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Design and Development of IOT based Telematics System for Electric Vehicle

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Abstract: This paper functionally designs an efficient electric vehicle telematics framework for smart transportation, aiming at providing an EV-related advertisement via digital multimedia broadcasting. The electric vehicle charge service develops a reservation protocol between drivers and stations, station-side scheduling, and path adaptation according to a new charge plan. Taking advantage of information technology and wireless communication, the telematics system can support electric vehicle tracking, vehicle sharing, charging station selection, and location data analysis. In addition, as a promising business model, electric vehicle sharing needs station placement and relocation schemes, to which a previous pick-up point analysis result can give a helpful guide. The telematics framework enriches the related applications with diverse basic service building blocks and thus accelerates the penetration of electric vehicles into our daily life.

Keywords: Electric Vehicle Road Network, Smart Grid, Path Adoption, Malware

1. INTRODUCTION

In the era of connected technology, every technology-driven business is talking about various use cases and new trends of IoT and connected applications within different industry paradigms. Considering the automotive sector- it has been industry-altering technology advancement in this era, which is gathering the attention of researchers, tech-savvy personals, and many start-ups who are seeking rapid digital transformation [1]. Some of these technologies have become an important part of most of the vehicles in the automotive world, now. There has been technological advancement in this paradigm when companies started working with integration of sensors and connectivity protocols and then it headed towards current trends like AUTOSAR, ADAS, Advanced Telematics, Infotainment systems, Autonomous Vehicles, and Electric Vehicles (EV). The current growing segment in the automotive segment is the Autonomous and Electric Vehicles. Both areas have different levels of success where the electric vehicle segment is growing rapidly.

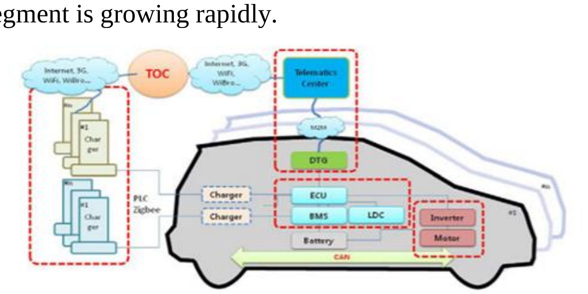

Fig -1: Electric Vehicle Architecture (Kim, T. Et Al., 2011)

An electric vehicle owner needs to understand when and where they can charge the vehicle on run. Ergo, many countries are developing nationwide charging station infrastructure so EV users can get the ease of battery charge. Most hybrid vehicle owners end up using gasoline more due to the unavailability of information on a battery charge, which does not fulfil the basic advantage of EV vehicles [2]. This will also provide communication between the power grid and Vehicle (V2G), so users have access to the peak load hours, and they can utilize the grid power according to the peak charges schedule to reduce charging cost. “For better deployment EVs and charge services, telematics technology is essential, as it provides useful information.

One of the basic applications for EV telematics is the live map updates. It provides details on the real-time location of EV vehicle on a digital map. This navigation system works on GPS, which helps in tracking the location of the vehicle and sends data via connectivity protocols like Wi-Fi, 4G, LTE, and CDMA, etc. for remote access[3]. This map helps in getting the real-time traffic situation on the road so the user can set the best route to the destination to save average energy consumption with a reduction in total distance travelled. Path finding system of telematics calculates the distance a vehicle will travel and provides analysis on the required charging for batteries while recommending a travel route that has a charging station available for re-charge.

1.1 Telematics Control Unit

Telematics is a communication system for the automotive industry that relies on data traveling to and from automobiles over wireless networks. The automobile industry is being pushed into the information age by the combination of wireless technology, location technology, and in-vehicle electronics. Data is generated in the vehicle unit and communicated to the back office systems, or the back-office systems push data to the vehicle unit such as maps, weather reports, stock updates, Internet data packets, and so on[4]. This exchange takes place by cell phone or the unit installed in the vehicle itself. The car communicates and maps its whereabouts using a matrix of cell phone towers and satellite technologies.

2. METHODOLOGY / ALGORITHM

A summarized algorithm explaining the product working mechanism is explained below. The algorithm provides an outline of the flow that is followed for the technical implementation and integration of various technologies that are used in the product.

Step 1: Integrate MCU with MC60 evaluation board, using USART communication protocols.

Step 2: Activate the GSM module using AT Commands.

Step 3: Establish connection with AWS IoT-Core.

Step 4: Request data from the MCU.

Step 5: Transmit data parsed in JSON format to the AWS IoT-Core.

Step 6: Data received in JSON format is passed onto Lambda function for sorting as per requirement.

Step 7: Latitude and longitude values are sent separately as a second message.

Step 8: Latitude and longitude values are passed onto AWS Fire hose.

