Context Aware Recommender Systems for Smart Cars using GSM Enabled Applications

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***Abstract*— Smart Cars is an interesting area of research as far as Ubiquitous Computing is concerned. Context Awareness is a prime feature of Smart Cars. This article has proposed the architecture of Connected Cars with Context Awareness. Several new areas for route optimization and efficient transportation have been explored in this paper. We have proposed Traffic Rush Detector and Solver for getting a live view of the traffic and suggesting an alternate less congested path. We suggest using DSSC (Database Server for Smart Car) for getting information about the road conditions of the approaching road. Whereas for cars in the same vicinity we suggest to deploy a Vehicular Information Transfer Protocol (VITP) with Vehicular Ad Hoc Networks (VANETs) for inter-vehicle communication. For time saving and efficient transportation the proposed method is very useful. Moreover, this method is going to be helpful for non-familiar places.**

Keywords—inter-vehicle communication; connected cars; context awareness; route optimization

I. INTRODUCTION

Over the last decade or so, motor cars have become an indispensable part of the modern life. Cars are becoming more and more ubiquitous as almost every person (either he is student, a working person, or a business man) has to travel a lot on his/her car. Moreover, the average time spent by a person in a car is increasing day by day. Due to this increase in the use of cars and the rapid growth of information and communication technologies (ICT), people expect their cars to do more than being a mere vehicle. Therefore, there has been a lot of emphasize by the car vendors and researchers now on embedding the state of the art technologies within a car to enable communication among cars and also with their internal and external environments.

The advent of miniaturized sensing devices, various wireless communication technologies, mobile internet, and sophisticated GIS and map applications have triggered a new automotive revolution. The focus is now on developing smart cars with the capability to sense their environments to assist the driver with better driving experience, less workload and less chances of getting the car damaged. For this purpose, a smart car is equipped to sense, analyze, predict and react to road situations which it faces. All of this is achieved with the help of context awareness which is a prime feature of smart cars.

This context-awareness in smart cars enable the coordinated, cooperated and proactive decision making among cars on the roads, which in turn, paves the way for efficient traffic monitoring and control. The major driving forces for these smart connected cars are threefold: (i) reduce the traffic congestion, (ii) ensure car safety, and (iii) eliminate (or reduce) car accidents.

Traffic congestion negatively impacts the daily lives of the people as it causes inefficiency of transportation infrastructure and increases the total travel time. Furthermore, it also results in increasing the level of air pollution and fuel consumption. If we have a recommender system which can provide an alternate route instead of the congested path, we can get rid of the problem. For car safety, there is a need to collect information from various sensors (installed in the car), such as engine faultiness, battery weakness, and breaks or clutch failure condition. This information is then used to detect any anomaly and intimate the driver about that so that he can deal with the issue in proactive manner. Another important aspect that is desirable in the context of smart cars is the accident detection. In case the car is involved in an accident, the hospital and the family of the driver should be informed immediately through a text message or a phone call.

Several technologies have been developed in this regard such as advanced driver assistant system by Küçükay and Bergholz [16] and Intelligent Transportation Systems by Anthony D. Joseph [17]. Most of the present smart cars are not fully context aware. They use simple road conditions and display this information (as is) to the driver without performing any complex reasoning on this contextual information. These weaknesses limit the smart car to provide sufficient support to the driver.

In this paper, we propose an architectural framework for dealing with the issues stated above. We aim to provide car accident detection by using dent detection sensors, car safety through monitoring of various car actuators (e.g. brakes, clutch, and engine), traffic monitoring using (aggregated) information collected by individual cars and Google Maps, and an internet enabled GSM SIM. Moreover, a GPS receiver and the Ad Hoc mode of 802.11b WLAN Network is used for nearby road surface monitoring, whereas, a GSM enabled SIM is used for distant road surface monitoring using a Database Server placed in Transportation Department.

The rest of the paper is organized as follows. Related Work is mentioned in Section 2. Section 3 contains General Architecture of the proposed Smart Car. Section 4 contains recommender system for Traffic Rush Scenario. Section 5 describes proposed methods for Inter-Vehicle Communication. Conclusion is drawn in Section 6.

