Data Analytics based Driver Assistance System in Vehicular Ad-Hoc Networks

Jetendra Joshi, Dandu Geet Kamal Tej, Pranith Kumar, Rohith Samineni, S R Rahul, Siddhanth Polepally, and Vishal Rajapriya
Department of Electronics and Communications
NIIT University, Rajasthan, India

ABSTRACT
Vehicular Networks has a great potential to enhance the lives of people. When vehicular networks are integrated with Mobile Application, Web Application, cloud technology and Internet of Things, it helps to make the driving experience pleasant and safe. This paper aims to enhance the driver assistance by assisting in directions, transit time, and to cope up with the avoidable situations and emergency situations by also monitoring the vehicle’s position, speed, lane tracking. The defined model aims to deliver reliable help in emergency situations by using efficient protocols to communicate to the cloud and efficient database retrieval methods to make the query respond faster and to provide a unique and safe experience to the driver.

Keywords
VANET; Android; Web service; CoAP2; MongoDB; Internet of Things; Cloud technology.

1. INTRODUCTION
The continuous advances achieved in wireless communication technologies, for past few years, have yielded a scope of new networking research fields aiming at extending connectivity to environments where wired solutions are not feasible. As such, Vehicular Ad hoc Networks (VANETS) stand as one of the most attracting and promising research field for researchers, automotive companies, students. VANETs promising applications are not only restricted to road safety but also focuses on vehicle traffic optimization like congestion control, route optimization to commercial applications like recommendation systems, internet access and emergency services.

Vehicular Ad hoc Networks:
Vehicular Ad hoc Networks are considered as a branch of vehicular wireless networks, developed to provide communication within a group of Smart vehicles. Two communicating nodes that are far away from each other may rely on intermediate nodes to relay messages or may use a set of stationary communication units along the road called Road Side Units (RSUs). Vehicles communicate either with other moving vehicles using V2V (Vehicle to Vehicle) communications or with fixed network nodes placed alongside the road using V2I (Vehicle to Infrastructure) communications, called road-side units (RSUs). RSUs provide moving vehicles with access to an infrastructure network, as well as infrastructure-based services. Road-side units can be placed next to the road in regular intervals, or be integrated in existing road infrastructures, e.g. road signs, bridges, or toll gates.

A VANET must be equipped with wireless communications devices and Global Positioning Systems so that they can communicate and analyze the collected sensor data and process information in network. Many applications of VANETs are classified in terms of delays and services. Many accidents could have been avoided if the driver was informed about the distress that lies ahead just some seconds prior. VANET can be divided into three categories: Safety application, traffic assistance and infotainment applications. However, infotainment application is not discussed in this model.

Safety applications are to make sure that the driver as well as the passengers / pedestrians are safe by providing necessary information to the driver at optimum time to avoid accidents. These actions and response time is time critical and so needs strict real-time communications techniques.

• Danger/Caution warnings
• Vehicle 2 Vehicle Assistance
• Sign analyzing

Danger/Caution warnings:
This application notifies of the warning, danger signs of the nature of the road. Ex; these signs are generally slippery road, a work zone, a sharp turn. Road side units transmit these types of messages to the VANETS entering such zones.

Vehicle 2 Vehicle Assistance
VANETS broadcast information to all the neighboring VANET within a predetermined geo fence. Vehicles run algorithms on the received data to assess the threat of other vehicles or passengers. Due to this alert, the driver will have enough time to take decisions and substantially avoid the distress.

Sign analyzing:
A driver can optimize and regulate speed as per the locations of the traffic lights and signal timings when the information is received at optimum time intervals.

Traffic assistance related application aims to share information between vehicles present in the geo fence to optimize traffic flow and enhance driver experience.

• Intelligent traffic flow control
• V2V Merging Assistance

Intelligent traffic flow control:
The application enables Road side units to collect traffic information and various other information to predict traffic congestion. Once this prediction is done, the RSU transmits the required information to the vehicles in the geo fence so that the VANETs can choose a difference route in case of congestion and get the nature of traffic.

V2V Merging Assistance:
This application allows VANETS to merge from one route to different route without disrupting the traffic and merge with ease. The vehicles can communicate with adjacent traffic to ensure this.

