Automobile Prudent System

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***Abstract*: Safety within automobiles is an aspect that can never be guaranteed no matter how sophisticated and advanced their core design is. This is an extremely vital problem that can be categorized as large-scale primarily because the number of automobiles plying on the road currently is massive and the numbers are expected to grow rampantly in the future. The pivotal reasons that deteriorate safety and increase the fatalities to accidents ratio are over speeding, driving distraction due to usage of mobiles, unconscious driving, defying safety rules, lack of prompt medical attention, etc. To come around all these, we have designed a system that allows only a sober driver who wears his helmet/seat belt to start the vehicle and once he does, the vehicle is being constantly monitored throughout the journey and the rider's acquaintances can be updated of the same through an interactive application. Rider's calls are being intercepted all through the journey and he is blocked from attending them post which he is prompted to bring the vehicle to a halt, to attend the call. This is achieved using a call-interceptor module which uses Bluetooth technology and has a speaker in-built. The driver is also continuously notified whenever his speed crosses the accepted limit. Additionally, an injured driver lying on the road is forwarded to the right medical support within the stipulated time by informing his location to the emergency helpline workers. The application also fills the gap between the driver and the service provider by providing a multitude of service options so that the process of vehicle service doesn't get tedious.**

***Index Terms*: GSM, GPS, Call-interceptor, Alcohol, Automobile, Sensor, Arduino, Safety Application**

I. INTRODUCTION

Injuries and deaths stemming from road accidents is now officially conceded to be a global phenomenon and this issue has not been completely alleviated as of today which is a matter of concern for road safety experts in virtually every single country across the globe. The lives of approximately 1.4 million people are put to an end annually due to this perennial problem [9]. Global status reports on road safety say that more than 80% people lose their lives on roads due to negligence of standard safety regulations. Woefully, crash injuries have moved higher in the list thereby being considered to be the seventh leading cause of deaths across all age groups and in terms of YLL and DALYs, it would sadly capture the second and third spots respectively by 2030. The culmination of all these is estimated to deteriorate the world economy by approximately $ 2 trillion from 2015 - 2030 which corresponds to around 0.12% on global GDP. On performing a comprehensive causal analysis, the primary reasons which engender this issue are over speeding, helmet negligence, drunken driving, mobile phone usage, seat belt negligence. The origins of data for this study are the World Health Organization publications, International Road Federation annual statistical yearbooks, Asian Development Bank funded Road Safety in Asia/Pacific, the Inter-American Development Bank financed Latin America Study, the European Commission PHARE Multi-Country Transport Program and other country studies. It is also worth noting the fact that the crash death rate in low-income countries is threefold higher as compared to that in high-income countries. This could be attributed to the fact that the safety regulations in low-income countries is more liberal than that with a high income. Speaking in terms of numbers, although LMICs account for only 60% of the world's registered vehicles, more than 90% of crash deaths occur in these countries. Most accidents outside cities occur due to drunken driving and more importantly, no testing methodologies are being adopted to avoid these fatalities in highways. Studies reveal that BAC levels of drivers directly affect them in many aspects, including their judgement, attitude, reaction, vigilance, perception and controlling. The legal BAC limits all over the world range from 0.01% - 0.08%. Although recent years have seen a drop in the number of alcohol-impaired-driving crashes from 10976 in 2019 to 10482 in 2020, the overall number is still significant [10]. This shows that the problem of drunken driving is far from over. Helmet and Seatbelt negligence comes next in the list. Despite increased awareness on the use of helmets and enforcement of safety rules, the number of deaths due to non-use of the headgear increased by 34% and that due to the use of mobile phones while driving increased by nearly 33% since 2018. Next in line comes speed which is responsible for about 30% of road accident deaths in high income countries, while about half of road accidents in low and middle-income countries. Studies suggest that the likelihood of a driver to not respond to a critical highway-traffic situation range from 21% when placing a call or holding a simple phone conversation to 32% for holding a complex phone conversation. Owing to all the above-mentioned reasons, rapid measures are to be taken to reduce the exorbitantly high ratio of casualties to accidents by performing a timely emergency act.

II. PROPOSED SYSTEM

Since the problem that we intend to tackle has its influence on multiple domains within critical safety systems, an approach that is well-defined and that which could be easily conceived, handled and maintainable throughout the design process is chosen. This is nothing but the Object-Oriented approach. This approach makes the design more intuitive, quicker to develop, more amenable to modifications, and easier to comprehend. With the traditional, procedural-oriented/structured programming approach, a program describes a series of steps to be performed. Contrary to that, an object-oriented approach follows a smart strategy where instead of programs consisting of sets of data being loosely coupled to many different procedures, they consist of software modules called objects that encapsulate both data and processing while hiding their inner complexities from software designers and hence from other objects. The blueprint of any system is its software architecture and it is the framework on which the system's efficiency and its processes depend. But this framework is only effective if it is communicated properly to all those using and working on it. Hence, in order to model our system as a collection of objects and since there are a good amount of them to consider, we require a design language to help us clearly envision the system. For this purpose, UML has been chosen. We start off with the High-Level Design of the system which is achieved through the Use Case Diagram shown in Fig. 1. Following this, we look into the static view of the system which basically consists of its classes as in Fig. 3,4. Once the objects are clearly defined, we move on to model the system's dynamic perspective with the help of Sequence Diagrams which give us the overall process flow and the interactions between objects as in Fig. 5,6,7,8. State diagrams are used to analyze the temporal nature of the system and understand its behavior comprehensively by focusing on the states through which the system could possibly transit throughout its entire lifetime as shown in Fig. 9,10,11,12. Finally, we complete the overall picture by figuring out the constraints and conditions which cause each and every event thereby clarifying intricate use cases as done in Fig. 13,14,15,16. This dynamic analysis is performed using Activity Diagrams.

