Smart Transportation Tracking and Management System using IOT

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Abstract:

The intelligent vehicle technologies have been one of the most widely studied emerging technologies recently. Its backbone, the vehicular grid (V-grid), allows information sharing among vehicles with IOT components interconnected through a beacon that can receive signals (or data) from moving objects. These interconnected "things" in the V-grid constitutes the Internet of Vehicles (IOV). The IOV enables better traffic management, road safety services, quick emergency response and efficient logistics management. The Global Positioning System (GPS) is currently the most trusted technology to track a vehicle's location. For real-time positioning, the GPS satellites receive data from a sensor, like a GSM module, inside the vehicle. However, stable connectivity can be a big problem in mountainous or desert regions where there is weak or no GSM signal available, or what we call the dead spot terrains. Hence, this research intends to investigate how to continuously track vehicles passing through dead spot areas. Furthermore, this research paper aims to develop a Smart Transportation Tracking and Management System (STTMS) with uninterrupted location tracking of vehicles using IOV sensors and modules for real-time data collection and processing. STTMS aims to benefit vehicle drivers, transport companies, their customers and economic sector. The main goal of this research is to design, develop and implement a Smart Transportation Tracking and Management System (STTMS) using IOV technologies to enable uninterrupted transport route monitoring of delivery trucks in our country.

Keywords: Smart City, Smart Transport, Vehicular Network, IOV, GSM, Real-time Location Tracking.

I. INTRODUCTION

A Smart City is an integrated environment comprised of smart buildings, smart energy sources, intelligent Vehicular Grid (V-grid) [1] and other emerging smart technologies. A Smart City uses many IOT sensors backed by communication infrastructures that create a network of "things" to make city life a sustainable environment - less reliant to human interventions and more on automated processes [2]. Among the components that make up a Smart City, the V-grid is the latest to get the attention of academic researchers. In the recent past, studies have shown that V-grids (or vehicular networks) enable data communication between vehicles (V2V), vehicles to infrastructure (V2I), vehicle to a data center, and vehicle to a cloud server (V2C) [3]. Different IOT sensors, GSM modules, the road-side telecommunications towers and the GPS satellites typically make up the V-grid communication technologies, or simply, the Internet of Vehicles

(IOV). Autonomous vehicles, environmental hazard warning systems, real-time traffic monitoring, and transport management systems are among the interesting applications of IOV [2][3] [4].

II. SMART TRANSPORT MANAGEMENT SYSTEM OVERVIEW

A Transport Management Systems (TMS)helps with the efficient dispatch of company vehicles, such as a fleet of trucks that deliver goods to customers. The use IOV technologies makes the TMS a "smart" TMS [5] using real-time data to monitor the delivery vehicle's location, measure the speed it is running at a certain distance, or automatically notify rescue teams in case of accidents [6]. Additionally, a typical smart TMS has benefits such as the ability to record engine hours, fuel consumption and travel time; thanks to IOV real-time data collection. All these information can be useful to manage company resources such as money, time, and people (drivers). Furthermore, smart TMS helps to make informed planning and decision-making based on real-time data from the fleet on the road. For instance, when one of the IOV-enabled trucks experience delays due to some traffic situations, the smart TMS can reroute the fleet to minimize the potential losses in business revenues due to the delay. Finally, with the use of IOV in smart TMS, the company can monitor the driver's behaviour such as reckless driving, speeding, changing lanes, unnecessary stops, and other driving conditions that may be detrimental to the business. The figure below shows a general overview of smart TMS.