The VANETs when coupled with reliable driver assistance helps the driver to have a unique and safe driving experience.
driving assistance system aims to help the driver to find routes, get the transit time and distance to destination. It also helps the driver in case of emergency situations by locating the nearest emergency places such as Hospitals, Police Stations and Fire Stations and provide instant information of these places and provide facility of call, message or find route so that the driver does not need to search for numbers and search for routes at the most panicking hour. The Model also alerts the driver in case of over speeding or violating lane discipline by sending warning message on the display panel of the On-Board Unit. This complete package of software and hardware integrated together makes a reliable driver assistance system that makes lives of transit passengers comfortable and safe.

Further sections are divided as follows, Section 2 contains the related work, and Section 3 contains the background. Section 4 discuss problem formulation. Section 5 discusses the system architecture of the App. Section 6 analysis the performance. Section 7 is the Conclusion and Section 8 contains the references.

2. RELATED WORK

The need for driver assistance system in intelligent transport systems have been a great demand. Many researchers and developers have made the system more sophisticated, than it was a few years back. Many automobile companies have also started to understand the importance of customer safety and have been deploying many more safety features since then. In this section, we will discuss the broad developments made in this field. The author [1] has described a model of video-based lane estimation and tracking system. The system aims to detect accurate lane-marking detection. Steerable filters are used to provide an efficient and robust method for detecting solid-line markings, circular-reflector markings, and segment-line markings, curvature marking under different lighting and road conditions. They can assist in lot of varying scenarios and environments. Lane-Departure-Warning Systems Driver-Attention Monitoring Systems Automated Vehicle-Control Systems [2] Traffic Sign Recognition (TSR) regulates traffic signs, trigger warning to driver, and alert certain actions. A real-time automatic traffic sign detection and recognition can support the driver in times of SOS and increase driving safety. Automatic recognition of traffic signs is also important for automated intelligent transport systems. Traffic Sign Recognition system need to also take human visuals [3]. TSR generally splits into two stages: Detection and Classification. Detection locates sign and input images whereas classification deals with the type of signs we are looking at. The author [4] describes a model which has three main components: the environment, the human driver, and the vehicle. The human driver model includes four categories that make up this model, sensing-perception, long term memory, working memory and motor response. The Collision detection triggers warning in case of emergency and collision avoidance response is initiated. Also, taking ecological parameters into consideration, authors [5] proposed ecological driver assistance system that measures instant vehicle-road-traffic using advanced communication technologies and sophisticated sensors. Using models of vehicle dynamics and traffic flow, future situations of the vehicle-road-traffic network can be anticipated which can estimate fuel consumption and generate the required control input necessary for ecological driving. This can be achieved using human interface. Authors [6] propose a system that depends on Vehicular Ad-hoc NETworks and video-streaming technology namely the See-Through System. The system enhances driver’s visibility and supports in overtaking decision in difficult situations like overtaking a vision-obstructing vehicle. This model helps the driver to determine if he should start the overtaking maneuver. [7] The advances in cloud computing and internet of things (IoT) has been very prevalent in the field of Intelligent Transport Systems. It has helped us sync various sensors to the cloud for central monitoring purposes. [8] The authors developed a prototype of a longitudinal driving-assistance system that adapts to driver behavior which includes acceleration and accident warning. Using data analysis, a driver model imitates the driver's operation to generate desired acceleration and brakes. The algorithm used is a self-learning algorithm. [9] The urban driving environment requires complex sensors for the driving assistance systems. These sensors must collect relevant data in as much as low time possible. The sensors were able to detect and track clothoid and non-clothoid lanes, cars, pedestrians and drivable areas in the absence of lane markings. The authors [10] estimated the driver's visual distraction level using a video-based driver monitoring system. Lane-keeping support is provided by an additional torque applied on the steering shaft in order to regain an appropriate lane position such that the system can keep a check if the vehicle has drifted away from the lane. The authors [13],[14] proposed a technique to gather reliable data and evidence against the regular defaulter vehicles monitoring and pass it on to the police officials and explained the idea and partial implementation of the Traffic Management system as service in Cloud model used in VANET.

