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# An IoT-Based Smart Helmet for Riding Security and Emergency Notification

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***Abstract*—A motorbike is more commonly utilized than other types of vehicles due to its affordability. On the contrary, this is the riskiest vehicle because driving too quickly or when intoxicated can result in an accident. The number of daily traffic accidents, including bike accidents, in Bangladesh is increasing tremendously. Without a helmet, the impact of a high-speed collision on a motorcycle is exceedingly dangerous. A helmet may even save a life by reducing the effects of a collision. In many zones, bikers are required to wear helmets when riding their motorcycles, but they take the chance not to wear helmets. To prevent accidents, we have proposed a smart helmet system that will minimize the chances of accidents occurring. The system is divided into two sections: the mobile application, where the rider will monitor the current status of riding a motorcycle, and the helmet circuit, which is the core segment that takes input from the environment. The helmet circuit initially includes a NodeMCU, an alcohol detection sensor, a crash sensor, a motion sensor, etc. The automotive circuit includes a tachometer to measure the bike's speed, and the mobile application section shows the overall performance result to guide the biker. The helmet circuit sends the detected signal to the mobile application, where the biker can see the present status of system sensors, whether alcohol, motion, or overspeed are detected or not. The mobile application section sends a notification to the nearest police station, hospital, and default relative's mobile.**

***Keywords*—Accident, IoT, Security, Device, Rider, Helmet, Emergency.**

## I. Introduction

Bicycle accidents are one of the accidents that cause the majority of deaths and injuries in the modern world. The number of people who pass away too soon in road accidents each year is more than 1.3 million, which is drastically rising. An estimated 20 to 50 million people each year experience non-fatal injuries, and some of them continue to suffer for years [1], [2]. Most countries lose 3% of their gross domestic product due to accidental damages. In Bangladesh, there were around 6,749 traffic deaths in 2022; at minimum, 9,951 lives were lost, while 12,356 others were hospitalized due to accidental issues. Compared to 2021, the number of crashes climbed by 18.8 percent while the fatality rate jumped by 27.43 percent [3]. According to the Road Safety Foundation, 268 youngsters who died riding motorcycles. According to a study by BUET, 28.4 people die in motorbike crashes annually for every 10,000 bikes in the nation, where about 40 percent of individuals are between the ages of 24 and 30. Wearing the appropriate safety equipment is crucial when riding a motorcycle to keep the person riding it safe in case of an accident.

Moreover, there seem to be currently 3,897,031 bikes licensed, with 992,148 in Dhaka alone. According to ARI, motorbikes make up 62 percent of all automobiles on the nation's roadways and are involved in 26 incidents for every 10,000 of them. According to Expertise, which emphasized the risky existence of motorbikes, the main factors contributing to bike accidents include difficulty maintaining balance, driver behavioral issues, a refusal to obey traffic laws, and a refusal to wear protective gear [4], [5]. However, a helmet is the main part of those gears that can save major losses and lives when an accident occurs by protecting a rider's sensitive part (Human Head). The traditional helmet is just safety gear that just protects the head, while a smart helmet can protect the head and make riders aware before falling into an accident. Considering the above scenario, the contribution of this paper is as follows–

- We developed a smart helmet that can detect the presence of alcohol, overspeed of bikes, crash incidents, and nearby objects (vehicles) while riding on the road in heavy traffic.
- It can communicate with riders and send real-time information to riders and default persons.
- Finally, we evaluate the proposed system's performance using various sensors and devices.

**Organization:** Related works are presented in section II. Also, system architecture is proposed in section III. Moreover, section IV presents the real-time prototype of the proposed system. Furthermore, the result analysis and discussion of the work have been described in section V. Finally, the conclusion is presented in section VI.

## II. Related Works

Several works are being done to tremendously implement bike contributions to complex interactions. The author, Divyasudha et al. [6] designed a project known as a cost-effective solution for riders where it can track the biker and regularly communicate using GPS location to pre-defined numbers. It will also avoid traffic accidents and detect alcohol intake. Additionally, it can send a notification when a crash occurs to the predetermined number and the neighborhood police station.