Step 9: Data from Fire hose and lambda function is parsed into a dynamic cloud

Database called Dynamo DB.

Step 10: The database stores all the values at regular intervals of time in an orderly fashion.

Step 11: REST API is created to access the data from the database in a secured fashion.

Step 12: Database is integrated with the front-end dashboard development tool.

Step 13: Using SQL Query and REST APIs the data is obtained on the dashboard.

Step 14: The obtained data is mapped as charts and graphs for easy visualization and monitoring of the values in real time.

3. Literature and Survey

3.1 Literature Review #1:” Electric Vehicle Telematics Framework for Smart Transportation

This paper functionally designs an efficient electric vehicle telematics framework for smart transportation, aiming at providing an EV-related advertisement via digital multimedia broadcasting.

3.2 Literature Review #1:” Development of Telematics Control Unit for Electric Vehicles”

Development of a Telematics Control Unit that bridges the gap between the vehicle and the user is absolutely necessary. The primary objective is to develop a system that enables control, tracking and visualization of the vehicle location and other parameters from a remote location. In order to realize such a system, a technology called Internet of Things has been adopted which acts as a framework for development and implementation of the product providing an end-to-end solution. Various state of the art protocols such as MQTT, CAN, USART.

3.3 Literature Review #2:“Electric vehicle Telematics framework for smart transportation,”

This paper functionally designs an efficient electric vehicle Telematics framework for smart transportation, aiming at providing an EV-related advertisement via digital multimedia broadcasting.

3.4 Literature Review #4:“Vehicle Tracking System,”

This project is developed using the Extreme Programming methodology. During the planning phase, requirements are gathered through a questionnaire from 40 participants. Requirements and data collected are analysed, and features that need to be included are identified. Iteration starts at design phase where every time there are changes to the system, the design needs to be changed first. Coding is done

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based on the features, functions, flows, and interfaces from the design phase.

3.5 Literature Review #3:"Cloud Based Electrical Device Control Middleware APIs for IoT,"

Lots of programming is to be made to control the electrical devices from the web or Internet, due to it the lots of time are consumed for such programming. So in this research, framework to control the electrical devices like stepper and servo motor was developed All APIs development in higher programming language on the proposed algorithm.
The increased rate of vehicle theft led to increasing concern among vehicle owners. In addition, most of the smaller car rental companies or
personal car rental are also a concern when their rented vehicles are not returned on the date line. Thus, the purpose of this project is to study and
Analyse the existing vehicle tracking system. Next, a tracking system is configured and developed using the Internet of Things platform (Arduino) and

3. BLOCK DIAGRAM OF TCU

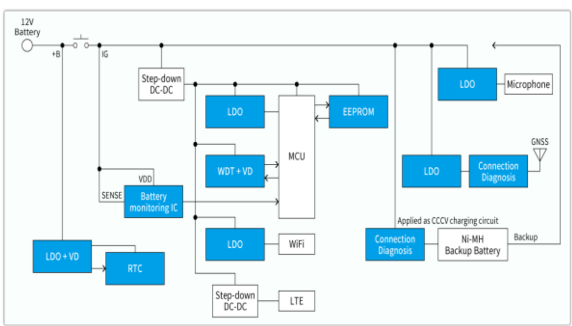

Fig -2: TCU Block Diagram

(https://www.ablic.com/en/semicon/applications/telematics-control-unit)

This technology is incorporated into and controlled by a Telematics Control Unit. In the automotive industry, a telematics control unit (TCU) is an embedded device on board a car that wirelessly links the vehicle to cloud storage or other vehicles through V2X standards over a mobile network [5]. The telematics Control Unit collects telematics data from the car, such as location, speed, engine data, connection quality, and so on, by connecting with various subsystems in the vehicle via data and control buses. It may also offer in-vehicle networking via Wifi and Bluetooth, as well as the e Call capability in certain areas.

A Telematics Control Unit is made up of the following components:

- A satellite navigation system
- A microcontroller
- A mobile networking unit
- An external unit for cellular communication
- A unit that processes electrical signals
- A memory card to store valuable information
- Battery module

4. METHODOLOGY / ALGORITHM

A summarized algorithm explaining the product working mechanism is explained below [6]. The algorithm provides an outline of the flow that is followed for the technical implementation and integration of various technologies that are used in the product.

