence safety initiative should also be different and specific to problems and issue of developing countries. So this paper explains one application of this road safety for Hazardous substance carrying vehicle's safety and safety for other road travels and residents. Proposed application only can achieve effectively in 5G network [1]. In 5G network, device to device (D2D) communication system gives a useful infrastructure which helps to enable different applications for public/human safety. In future world, complex establishment of wireless sensor networks (WSNs) is using D2D communication in 5G networks [2]. This communication enables communication between in particular cell and mobiles in that cell using cellular communication links and improving the energy efficiency, spectrum utilization, and system throughput of the network. 5G network can be used and D2D communication is used where all software defined network (SDN) system interacts with the in the cell to reduce the chunk of requested communication links like long term evolution (LTE) and can be used for hazardous vehicle related safety and human safety. The system architecture can be used to maintain the communication between disaster or hazardous victims, places and respective authority by installing multi-hop routing path with the use of the cellular communication network system. This paper highlights how to use of system by presenting a human/public vehicle which is one node of WSN, road safety scenario such as disaster or Hazardous vehicle accident and importance of cyber security. Below fig shows basic use of wireless sensor network (WSN).[4]

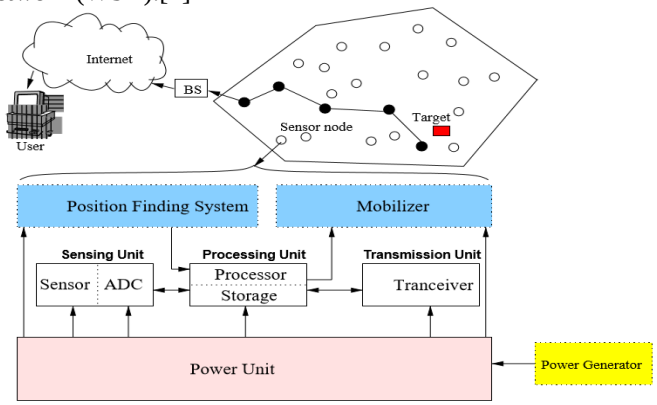

Fig 1. Basic components of Wireless Sensor Network [4]

II. HAZARDUS VEHICLE SAFETY CONTROL

To evaluate the performance of this system we required 5G enable communication network. Hazardous substance carrying vehicle act as one sensor node of WSN. Some cases of hazardous vehicle accidental cases shown in below fig1.

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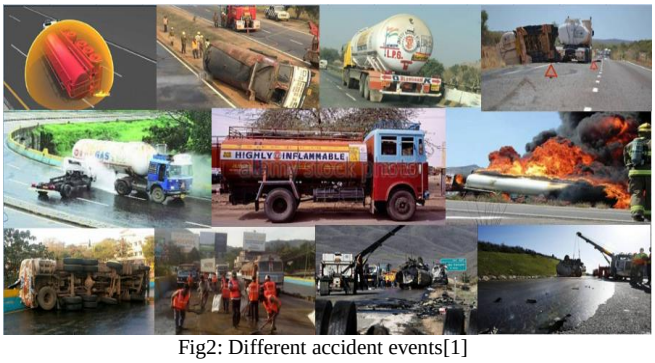

Fig2: Different accident events[1]

On vehicle different sensors are placed on vehicle by OEM, these sensors data collected by different body ECUs available on vehicle and these ECUs send this information over CAN to BCM and BCM used this information for appropriate action or logged this information for future diagnostic.

In proposed system different sensors need to fitted on vehicle like pressure sensors, tilt sensors, level sensors, steering angle sensor, vehicle speed sensor, Indicator detection sensor, seat belt sensor, GPS etc. and these sensors will give information to BCM over CAN. For this OEM needs to update their CAN matrix. 5G Transceiver module need to fitted on vehicle in Fig 3. Basic functional block shown in fig 4. BCM send this information to 5G Transceiver module to send message to Base station for further action. Base station will send this information to respective authority based on message shown in fig 7.