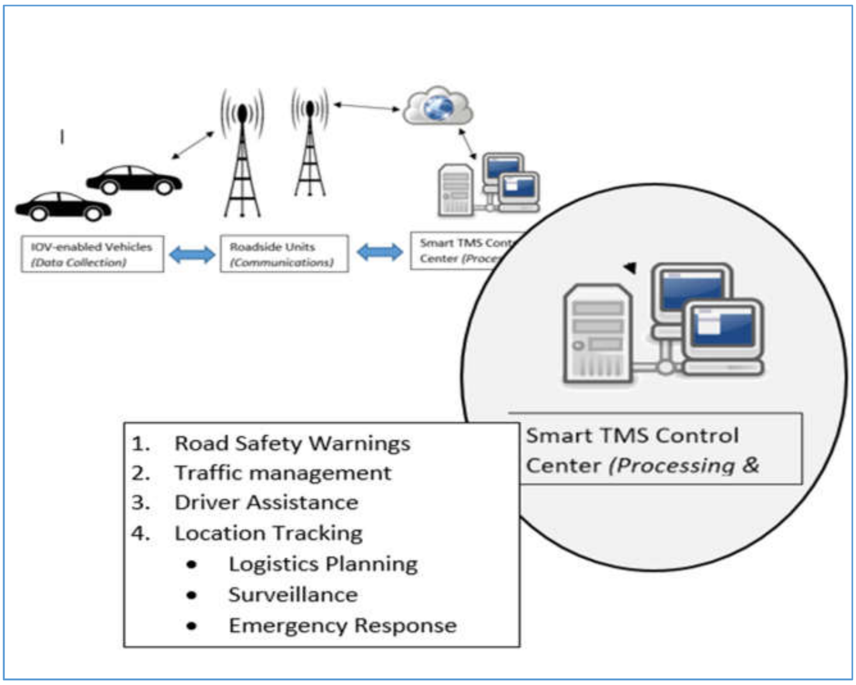

Figure 1: Smart Transportation Management Systems

III. PROBLEM STATEMENT

The emerging vehicular technologies using IOVs can improve the efficiency of the delivery of goods and services by implementing smart transportation monitoring systems [5] that can provide real-time updates about road and vehicle conditions. The smart vehicular systems can easily be realized in countries with less varied landscapes. However, implementing these smart vehicular systems could be more challenging in countries with diverse environments. Varying terrains causes the differences in communication service coverage when a state or a city which has a diverse topographic feature including mountains, deserts, valleys, coastal areas. For instance, the city of strong mobile network signal until you reach the road that passes between high mountains. Between cities, a cargo delivery can pass through some or all kinds of these terrains. These different terrains and the variances in the communication signals challenges the effective implementation of intelligent transport monitoring systems. This research is driven by the challenge to use IOV to effectively monitor vehicles even in road stretches with weak or no signal in the same way that it would in urban cities with strong network signal.

IV. LITERATURE REVIEW AND ANALYSIS OF RELATED WORK

During past decade several studies have been done about IOVs focusing mountains and terrains. However, as of this writing, most of these studies were done in simulated environments or testbeds [1]. Figures 2 and 3 below provide an overview of the IOV research done in the past six years and their implementation statuses [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20][21][22] [23].

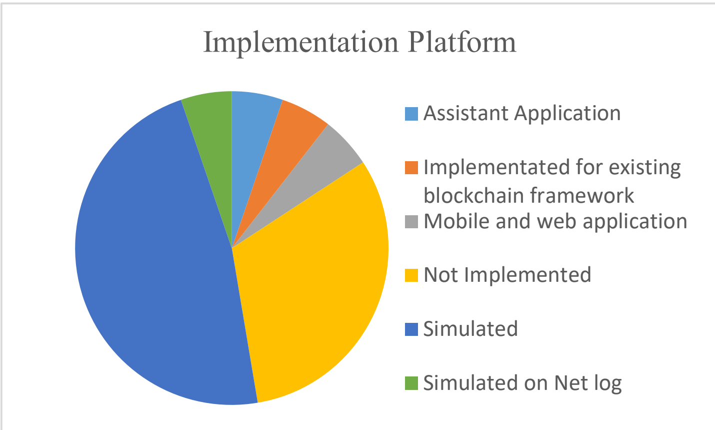

Figure 2: Implementation Platforms of IOV Research in the Past decade

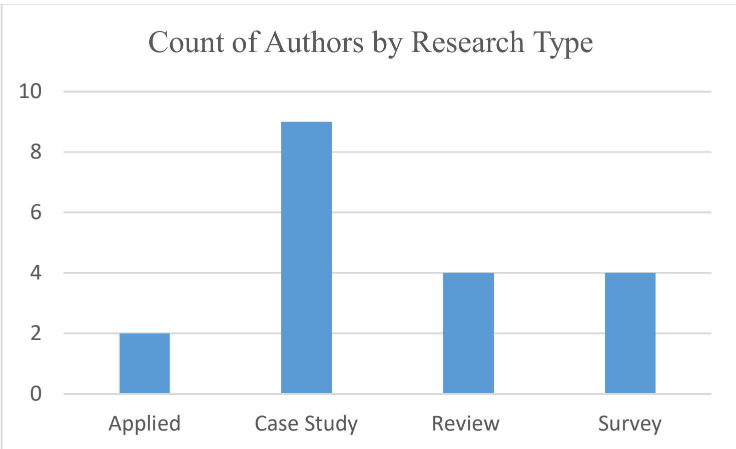

Figure 3: Types of IOV Research in the Past decade

The industrial sectors have also placed their interest in the emerging vehicular technologies. In fact, in the report [24], eight automakers and 2500 vehicles participated in the Michigan V2V project. There are now commercially available smart cars equipped with intra-vehicle sensing technologies for added driver/passenger safety. However, there is still a lot to research about inter-vehicle communications, where vehicles can share useful data to other vehicles within a certain range, forward the same data to company data centers or to the IOV cloud. According to one participant in the Michigan V2V project, “a V2V communication can be effective when roughly a quarter of vehicles on the roads are equipped (with IOV technologies)”.To this end, implementing V2V (peer) communications may have to wait until the national communications infrastructure has been set up for the Smart City. Nevertheless, this does not limit the researchers to find other ways of monitoring transport routes under the existing infrastructure, given the varying communication signal strength in the nation. This research will provide an alternative way for continuous transport route monitoring in all terrains, thus, improving the efficiency of goods delivery across the nation.