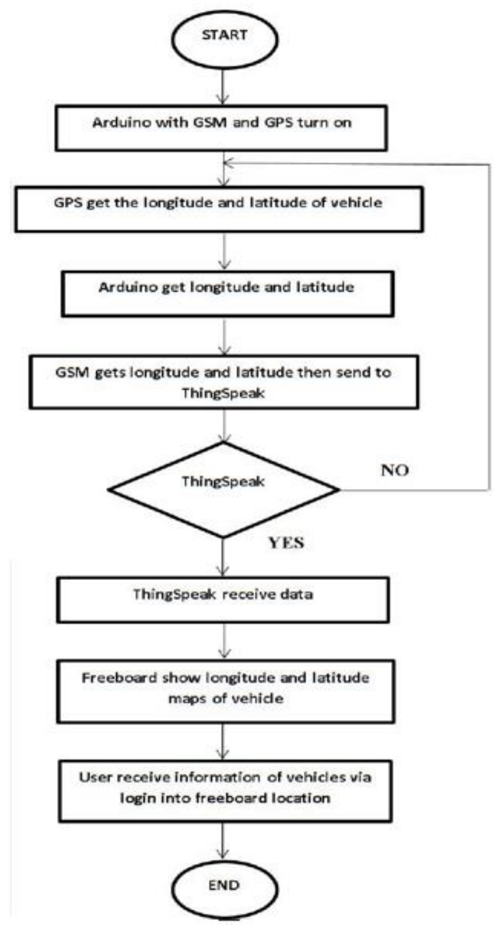

Fig -3: Flow Chart of Real-time Vehicle Tracking (IOT Based Real-Time Vehicle Tracking SystemA. Alquhali, M. Roslee, M. Y. Alias, K. S. Mohamed)

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EV Tracking As the most basic and essential application of telematics systems, vehicle tracking service traces the current location of EVs on the digital map The location of each vehicle can be expressed either in (longitude, latitude) coordinate.

5. IMPLEMENTATION

The product being developed consists of both hardware as well as software components. Various software and platforms have been used for configuring and integrating all the subsystems of the TCU [7]. As per the IoT framework the product implementation has been divided into three major aspects namely:

5.1 Hardware Subsystems:

The various subsystems of the Telematics Control Unit as discussed earlier have to be integrated with each other. The following section explains how each subsystem is integrated with each other and how central control operations are managed by the MCU [9].

MCU is responsible for the control of the transmission and reception of all the data between the Electric Vehicle and IoT platform

5.2 Developed IoT Monitoring system

The presented monitoring system allows for continuous recording and display of LiB magnitudes. These data are collected from equipment to which the LiB is directly connected. Namely, the BMU of the LiB measures the voltage, current and temperature, and estimates the SOC. The GX gateway retrieves this information and makes it available for other equipment. On the other hand, the MPPT solar charger, from Victron Energy manufacturer, is also integrated to manage the PV production. This device is connected to the gateway through a proprietary bus, VE.Direct, so its measurements are also available for monitoring tasks[10].

6. RESULTS AND DISCUSSION

The experimental results obtained of the LiB operation in the micro grid are reported in this section aiming at proving the suitability of the developed monitoring system. Moreover, a discussion of such results and the main findings is carried out in the second subsection.

6.1. Monitoring interface description

The dashboard has been organized for a rapid inspection of the LiB magnitudes by means of both numerical and graphical information In the upper part, instant values can be read, whilst dynamically updated graphical charts represent the evolution over time of two or three variables. Both predefined and customizable time intervals can be chosen by the user, so instant, short and long-term data can be easily displayed. The ability of selecting different presentation intervals is an advantage for R&D projects, among others in renewable energies and battery energy storage [11]. Besides, each panel can be seen in full screen and zoom can be applied to select

The current delivered by the PV array (green curve) is also plotted in a chart together with the battery (yellow curve) and load (black curve) currents for a clear representation of the balance of currents. Note that the displayed PV current corresponds to the values after the conversion performed by the MPPT charger, IPVA. As the power delivered by the PV array varies, the battery current is adapted depending on the demand of the detailed visualizations. Options like data exportation are available for each panel, so the user can perform local data download corresponding to the selected time interval.

6.2. SOC and current evolution

The SOC and current evolution during the considered interval can be observed in fig.4. The first day is a partly cloudy day, which causes variations in the current received by the LiB. The SOC grows from 48% (at 09:50) to a maximum of 96% (at 17:50), which is maintained for approximately half an hour due to the fact that the current provided by the PV array is enough to meet the load demand but there is no enough irradiance to continue charging the battery.

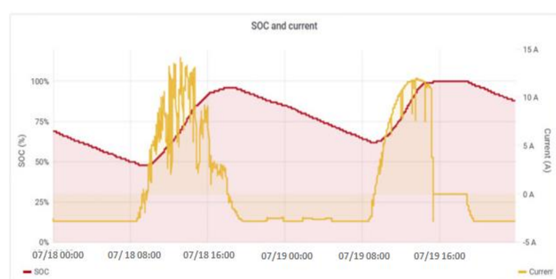

Fig -4: SOC and current variations during 18 and 19 July 2023.

