International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 11 Issue 03, March-2022

NB-IoT based Road Accident Alert System

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***Abstract*— Even a small road accident can cause major collateral damage, a person's lifetime loss can cause damage to one whole family. Road safety is a major concern in any part of the world, the huge number of deaths caused by road mishaps can be reduced with the help of advanced IoT technology. The paper proposes one such implementation of using a collision detector module to detect an accident. To make sure that the collision is not a false alarm, a Micro-electromechanical systems accelerometer with an ultrasonic sensor is used to get confirmation of an accident at a particular place. Once the confirmation is received, the exact live location of the mishap is attained with the help of the GPRS module's longitude and latitude data coordinates. This information relay is compared with multiple communication protocols such as ZigBee, cellular, LoRaWAN, and NB-IoT, and this information is relayed efficiently with NB-IoT protocol and with pushing-box API to the emergency service station for immediate action. The system is also incorporated with a speaker to alert others nearby. With this basic and easy implementation of a smart post-collision alert system, instantaneous measures can be taken, damages can be mitigated, and many lives can be saved.**

Keywords*— Micro-electromechanical systems; accelerometer; ultrasonic sensor; GPRS; NB-IoT; LoRaWAN; ZigBee;

I. INTRODUCTION

Road accidents have a huge socio-economic consequence including the loss of productivity, pain, and suffering of the victims. The compensation for the damage caused could vary from repair, legal expenses to that of the person and the victims' life being put at risk. Different factors that could contribute to accidents could be because of infrastructure or drivers that are over speeding, rash driving, violation of rules, ignoring traffic signs, fatigue or alcohol, it could also be because of the carelessness of the pedestrians but the control of the vehicle lies in the hands of the driver. Hence to avoid the situation the vehicles should be equipped with driver assisting aids in form of an alerting and prevention system which could avoid the loss of life.

The Safety system Approach within the road transport system is built around the premise that death and injury are unacceptable and avoidable. The safe system outruns the fatalistic view that road traffic injury is the price to be paid for achieving mobility. It aims to eliminate road crash fatalities and serious injuries in the long term, with interim targets to be set in the years towards road death and serious injury elimination.

Smart technologies for road safety [1,2,3] are available only in high-end vehicles, including forwarding collision systems, lane departure technology, blind-spot detection, automatic emergency braking systems, backup cameras, cross-traffic alert systems, and rear crash-imminent braking, driver monitoring systems. The Internet of Things (IoT) consists of the system of a physical item or things embedded with electronics, software, sensors, and network connectivity. This enables to collect data and exchange of data. It allows objects to get sensed and remotely get controlled across the existing network infrastructure. In the case of an emergency due to unforeseen circumstances, IoT-connected vehicles as in
[4] send automatic SOS messages to emergency services, assisting in providing rapid attention to reduce accident-related death rates. This progress will bring changes that would prevent accidents, bring down traffic congestion, and provide assistance even in remote locations. But such basic safety features are lacking in most vehicles in India.

The annual report of the National Crime Records Bureau (NCRB) showed that around 3,54,796 cases of road accidents occurred during 2020 in which 1,33,201 people died and 3,35,201 were injured. The NCRB report also expresses how the number of road crashes as the restrictions on vehicle motion were elevated during the last half of 2020. IoT devices communicate with each other using different protocols and the solution proposed in [5] aims to reduce the number of deaths by using protocol-based General Packet

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Radio Service (GPRS) systems. The system notifies the concerned authorities of the time and location of the accident for quick response. Thus the paper focuses on implementing a solution that could be integrated into all types of vehicles such as trucks, buses, cars, bikes, and scooters. This helps in having efficient communication between the help stations and the place where the accident has occurred. The proposed method will be of assistance in remote areas with, maximum data rate, range, low power consumption, and cost-efficient.

