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V2V Communication using fog Computing for Safe Commute

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Abstract*: *In this real-world, there is a great necessity to satisfy the demands in all the communication systems to experience the best ever convenience and flexibility. Advancement in the IoT concept in the form of IoV has been a solution to overcome all the difficulties experienced during driving vehicles. The complete potential of IoV addresses many challenges of traffic monitoring and road safety measures by forming a distributed network of vehicles and collaborate between heterogeneous vehicular systems. IoV refers to the integration of networks that transmit information periodically between vehicles to vehicles, vehicles to roadside units and it is intended to play an essential role in this. The prevailing solutions like VANET, Vehicular Cloud Computing (VFC), and Mobile Cloud Computing are not ideal as there is high latency and delay in responsiveness. The collaboration of vehicular networks and fog computing forms a promising paradigm called Vehicular Fog Computing (VFC) which serves as a effective yet alternative method for VANETS's. This paradigm consists of multiple near-end devices to carry out communication and computation of every vehicle. This paper presents certain scenarios of moving and idle state of vehicles by adapting VFC methods, wherein as a result of this communication and computation infrastructure, it showcases the capabilities of VFC. The objective here is to present four different scenarios of a vehicle in motion and in idle state, which brings out an interesting relationship between the communication capability and connectivity of the vehicles.

Keywords: Internet of Things (IoT), Internet of Vehicles (IoV), Vehicular Cloud Computing (VCC), Vehicular Fog Computing (VFC)

I. INTRODUCTION

Fog Computing is a virtualized and decentralized paradigm that servers as an intermediate layer between cloud data centers and user devices. The term fog computing was formulated by Cisco in the year 2014 [1]. Fog is a low power communication technology that stretches out the services offered by the cloud to the sting of the network. As for how Cloud manages data computation, storage, and application services to end clients; fog also furnishes the same [3]. In Fog computing architecture data computation, storage and applications are distributed geographically, unlike the cloud [2]. The goal of fog computing is to expand the cloud nearer to the IoT devices to provide a better quality of services and support application that needs high mobility, responsiveness, and lower latency. Hence, it thereby reduces the amount of data traffic that is sent to the cloud server during processing. This framework makes use of edge devices to hold out a generous amount of processing, storage, and communication, locally routed. Fog and Cloud Computing are interconnected and hence is the extension of cloud computing. The layer of fog is composed of numerous edge nodes immediately connected to user devices [4]. In Figure 1, all the fog nodes are very much closer to end devices than compared to the cloud[2]. This is the reason for fog nodes to provide instant connections for faster processing. As fog is a decentralized server, it allows us to perform the faster computation for a greater amount of data. The purpose here is to support intense IoT applications that require lower latency. Fog Computing also acts as a mediator between the remote servers and hardware and regulates which data to be sent to a centralized server and which data to process locally in the nearby edge nodes. Accordingly, fog computing reduces the computation and routing burden on the cloud. The main motive of fog computing is that user devices that are in the closest proximity of the fog nodes send their data using the direct link which is Device to Device (D2D) interaction in a network. In this way, fog acts an intelligent gateway which decides the mode of data processing and also provides efficient information storage and analysis

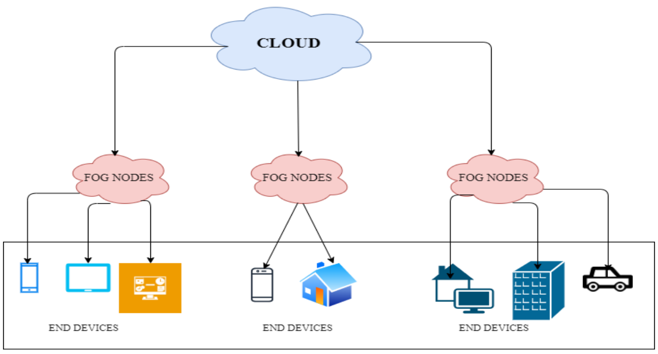

Figure 1: Schematic representation of Fog Computing

Features of Fog Computing: The below-listed features of fog computing makes it a better architecture compared to the cloud [1-5]

1. **Heterogeneity:** As Fog is a decentralized framework, the numerous fog nodes are deployed in a wide range of environments.

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2. Geographical distribution: All fog services and applications are widely spread.