6.3. Voltage and current

The LiB voltage and current are displayed together in the graph depicted in fig.5 As previously mentioned, 19 July 2023 is a representative day, so the LiB charging process can be appreciated. To begin with, during the bulk phase, the

MPPT charger extracts the maximum available power from the PV generator to supply the load and rapidly recharge the LiB. The maximum current accepted by the battery during this phase is 12 A (at 13:41). As a consequence of the charge increase, the battery voltage progressively grows up to the maximum voltage reached, 56.21 V (at 15:22). In such a moment, the SOC reaches the maximum value, 100%, and the float stage starts, so the float voltage is applied for the battery to be maintained fully charged. Hence, the voltage is stabilized in 54.89 V (current null) until 18:38.

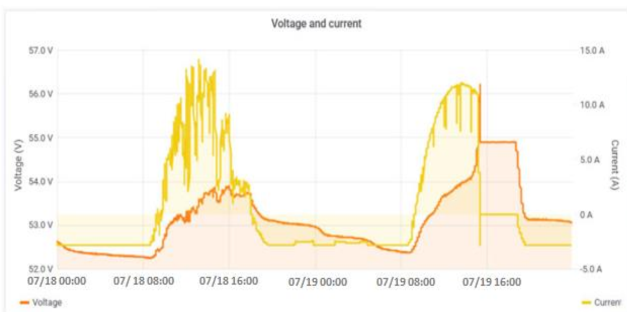

Fig -5: Voltage and current variations during 18 and 19 July 2023.

6.4. Temperature and current

As it was commented in the Introduction, the temperature of the LiB is critical aspect that needs to be tracked. In fact, operation of LiBs outside the safe operating temperature directly affects their cycle life, efficiency, reliability and safety [12]. In this regard, the temperature is very stable during the observed period; it varies between 28 °C and 31 °C (fig.6). It must be remarked that the temperature signal is an integer number provided by the BMU.

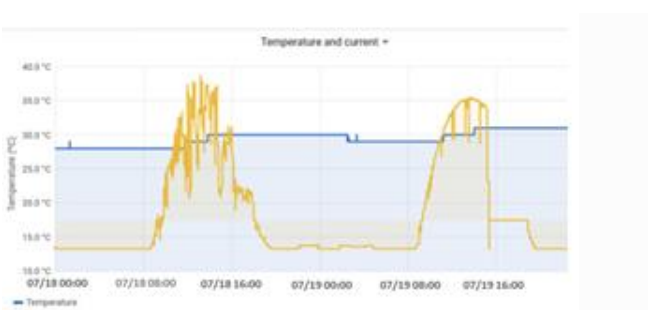

Fig -6: Temperature and current visualization during 18 and 19 July 2023.

6.5. Discussion

The developed system has been validated through experimental results over long-term period (two years) for continuous monitoring of a LiB that acts as the backbone of a micro grid with PV power to generate green hydrogen.
Online networked access to real time data of the LiB is enabled by means of IoT technology. Charging and discharging cycles can be visualized in real time or selecting the period of interest. Both developers and remote users have a large amount of customization and configuration possibilities to achieve interactive and user-friendly display of the LiB information. This feature is particularly relevant for R&D tasks [13], [14]. Moreover, Grafana plug-ins are being continuously being developed and can be incorporated to the reported interface in order to enhance its interactivity and functionalities.

Data visualization and storage are successfully performed by the IoT server implemented in the Raspberry Pi. This avoids dependencies on external servers and provides a greater degree of freedom to the developer [15].

Safe and reliable operation of the LiB requires continuous gathering, visualization and evaluation of SOC and temperature. The monitoring system performs these tasks successfully by means of graphical and numerical displays, as well as through alerts to detect outranging of such magnitudes.

7. CONCLUSION AND FUTURE SCOPE

7.1 Conclusion

Primary objective of the project is to develop an In-House Telematics Control Unit (TCU) for real time visualization, analysis and tracking of various parameters of an Electric Vehicle (EV) such as location, SOC, voltage, residual charge, range, etc., which play a vital role in determining the battery health and condition of the Electric Vehicle, enabling the users to monitor and take actions as per the notifications. The implementation of this project involves data received and processed by various hardware components and server based database systems that are analysed and displayed in the front-end in real-time. However, with this much influx of data over time, it would be very beneficial to perform data science and Machine Learning on the data. It is very likely that there are trends in the data we don't notice first hand, but some analysis and oversight can prove to be beneficial for the application.

7.2 Future Scope

The implementation of this project involves data received and processed by various hardware components and server based database systems that are analysed and displayed in the front-end in real-time. However, with this much influx of data over time, it would be very beneficial to perform data science and Machine Learning on the data. It is very likely that there are trends in the data we don't notice first hand, but some analysis and oversight can prove to be beneficial for the application. Similarly, Machine Learning can be used for anomaly detection in the data

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