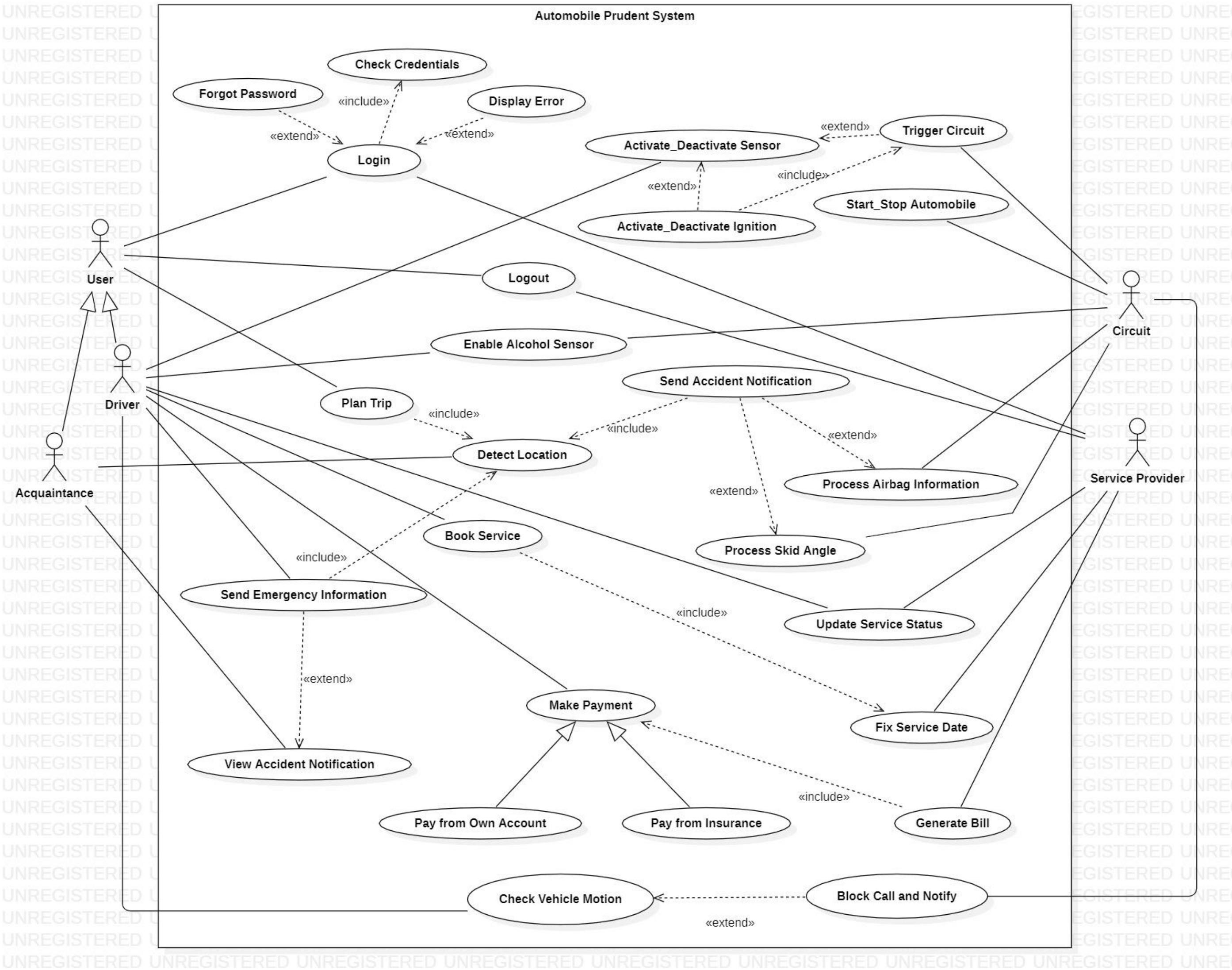

Figure 1 Use Case Diagram

APS uses a template to document a use case. An example of a template is shown in the figure. Stakeholders described below are the people who are directly or indirectly affected by the launch of the system. Precondition defines the mandatory criteria that must be fulfilled in order for a particular use case to function. Main Success Scenario describes a typical scenario through which the system passes from the particular use case's perspective.

Use Case: Send Accident Notification

Scope: System
Level: Sub-functional level
Primary Actor: Circuit
Stakeholders and Interests:

- Driver – Requests help under emergency situation.
- Co-passengers – Avail help along with the driver during emergency situations.
- Driver's Acquaintance – Can perform a timely action in case of an emergency.
- Helpline workers – Can receive accident location and provide timely help

Preconditions:

- Should be a registered and authenticated user of the system.
- The airbag state/ skid angle should be in the danger level.

Success Guarantee:

- The location of the driver gets tracked.
- His acquaintances get notified.

Main Success Scenario:

- Driver is on a trip.
- Encounters an accident.
- His car's airbag gets ejected.
- His brother receives notification from the system.
- He shares the spot of accident to the helpline workers.
- Helpline workers reach spot of accident and rescues the driver.

Extensions:

- Driver is on a trip.
- Encounters an accident.
- Due to bugs in his airbag system, it doesn't get ejected.
- His brother doesn't receive any notification.
- Driver dies.

Special Requirements:
System requires a state-of-the-art level detector/ airbag system that is synchronized with the circuit.
Frequency of Occurrence:
Rare.

Figure 2 Fully Dressed Format

Process Airbag Information and Process Skid Angle use cases occur optionally and in the event that they occur, they trigger Send Accident Notification which in turn uses the Detect Location use case to identify the vehicle's current location and transfer it to the Driver's Acquaintances in order to ensure the fact that timely emergency action gets undertaken [2].