II. RELATED WORK

Smart Cars has been an area of focus for both the researchers and the industry people. Several quotable advances have been made in this field over the last decade. For instance, autonomous self-driving cars are produced by several car manufacturing and tech companies. The so called 'Auto-Pilot' feature allows a car to steer within a lane, and it also allows for the change of lanes with a simple tap of a turn signal. Moreover, these autonomous cars can manage their speed by using traffic-aware cruise control. One of the many such cars has been produced by Tesla [10]. Similar advancement is in the use of Digital control of motors, brakes, and steering which helps avoid collisions from the front and sides, and prevents the car from wandering off the road.

Similarly, there are several other companies which are working for automation of their cars and to provide enhanced driving features. Several car producers have provided Intelligent Driving and Intelligent Parking features in its cars. They have provided Intelligent Parking features in its cars that not only parks the car automatically and it also searches for parking space. This Automated Parking feature has also been enabled in Tesla and in BMW.

Car manufacturers are working on Intelligent Drive Driving Assistance Systems. They provide Semi-automated driving on freeways, highways and even in city traffic. Now some companies are also working on Connected Drive feature in their cars. Connected Drive is a concept which is now in progress. Companies want to give several services in their cars such as Car Online feature, Emergency Call and Intelligent Driving feature in them. BMW has started working on these aspects and is now making such cars [11].

As far as safety and security of the car is concerned autonomous braking has been introduced in cars which works automatically in hazardous situations. Mercedes Benz is working on it. Moreover, Mercedes Benz is also developing a system that utilizes stereo cameras and radar sensors to monitor the surroundings around the car. Similarly, companies are developing Pre-Collision System (PCS) with Pedestrian Detection. This system will be able to detect vehicles in the driver's path and if there is a possibility of frontal collision then the car will apply brakes to assist itself automatically.

Driver behavior characteristics are very important and numerous researches have been made in this field. The auto sensor applications that link quantified-self sensors (sensors that measure the personal biometrics of individuals like heart rate) and automotive sensors (sensors that measure driver and passenger biometrics or quantitative automotive performance metrics like speed and braking activity) are a great area of interest.

In Inter-Vehicle communication, cars exchange data and alter drivers to prevent potential collisions. They talk to sensors on signs on stoplights and bus stops and even sensors embedded in the roads to get traffic updates and rerouting alerts. They communicate with your house, office and smart devices, acting as a digital assistant, gathering information that is needed to go about your day. Several proposals have been made to make Inter-Vehicle communication. According to Marios D. Dikaiakos et. al. [8], you need Vehicular Ad Hoc Networks for the establishment of Vehicle to Vehicle communication. The protocol used by them for inter-vehicle communication is Vehicular Information Transfer Protocol (VITP). This method uses a GPS receiver and the Ad Hoc mode of 802.11b WLAN Network for the establishment of Vehicular Ad Hoc Networks. Similarly the Middleware proposed by Carl-Fredrik Sørensen et. al. [6]; uses MANETS for the establishment of Inter-Vehicle Communication.

The above details show that a lot of work is in progress in the field of Autonomous Driving, Safety and Vehicular Communication. Now the next trend is towards the optimization of routes for the driver of a Smart Car and this field has been discussed in this paper.

III. GENERAL ARCHITECTURE OF THE PROPOSED SMART CAR

A Smart Car is a combination of different sensors, actuators and controlling units. Previously some models of smart cars have been proposed. These models include sensors, actuators and other controls for monitoring the car's activity. Similarly, they have proposed radar and vision-based technologies for determining traffic density.

In contrast, we propose an architectural framework for the continuous car and traffic management. The proposed solution makes use of the following components:

- Automatic Dent Sensors for monitoring Car' Activity
- Google Maps, (aggregated) information collected by individual cars, and an internet enabled GSM SIM for Traffic Monitoring
- A GPS receiver and the Ad Hoc mode of 802.11b WLAN Network for nearby road surface monitoring
- A GSM enabled SIM for distant road surface monitoring using a Database Server placed in Transportation Department.