3. Lower latency: In fog, lower latency is achieved as these fog nodes are just one hop away from the end devices.

4. Instant Responsiveness: User experience is very much improved, as fog nodes are much closer to physical devices and computation is instant.

5. Interoperability: All the fog nodes must interoperate which means they work across different domains to provide a wide range of services like streaming.

Table 1, provides a comparison of Cloud and Fog Computing [2].

Table 1: Comparison of Cloud and Fog Computing

Cloud Computing	Fog Computing
1. Centralized System	Decentralized System
2. Large data centers are distributed globally.	Millions of small fog nodes are located close to the end devices.
3. Processing of data takes place at remote servers.	Data Processing takes place at edge of the network, closer to user devices.
4. Slower responsiveness due to longer time deep analysis.	Instant responsiveness due to short term edge analysis.
5. Higher latency	Lower latency
6. Fails in case of lack of internet connection.	Risk of failure is very much less.
7. Less secure compared to fog.	More secure due to its distributed framework.
8. Huge number of data sources are integrated.	Millions together of data sources and devices are integrated.
9. Multiple hop	Single hop.
10. Consumes more bandwidth.	Consumes less bandwidth.

Internet of Vehicles (IoV)

In order to address certain traffic and vehicular issues and also to extend VANET capabilities a new concept has been emerged from IoT, that is called Internet of Vehicles (IoV). IoV was presented in order to tackle the traffic problem and to provide convenience for drivers. Vehicle networking could be towards the direction of solving certain traffic problems [6-8]. Cloud computing alone is not enough for storing and processing of mass amount of data generated from IoV as their is resource, latency, responsiveness and bandwidth constraints. The biggest demerit in cloud is multi-hop communication. This paper presents IoV architecture based on Fog Computing in two different types of wireless communication which are Vehicle-to-Vehicle (V2V) and Vehicle-to-Road (V2R). V2V leads to information exchange between the vehicles directly. In V2R exchange of information takes place between the vehicles and roadside units. Higher stability and lower latency is both are achieved in V2V and V2R. All the connected sensors and the other devices in the vehicle, collect the data. This data is stored, computed, and processed in the nearby fog servers and thus provides cost-effective and on-demand fog computing for IoV applications and thereby utilizes the mobility of vehicles. The objectives of this paper are to create IoV system to assist vehicles, in order to detect the potholes and humps thereby, notifying the drivers and thus avoiding road accidents also to notify the drivers about the idle state of vehicle in case of any emergency in V2V system.

Vehicular Fog Computing (VFC)

The rapid growth of vehicular mobility in urban zones has lead increase in vehicle traffic, traffic congestion and accidents. As great number of user devices are becoming internet friendly, traffic congestion along with road safety measures can be collaborated with internet to make them work in an effective way [10]. Significant efforts has been made in order to improve vehicle safety by means of Intelligent Transport System (ITS). The early attempt towards this is to connect vehicles via Vehicular Ad-Hoc networks (VANET). When the neighboring vehicles are connected through VANET they were able to interact with each other vehicles via Vehicle-to-Vehicle (V2V), in turn improving driving safety. Due to unavailability of internet access in VANET, it shrinks the scope of this application. In VFC each vehicular fog node as a wireless access point and equipped with multiple network interfaces, thus able to gather traffic related information [9]. In Vehicular Fog Computing (VFC), vehicles acts as smart nodes and are equipped with wireless networks that enables the smart vehicles to collaborate with each other for data sharing and communications. This architecture deploys a network of fog nodes between the underlying network and cloud [5].

Few of the factors of VFC makes it a better architecture than VCC. They are

1. Reduction in latency: Faster results are be provided in real time processing. Data processing takes place on the edge of the network which are very closer to user devices and hence results are provided to the connected vehicles at a faster rate.

2. Limited storage space: Storage required for processing is very less as fog nodes are distributed locally near to the user devices, also they can be merged for better services in a fog network.

3. Improved Quality of Service: Very Fast data rates with reduced latency and response time is offered by the applications.

4. Improved network efficiency: End to end traffic is avoided in fog between cloud servers and vehicle devices, this in turn reduces the bandwidth

5. Minimised energy consumption: Biggest advantage of fog computing is limited battery support in devices.

6. Improved agility of services: Cloud servers and services are paid. In order to avoid this users can customize their own new applications.