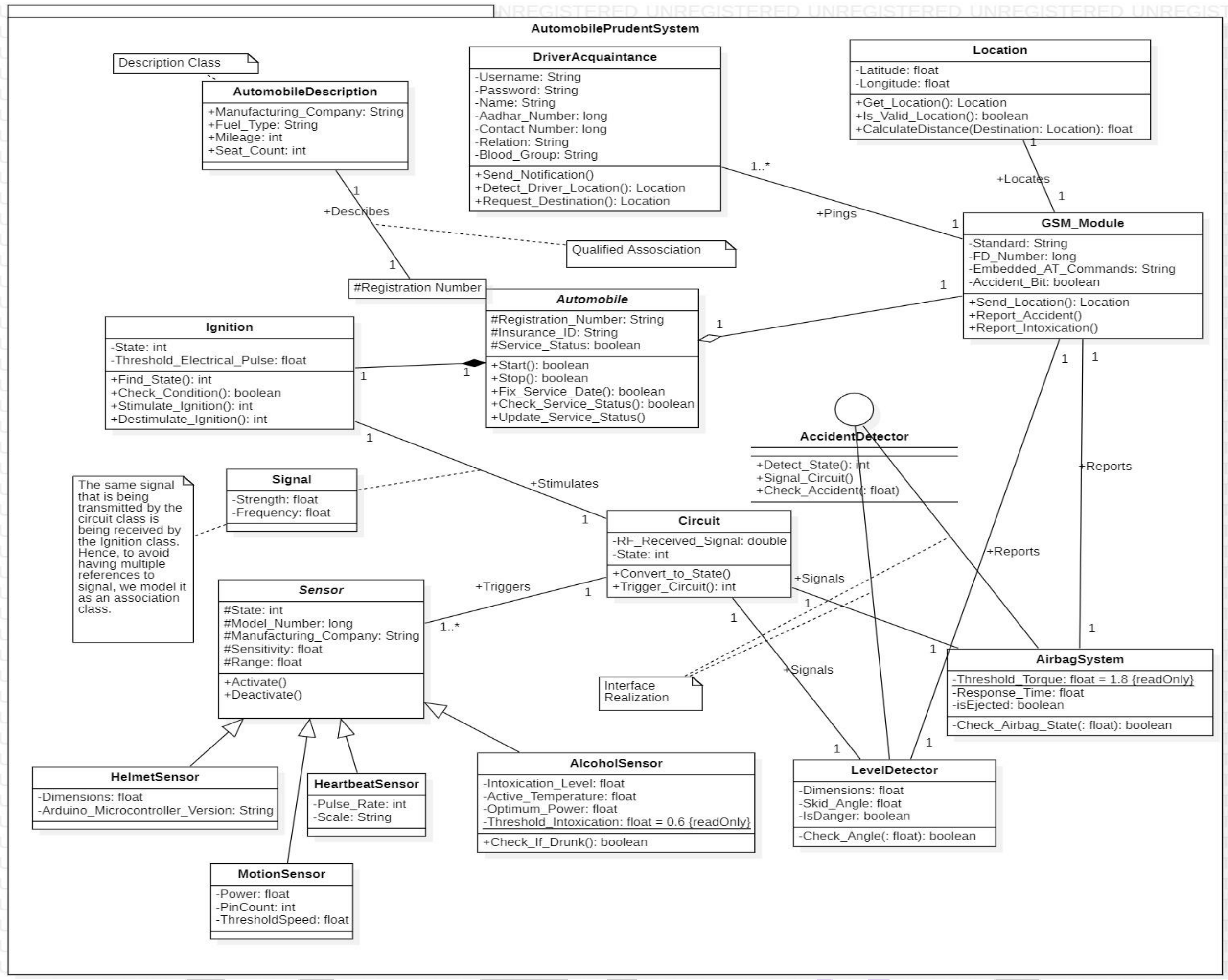

Figure 3 Class Diagram 1

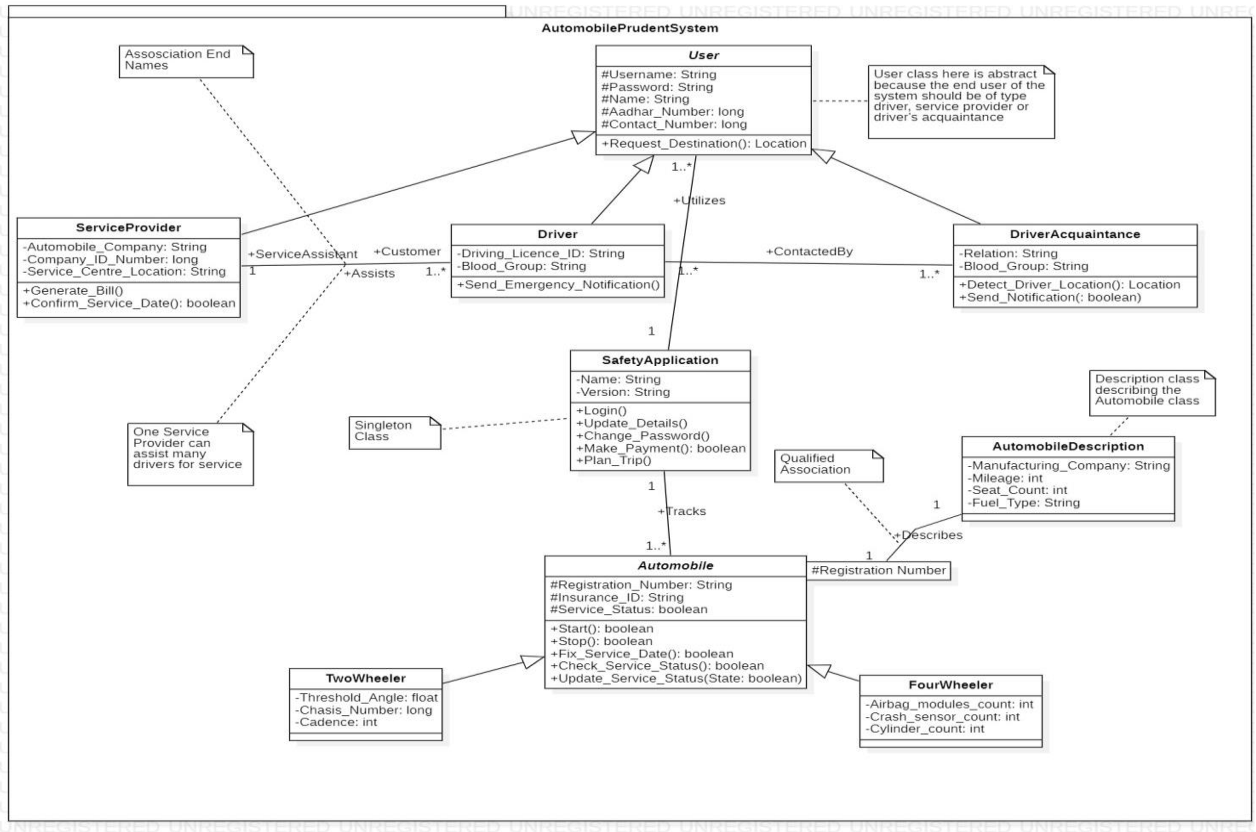

Figure 4 Class Diagram 2

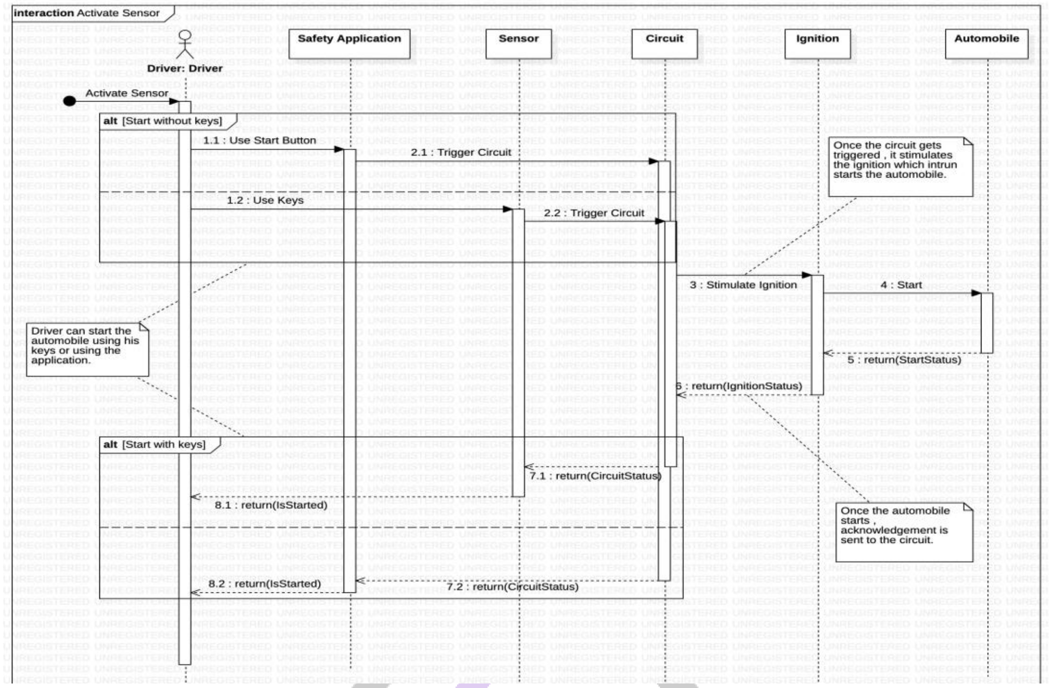

Figure 5 Sequence Diagram 1

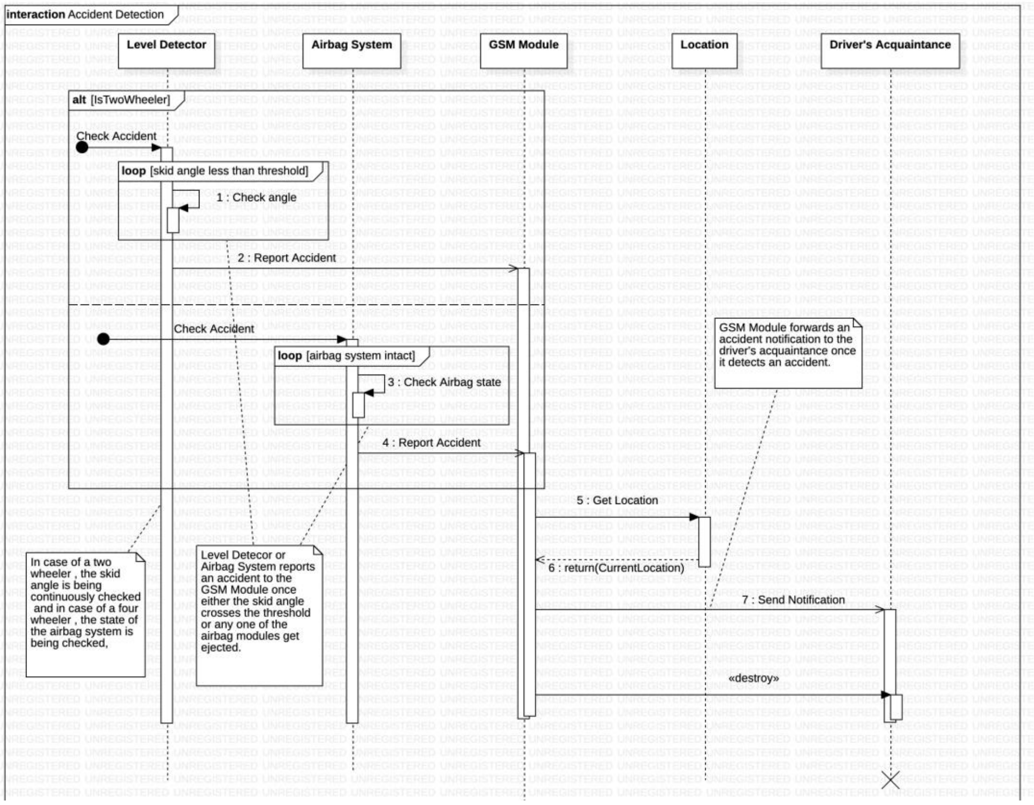

Figure 6 Sequence Diagram 2

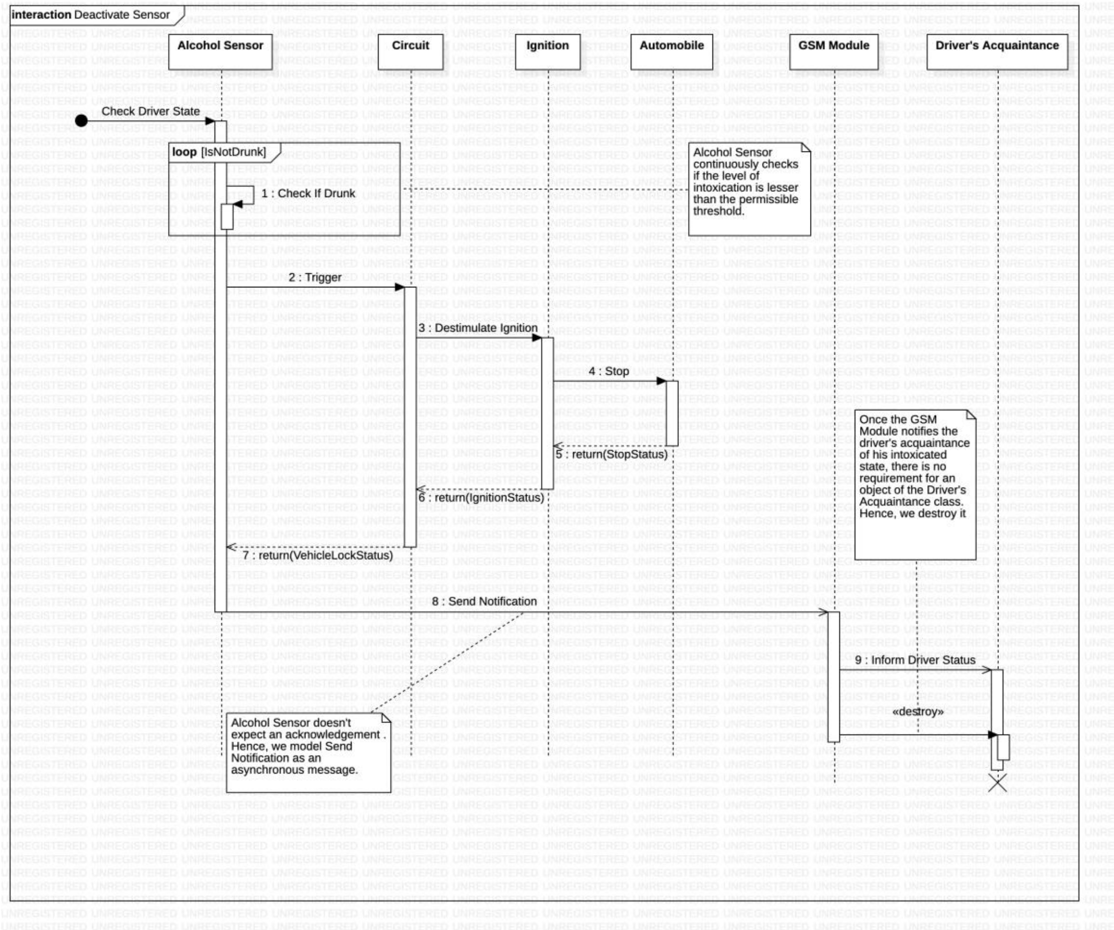

Figure 7 Sequence Diagram 3

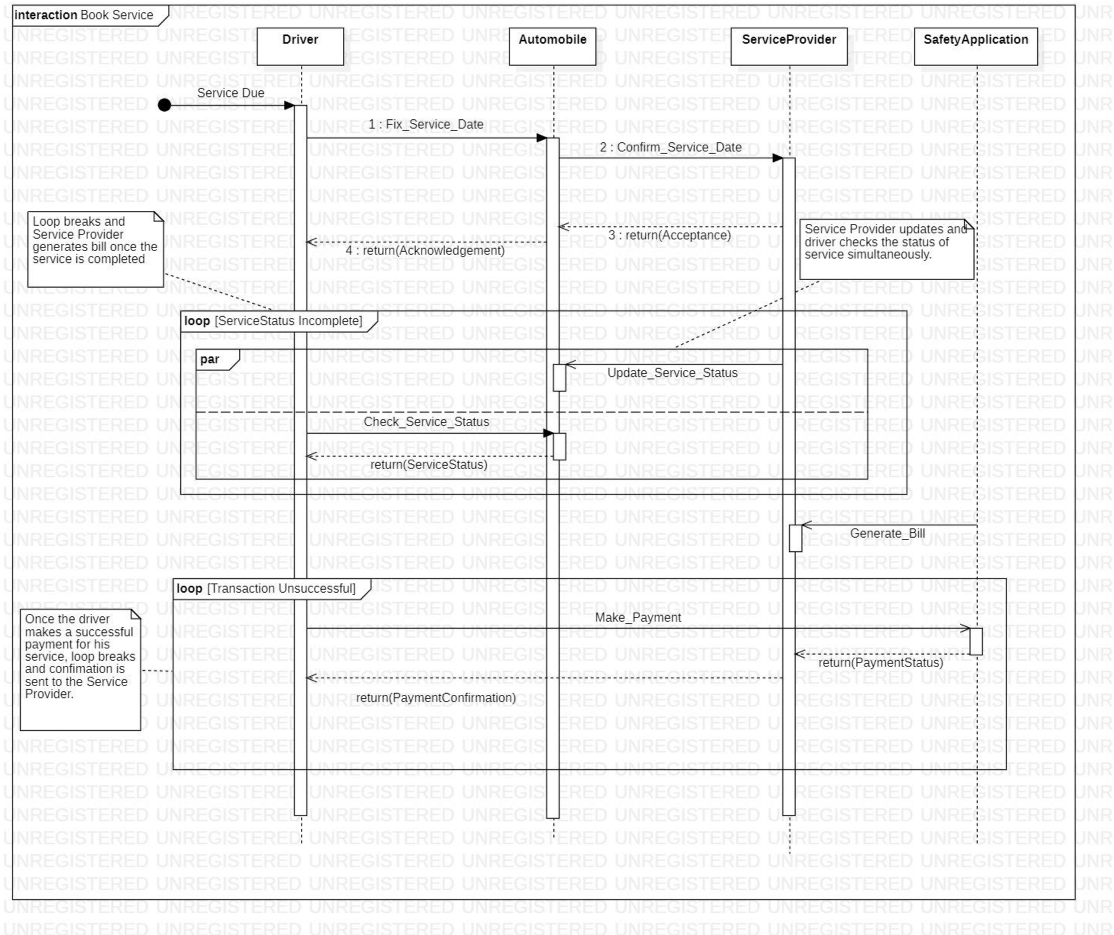

Figure 8 Sequence Diagram 4

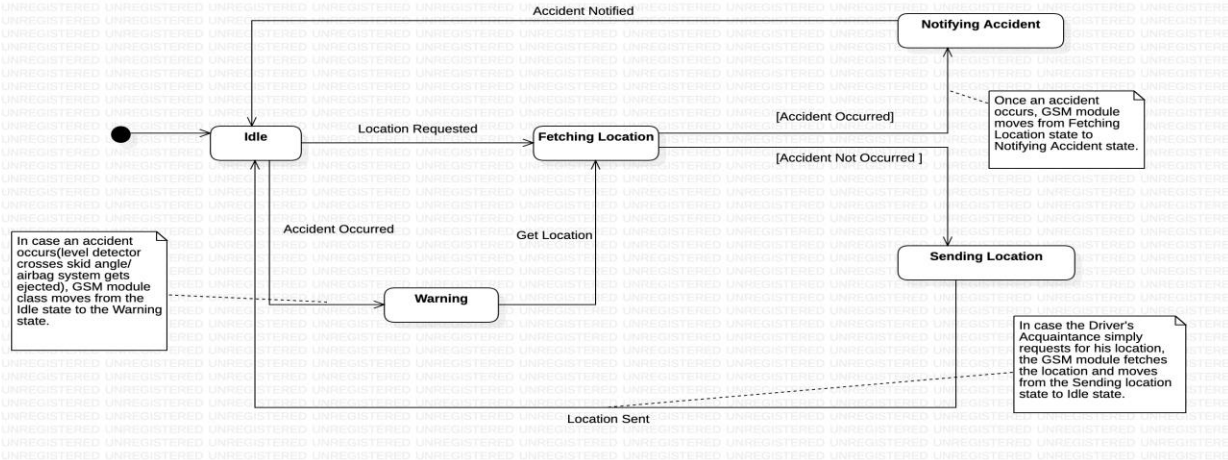

Figure 9 State Diagram 1

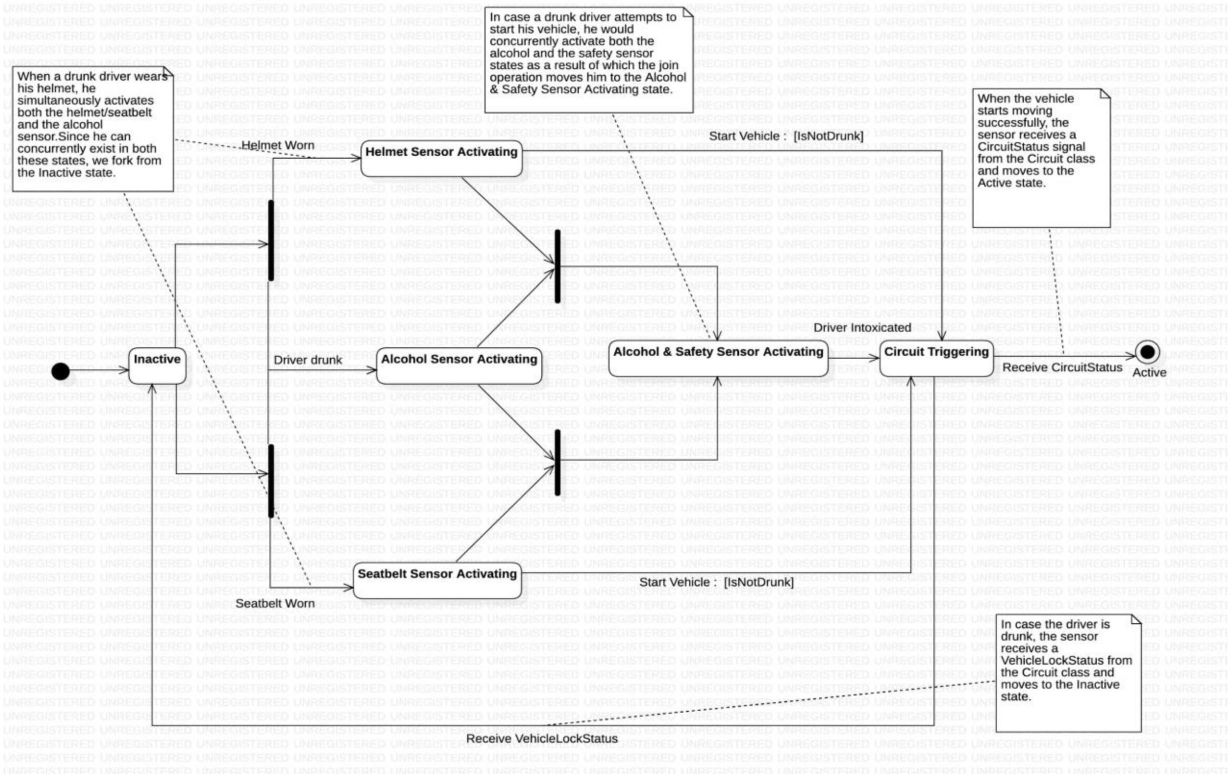

Figure 10 State Diagram 2

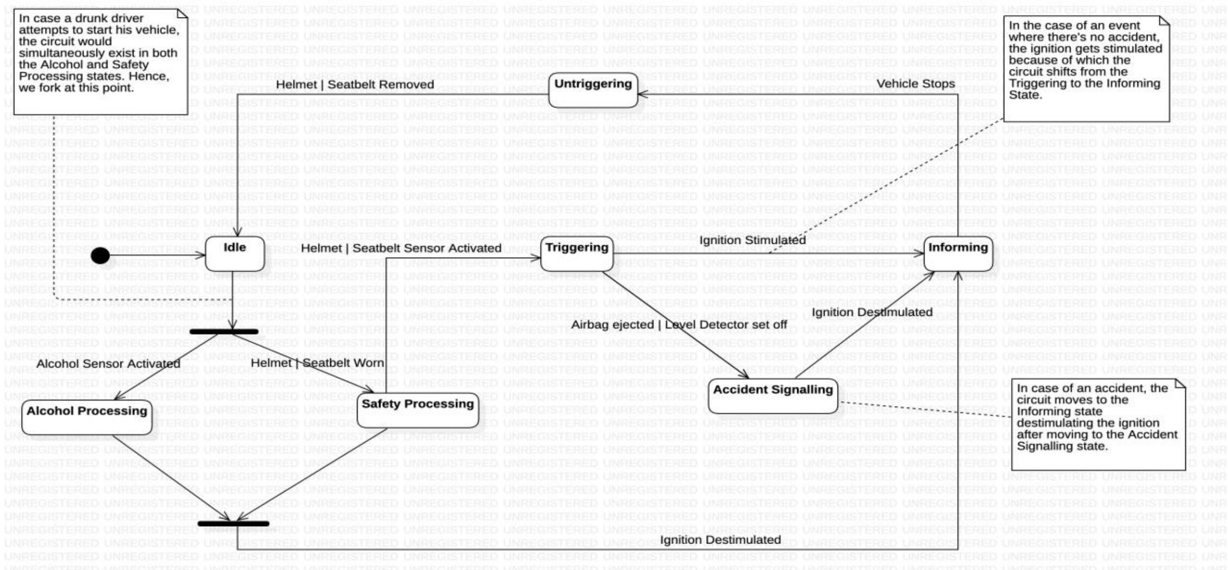

Figure 11 State Diagram 3

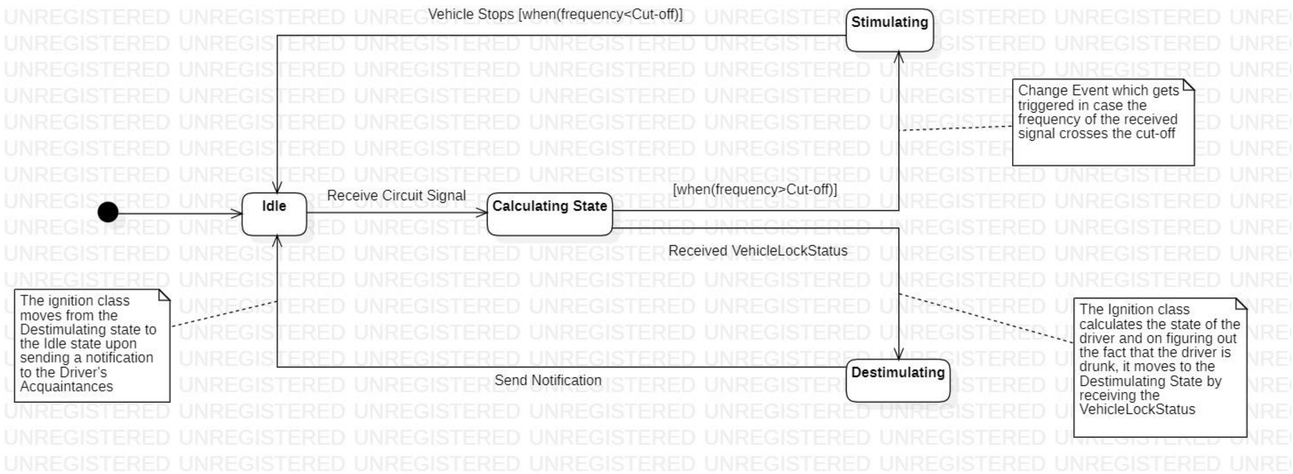

Figure 12 State Diagram 4

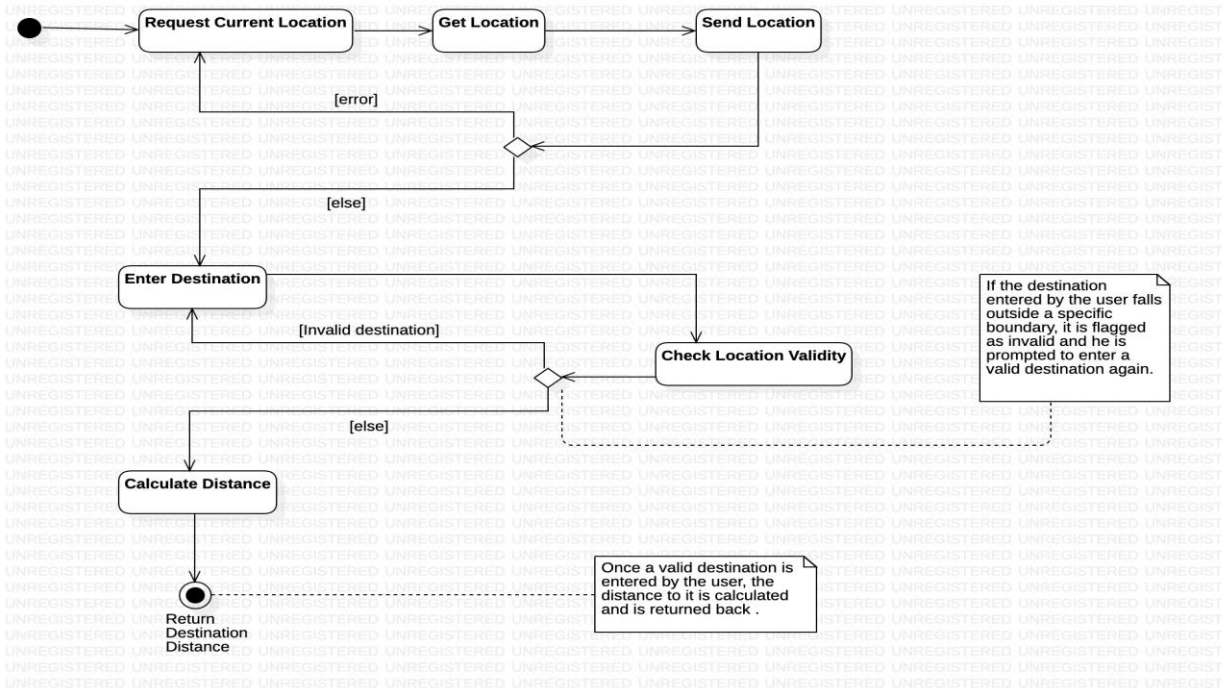

Figure 13 Activity Diagram 1

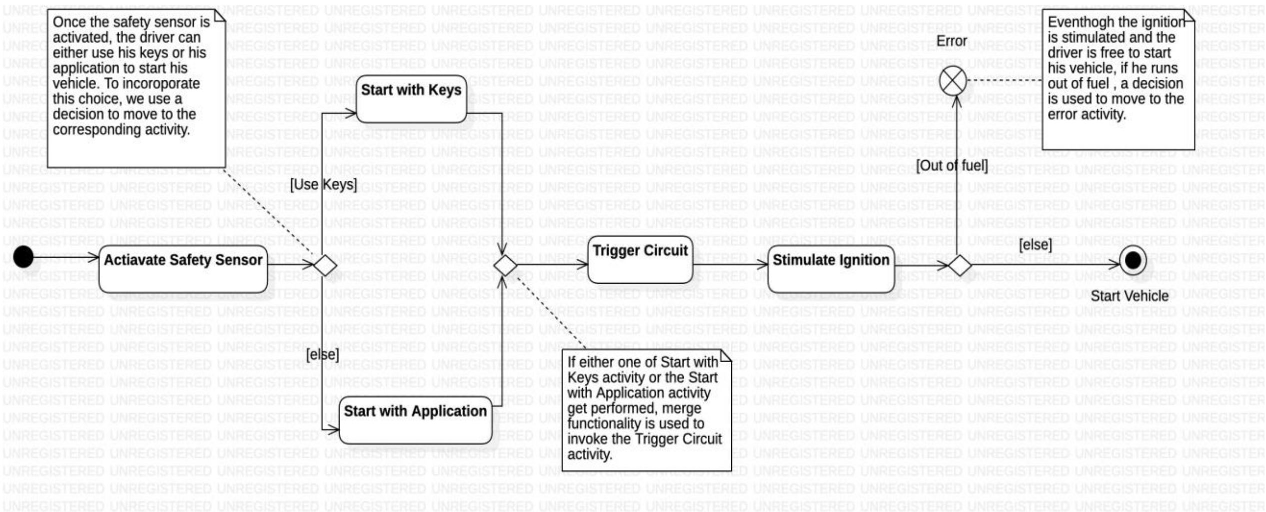

Figure 14 Activity Diagram 2

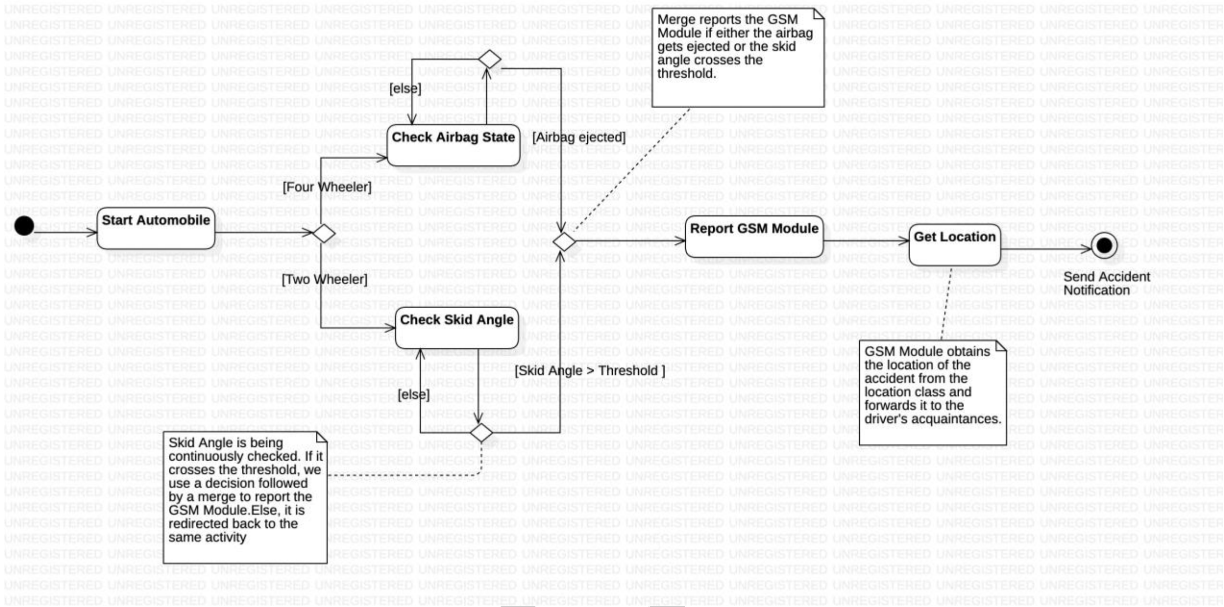

Figure 15 Activity Diagram 3

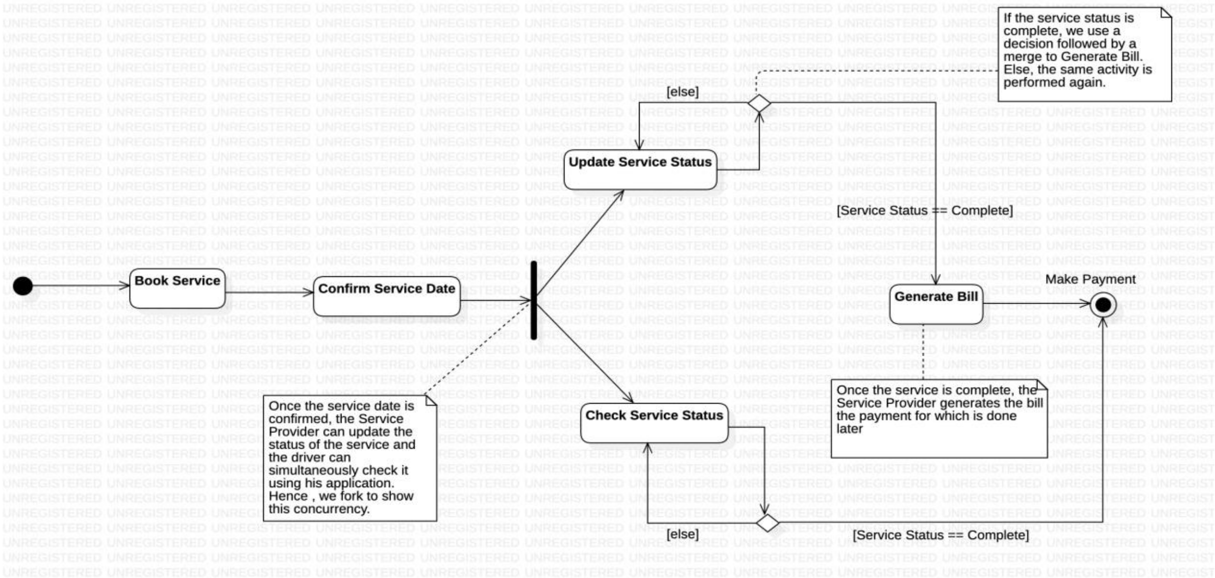

Figure 16 Activity Diagram 4

III. METHODOLOGY

APS mainly consists of 2 modules; protection module and the vehicular module. Helmet contains three pressure sensors centered around the crown of the head and in case of four wheelers, the rear side of the seat belt contains six PLSNSR1 heartbeat sensors spatially separated by equal amounts such that it covers the chest area of any average driver. These are connected to a microcontroller unit. An alcohol sensor and an RFID tag are placed accordingly in the protection module. The vehicular module consists of an accelerometer (to keep track of vibrations), relay, GPS module and an RF decoder microcontroller unit.