V. OBJECTIVES AND RESEARCH METHODOLOGY

IOV, as the emerging technology in transportation, will be a building block to the realization of this goal. The main goal of this research is to design, develop and implement a Smart Transportation Tracking and Management System (STTMS) using IOV technologies to enable uninterrupted transport route monitoring of delivery trucks in our nation or state. The research includes business and safety controls that could be beneficial in the following ways:

- Creating safer roads for drivers and passengers
- Providing On-time traffic and road situation updates
- Enabling effective planning and dispatch of delivery vehicles
- Monitoring of delivery for efficient farm-to-market/ supplier-to-customer transfer of goods
- Increasing the awareness on how IOV technologies can benefit the transportation sector.

This research has the following specific objectives:

- To investigate on the current situation of road-side communication signal strength.
- To explore the available IOV enabling technologies that work with the existing communication infrastructure in the nation or state.
- To design the IOV solution with tracking location algorithm to collect real-time data wherever there is a good network coverage while utilizing a dead reckoning algorithm to compensate for the missed updates when the signal is lost.
- To develop the web application as the control center for the STTMS.
- To develop a mobile app for rescue teams to monitor and receive notifications in case of accidents.
- To test the interconnectivity of all the components of the STTMS.

This research will be executed in the following stages:

- Literature Review and Analysis:

The first stage of the research is to find out if there is a scope for the proposal and see if there is enough supporting previous works available. The research problem of this paper is based on an existing signal coverage condition in the country. Therefore, the researchers will investigate what has been done in the previous works and build on those ideas for the proposed solutions.

- Data collection:

This stage involves identifying the environmental factors, the existing systems, driving conditions and communication infrastructure in the research locale. From this information, the technical and non-technical requirements can be identified. Here, the researchers will check the availability of the appropriate types of IOV modules, sensors and/or actuators (hardware requirements) as well as the programs needed for the development of the control center and the mobile app.

- Design, development, testing of IOV prototype:

Based on the technical specifications identified from the previous stage, the IOV model can be designed, built and tested. This could take several stages until the non-functional requirements are met. Figure 4b describes the block diagram of the IOV prototype for this research.

- Design and development of STTMS Control Center Web and Mobile Application:

This stage will cover the design and development of the STTMS applications based on the technical and non-technical (software-side) requirements set out in the Data Collection phase.

- Integration and Testing of the IOV prototype with STTMS Web and Mobile Apps:

At this stage, the IOV model and the STTMS apps are in place. All the components will be put together and will be tested and evaluated. This may be done in several stages, until the communication processes among the 3 elements of the whole system (IOV, Web App and Mobile App) work together seamlessly. Figure 4 shows the integrated system's workflow.

- Results discussions:

This is when the recorded test results and their implications to the research industry, the academe, and the target beneficiary will be reported or disseminated. Production, presentation, and publication of the research paper follows.

VI. PROPOSED ARCHITECTURE

The following two figures show the initial plan for the STTMS and its IOV architecture:

Below figure presents the process flow of the whole STTMS, where the GPS and accelerometer sensors are providing the input to the system. After processing the sensed data, the GSM module will push the location's map coordinates and other real-time data to the control center. A notification of accident will be sent by the GSM module based on a condition set on the accelerometer data.