II. LITERATURE SURVEY

Cloud computing could not resolve all the drawbacks of connected vehicles and hence fog computing comes into picture. However, services from cloud computing could not benefit all their necessities and hence it makes fog computing as an efficient emerging platform for connected vehicles which extends till the core of the network.

This distributed computing infrastructure allows storage, computation and services in the near by fog nodes [2][3].
The real scenarios and applications of smart grid where it provides less latency, location tracking and quality of service (QoS) using smart meters and micro grids is addressed. Similarly, in smart traffic light ambulance's flashing light is automatically sensed by cameras and it in turn open the lanes for the vehicle movement [4]. An intelligent transport system in order to improve driving comfort of the traveler, provides wide variety of intelligent services in connected system in the form of music and gaming through satellite communication. Wherein, here vehicle directly interacts with traffic monitoring system which broadcast time to time traffic information. An effective way to solve vehicle safety problems by collaborating cloud and fog infrastructure with storage and computing capabilities at edge nodes is proposed. Real time status of the vehicle is monitored using a device called car driving recorder which provides information of a road accident to all the road side units [6]. Combining of VANET's with cloud and fog frameworks to define an architecture for different scenarios enables interoperability, geo-distribution, time constrains aspects and scalability of mobility systems [8]. IoV advantages such as traffic control, Human proximity detection, Theft avoidance, Accident avoidance and Emergency response are addressed [9]. Poor VANET connectivity is substantially enhanced by Parked Vehicle Assistance (PVA) by making them as static nodes. Network connectivity in VANET's can be greatly improved just by connecting a small proportion of parked vehicles [12]. Fog node's cache size is set as a criteria to estimate its performance on fog enabled VANET nodes where byte hit ratio, energy consumption, mean response time and utilization of RSUs (Road Side Units) are taken into account for evaluation [14].
Quantitative analysis is carried out to measure the capacities of VFC by combining of individual vehicle resources that greatly increases quality of service. This reveals a better relationship between connectivity and communication capability. [16]. Emergency notification mechanism should be quick enough to avoid any kind of disaster that might happen in connected systems. Notifying such incidents to concerned authorities are much prominent [17]. Domain ontology which describes a publish/subscriber fog model is proposed [21]. Here, when the data is propagated to all fog nodes, the nodes which are only subscribed that event receives that concerned information. Traffic density estimation techniques by using connected vehicle technology in order to avoid vehicle congestion system which mostly arise in urban areas are noted in paper [19].

III. METHODOLOGY

This model is designed using Arduino, 3 Node MCUs, GPS Module, GPS Antenna, Vibration sensor, Ultrasonic sensor, Switch and LCD Display. Arduino along with Node MCU is the main component of this system. The sensors here used for following purposes: GPS Module to detect the idle state of the vehicle in case of any emergency, Vibration and Ultrasonic sensor to detect the hump and pot holes, switch button to press if their is any kind of emergency, LCD display to display all upcoming data from the sensors. Arduino creates its own hotspot and hence it acts as an infrastructure less network. Infrastructure less network is nothing but they must be capable to creating their own network and must allow other devices to connect to it. To make each device to connect to the network should act as an access point, wherein other devices should start connecting to the network and start data exchange between them. In order to exchange the sensor data from one Node MCU to other Node MCU the protocol used is MQTT protocol (Message Queuing Telemetry Transport)
MQTT protocol is simple, lightweight an instant message delivery protocol used for exchange of information between the devices/clients. It is the most widely protocol in machine to machine for communication. MQTT makes wearable, cars and most of the devices to publish/send information about a topic to another device that previously subscribed to the topic. Here, topic can be any message/command. In order to transfer data, machine has to subscribe the topic.

IV. IMPLEMENTATION AND RESULTS

Here, server is an Arduino itself and data is communicated to all nearby connected devices. IoV system itself creates a MQTT queue and should start publishing it by maintaining its own queue. Their also should be other subscribers which are connected to the same queue. A unique name is given so that the other subscriber devices are connected to it.
Here,

- IoV system connected with all the sensors acts as its own access point.
- Node MCU creates its own self hotspot where other devices can connect and within the hotspot it should publish MQTT queue.
- IoV system creates MQTT queue and wait for subscribers to access that queue.
- Subscribers subscribes to the topic and access data from the queue.