Another system has been designed by Rahman et al. [7], which is a project-recommended approach to making alerts about accidents by reporting their location to the nearest hospital, police enforcement, and family members. High-accuracy accident detection algorithms automatically show, identify, and report accidents to the authorities. After a year while this is being developed, MohanaRoopa et al. [8] have designed a project that assists in lowering the number of vehicle accidents by reminding the user to put on a helmet if he isn't currently doing so. Additionally, it detects when a rider has ingested alcohol and alerts hospitals and emergency contacts in the event of a collision. Prasetyawan et al. [9] have designed a project using IoT technology that has been successfully incorporated into the intelligent prototype system, which may allow communication between objects like motorcycles, helmets, and riders via smartphones to improve rider safety. Functional testing has been done on four system components. They are accident detection and notification, fatigue detection, helmet detection, and accident location monitoring. The Android app lets users keep tabs on the rider's condition and whereabouts.

## III. System Architecture

### A. Proposed Model

The system model is designed to interact with the environment during the ride via different types of sensors. The sensors will sense the real-time data and put it in the cloud for various objectives to be met. The conceptual scenario is given in Fig.1. Based on the input, the processor will make decisions regarding providing an alert to the rider. The components are shown in Table I. Some important sensors used in the system are described below:

TABLE I
Main Components Used in proposed system

| Items | Names | Benefits | Cost (TK.) |
|---|---|---|---|
| 1 | NodeMCU (ESP8266) | Reduce Hardware Complexity | 420 |
| 2 | PIR Motion Sensor (HC-SR501) | It consumes less energy | 85 |
| 3 | MQ3 Alcohol Sensor | For Alcohol Detection | 175 |
| 4 | Crash Collision Sensor (YL-99) | Detects Crash | 250 |
| 5 | Speed Detection Sensor (F249) | Speed Detection | 1050 |
| 6 | Object Detection sensor (Ultrasonic US020) | Object Detection | 400 |
| 7 | Others | – | 1000 |
| **Total** | | | 3380 |

*1) Alcohol Detection:* This module is designed to increase the road safety of bikers. The intelligent helmet will help people detect alcoholic men while driving their bikes. Also, this system will notify the biker whether alcohol is detected or not in the biker's breath. The MQ3 module is used as an alcohol detector in our system.

*2) Accident/Crash Detection:* It might be very challenging to assist a wounded individual at a given time in our hectic lives. It's also challenging to get in touch with the injured person's family. Our intelligent helmet will assist in obtaining such information, and family members will receive an SMS containing the accident location's latitude and speed so they may reach the scene as soon as possible. A crash collision sensor (YL-99) is used in this proposed system for detecting accidents.

*3) Speed Detection:* Bikers occasionally ride their bikes too fast without realizing it. When that happens, the rider will receive a notification on his smartphone, and our smart helmet will assist by beeping five times. The speed detection sensor (F249) used in this context will produce this notice.

*4) Object Detection:* An object detection sensor's job is to help systems locate and identify items in their range of vision so they may interact with them and experience their surroundings. If you continue to wear our intelligent helmet, it will assist you in detecting objects. Any obstacle approaching this helmet will be detected. The ultrasonic US020 module is used in this system to detect objects [10].

### B. System Prototype Design

The whole prototype of the system is designed in Fig. 2 where the detailed scenario of the smart helmet is represented. It will be necessary to charge the device because the entire system will run on DC current. The blue LED will signal a completely charged state, while the red LED will indicate the charging mode. As soon as we power on the system, the NodeMCU and SIM modules will operate. The smart helmet will be active and sense the environment using an arranged sensor module. The sensing information, such as the presence of alcohol, crash occurrence, overspeed, and others, will be converted from analog to digital format for node MCU (ESP8266) reading. This processor chip will make decisions based on the inputted value and its limits. If the rider is in a safe mode, the helmet will respond in optimal mode: otherwise, it will alert the rider by sending a message or other alert system.

### C. Working Principles

The microcontroller connects to the SIM module immediately after getting power and determines whether or not other components are attached. A SIM card has been installed in the SIM module, and the microcontroller first verifies that the network is operational. It then establishes a connection with the server or wireless network. The proposed system will work in two modes, i.e., riding mode and security mode.