Protection Module: Helmet consists of three pressure sensors which are placed at the inner surface of the helmet. They continuously check the helmet's stance and send its status to the microcontroller unit and then to the RF transmitter. The sensors get activated only when the driver positions the helmet properly around his head and wears the buckle. The alcohol sensor used in this section senses the intoxication level of the rider and returns the BAC from his breath. The speed of the automobile is recorded by using a Reed Sensor. The comparator checks the data stored by the alcohol sensor and the speed sensor and gives it to the RF encoder. If the rider has an alcoholic breath, then the bike ignition gets locked, else, he is permitted to start the vehicle. In case of four-wheelers, the heartbeat sensors placed at the rear side of the seatbelt continuously evaluates the rider's pulse rate and sends the status to the microcontroller unit which in turn transfers it to the RF transmitter.

Vehicular Module: The main objective of this module is to receive the data from the sensors of the protection module and send it to the microcontroller unit. When the heartbeat/helmet sensor gets activated, the transmitted signal is received by the this module which in turn unlocks the vehicle's ignition system. Now, the driver is officially allowed to start his vehicle. In the case where the skid angle of the vehicle crosses the threshold or the airbag system of the four-wheeler gets ejected, an accident is detected and the GPS module is informed to locate the vehicle's position. The accident status is then sent to his acquaintances using the

GSM module. All these sensors and parameters are controlled by the microcontroller thus requiring a dedicated server. A WIFI module is used to connect to the internet connection and sense all data through the MCU. For the login process, https protocol is used. Raspberry Pi3 module is also used in this section. Java language is used for building the application.

MODES OF COMMUNICATION

GSM Module: In our system, GSM helps track the driver's location at all instants of time during his journey and notifies his acquaintances and the emergency helpline workers in the event of an accident. Although there has been a good amount of research in recent times regarding vehicle tracking using smart phones, it has a lot of drawbacks [4]. Additionally, it facilitates the driver to plan his trip in advance by suggesting to him the shortest possible route and the corresponding time to reach his destination. Nowadays, it is widely used for communication through mobile using TDMA and CDMA appropriately depending on the situation. GSM compresses the data and digitizes it which is then forwarded through a channel with other streams. The GSM operates at the frequency band of 1000 MHz or 2000 MHz It has four parts.