3. BACKGROUND

Many application developers have developed applications to enhance the safety of the Highway traveling passengers. Also, companies have started to understand the safety of Vehicular transit and various researches in this field have been carried out. Automobile companies have been very keen to take the safety consideration of their customers for better brand reliability and making the lives of people safer. Applications have been developed to safeguard the travelling like SMS blocking, call blocking, recording the routes, check on acceleration, parents notified about child’s driving speed, sound alert notifying the close distance between your car and the car ahead by measuring distances, etc. Many products exist in the market like Google maps, Waze, here maps, etc.

4. PROBLEM FORMULATION

There have been many Vehicular monitoring techniques that has emerged and are in practises. But at many a times the technology used and the monitoring ways have been still ancient in its ways. Insufficient sign boards along the road, many blind turns, speed control, distress management have been some of the areas which is still premature. With the increase in developments in the field of Internet of Things and Cloud computing, many efficient solutions can be thought of. Along with monitoring, the driver can be given assistance in many cases of distress include the detecting of problem just a few seconds before accident can help in avoiding an accident, automatic signs of speed reduction on OBU’s, etc. will be discussed in this paper. With this driver assistance model, the VANETS can be smart enough to help drivers, notify of coming dangers and handle situations in case of distress.
5. SYSTEM ARCHITECTURE

5.1 Software Application:
Intelligent Transport Systems have been facing many challenges to secure the driving environment by implementing various algorithms and advanced technologies. Critical area in this field includes avoiding accident and handling situations in case of distress. An interactive Mobile Application is given to the user from which they can easily take help in case of distress. This application start by prompting for two SOS numbers. As soon as the numbers are entered, the app prompts for source and destination address.

Figure 1. The Android Application

Figure 1 is the main page of the android application having all important features on the main page itself.

Once the address is filled, the map directs the user on the map using polyline. The application can also compute the exact time to travel and the distance left to travel.

In case the driver meets with a distress, then the user can click on the find places button and the nearest Hospitals, Police Stations and Fire Stations pops up and the user can access the places by just tapping on the marker. Full information of the place is displayed to the user. In case of emergency, if the user wants to contact the emergency place, the user must tap on the marker nearest and click on the call button. This feature is to help users those who travel on highways, urban roads, traffic areas to spot the correct nearest location. Even if the user is travelling through an unfamiliar area, the feature can help to pin point the nearest place of interest.

The user can also make distress call to the pre-saved SOS number or send message to the numbers. The App continuously sends the Lane data to the cloud to be monitored. In case the user exceeds speed limit above a threshold, the OBU flashes speed limit warning on the LED display that is fitted on the dashboard of the vehicle. Even if the Lane is changed very frequently, the alert message if flashed. The vehicle uses Ranking algorithm to trace out the vehicles around it. This algorithm sorts the vehicles in order of the priority and sends warning message to the nearby vehicle in case of sudden breaks, vehicle break down, detect vehicles that are at blind spots or the vehicles that needs to take blind sharp turns. The Ranking algorithm is run at OBU to constantly check for nearby vehicles and predict the critical accidents. This can help reduce accidents by warning the drivers of the forthcoming dangers. The required data is collected from OBU to the app through Bluetooth and is sent to the cloud using cellular data. CoAP (Constrained Application Protocol) is used for data to be transmitted from the sensors to the OBU. The data collected are speed, latitude and longitude co-ordinates, vehicular ID and lane information. The data is then ingested in a Monitoring Website.

Figure 2 shows the data plotted on the Thingspeak cloud that is sent from the android app.

Figure 3. Monitoring Website.

Every action of the Vehicle is being monitored through Monitoring Website. If the speed of the vehicle is constantly above the threshold or the lane is changed frequently violating the lane discipline for a preset threshold time, then an alert is generated and the user is sent an Email. The Monitoring website can be used for various purposes depending on the situation. It can be used by parents to monitor their child’s driving habits, it can be used by traffic police or highway patrol to monitor the speed and lane discipline and track the vehicles, it can be used by automobile companies to enhance the driving experience and help their customers in case of breakdown.
The application is developed in Android Studio. The Website is locally hosted on Wamp server; the e-mails are generated by IFTTT. The map application is powered by Google. ThingSpeak cloud is used for the data monitoring and sending data to the Website.