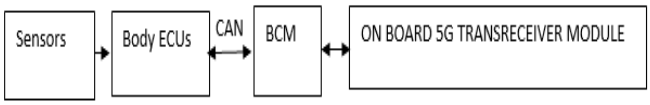

Fig 3. Proposed Components on Hazardous Vehicle

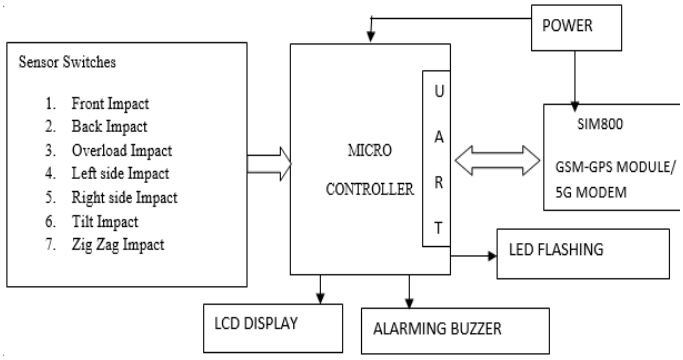

Fig4. Functional concept block diagram

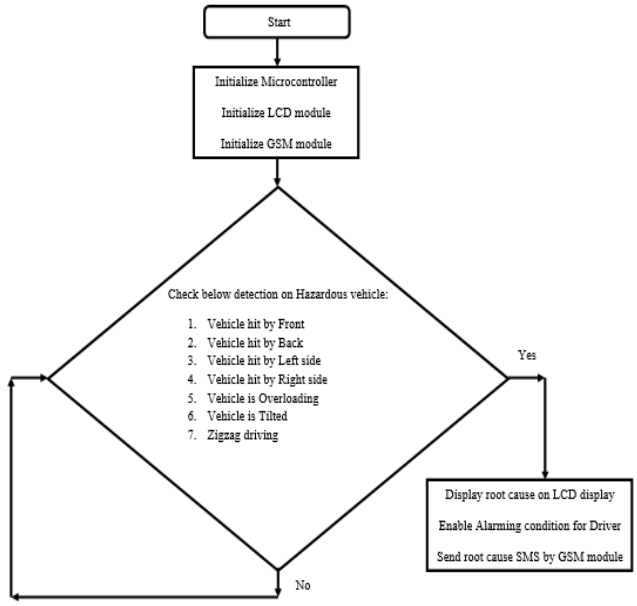

Fig 5. Flowchart for root cause SMS by Hazardous Vehicle

Sr. No	Event	Message
1	Vehicle hit by Front	FRONT IMPACT
2	Vehicle hit by Back	BACK IMPACT
3	Vehicle Hit by Left Side	SIDLH IMPACT
4	Vehicle hit by Right Side	SIDRH IMPACT
5	Vehicle is Overloading	OVRLD IMPACT
6	Vehicle is Tilted	TILT IMPACT
7	Vehicle Driving Zig Zag	ZIG ZAG DRVG

Fig 6. Mapping of Messages and Events

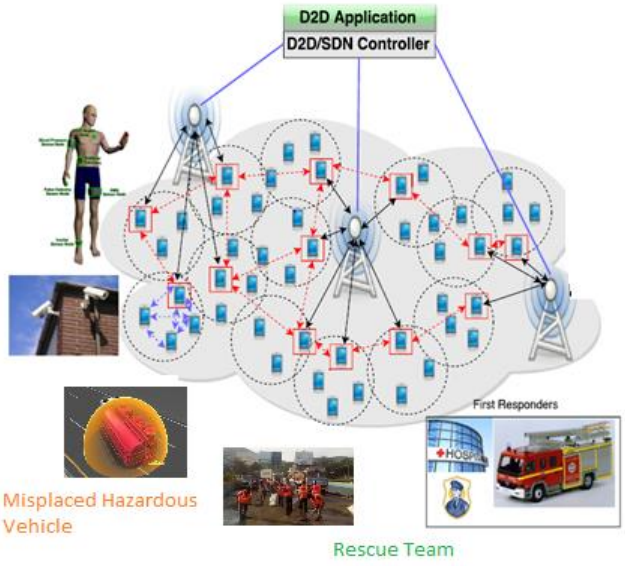

Fig7: Proposed system for hazardous vehicle safety application

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Possible cause of accidents:

