

Employing the Internet of Things in Vehicle Monitoring

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Abstract— This paper proposes a system for remotely monitoring the behavior of a vehicle. It monitors a vehicle in terms of four parameters which are engine temperature, rotational speed of the crankshaft and as well as the frequency and amplitude due to the vibration of the vehicle engine. These parameters can be used to trace malfunctions leading to abnormalities in the parameters. Diagnostics data are sent to the vehicle owner and it's mechanic through the Cloud. The owner of the vehicle and the mechanic can visualize the data on their smart phones. A Liquid Crystal Display screen on the dashboard also shows the values of the parameters being continuously measured. An application was created for the system to allow for visualization of diagnostics data, manual scanning of the vehicle and determination of it's location. The system has stored threshold values for the parameters being monitored. If a threshold value is exceeded, the system sends a notification to the owner and the mechanic. Four Internet of Things protocols are used to send data. These are General Packet Radio Service, Wireless Fidelity, Bluetooth and Zigbee. The system architecture allows vehicles to serve as relays for each other in some situations. The relay actions are achieved by Bluetooth and Zigbee. The system was simulated in Proteus professional software and it was found to be operational. A prototype was also constructed and tested, and proved to be functional. The application could also receive notifications accordingly.

Keywords— Remote Vehicle Diagnostics, General Packet Radio Service, Global Positioning System, 3G/4G, On-Board Diagnostics

I. INTRODUCTION

The Internet of Things (IoT) is a network formed by everyday objects connected to the Internet in order to enable them to communicate with the rest of the world. Through the use of communication modules, sensors, actuators and other electronic components, objects can be linked to the Internet for remote monitoring and control. The sensors gather measurement information which is sent to remote base stations by the communication modules. The communication modules also receive control instructions meant for actuators. Remote Vehicle Diagnostic (RVD) systems are one of the applications under IoT. They allow mechanics to monitor vehicles remotely. Different setups of RVD's have been deployed.

However they come with some drawbacks. Nille et al. [3] proposed the use of a microcontroller (MCU) and an Android phone as an RVD. The MCU based diagnostics tool picks up diagnostics data and feeds it to the Android which then uploads to a server. In case of no cellular network coverage, the Android won't upload data, which limits the remote monitoring capability of the technique. Ferhatović et al. [4] created an RVD based on Global System for Mobile Communications (GSM). It consists of On-Board Diagnostics Version 2 (OBD-II) scanner, MCU and a GSM module which exchanges control instructions and diagnostics results with a remote server through Short Message Service (SMS). The system is limited only to GSM networks. Nkenyereye and Jang [5] proposed an RVD system that uses OBD-II scanner and an Android tablet. The Android tablet allows for on-board diagnostics by providing an interface and serves as 3G/4G and Hypertext Transfer Protocol (HTTP) based gateway to connect a vehicle with remote servers. The methodology will be functional only in case of 3G and 4G networks and HTTP supporting platforms. Wenjun et al. [6] designed a system that performs real time car monitoring using OBD and Global Positioning System (GPS). Results are sent to servers using GPRS which means in the absence of GPRS connections, there won't be remote monitoring. Al-Taei et al. [7] designed an RVD based on GPS and GPRS. During operation, the OBD scanner reads the vehicle faults and sends them to remote servers using GPRS. The system will also be deficit of remote monitoring capability if there is no GPRS service. Zachos and Srinivasa proposed usage of Zigbee for monitoring the military vehicles of the United States of America (USA) in [9]. The system was tested using Zigbee radios. Due to the shorter range of Zigbee, vehicles to be monitored must be closer to the base station to stay in connection. Patil and Kakatkar [10] developed a system for monitoring a car and its driver. The car is monitored using OBD while two sensors are used to check the driver for alcohol and seat belt connection. Wi-Fi is used for uploading data to a server. The system will not operate in the absence of Wi-Fi access points. Chen and Wei [11] assembled an OBD-II scanner, GPS and 3.5G module for remote diagnostics of a vehicle. The 3.5G module sends the results of OBD-II and GPS to a remote vehicle surveillance server. Since the system is dependent only on

3.5G networks, it is not suitable for operation in areas without the coverage of 3.5G networks. Kumbur et al. [12] designed a system for accessing vehicle data including diagnostics data. The authors use GPRS to access the data. The system is only bound to GPRS, which will disable the data access system when there is no GPRS service.

PROPOSED SYSTEM

The system proposed in this paper addresses the limitations of communications. It integrates four communication standards to provide vehicles with connectivity at if not all times. These are GPRS, IEEE 802.11 (Wi-Fi), IEEE 802.15.1 (Bluetooth), and IEEE 802.15.4 (Zigbee). Bluetooth and Zigbee are meant for vehicles to serve as relays in certain situations. These would be when there is congestion in Wi-Fi networks, lack of access points for GPRS and Wi-Fi. Fig. 1 shows such a relay system of vehicles in a real community.