II. LITERATURE REVIEW

The smart system proposed in [6] is built to describe the alerts and control the speed of a vehicle by notifying the individuals accordingly when an accident occurs. The system monitors the distance between vehicles and the obstacles that are in front of vehicles using a distance sensor. The system alerts the driver to control the speed and reduce the speed by itself when an obstacle comes within the limit.

In [7], using Long Range Radio (LoRa) terminal devices attached to vehicles and a LoRa receiver unit, acting as infrastructure. Here it is to evaluate the equivalence between experimental and simulated results that are obtained from the communication link between the LoRa module inside a vehicle and a LoRa receiver compared to those produced by NS-3 simulation. Three metrics are taken into consideration and are evaluated: Packet Delivery Ratio (PDR), Packet Inter-Reception (PIR) time, and Received Signal Strength Indicator (RSSI). Results show that all the metrics evaluated in the simulated experiments are consistent with the results of the real experiments.

LoRaWAN, a Long-range wide area network, as in [9] is one in every of the low-powered area technologies. It is a star network topology, where the top devices can only communicate with LoRaWAN gateways and circuitously one another. The work is based on the spread-spectrum modulation techniques derived from chirp spread spectrum (CSS) technology. These represent each little bit of payload information by multiple chirps of knowledge. LoRaWAN is developed in concert with the cloud-based medium access control layer protocols which can manage the communication frequencies, data rate, and power for all the electrical devices that are commonly used.

Concerning [10], in step with to experiments conducted on LoRaWAN and NarrowBand-Internet of Things (NB-IoT), considering the results supported to energy consumption, the expected battery life, and also the packet loss, LoRaWAN protocol can increase the battery life up to ten times when compared to NB-IoT in the applications of delayed transmissions. Since there is a necessity to transmit data at a faster rate, it is noble to use NB-IoT for road accident prevention. Table I. Represents the comparison between different protocols considering some attributes as mentioned.

TABLE I.

Protocols	Frequency	Range	Power usage	Data rate	Cost
GSM	(900 to 2100) MHz	35km to 200km	40mW to 80mW	35 Kbps to 10 Mbps	₹7000 to ₹8000
ZigBee	(900 to 2499) MHz	1.2 km to 3.2 km	10mW to 100 mW	250 kbps	₹1000 to ₹ 2000
NB- IoT	(1850 to 1910) MHz	1 km to 10 km	710mW to 840 mW	26 kbps to 62 kbps	₹300 to ₹1000
LoRaWAN	(169 to 950) MHz	5 km to 15 km	10mW to 100 mW	0.3 kbps to 50 kbps	₹800 to ₹1000

NB-IoT is competitive in terms of offering the best Quality of Service (QoS) and guarantees message delivery compared to the 64% LoRaWAN packet delivery ratio. Therefore from the above literature survey and Table 1. NB-IoT is chosen because the perfect protocol for road safety applications.

As in [8], the system is intended to trace the vehicle when it is lost using the Global positioning system (GPS) and Global System for Mobile Communication (GSM) technology. GPS receiver and GSM module use Arduino UNO controller to forward the commands. This system is fixed inside a vehicle. The GPS module will transfer the placement values to the controller. The controller will receive it and send that information to the auto user using the GSM modem.

SoSMart application [11] detects accidents automatically using the internal sensors and accelerometer of the smartphone. After accident detection it sends an alert notification with location to pre-selected contact, so the contacted one can send rescue services as soon as possible. This application uses professional and sophisticated algorithms that are developed and tested on real car crash data from the National Highway Traffic Safety Administration [10]. Using these algorithms, it is easy to differentiate the sensitivity of accidents whether it is hard, normal, or just minor to avoid false alarms.