1. Base station subsystem
2. Network switching subsystem
3. The operation and support subsystem
4. The rider's mobile handset

WIFI - Since the system is integrated onto a mobile application, the rider's location is to be updated on a live basis. This is made possible with the help of radio waves for network connectivity. The above stated connection is established using a wireless adapter which creates hotspots using a wireless router. This is one of the world's most popular networking technologies used these days where radio waves are used to provide high speed internet and network connection based on IEEE 802.11.

Bluetooth: When the rider receives a call while driving, the motion sensor detects the vehicle's movements and blocks the user from attending the call even if he wishes to. This information is communicated to the rider using a speaker on the helmet/car by taking advantage of the popular Bluetooth technology where the driver is requested to park his vehicle post which he will be permitted to attend his call. It is a wireless communication technique which can be used for transmitting data between two devices. It is mainly used with reference to PANs which have a frequency of 2.45 GHz. Its physical range is typically less than 10 m.

RFID: Most people try to bend traffic rules as per their own wish and this lack of fear on traffic regulatory authorities and the confidence that they won't get penalized for their actions is in itself a major untold cause of traffic violations. In order to come around this, as responsible riders, we need to install an identification system onto our vehicle so that traffic authorities can track our actions. It is here where we use the Radio Frequency Identification Technology which is primarily used for monitoring and identifying objects individually. RFID can monitor objects during the moving stage. This technology is an efficient alternative for bar-coding systems. Using this, we can easily identify objects. RFID consists of 2 components.
1. RFID tag: Tag consists of a chip and an antenna. Chip holds the information about the object and antenna provides communication between the receivers.
2. RFID reader: It reads the RFID tag details using the antenna which is built inside the tag.

SENSORS

MQ7 Alcohol Sensor: Drinking and driving tops the list of the main causes of road crashes worldwide. In order to reduce the fatalities, a state-of-the-art alcohol sensor is installed which detects the presence of alcohol from the rider's breath. This sensor operates at temperatures ranging from 10 to 50 degrees. It gets activated when the rate of intoxication of the driver crosses the threshold. Power supply required will correspond to voltages less than 150 mv to 5v. This sensor is mainly used by traffic authorities. MQ-7 is one of the famous types of alcohol sensor which is suitable for breath analyzer [3].