The devices proposed in this paper and the General Architecture of the Smart Car is shown in Fig. 2.

A. *Traffic Monitoring*

As shown in Fig. 2, the car uses Google Maps Traffic to do Traffic Monitoring and with the help of Traffic Rush Detector and Solver it will suggest clear alternate paths. The Car will contain a Smart Car Screen with specially designed software and a processor that will show Google Maps, Google Traffic and the result of Traffic Rush Detector and Solver app on the screen. Most importantly the car will have GSM 4G enabled SIM embedded in it. Therefore, mentioned softwares will work on the 4G GSM SIM by connecting to the internet.

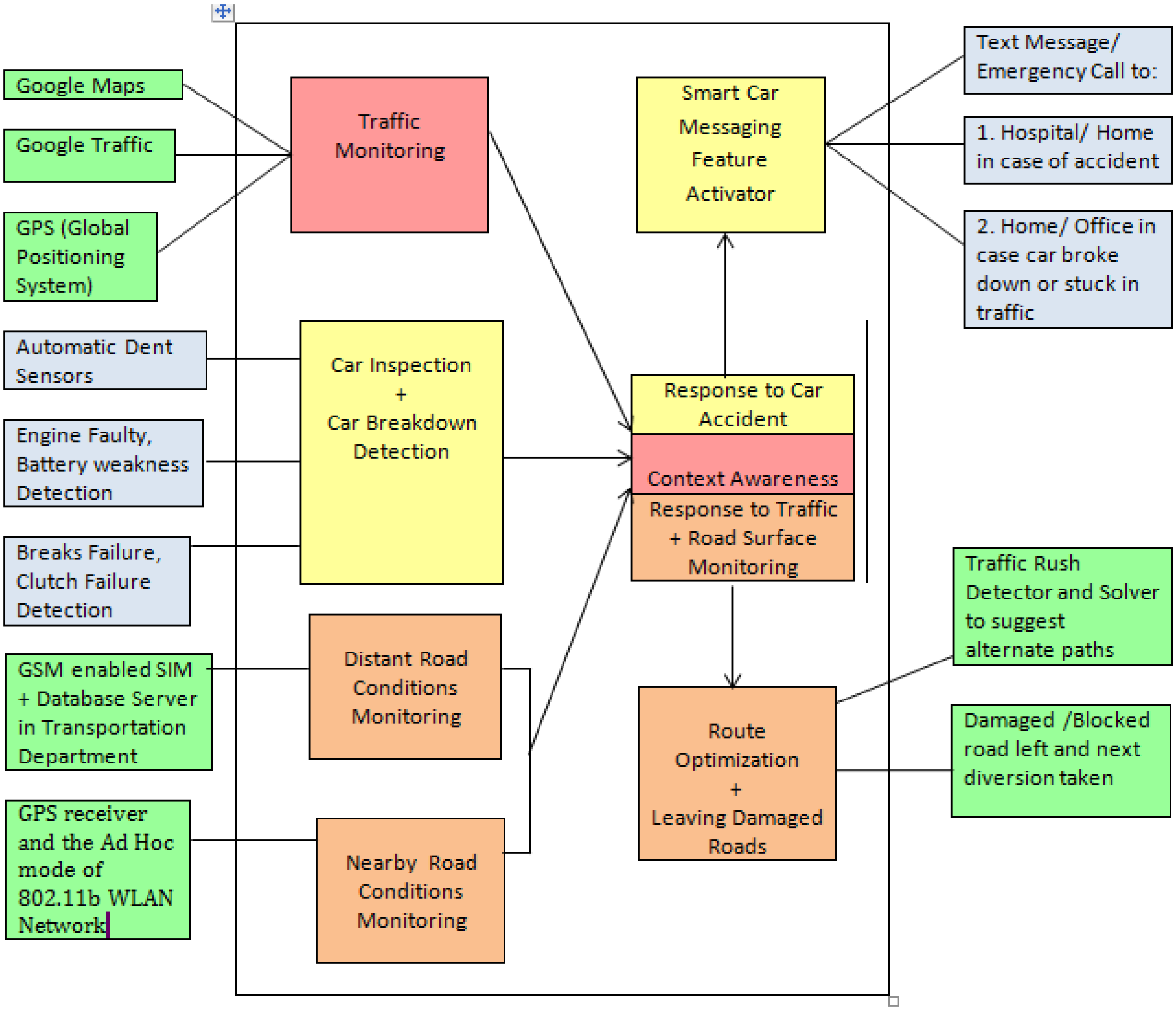

Figure 1: General Architecture of the proposed Smart Car

B. *Automated Detection of Car Break Down*

The car will also have engine faulty, battery weakness, breaks failure and clutch failure detection system and in case of any failure it will be displayed on the screen. Moreover, it will be the task of 4G enabled SIM to send messages to the destination when the car breaks down, is stuck in a rush or when the car has encountered an accident.

The prerequisites for this type of automation would include the connection of smart car software with several performing tools/machines of the car. It will include the engine faulty condition, battery weakness condition, breaks failure condition and clutch failure condition to the smart screen software. Along with 4G enabled Voice Messaging Application installed in the car. Our scheme works in a way that when the engine stops working or when the battery fails then the Smart Car Software detects it and shows a message on the smart car screen. Then it will make an emergency call/ send relevant text message to the home/Office that the car has broken down and its engine has stopped working or its battery has failed. Similar is the case for Breaks Failure and Clutch Failure Condition.

C. *Automated Detection of Car Accident:*

The prerequisites for this type of automation would be Automatic Dent Sensors for monitoring Car's Activity [5] and the 4G enabled Voice/Text Messaging installed in the car. The Automatic Dent Sensors have 3D laser scanner as the data acquisition device. They get the scan every time the car is hit and the scan is matched with the original image of the car's body. So when the metal is hit and it is bent then the Automatic Dent Sensors detect it with the Smart Car Screen not only the alarm is generated but also a Text and Voice Message is sent to the destination that the car has encountered an accident. When the car is going towards the home then the destination includes only the house contact numbers. When the car is going towards the office then the destination includes both house and office contact numbers.