1. Over speed of vehicle
2. Seat belt not used
3. Lane cutting without indication
4. Drunk and drive
5. Overloading vehicle
6. Vehicle not serviced
7. Non skilled and authorized driver
8. Break fail of vehicle
9. Tyre burst
10. Tyre pressure not maintained
11. Hit by backside vehicle
12. Hit by opposite side vehicle etc.
13. Leakage of Hazardous substance i.e. Gas, oil, Acid.
14. Road condition not maintained
15. Road signs not placed correctly
16. Driver not take sufficient rest

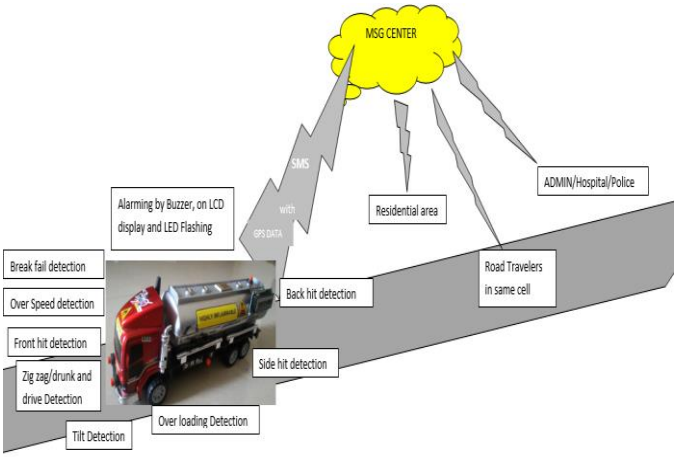

Fig 8: Hazardous vehicle and human safety risk and condition detection and intimation application.

Below some sensors can be applied on hazardous vehicle:

1. Vehicle Speed sensor or speed data from CAN database.
2. Tilt sensor
3. Tire Pressure sensor
4. Tank pressure sensor
5. Engine cooling fan on/off detection sensor
6. Vehicle starring angle sensor or starring angle from CAN database
7. Vehicle indicator sensor
8. Seat belt sensor
9. Vehicle break fail indication and detection
10. Vehicle servicing information detection

This information can be sent to first Message center base station and then message center can send it to respective authority like Police, Hospitals, Rescue team with location GPS coordinates and cause of accident. This information is also necessary to send people who are present in particular area or cellular circle to intimate of if any Gas carrying vehicle is misplaced in area. This action will be taken by message center or base station. And people who are travelling by same road or who are entering in that particular cellular network can intimate for inflammable or oil carrying vehicle get misplaced on road.

III. 5G NETWORK

The management and increase in number of cellular communication devices and load of traffic in interfacing with the spectrum crisis shows the basic requirements for the 5G cellular networks. So, use of 5G networks required to use to find out way to guarantee of highly reliable system, increase capacity and latency need to be less. This technique shows many upcoming technologies such as Software-Defined Networking (SDN) Network Function Virtualization (NFV) and Device to Device (D2D) communication. Capacity bottleneck issue of cellular communication systems can be resolve by D2D communication system. [2]

This new system triggers interface between in circle or cell 5G or 4G based devices, reducing the data transmissions in the communication network. This system provides different use cases as Direct communication delegate information data from spectrum to other technologies with improving spectral efficiency, data rates and coverage can be increased for devices tracking and direct access to the cellular infrastructure system with higher energy efficiency which can be achieved by close proximity of cellular devices which required low transmission powers.