Reed Sensor: The reed switch is made from two or more ferrous reeds used to measure the flow of electricity in the circuit. It effectively works like a gate in an electric circuit. In APS, this facilitates in checking for the movement of the vehicle playing a pivotal role in the call-interceptor unit. In case the driver receives a call, the reed sensor examines if the vehicle is on the move, thereby enabling the call interceptor to block the call. Unlike mechanical switches they are controlled completely by invisible magnetic fields, operating between 50˚C to 150˚C.

Accelerometer: Being one of the most widely used motion sensors, the accelerometer enables shock protection and activity detection. The movement of the vehicle being detected here is utilized in the call-interceptor unit. Acceleration forces are measured by using this component. It measures the change in speed or velocity divided by time. With the aid of an accelerometer, we can determine whether an object is moving uphill, falling over, flying horizontally or downward, tilting. A specialization of the accelerometer used to tabulate the tremors and vibrations experienced by the vehicle is the piezoelectric sensor. The vibrations and movements of the vehicle are sensed enabling the system to report an accident in case of any erratic movements [1].

Pressure sensor: Helmet/ Seat Belt violations are a common sight these days and a major cause of road accidents. It is used for pressure measurement in liquids and gases. Pressure is defined as force per unit area and is the force required to stop a fluid from expanding on a surface with an area equal to unity. It acts as a transducer and the generated signal is electrical. It indirectly measures the variables such as speed, altitude, gas or fluid flow and water level. Pressure sensors are also known as pressure indicators, manometers, pressure transducers, pressure senders, piezometers and pressure transmitters. They can vary drastically in performance, design, technology, cost and application suitability.

The overall system architecture diagram incorporating all the above-mentioned components is shown in Fig. 17.

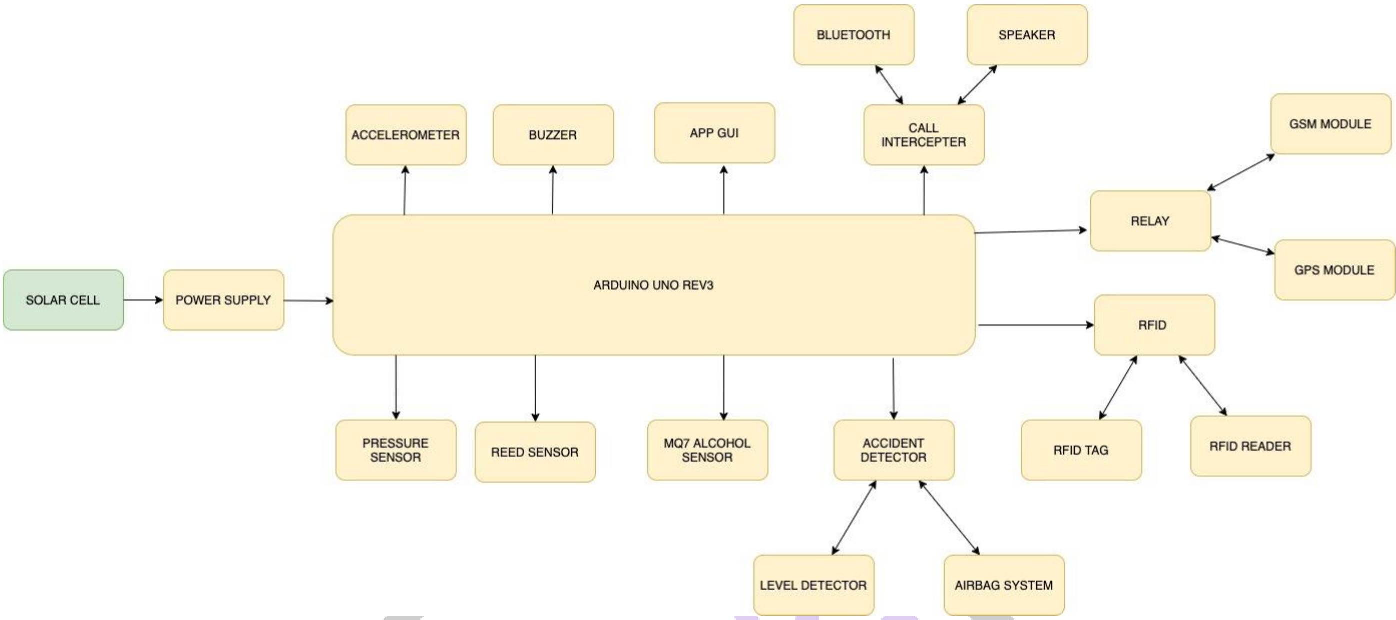

Figure 17 System Architecture Diagram

IV. FUTURE SCOPE

Although most of the advanced countries in the world have well-defined safety regulations in place, people somehow or the other figure out a way to violate traffic rules. We consider an example to illustrate this fact. Although high-resolution powerful cameras are installed by governments to penalize drivers who overspeed in highways, daily travelers would get to understand the position of the cameras with experience and hence, they can easily escape from getting caught by slowing down when they reach near the cameras and over speeding in every other location. To tackle this issue, another feature can be added to our system that can in turn use a third-party application to judge the accepted speed limit of a given location and warn the user if he crosses the accepted limit twice and upon violating it for the third time, the GSM module that is part of our system could directly notify traffic regulatory authorities regarding the violation along with the details of his vehicle which the user in any case cannot bypass. This is a completely new and efficient approach as it is equivalent to having the police eye the driver at each and every instant of his journey. This would consequently give zero room for the driver to violate traffic rules. Another important improvement could be the installation of solar cells over the vehicle and the helmet since it is an unlimited renewable green energy source that is abundantly available everywhere. This could in turn power the vehicle and reduce its fuel consumption to a large magnitude.

Abbreviations and Acronyms

APS - Automobile Prudent System
BAC - Blood Alcohol Consumption
CDMA - Code Division Multiple Access
DALY - Disability Adjusted Life Years
GDP - Gross Domestic Product
GSM - Global System for Mobile communication
GPS – Global Positioning System
LMIC - Low to Middle Income Country
MCU - Microcontroller Unit
PAN - Personal Area Network
RFID - Radio Frequency Identification
TDMA - Time Division Multiple Access
UML – Unified Modeling Language
WIFI - Wireless Fidelity
YLL - Years of Life lost

V. Conclusion

We have modelled a system that encompasses all the aspects of a safety system in a clean and concise manner. It is strategically defined in such a way that it cannot be attached/detached from the system as and when the user wishes. It is formulated in a way that it cannot be dissociated from the automobile once it's installed during the manufacturing phase. An important functionality that is accomplished is preventing people from driving their vehicles when they are in an intoxicated state. Another cardinal feature is that the system automatically informs the driver's acquaintances and emergency helpline workers in case any grim actions happen to him by detecting the vehicle's location instantaneously and forwarding it along with a danger message so that he can be attended to as soon as possible. Since a significant number of accidents occur due to distractions caused by calls, a separate unit has been designed to come around this issue. Upon receiving a call while driving, the driver would be informed regarding the same and would not be permitted to attend it even in case he tries to. In case of a four-wheeler, the driver would be restrained from starting the vehicle if he has not positioned himself in the right posture and worn the seat belt properly. A similar setup is facilitated in two wheelers through the installation of pressure sensors. Performing timely service for vehicles has become a tedious task for the owners. To come around this, we have dedicated features in the application that reflexively takes care of this. This is specifically vital post accidents as the vehicle would be in a state of mandatory refurbishment. Overall, this system proves to be one of its kind by attacking each and every fundamental cause of road accident at their grassroots.

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