D. *Monitoring of (Nearby and Distant) Road Conditions*

The GPS receiver and the Ad Hoc mode of 802.11b WLAN Network are used for cooperation and coordination between cars. Whereas the 4G GSM enabled SIM plus the Database Server placed in transportation are used for getting road information for distant cars. For cooperation and coordination between cars several methods have been proposed. The previous methods suggest that for communication between cars you would need a VITP, an ad hoc WLAN network and a cooperating car that transmits the latest signals to the following car. There are several researches in relation to these such as done by Marios D. Dikaiakos et. al. [8]. In this paper we have suggested to use a Vehicular Information Transfer Protocol (VITP) with Vehicular Ad Hoc Networks (VANETs) for inter-vehicle communication. In a similar way Carl-Fredrik Sørensen et. al. [6] have proposed a Middleware for making inter-vehicle communication possible. In both these methods, the communication between cars takes place with the help of a GPS receiver and the Ad Hoc mode of 802.11b WLAN Network.

Smart Car Screen installed in the Car

The software includes all the necessary applications such as Google Maps, Google

Figure 2: Smart Car Screen

E. *Traffic Rush Detector and Solver:*

Our Smart Car Software will also have Traffic Rush Detector App installed and it will also suggest alternate routes to the destination. The prerequisites for this functionality are Google Traffic App, Google Maps and the Smart Screen Software introduced in our car. Suppose that the person is going from his office to his home in his smart car. When he feeds the car about the destination then the smart car software observes rush roads towards his way home. It not only displays the roads where there is high traffic rush but it will also offer alternate paths to the home which are clear.

The Google Traffic App is a feature of Google Maps. The Google Traffic App works by observing the GPS determined locations of a large number of mobile phone users which are on that road. Google creates a live traffic map by calculating the speed of users along the length of road. Google Traffic map changes color from Green to Red when the traffic density goes from lowest to highest.