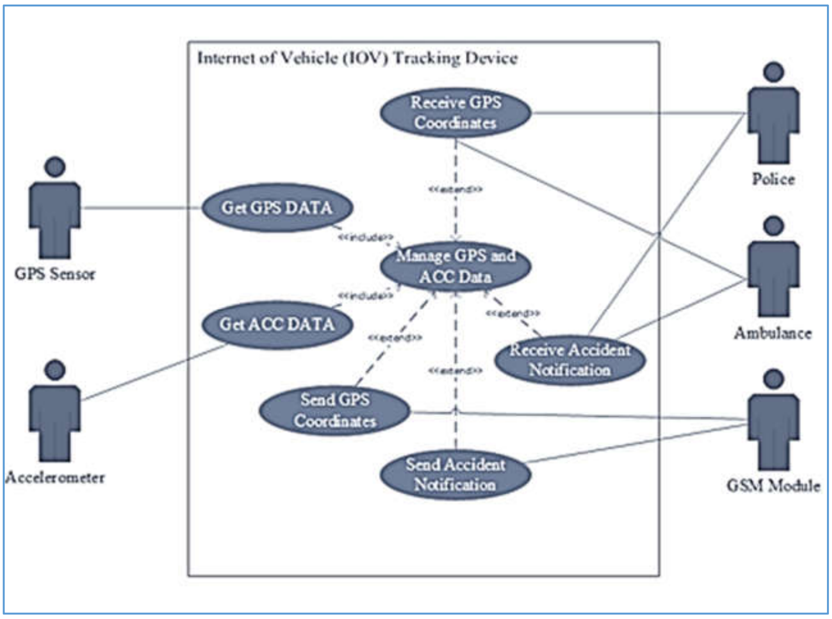

Figure 4: STTMS Use Case Diagrams

The proposed system architecture in below figure monitors the company vehicle status by sensing values from sensor modules. The IOV device to be mounted in each vehicle consists of the main Arduino board, accelerometer, GPS, and GSM Module.

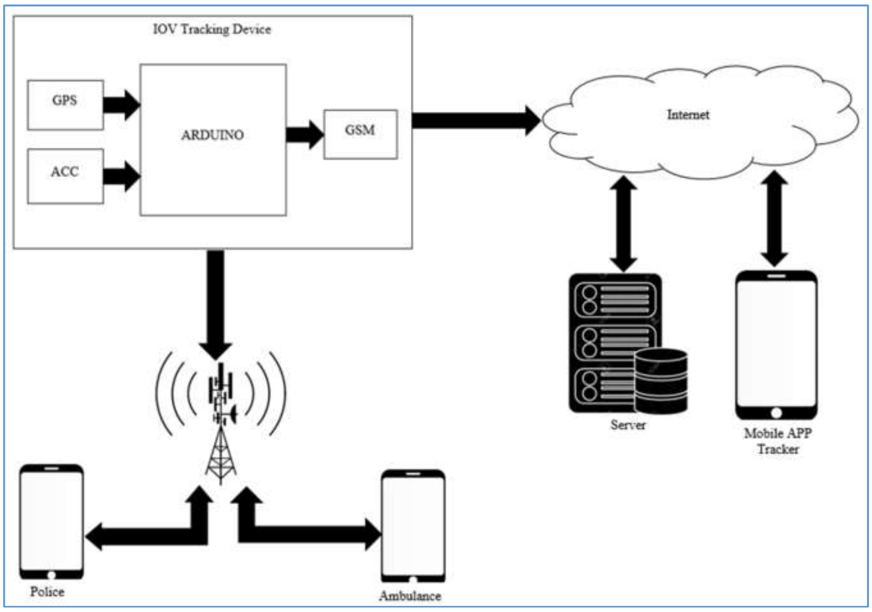

Figure 5: IOV Architecture for STTMS

The microcontroller Arduino Board will interact with the modules that gather information about the vehicle such as its current location, measure its speed and based on this data, in case the vehicle entered a dead spot, an algorithm will be used to process dead reckoning to compensate for the time signal was lost to continuously monitor the vehicle. Based on the said data also, notification alerts for an accidents can automatically be sent. All data will be collected and recorded in the central server for management purposes. The real-time tracking of the vehicle is achieved through a GPS device that checks the location. In case of a vehicle accident, the accelerometer sensors will detect the strong impact of vibrations. GSM module will send an SMS notification to the company, police, and ambulance station. The police and ambulance mobile application will receive SMS for assistance purposes, which is the vehicle's current location. The google map will be used to locate the vehicle by clicking the SMS message coming from the IOV tracking device. Lastly, the Mobile Application Tracker will display the real-time status of the vehicle as it travels to its destinations. By monitoring the vehicle location, the company obtains a more reasonable presumption of arrival time to the destination and the vehicle's status to manage and schedule goods delivery on time.

VII. CONCLUSION AND FUTURE WORKS

As states in figures 4 and 5, we intent to design, implement and test the proposed IOV architecture. In the advent of IOV technologies, vehicles are increasingly becoming a good platform for sensing data; thanks to its mobility, it can gather timely data based on its surrounding environments. The STTMS has the following significance to the transportation sector. Being an essential player to a country's economy, the transportation sector can benefit from smart systems. The STTMS using IOV technologies can ensure efficient delivery of goods, services, and people across the nation. The real-time data that it gathers from its surrounding environment can help the control center at the dispatch office to make decisions such as rerouting, rescheduling of fleets, or sending backups, which are especially useful for time-sensitive cargos and perishable goods. It also contributes to safer roads for drivers and passengers by monitoring real time location of vehicles, the speed at which it is running, notify rescue workers when accidents occur, and issue road hazard warnings.

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