Fig. 1: A real community showing the vehicle monitoring system using GPRS, Wi-Fi and Bluetooth and Zigbee relay systems

The system monitors a vehicle in terms of engine temperature, engine vibration amplitude and frequency and crankshaft rotational speed. Morad and Alrajhi [8] mentioned that the causes of engine overheating may be due to plugged radiators, stuck thermostats and cooling system problems. These incidents therefore drive the motivation for monitoring a vehicle engine temperature. Although assumed to be constant, variations in the rotational speed of the crankshaft can be an indication of engine misfire as stated by Bohn et al. [2]. In this system, the malfunction is detected by monitoring the crankshaft rotational speed. According to AlDhahebi et al. [1], too much vehicle vibrations lead to vehicles being uncomfortable and leaving the passengers with blurry visions. Nopiah et al. [14] stated some of the causes of engine vibration as malfunctions due to piston striking, motor control, driving wheel, suction system, cooling fan, motor surface and exhaust. The sensors used are the LM35 for temperature, piezoelectric diaphragm for vibration and hall-effect for rotational speed. These are interfaced to PIC16F877A MCU for processing. A Liquid Crystal Display (LCD) provides

results to those on-board the vehicle while GPRS, Wi-Fi, Bluetooth and Zigbee modules send data to the cloud. The system proposes to use SIM900A GSM module for providing GPRS connection, ESP8266 Wi-Fi module, HC-05 Bluetooth module and Xbee Pro radio for utilization of Zigbee. Fig. 2 is the flowchart of the system while the circuit diagram is shown in Fig. 3. The values of engine temperature, rotational speed, frequency and amplitude are determined and stored. If a value exceeds the threshold, this initiates the transmission of a notification to the owner and the mechanic through the Cloud. The notification would be about the abnormal parameter. The algorithm searches for the available IoT protocols and use the first detected one for data transmission. From the cloud, data can be accessed by the vehicle owner and it's mechanic. Visualization of the vehicle performance is done on an Android based application specially designed for the system. The application is named "SmartCar" as shown in Figs. 4 and 5. Both the owner and the mechanic have the application. If the threshold values are exceeded, notifications are sent to the application via the Cloud.