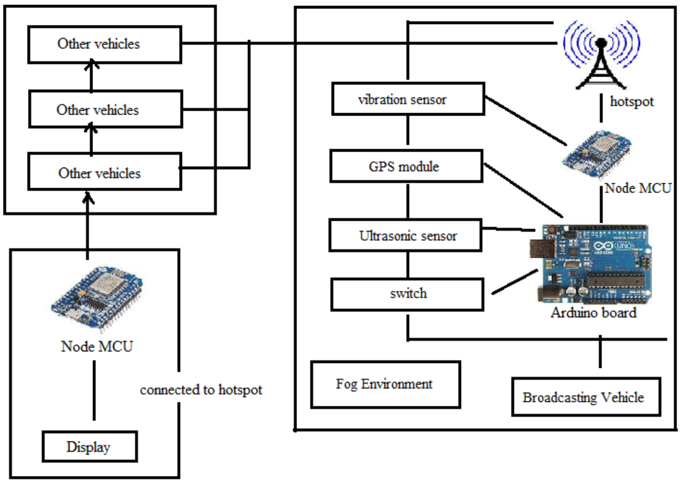

Figure 2: Architectural design of the proposed system

In Figure 2, Data sensed from all the sensors are brought into the publisher by means of MQTT queue. When subscriber access to that queue data is transferred. Hence, storage and computation takes place at nearby fog nodes.

This makes the data to be displayed on the LCD attached to all connected vehicles. Figure 3, 4, 5, 6 shows the results.

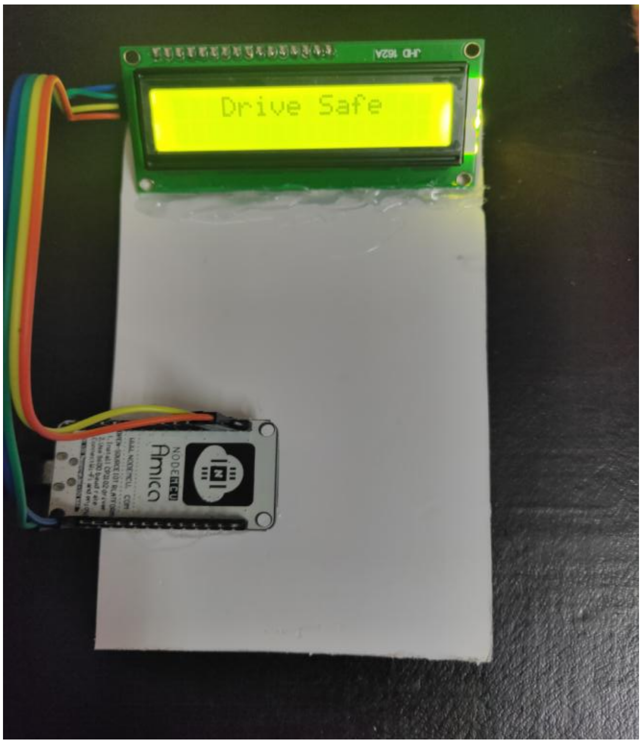

Figure 3: Initial notification for all connected systems.

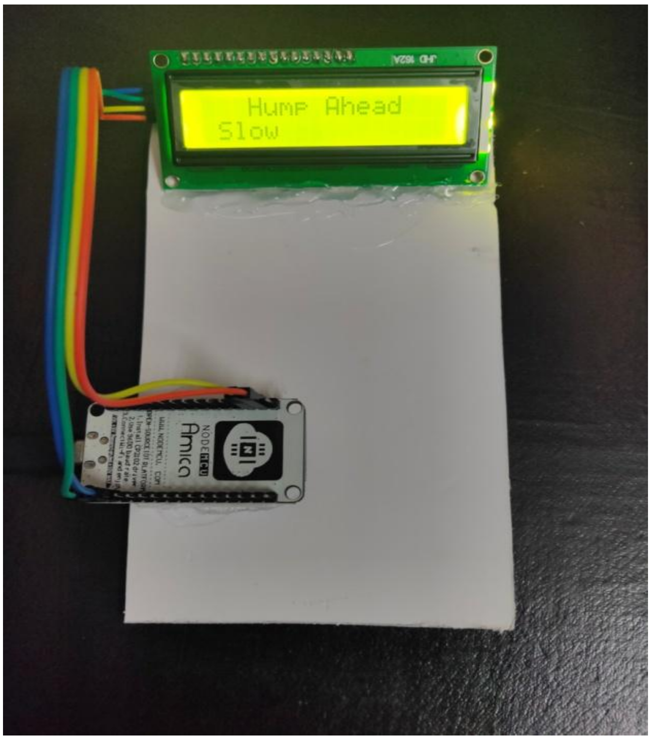

Figure 4: Hump notification is displayed on other connected vehicles.