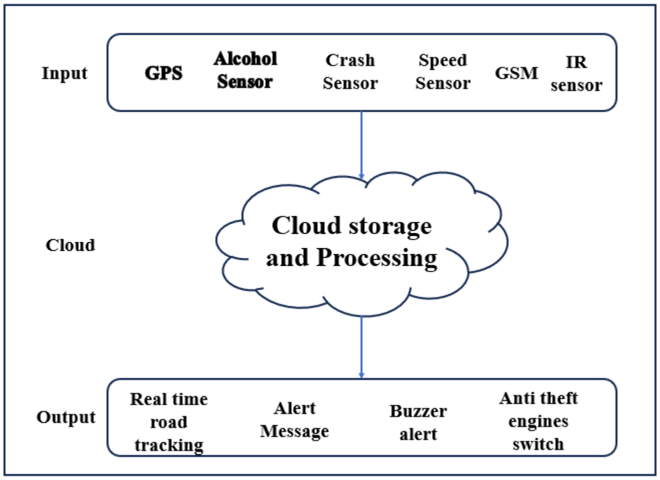


Fig. 1. Conceptual Framework

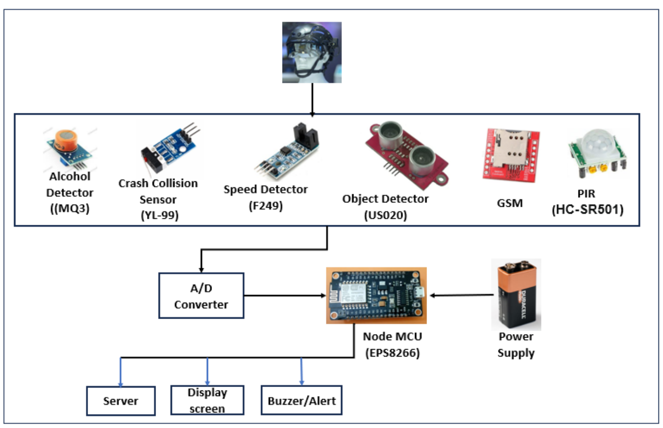


Fig. 2. Block Diagram of the Proposed System

While in riding mode, it initially determines the presence of alcohol based on the rider's breath and generates a numerical measurement. If the alcohol is absent, the controller then looks at the speed of the car. If the speed is at its optimal value, it will stay in normal mode and continuously sense for any crashes that occur. The rider's dashboard displays output from the microcontroller along with alert tones for each true sensor reading. When alcohol is present, the device continuously beeps for 20 seconds before beeping once more and sending a message to the rider's dashboard. The car's speed is continuously monitored by the speed sensor, and if it detects that the vehicle is traveling at an excessive speed continuously, it sends the data to the microcontroller, which causes a 20-second beep alert and sends messages to the rider's dashboard. The essential aspect is that the sensor notices any crashes and communicates the data to the microcontroller. The microcontroller beeps for thirty seconds, allowing the rider to stop the sound and whatever messages they have specified. The overall principles are shown in Fig. 3. While in security mode, it verifies that each object in the vicinity of the helmet is a distance-measuring device. The buzzer will beep constantly for 20 seconds while the system first determines whether an object has been detected. The system remains in optimal mode if there is no object. This project's utilization of all these sensors satisfies the user's riding requirements [11].

## IV. Real-time Prototype of the Proposed System

In this section, we have developed a smart helmet system where we have represented the inner side and outer side of the helmet. This is the outer side of the system, which is shown in Fig. 4. In this Fig., we can see that the PIR Motion Sensor- SR501 is set on top of the helmet so that it can check for objects around the helmet. There is a voltage reducer (LM2596), which is part of the bike ignition. It maintains speed as it is set in the back of the helmet. The F249 sensor is used to detect the speed of the bike. It is also part of bike ignition. When a rider rides a bike, this sensor measures the continuous speed of the bike and makes an alert for an over-speed situation. A battery is used to power up this sensor because it needs more voltage to start the motor and to be continuous.

Moreover, Fig. 5 depicts the inner side of the helmet, where we can see the speed sensor (F249) detects the overspeed of the bike. SIM module 800L is used for alerts of any bike crashes. When the rider crashes his bike, the SIM module sends an emergency message to the default contacts. There is a battery to power up the system. The alcohol sensor (MQ3) is used to detect the alcohol percentage from the biker's breadth. If alcohol is found, then it makes an alert by using a buzzer. The mother of the system is the microcontroller NodeMCU Esp8266, where all conditions of sensor input are processed and make their alert to the aware rider, and the PIR motion sensor (SR501) is there for object detection around the area of 30cm, and for the positive value, it makes an alert [12].