5.2 Hardware and Applications:
The vehicle has many devices that influence the application directly. All these devices are incorporated inside a single unit namely ON-BOARD UNIT (OBU). The OBU contains various hardware that assists the driver in various situations and constantly communicates with the Android app to send GPS data, speed data, vehicle ID, lane data, etc. The OBU runs the Ranking algorithm to check for nearby vehicles. The OBU is connected to a LED display that flashes a warning error in case of danger. Various hardware used in the model have been discussed below.

Bluetooth Module
Bluetooth is a wireless technology for exchanging data over short distances. The ISM band range is from 2.4 to 2.485 GHz. The GPS data, speed and vehicle ID is sent to the Android app through bluetooth module so that the data can be further pushed to Thingspeak cloud and the data can be read at the Monitoring Website.

MPU6050
IMU sensors usually consist of two or more parts: accelerometer, gyroscope, magnetometer and altimeter. The MPU 6050 is a 6 Degrees of Freedom or a six axis IMU sensor which gives six values as output. Three values from the accelerometer and three from the gyroscope. The MPU 6050 is a sensor based on Micro Electro Mechanical Systems technology. Both the accelerometer and the gyroscope is embedded inside a single chip. This chip uses I2C (Inter Integrated Circuit) protocol for communication. MPU6050 helps in lane assist which helps the user in maintaining lane discipline. If the lane discipline is violated for a certain preset threshold time, then the user is notified with an alert message on the display panel of the OBU.

GPS Module
The coordinates are sent from GPS module to android app through bluetooth module. This GPS data along with speed and vehicle ID is sent to Thingspeak IOT cloud so that data can be read on the Monitoring Website. The GPS module is responsible for the exact tracking of the vehicle. GPS module transmits coordinates and speed to the Android app so that this data is pushed to the ThingSpeak cloud so as to plot the data on the Monitoring Website.

5.3 Outline of the Model
Outline of the model and features are discussed.

a. SOS Numbers
   Two SOS numbers are required from the user to call or send message to the given SOS numbers in case of distress.

b. Source and Destination address
   To track the vehicle along the route and direct the user on the map using polyline feature.

c. Find emergency places
   The user can click this button to spot all the nearby places around 5 Km radius. Once the markers pop up, the user can touch a marker to get the full details of the place including an instant calling button to call that place. By default, the place is chosen as hospital for emergency.

d. Speed Limit checker
   The speed of the user is constantly checked. In case the speed is above the current limit, the LED display on the OBU flashes warning and an automated e-mail is sent to the user.

e. Lane Assist
   The lane assist feature checks for changing of lane frequently. If the user breaks the lane discipline or frequently changes lane, a warning message is flashed on the LED display of the OBU and an automated e-mail is sent to the user.

f. Collision Warning system
   With the help of ranking algorithm, the nearby vehicles are sensed by the VANET’s OBU. In case of sudden breaks, blind turns (other vehicles approaching from a blind curve), etc. is displayed on the LED display of the OBU.

g. Thingspeak Cloud
   All data, that is Vehicle ID, Latitude and Longitude coordinates, speed, lane data is been sent to the cloud from the android app.

h. Monitoring Website
Monitoring website ingest all data from the cloud and plots all the vehicles on a map and tracks every vehicle’s location, speed and lane.

i. ON-BOARD UNIT
On board unit consist of various hardware that is mounted on the console of the VANET. The hardware includes Microcontroller, Bluetooth Module, MPU6050, GPS Module and LED display.

6. PERFORMANCE
The performance of the system is measured by the time lapsed for the transfer of data from the on-board unit of the vehicle to the Microcontroller and then to Mobile Application which in turn sends the data to the Monitoring Website. We shall discuss performance for the protocols involved in transferring data from sensor to microcontroller, android application to the cloud and data retrieved from a database. There are various protocols that significantly affect the data transmitted time. The few basic protocols used for IoT are HTTP, MQTT, XMPP, DDS, and AMQP. We shall use CoAP (Constrained Application Protocol) to collect data from sensors to the microcontroller. CoAP is a client/server one to one request/response protocol supporting multicast. Like HTTP, it has REST client approach. CoAP is designed to interoperate with HTTP and RESTful Web through proxy making it natively compatible to the Internet. To incorporate an energy efficient protocol, CoAP uses UDP which in turn ensures minimum battery consumption. Packet size of CoAP is also comparatively less that other protocols. CoAP can also ensure security as it works on Data Transport Layer Security. The Table II shows comparison of the two different protocols. The battery life consumption increase with number of messages in CoAP and is only suitable when data is less.