To use these in different applications, D2D communication architecture required to powerful, flexible which cover the requirements of all cellular applications and public or human safety applications. The generation of human/public safety applications with this 5G communication networks sometimes creates issue in communication to finalize the D2D communication system because of more rigorous requirements of public safety applications in the world

IV. USE OF CYBER SEQURITY

Nowadays, vehicles are totally connected to mechanical machines that are mostly used for transportation. Peoples are increasingly demanding a smooth and continuous connected experience in all aspects and driving. The techniques of vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications, telematics, and the use of smart phones and Bluetooth devices, connected vehicles represent an eco-system that is part of a fully connected world. Connected vehicles are an integral part of the smart city vision and a node in the world of Internet of Things (IoT)[4][5]. Also vehicles are now controlled by hundreds of Electronics Control Units (ECUs) that form an internal network of devices within the vehicle. While increasing automated and connectivity in vehicles bring many improvements in terms of functionality and convenience, it also brings a new cyber threat/attack plane into life where vehicles become a new target for attackers/hackers. So in our application hazardous substance carrying vehicle is connected over internet with speed of 5G network so these vehicles need to get secure by any cyber treat or hacking. Hackers may user this vehicle to do any terror attack. All vehicles are now having internal in vehicle network can be seen in fig4.

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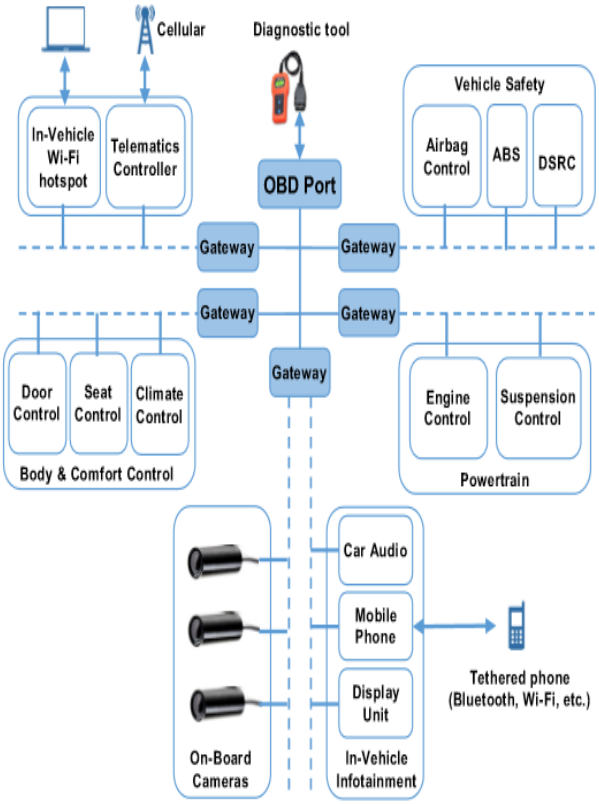

Fig 9. In vehicle network[4]

V. DEAD ZONE DETECTION AND ESTIMATION

In area where there are no cellular networks like small forest, hillside area easy question came in mind then what is criteria for Hazardous vehicle safety?

So this issue can be overcome by use of 5G network. Below few information need to collected by system.

1. Identify area where cellular network is not present.
2. Decide speed limit of vehicle.
3. Vehicle should be tracked by GPS
4. Traffic condition in that area.
5. Road distance in that area.
6. Vehicles maintenance status
7. Atmospheric conditions from that area.
8. Dead zone area crossing time need to calculate.

So based on above such data system can estimate time for vehicle should cross the dead zone area. In that time, if vehicle not crossed this area then information need to give authority.

VI. RESULTS AND ANALYSIS

Hazardous substance carrying vehicle shown in fig 10

Fig 10. Hazardous substance carrying vehicle

This system we can simulate by using SMS Auto Forwarding APP by URL Software Global Inc company. We can define setoff rule for different messages. We can do one set of rule for actual accident happen and vehicle will give possible root cause and can be inform to Highway authority, Police, Hospital, Resident people and Other road travelers.

And other set of rule for only intimation to Highway Authority and Police that vehicle is under risk.