Figure 3: Traffic Density New York (4 PM)

Figure 4: Traffic Density New York (4 AM)

The figure 3 and 4 show Google Traffic Map at two different time stamps of New York City. It can be seen that the traffic density is high at 4 PM (above) as compared to the density at 4 AM (below).

F. Description of Smart Traffic App:

The Traffic App described before can best be described through scenario shown in the Fig. 5. As shown in Fig. 5 above; the person is destined to go from his office (in West End Avenue) to the Sub Office in the East. The driver usually follows the way on the Madison Avenue. From West End Avenue the driver turns left; from there he turns right and

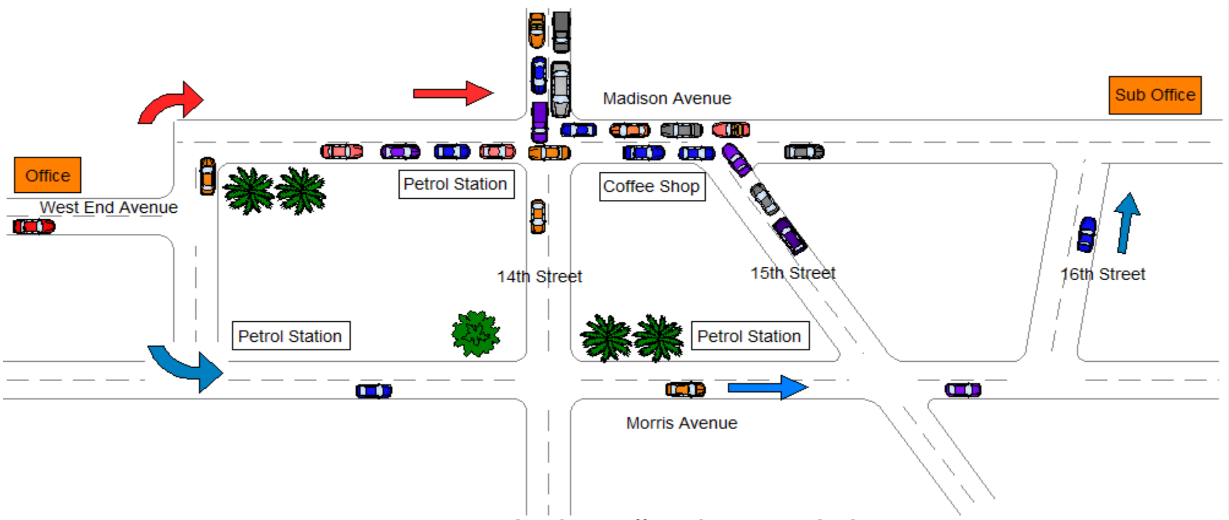

Figure 5: Scenario describing Traffic Rush Detector and Solver

enters the Madison Avenue. In this way the driver goes directly on the Madison Avenue and straight to his Sub Office.

But today there is a special situation. There is a traffic block on the junction of 14th Street on the Madison Avenue and it is a complete traffic jam. The functionality of our app comes here. When the driver enters his destination in the Traffic Rush Detector and Solver App, then the App not only shows the traffic block on the Madison Avenue on the Smart Car Screen but it will also show that since this road is blocked so the driver can turn to the right, take the path of Morris Avenue and go to his Sub Office by taking a turn from 16th Street. All this will be done using the Google Traffic App, Google Maps and the Smart Screen Software introduced in our car. The proposed method will not only provide an alternate blockage free route to the driver but will also save his time a lot.