## V. Result Analysis

The project or system has been put to several tests. We have examined the following things:

### A. Alcohol Sensor - MQ3 Test Result

TABLE II
Alcohol Detection Test Result

| Condition | Value (mg/L) | Expected Detection | System Detection |
|---|---|---|---|
| Alcohol | 0.02 | False | False (19 from 20 testing) |
| Alcohol | 0.50 | True | True (18 from 20 testing) |
| Alcohol | 0.03 | False | False (18 from 20 testing) |
| Alcohol | 0.40 | True | True (19 from 20 testing) |
| Alcohol | 6.00 | True | True (19 from 20 testing) |

Table II shows the alcohol concentration by sensing the presence of alcohol in the user's breath. The threshold hold

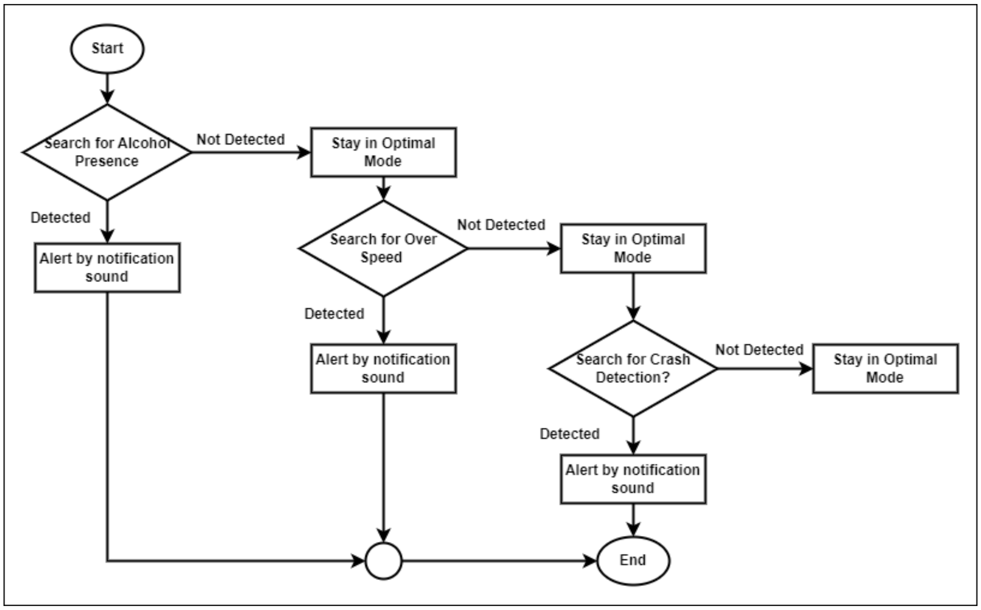


Fig. 3. Working Principles of Riding Mode

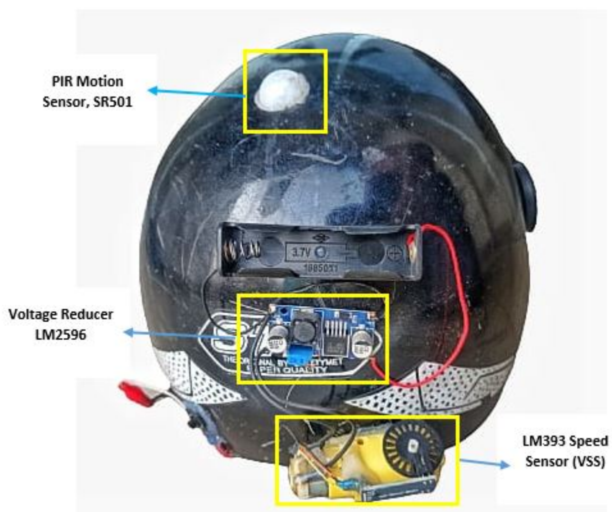


Fig. 4. Outer Side of the Prototype (Helmet)