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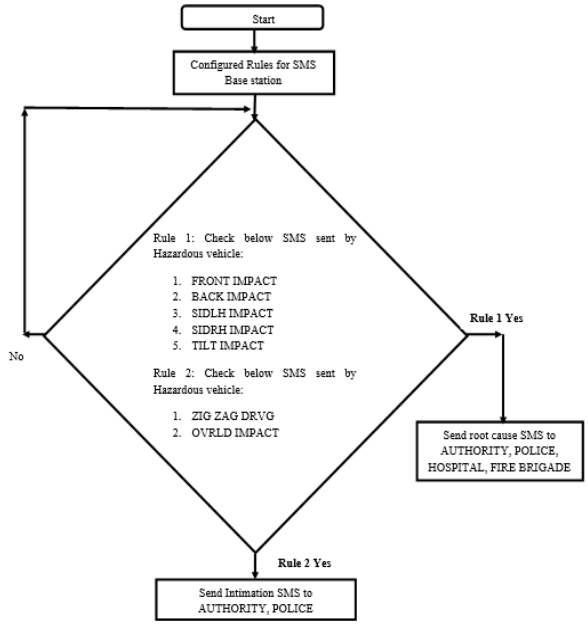

Fig 11. Flowchart for SMS forwarding based on set rule

Fig 12. SMS Auto Forwarding APP for simulation

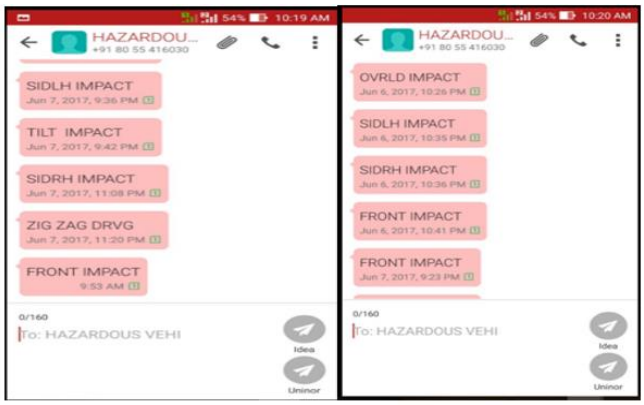

Fig 13. Hazardous vehicle sent SMS result

A. *PRE WARNING OF ACCEDENT*

Using different sensors fitted on hazardous vehicle, respective authority can detect possible chances of accident of hazardous vehicles.