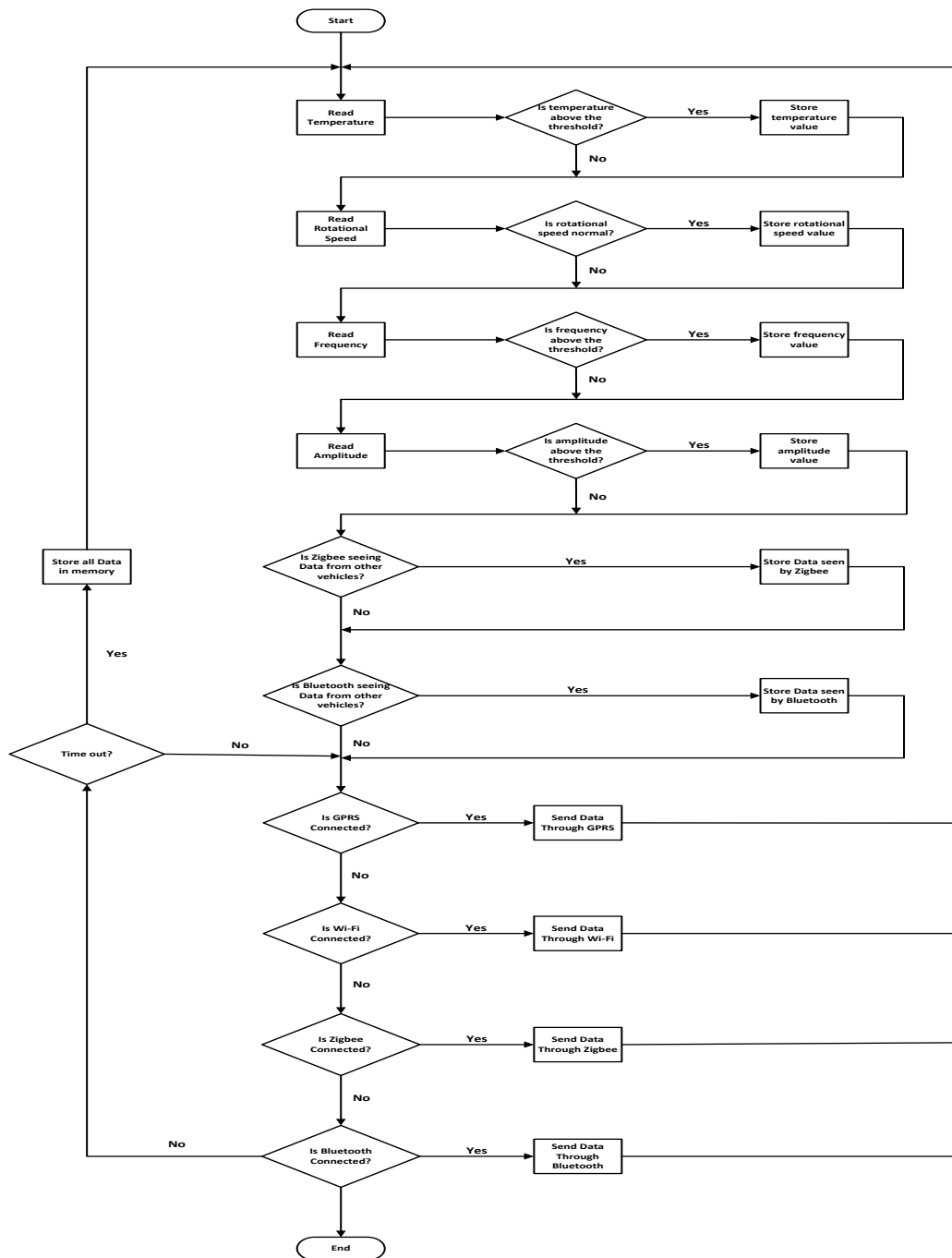


Fig. 2: Flowchart of the vehicle monitoring system

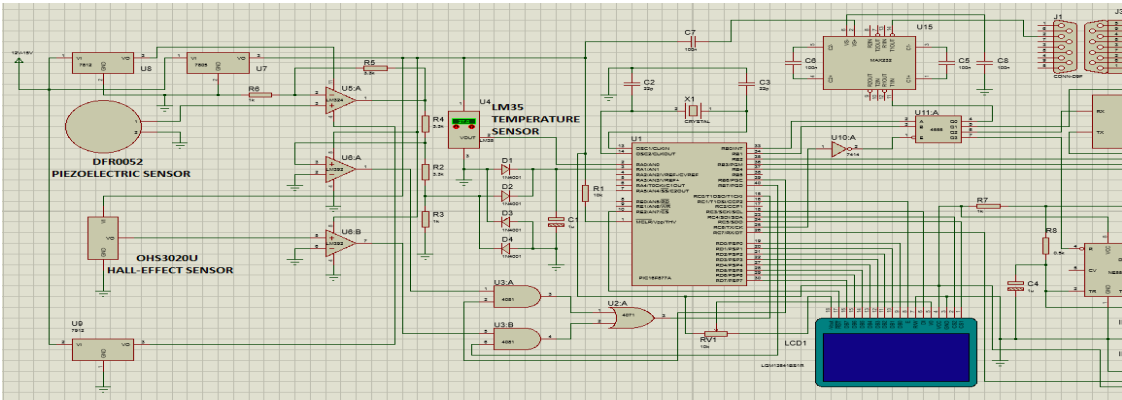


Fig. 3: Circuit diagram of the vehicle on-board scanning system

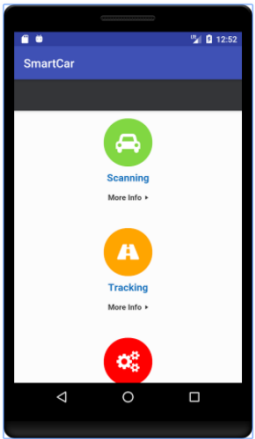


Fig. 4: SmartCar application showing the buttons

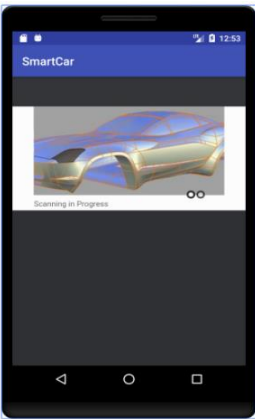


Fig. 5: SmartCar application showing manual scanning of a vehicle in progress

EXPERIMENTAL SETUP

The system was tested both in simulation and hands on ways. In simulation the software Proteus 7 Professional was used. The communication modules were replaced by virtual terminals which could display the data sent from PIC16F877A.

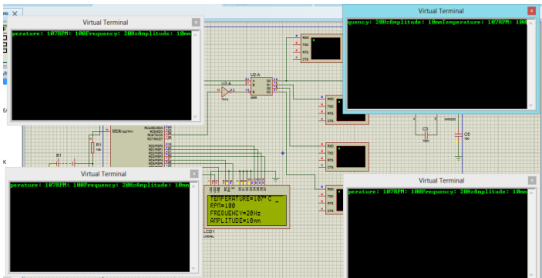


Fig. 6: Simulation in Proteus 7

In doing the hands-on work, only one sensor was available being the LM35 temperature sensor. The hall-effect and piezoelectric sensors were replaced by function generators to provide signals as if they were coming from the two sensors.

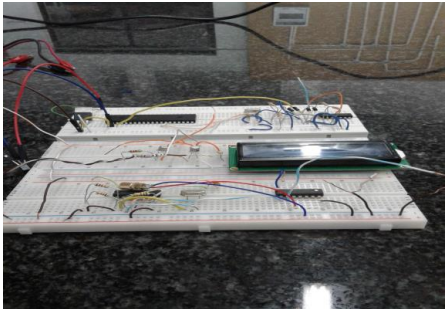


Fig. 7: System prototype on breadboard

A source of heat was used to provide heat that would be dissipated by a vehicle engine. In building the circuit, the modules of GPRS, Wi-Fi, Bluetooth and Zigbee were not included as they were not available, but instead they were replaced by Light Emitting Diodes (LED's) which blinked as data passed through them. The application also demonstrated the ability to display notifications from the vehicle on-board hardware that picked up diagnostics data as notifications could be sent to the application through the web.

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