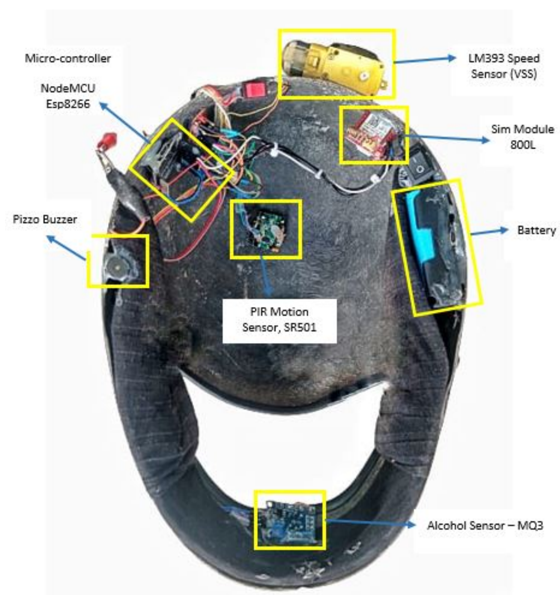


Fig. 5. Inner Side of the Prototype (Helmet)

value is set at 0.04 mg/l. So if the value is found above or equal to 0.04 mg/L, then the alcohol presence is true, and a notification sound will be provided to the user. When the result is seen below 0.04 mg/, then it will be considered alcohol presence as false and it remains optimal. Furthermore, in table III the system is tested for only alcohol detection. It shows the different states while a rider wears a helmet and is drunk. It shows a positive result, which means alcohol was detected. When the rider wears a helmet and doesn't drink alcohol, then it shows negative, which means the rider is sober and fit to ride.

### B. Speed Sensor (VSS) - LM393 Test Result

Table IV shows the observations in terms of speed detection. The threshold value is set as 70 KmPh, which represents that riding speed $\geq 70$ will be considered overspeed and will alert the rider via messaging and the buzzer alert process. Moreover, the observed values of 70 kmph, 90 kmph, and 120 kmph are detected as overspeed [13].

### C. Crash Collision Sensor (YL-99) Test Result

In Table V, it is observed that, if the helmet detects severe accidents in terms of falls, it will be considered a crash.

TABLE III
MQ-3 SENSOR TEST RESULT

| Users Condition | Expected Result | MQ-3 Sensor Reading Result |
|---|---|---|
| Drunk and No Helmet | False | False (18 from 20 testing) |
| Drunk and Wearing Helmet | True | True (20 from 20 testing) |
| Sober and No Helmet | False | False (19 from 20 testing) |
| Sober and Wearing Helmet | True | True (18 from 20 testing) |

TABLE IV
TESTING REPORT OF SPEED SENSOR (VSS) - LM393

| Speed (Kmph) | Expected Result | Result |
|---|---|---|
| 70 | True | True (19 from 20 testings) |
| 60 | False | False (18 from 20 testings) |
| 90 | True | True (19 from 20 testings) |
| 57 | False | False (18 from 20 testings) |
| 120 | True | True (20 from 20 testings) |

Sometimes it may shake the helmet, which will not cause a crash. If the sensor gets moved from its place, it will be considered a crash and will provide an alert and notification SMS.

TABLE V
ACCIDENT DETECTION TEST RESULT

| Condition helmet on head | Expected Result | Result |
|---|---|---|
| Fall Down | True | True (19 from 20 testing) |
| Shaking | False | False (16 from 20 testing) |
| Move | True | True (18 from 20 testing) |
| Not Move | False | False (19 from 20 testing) |

### D. PIR Motion Sensor - SR501 Test Result

TABLE VI
TESTING REPORT OF PIR MOTION SENSOR - SR501

| Length (CM) | Expected Result | Result |
|---|---|---|
| 190 | False | False (18 from 20 testing) |
| 310 | True | True (17 from 20 testing) |
| 720 | False | False (17 from 20 testing) |
| 400 | True | True (19 from 20 testing) |
| 600 | True | True (18 from 20 testing) |

PIR Motion sensor detects the status of an object by length (300 to 700 CM). So we considered 700 cm as the threshold value and any object that comes to 700 cm areas will be detected as an object. In the meantime, the system will alert the riders, notifying them when a nearby object is detected. In table VI, we can observe that, for 310 cm, 400 cm, and 600 cm, the result is true, i.e., an object is detected. But at 720 cm, it is out of threshold value, so the object is not detected. Since 190 cm is out of range (300 to 700) cm, the object is not detected, but any object that comes to 190 cm must be notified at least once when it is around (300 to 700) cm in distance. Finally, Fig. VII shows the comparison with recent existing works.