a. *Vehicle Drive Zig Zag*

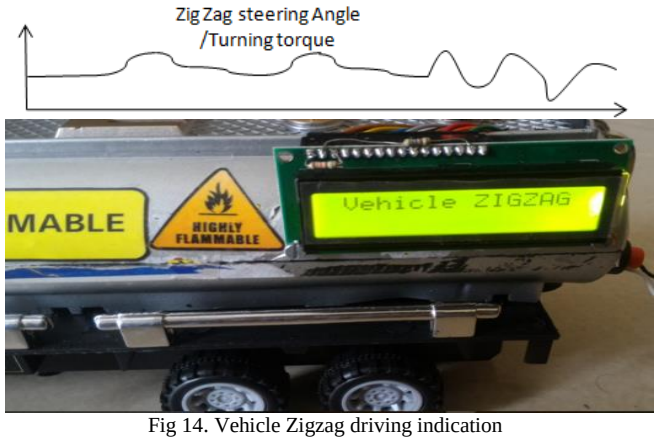

Fig 14. Vehicle Zigzag driving indication

b. *Vehicle Overload*

Fig 15. Vehicle Overload indication

B. *INFORMANTION OF ACCEDENT*

a. *Vehicle hit by BACK*

Fig 16. Vehicle Hit by back indication

b. *Vehicle hit by FRONT*

Fig 17. Vehicle Hit by Front indication

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c. Vehicle hit by LEFT SIDE

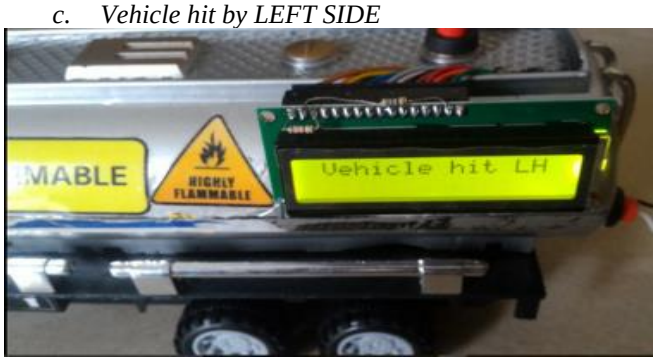

Fig 18. Vehicle Hit by Left side indication

d. Vehicle hit by RIGHT SIDE

Fig 19. Vehicle Hit by Right side indication

e. Vehicle TILTED

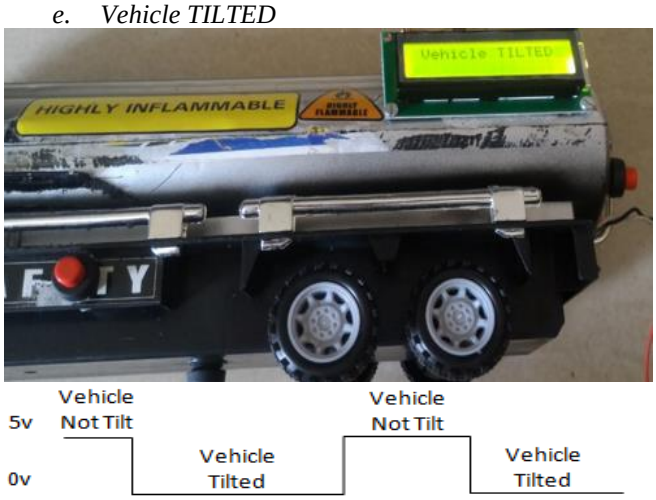

Fig 20. Vehicle Tilted indication

This information can be sent to respective authority like Police, Hospitals, Rescue team with location GPS coordinates and cause of accident. Using 5G network this information is also necessary to send people who are present in particular area or cellular circle to intimate of if any Gas carrying vehicle is misplaced in area. And people who are travelling by same road or who are entering in that particular cellular network can intimate for inflammable or oil carrying vehicle get misplaced on road.

Proposed Expected Result:

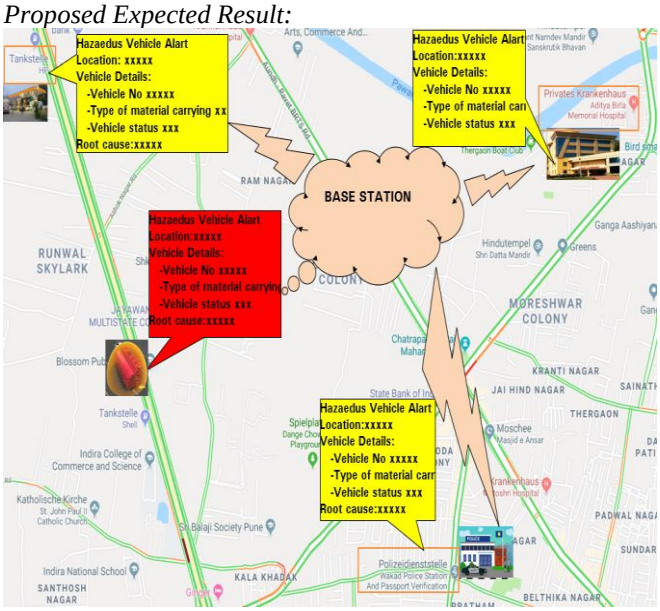

Fig 20. Proposed expected result

VII. CONCLUSION

In future world there will be a dense network of WSNs ranging from different application related to public /human safety and integration of these WSNs with future 5G networks is an open issue. This paper gives overview of how 5G network can be used for to detect possibility of hazardous vehicle accident, accident and place identification, Communication to respective authority and public who are available and entering in the cellular network. In case of disaster or hazardous situations, the SDN systems in 5G network can select multi-hop routing path between the disaster victims and respective authority system to maintain the communication between them. This helps that the first sender to exactly locate the victims or misplace vehicle that are in critical condition and need immediate aid or help. The mobile coverage in this architecture need to meet the needs of processing and storage demands of WSNs, where data from sensors can be processed from vehicle and need sent to respective responders to decide their rescue plan. Road Safety Control in Hazardous or Disasters Conditions can be control by wireless sensor networks and theses possess the potential for many applications too. The advance of technology enabled the creation of prototype WSNs, but the hardware and software both have a way to go before WSNs are practical, cost-effective, and usefully.

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