HTTP Stands for Hyper Text Transfer Protocol. Data must be transferred in a secured fashion from mobile application to the cloud and HTTP serves the purpose. The best way to protect data exchange on a website is an SSL certificate (Secure Socket Layer Certificate). When Web services use REST architecture, they are referred as RESTful API’s (Application Programming Interfaces). REST helps in reducing energy consumption and communication latency. The REST web service can be converted to objects to make it easy for manipulation the web service into composition [11]. They use HTTP to communicate the web server. RESTful API aims to minimize the limitations that have been encountered in the past used methods. Representational state transfer (RESTful) systems most of the time communicate over Hypertext Transfer Protocol (HTTP) using GET, POST, PUT, DELETE methods which the web browsers use to retrieve the web pages and send data to the remote servers. REST systems interface with web resources that can be identified by Uniform Resource Identifiers (URIs). REST relies on URL instead of using XML to make request. REST based Web services return the response output in a language that is easy to parse like Command Separated Value (CSV), JavaScript Object Notation (JSON) and Really Simple Syndication (RSS). REST has better performance by reducing the server load, because of its less overhead on top of HTTP. Further encoding representations in JSON format, we also enhance the network performance by sent minimal number of bytes. The performance can be tested on Apache JMeter which is open-source software that is popular for performance testing to test the REST API and to test the number of concurrent users the server can handle.

To overcome the limitations of the Relational Database (RDB) technologies, we use NoSQL (Not Only SQL) database like the Mongo DB. This technology can store unstructured data because the data schema-modification capability. Scale-out scheme reduces server expansion cost. Distributed storage and processing over multiple data nodes can process large amount of data with ease. Veen et al. [12] compared the read/write performance of an SQL database (PostgreSQL) with NoSQL database (MongoDB) for the sensor data-storage purpose and concluded that MongoDB is for smaller sensor data with higher priority to the writing performance. MongoDB unlike other DBs has its data structured designed independently as a unit so that a schema definition is not required. Even distribution of data is controlled by shard key which is a single indexed field that exist in every unit. By using hashing, MongoDB divides data into logical chunks of storage unit according to the shard key. This helps in data availability, safety and data consistency. Experiments have been performed for testing the performance of MySQL and MongoDB. Queries were created and the same fields were indexed in both MySQL and MongoDB. The response time were measured. The queries were for an event that occurred at specific points and at specific places with no multiple shards. The queries were run several times and the average was counted to see the overall performances. The test results show that MongoDB outperforms MySQL and is very stable and has a low response time.

![QUERY RESULT](image)

Figure 6. Graph depicting performance result of the query.
7. CONCLUSION

This application can be very useful for user who transit frequently. The application can help the user to find routes, nearby emergency places and ensure the safety of the user and other car passengers. The driver is always being monitored and the application stays vigil of the driver’s actions. This interfacing of IoT devices with the Android application and the Web technology provides user a reliable driver assistance system by harnessing the benefits of cloud platform. The application runs on the most reliable protocols and mechanisms has been deployed to make the Android Application and Monitoring Website respond faster to the IoT devices and the cloud. Using the technology of VANET, Mobile Application, Web Application, Internet of Things and Cloud technology, the model helps the user to have a pleasant and safe driving experience.

8. REFERENCES


[2] Auranuch Lorsakul, Jackrit Suthakorn; Traffic Sign Recognition for Intelligent Vehicle/Driver Assistance System Using Neural Network on OpenCV; The 4th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI 2007)


[7] Wu He, Gongjun Yan, and Li Da Xu, Senior Member, IEEE; Developing Vehicular Data Cloud Services in the IoT Environment; IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 10, NO. 2, MAY 2014

[8] Jianqiang Wang, Lei Zhang, Dezhao Zhang, and Keqiang Li; An Adaptive Longitudinal Driving Assistance System Based on Driver Characteristics; IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, VOL. 14, NO. 1, MARCH 2013