*1) Notification Format of the Proposed System:* In the output, which is the back-end part, there is a message alert for three emergency contacts, including a hospital, a police station, and a relative.

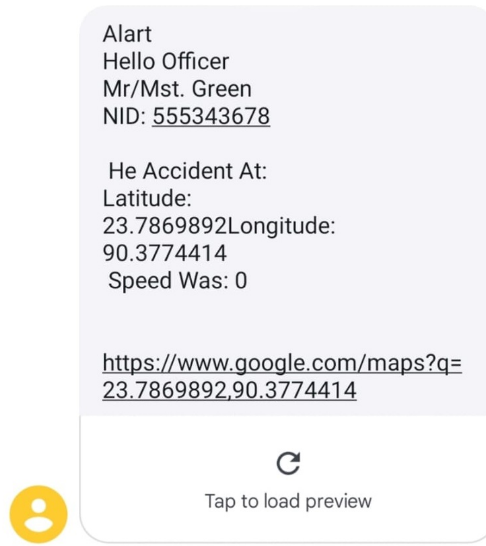


Fig. 6. Message Notification Format

This message alert format Fig. 6 is the module that passes the message to the default contacts as well as nearby police stations and hospitals. In this message, the rider's name is shown as Mr/Mst Green, with an attachment of his/her NID number. The NID is included for verifying the rider's full information from the database and taking the necessary steps for his or her accident through the bike. At the bottom of the message are latitude, longitude, and a map link, which helps the emergency contact person understand and know where the biker crashed.

### E. Confusion matrix

The overall performance accuracy is shown in the table VIII, where the speed detection accuracy is 95% and the alcohol detection accuracy is 97%. Moreover, collision detection and accident detection conflict, and the chance is about 4%.

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## VI. CONCLUSION

The smart helmet system is an advanced gadget in terms of modern technology, which reduces the possibility of two-wheeled accidents. An optimal gadget is designed with different sensors and a GSM module to make it interactive with the environment and the users. Our developed helmet can alert the users about alcoholic presence, overspeed riding, detecting

TABLE VII
COMPARISON WITH EXISTING WORKS

| Study Issues | Rahman et al. [7] | krishnan et al. [14] | Alim et al. [15] | Yustiana et al. [16] | Chandra et al. [17] | Santhakumar et al. [18] | Proposed |
|---|---|---|---|---|---|---|---|
| **Speed Detector** | NO | NO | NO | NO | NO | NO | YES |
| **Alcohol Detector** | YES | YES | YES | NO | YES | YES | YES |
| **Load Sensor** | YES | NO | NO | NO | NO | NO | NO |
| **Crash Collision Sensor** | NO | NO | NO | NO | NO | NO | YES |
| **GPS** | YES | YES | YES | YES | YES | YES | YES |
| **GSM** | YES | YES | YES | YES | NO | YES | YES |
| **IR Sensor** | NO | NO | YES | NO | NO | NO | YES |
| **Notification System** | YES | YES | NO | YES | NO | YES | YES |

TABLE VIII
CONFUSION MATRIX (IOT-BASED SMART HELMET)

| | Speed Detector | Alcohol Detector | Collision Detector | Accident Detector | No Action |
|---|---|---|---|---|---|
| Speed Detector | 95 | - | - | - | 5 |
| Alcohol Detector | - | 97 | - | - | 3 |
| Collision Detector | - | - | 92 | 6 | 2 |
| Accident Detector | - | - | 7 | 89 | 4 |
| No Action | - | - | - | - | 100 |

nearby vehicles, and other efficient ways. Real-time location tracking and the use of GSM make it one step ahead to interact with multiple corners. We design the prototype and simulate it with a real-time gadget. Afterward, we observe our performance parameter's optimal values by analyzing real-time results. Again, we have compared our improved module with different existing modules to find out the advanced cornerstone of our developed smart system in terms of functionality. However, our system has some limitations. We have used GSM module which is 2G instead of 4G LTE module. Moreover, We didn't focus on privacy, which will be improved in the further development phase.

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