III. PROPOSED METHODOLOGY

The system working flow chart is shown in fig. 1. It is a fairly simple system where the initial process is to detect if any accidental impacts have occurred to the vehicle which is done by the sensors as in references [4,5,6]. Following this, if the impact does not occur, the process is restarted. If ill fate prevails causing any sort of impact accident then the location data is acquired using the GPS module then the NB-IoT module is activated using the main microcontroller and an

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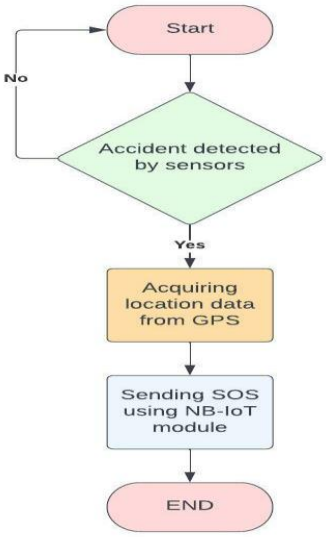

Fig. 1. Working Architecture

SOS signal is distributed within a variety of messages or calls or emails to all or any of the emergency services.

The paper uses the Narrowband transmitters embedded inside the dashboard of the vehicle together with the pressure sensor, Micro-electromechanical systems (MEMS) sensors, GPS, and GSM modules. At the purpose of the accident, the vehicle produces abnormal vibrations which will be detected by a microcontroller, and also the MEMS sensor senses the tilting of the vehicle and detects the occurrence of the accident. The GPS module transmits the accident location to the control station and GSM sends the placement to the hospitals.

IV. COMPONENTS USED

A. *Accelerometer*

An accelerometer is a device that will be used to measure the vibrations and motion of a structure. The force caused by vibration or a change in motion or acceleration causes the mass to squeeze the piezoelectric material which produces an electrical charge that is proportional to the force exerted upon it. The charge is proportional to the force and the mass remains constant, then the charge will be proportional to the acceleration. These sensors are used in a variety of ways from space stations to handheld devices, and there is a good chance you already own a device with an accelerometer in it. For an instance, all smartphones today have an incorporated accelerometer. They help the phone know whether it undergoes acceleration in any direction, and it is the reason why the phone display switches on when it is flipped. In an industry setting, accelerometers help engineers understand a machine's stability and enable them to monitor for any unwanted forces or vibrations.

B. *Ultrasonic*

Ultrasonic Sensors are primarily mapped to detect solid or liquid objects as targets with the help of sound waves. It works by sending out a sound wave at a frequency above the range of human hearing These compact sensors provide enhanced flexibility for areas with limited space and are excellent for standard packaging and assembly applications. These are ideal for the Perception of the targets that are challenging for photoelectric sensors to perceive.

C. *Shock and Impact sensor*

Shock and impact sensors are designed to detect instances of sudden impact or severe vibration to output a value or, in the case of impact switches, activate or deactivate a circuit or device. The Shock may be measured using piezoelectric or piezoresistive means as well as strain gauges. Shock sensors detect collisions and high impacts around the car, such as the shock of some person deliberately breaking the window. Shock sensors will function by identification when an impact occurs on the vehicle. If someone crashes a car's windows, the shock sensor detects this impact created on windows and transmits an alert to the alarm's computer.

D. *NB - IoT module (SIM7020E)*

NarrowBand-Internet of Things (NB-IoT) is a standards-based low power wide area (LPWA) technology developed to enable a wide range of new IoT devices and services.

SIMCom SIM7020E is a Multi-Band NB-IoT module solution in an SMT format. It is designed for applications that need low latency, low throughput data communication in a variety of radio propagation conditions. It is ideally suited for M2M applications, such as metering, asset tracking, remote monitoring, E-health, etc.

E. *GPS module (SUP500F)*

The Global Positioning System (GPS) is an intercontinental radio-navigation system. GPS modules contain tiny processors and antennas that directly receive data sent by satellites through dedicated Radio Frequency (RF) frequencies. From there, it will receive timestamps from each visible satellite, along with other pieces of data.