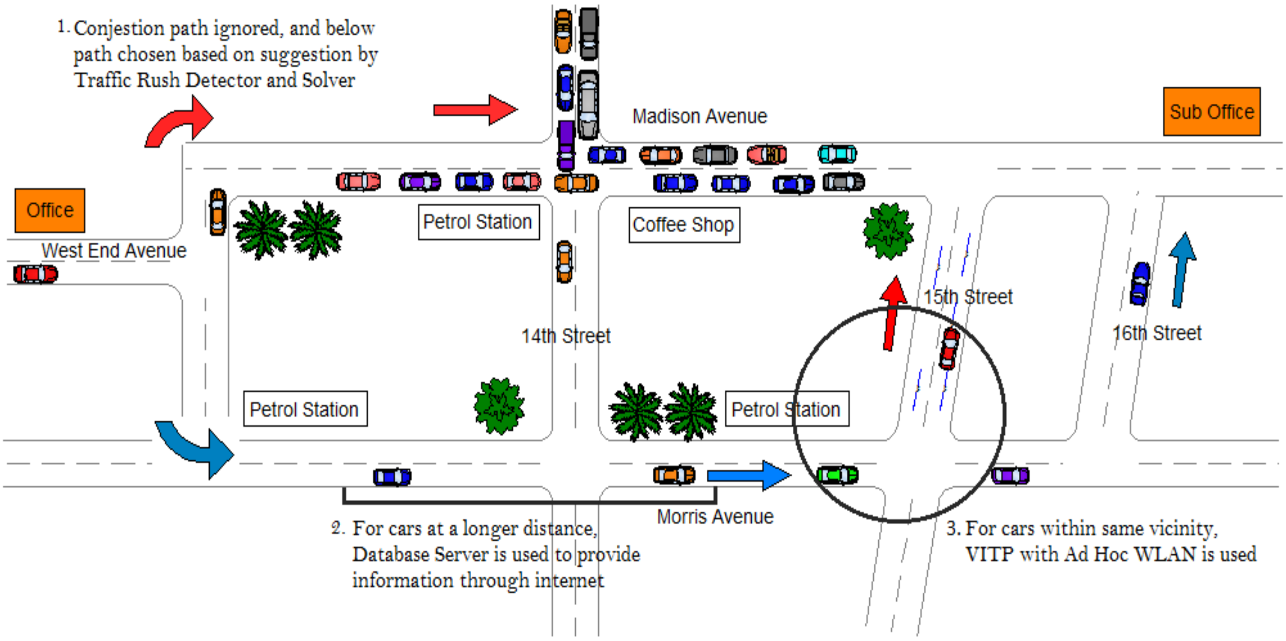

Figure 6: Combined diagram of proposed methods

IV. PROPOSED CONNECTED CARS V/S COOPERATING CARS

As discussed in Section III. the cooperation and coordination between cars takes place with the help of Vehicular Information Transfer Protocol (VITP) with Vehicular Ad Hoc Networks (VANETs). The devices required for inter-vehicle communication are also described in Section III.

In this paper, the author suggests using a VITP for car-car communication for cars in the same vicinity. Whereas for distant cars the author has proposed to use a 4G GSM enabled SIM to extract information from the Database Server. The GSM SIM embedded in the car will use internet to communicate with the server placed in Transportation Department and get information about the condition of the road. The information that the path has potholes in it or it is covered with water/ice or this road is blocked due to road accident will be transmitted to the Smart Car in two ways. One it will be transmitted through the DSSC (Database Server for Smart Car) and secondly it will be transferred through the cars in the using vicinity using VITP. The main advantage of using database server is that if nearby cars are not present even then the DSSC will work and provide information about the road conditions to the Smart Car Driver.

Previously we have described how Traffic Rush Detector and Solver works. Now we have proposed using DSSC (Database Server for Smart Car) for cars at longer distance and Inter-Vehicle communication through Vehicular Information Transfer Protocol (VITP) for cars in the same vicinity. All these methods and their combined working is shown in Fig. 6.