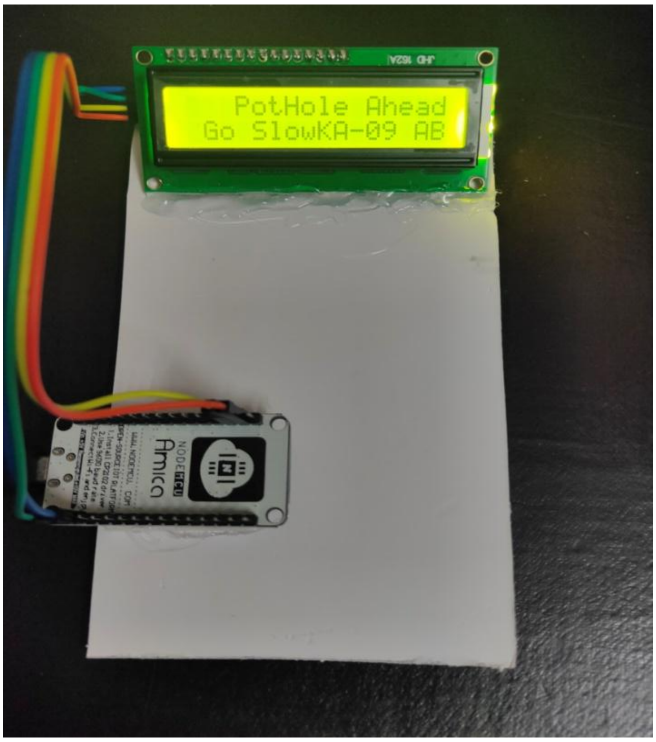

Figure 5: LCD displays pothole notification on other connected vehicles.

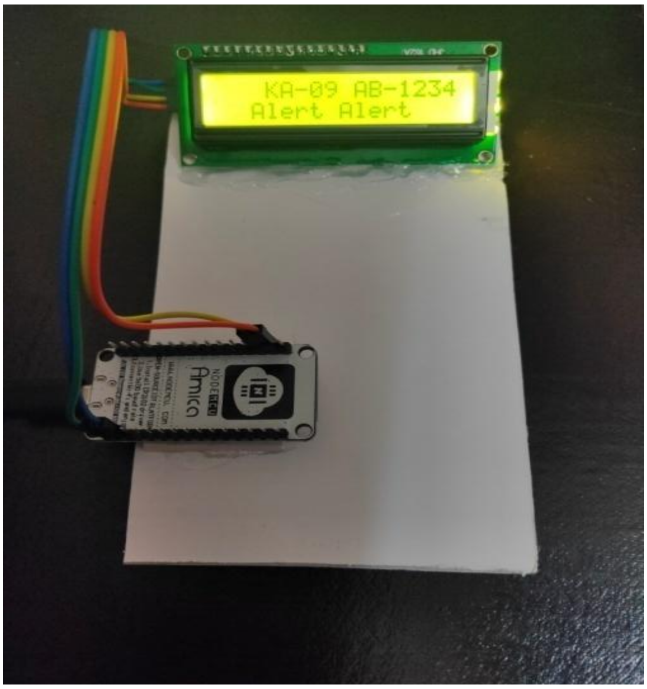

Figure 6: Alert notification is displayed on other connected vehicles

V. CONCLUSION AND FUTURE ENHANCEMENT

Internet of Vehicle (IoV) is a very emerging platform under the Internet of Things (IoT). Connected vehicles phenomenon is proposed to enhance road safety. This paper proposes a VFC system which provides the data to other connected vehicle regarding the pot hole, hump, idle state of the vehicle and notification on emergency.

All these data are displayed on a LCD which is placed on the other vehicles having the same Wi-Fi connectivity. This makes the data computation and transfer at faster rates by computing them at nearest fog nodes. Hence, system collectively enhances the communication efficiency, decrease data latency and improves location awareness.

This architecture can be further enhanced by computing the distance of parked vehicles and notifying the vehicle owner in case of damage caused by any other vehicle and can also be further enhance by providing voice commands for assistance for the driver while movement of vehicle.

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