F. *Raspberry Pi*

The Raspberry Pi 3 Model B is the brand new version of the $40 Raspberry Pi computer. The Pi is not like your typical machine, in its cheapest form, it doesn't have a case, and is simply a credit-card-sized electronic board of the type you might find inside a computer or laptop but much smaller. It is a low-cost, credit-card-sized computer that plugs into a monitor, and uses a standard keyboard and mouse. It is a capable little device that will enable people of all ages to explore computing and to learn how to program in languages like Scratch and Python.

V. IMPLEMENTATION

The NB-IoT design makes use of the basic functionalities of Long-Term Evolution (LTE). It significantly increases the consumption of power of devices and the capacity of the system. It is highly spectrum efficient in the field of deep coverage

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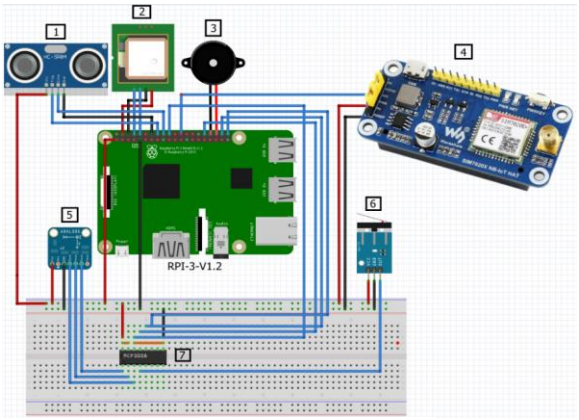

Fig. 2 Circuit of the system

The Raspberry Pi 3 Model B is a single-board computer that acts as the heart and brain of the system. Fig. 2. Represents the circuit of the system. The module is connected to an ultrasonic sensor (1) which detects obstacles using ultrasonic waves. MEMS accelerometer (5) and impact sensor (6) are interfaced with Analog to digital converter (ADC) (7) then connected to pi 3 for detecting accidents. GPS (2) is interfaced with raspberry pi for finding the exact live location of the vehicle and the buzzer (3) alerts the surrounding nearby ones. The location is sent via NB IoT module SIM7020e (4) which sends an SOS to the emergency services and other concerned persons so the damage can be mitigated.

VI. RESULTS

In Fig. 3. it is observed that once a collision has been detected and confirmed, the NB-IoT module sends the longitude and latitude data obtained from the GPRS module directly to the emergency services. Here paper has considered a persons' email id for demonstration purposes. This result is achieved using pushing box API and google sheet scripting. Additionally, calls and messages can be sent to important emergency services as well.

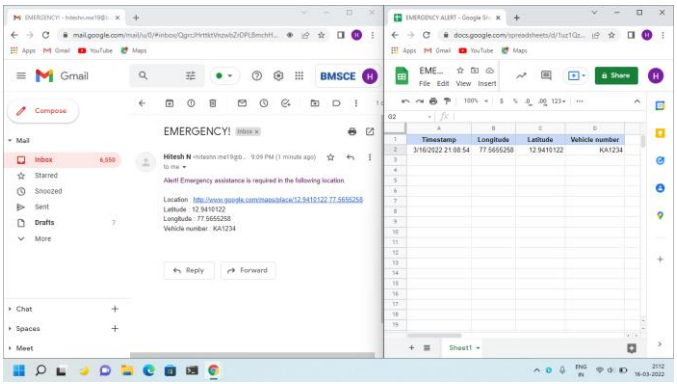

Fig. 3. Represents the Email alert and updates the excel sheet with timestamp, Latitude, Longitude, and Vehicle number

VII. CONCLUSION

The proposed system is easy to understand and implement. The wide use of sensors reduces error which could aid better performance, the use of NB-IoT will boost the range, enhance network capacity at a comparatively low cost. This detection solution can save the life of the victim quickly compared to other existing solutions.

When future scope is considered, There is a wide range of applications to implement and enhance the solution for various problems. The proposed implemented model can be further improved to use to find solutions for drink and drive cases, solutions for rash driving by obstructing spark-plug. This can also be implemented with voice-based real-time advising drivers when the person is over drunk or the person is rash driving on the road.

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