How the proposed connected cars work with DSSC and Vehicular Ad-Hoc Networks; it is best described with the help of diagram shown in Fig. 7. As shown in Fig. 7 the driver can take the route through 15th Street or 16th Street to his Sub-Office provided that he has already selected his path from Morris Avenue as suggested by Traffic Rush Detector and Solver. Now the driver can take the path from 15th Street or 16th Street to his Sub-Office given that the road on 15th Street is in real bad condition and there are potholes in the road. Now if the driver takes the path through 15th Street then he will be in real trouble and his car will be affected a lot. Now-a-days cars are being equipped with different types of embedded sensors. These sensors include position and obstacle detection to detecting road and weather conditions. One such sensor has been developed by Jaguar Land Rover. The technology developed by them will allow to detect, predict and share data on potholes. As per them, this technology will allow a vehicle to gather data about the location and severity of potholes, broken drains and manhole covers.[3]

The information collected by these sensors can not only be used within a car but it will also be transmitted to two other entities. One it will be transmitted to the cars within the same vicinity using VITP. Other it will be transmitted to the Central Database Server placed in the Transportation Department using internet of SIM embedded in the car. The server will contain all the city's road map along with the information regarding road condition. The information thus transmitted will be stored in the database and this path will be highlighted on the database that it has bad road conditions.

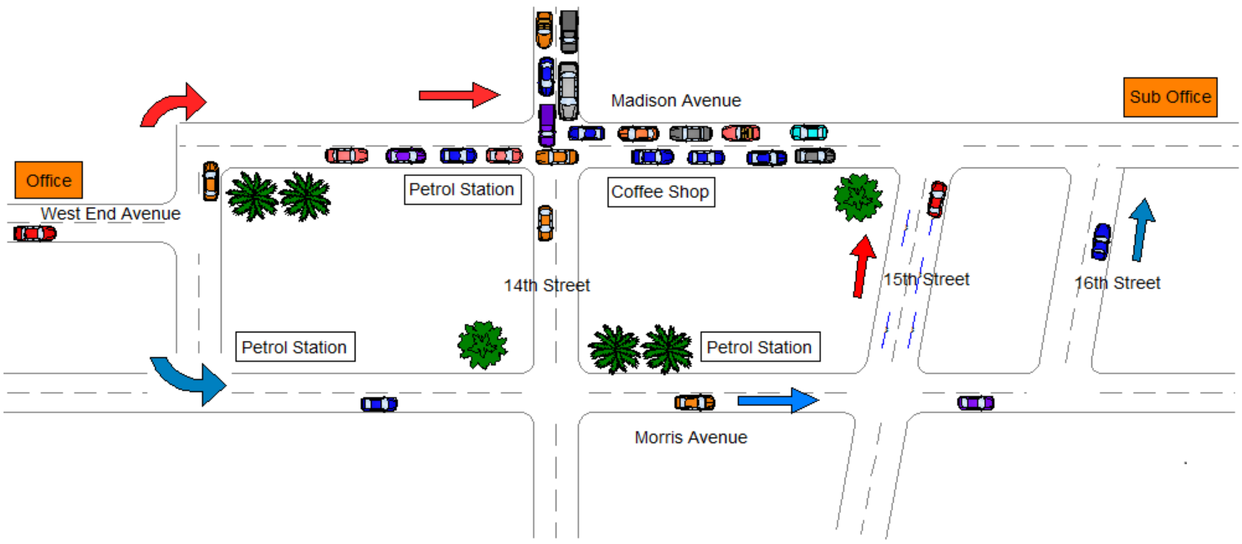

Figure 7: Scenario describing working of DSSC and Vehicular Ad-Hoc Networks

The main advantage of all this setting will be that any car with the aforementioned features and moving in the same vicinity will get the information through VITP that the road through 15th Street is in bad shape. Moreover, any connected car at a much greater distance from that area and moving towards the 15th street; since it will have internet access and a smart screen so it will connect to the fore mentioned Database Server and get this information beforehand that the road on 15th Street is in bad shape.

So, both these cars i.e. cars within the same vicinity and the connected car at greater distance will take their way through 16th Street and reach their Sub-Offices safe and sound.

The main advantage of the 2nd method is that any connected car moving towards Sub-Office from Morris Avenue will get this information will get this information from the Database server about the bad road condition. It does not need a cooperating car ahead of it that needs to transmit the latest signals to the connected car at that moment. The Flow Chart of how DSSC and Vehicular Ad-Hoc Networks will work is depicted in Flow Chart in Fig. 8.

The database of the Server placed in the Transportation Department will get updated when another car having the same sensors and internet access will visit that road again and find out that the road is still having pot holes or that they have been cleared because the road has been black carpeted again. The updating frequency of the Database Server is set to 5 i.e. when it will receive message from 5 smart cars that the road has pot holes then this thing will be highlighted on the map. In a similar way the Server will be updated if the road has been cleared of pot holes. Moreover, this thing can also be updated manually by a transportation department Official that the road is clear as its reconstruction is complete now.

For the database Server, we propose that there is not a single Central Database Server rather a separate Database Server for all the towns in which the City is divided into.

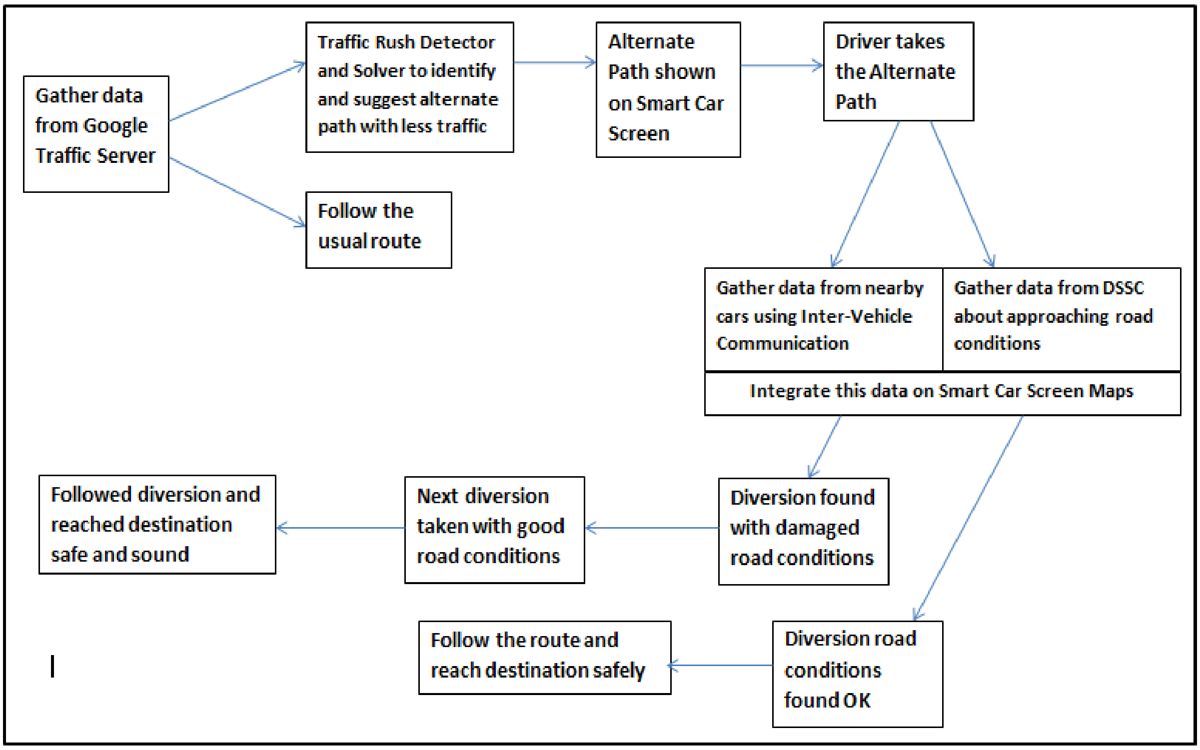

Figure 8: Flow Chart explaining how proposed methods work

V. Conclusion

Extending the trend of Smart Cars and autonomous automobiles we proposed the selection of optimized route with the help of Traffic Rush Detector and Solver. In a similar fashion we have presented a solution for the damaged road conditions using Inter-Vehicle communication with the help of Vehicular Ad Hoc Networks and by communicating to the Database Server for roads through GSM.

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