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Improving the Smart Cities Traffic Management Systems using VANETs and IoT Features

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Abstract: This paper discusses the creation of an integrated worldwide system based on integrating and linking automobiles with VANET, IoT, and AI technologies, which will have a substantial impact on the smart, safe transportation system. This paper aims to apply a proposed project to a specific area in Jordan to examine the project's viability and its impact on reducing the accident rate by controlling traffic with special traffic rules in the study area using a cloud database that stores all the private information for each car and receives information about the car's speed as it travels. When a driver exceeds the speed established by the Traffic Department, he receives warning messages informing him that he has over the speed limit, and if he does not respond to the warning messages, he gets a fine. The research focuses on optimizing the utilization of VANET network services, which is crucial for enhancing public safety applications involving data exchange between automobiles and RSUs. The simulation was conducted using OMNeT++ version 5.7 on Debian 11, Linux 5, and GNOME 3 operating systems. As a network simulator, it is a scientifically approved open-source tool

.**Keywords:** VANET, IoT, VEINS, OMNET++, SUMO, RSU, cloud storage.

1 Introduction

Vehicles now include Intelligent Transportation Systems (ITS) for the general well-being and safety of driving a vehicle in real-time; as the number of cars in the world grows, so do the number of manufacturers and the level of competition among manufacturers. The researcher discusses how to compute and run Intelligent Transportation Systems (ITS) in the research paper [1]. At the same time, the study employed the properties of this system to improve its performance inside the context in which we did the research.

Manufacturers began to outfit their vehicles with sensors, transmitters, and receivers to ease vehicle communication. Safety was improved by utilizing VANET networks, navigation devices (GPS), and public safety apps to lessen the risks associated with driving vehicles. The researcher evaluated the characteristics and structure of the embedded technology in the research paper [2]. At the same time, thestudy employed the GPS to enhance and improve the performance of the proposed system.

The scholarly study focuses on increasing the usage of VANET network services [3], which is important in developing public safety applications for sharing information between vehicles and RSUs [4, 5].

Cloud computing services have also been employed for their ability to improve the use of real-time applications [6-8] by facilitating the interchange of data and shared resources across the Internet and intranet [9] (vehicles and RSUs located on

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the side of the road). It also includes a database and applications required to organize traffic and exchange valuable information and data in the network (for example, location, speed, vehicle data, and a simulation file of the vehicle's record within two years). It is managed and controlled by the central traffic department.

Figure 1 depicts the structure of our proposed system to be used on the airport road in Amman, Jordan, with RSUs put on some of the lighting poles on the side of the road.

In this research, we propose to design a system consisting of a set of algorithms, simulate it in OMNeT++, and apply it to some cars on the airport road in Amman and some traffic management cars stationed in the study region.

Fig. 1: A model of the proposed system

The project's goal is to set up a tracking system that will convey data for cars with license plates in the city to traffic department devices, including cameras.

Send the plate number and all data of the car and the people inside the vehicle (via smart card) and record the speed of the car based on the places it passed and the coordinates of the navigation system, and electronically release the violations whenever the vehicles pass by the columns of receiving the special signal in the car data or through traffic by any police or traffic patrol.

The system can send long-distance distress signals in the event of an accident via Ad Hoc technology or direct contact with security services 911.

The system can build a simulated video in the case of a collision between two vehicles and send the model to the traffic controller via a special tablet device to determine the cause of the accident, each based on its speed, priorities, and direction.

Figure 2 depicts the system's decision-making Entity Relationship Diagram (ERD) and how the system would classify events to take the appropriate procedure and address the problem if one exists.

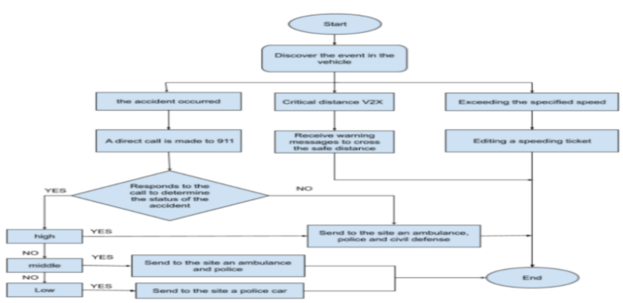

Fig. 2: System's decision-making ERD

2. Literature Review

Vehicle Dedicated Networks (VANETs) are an advanced technology that is scalable due to the unique nature of VANETs and their usefulness in addressing various vehicle-specific concerns. VANETs aim to connect devices within vehicles to create services relevant to the vehicular environment [10].

Cloud computing services have grown in popularity due to their unique characteristics ,such as virtual data storage, real-time computing, and [11-13]. The integrated architecture of cloud computing and VANET is an advanced real-time data storage and retrieval service system. Numerous models have been proposed to integrate VANET with cloud computing [14].

Some routing protocols have been employed in the VANET environment to verify the accuracy and performance of the

VANET in its operational environment. Routing, quality of service (QoS), security, the accuracy of information distribution during emergencies [15-17], and some of the wireless protocols used in VANET were also discussed [18].
Localization in VANET was employed, and the recommended technologies were highlighted. GPS technology, which is easily integrated into automobiles, and wireless communication technologies such as the Internet of Things (IoT) and VANET localization can be implemented in areas where GPS service is not accessible [19].
The researcher discussed the importance of information transferred between cars regarding road safety and traffic conditions, as well as how trust is created between vehicles to maintain the integrity and trustworthiness of the reports received—the occasion [20].
The Internet of Things (IoT) has been utilized in VANETs to broadcast information about vehicles **,**such as their positions, speeds, and detailed data about them to improve **the** safety field [8, 21].
The study discussed many communication techniques in VANETs, such as V2x Vehicle-to-Everything, V2I Vehicle-to-Infrastructure, and Vehicle-to-Infrastructure.
-to-V2V V2V connection via vehicle communication employing short-range technologies such as the IEEE 802.110 standard or cellular means such as the 5G network. This is done to improve the efficiency of the Intelligent Transportation System (ITS) [22].
In this research paper, an integrated research system has been established to exchange information about vehicles and find new algorithms to improve the level of safety for drivers, cars, and pedestrians through a cloud storage service for vehicle and owner data, adjust the vehicle speed according to the region in which the vehicle is in coordination with the Central Traffic Department, and address the mechanism of communication with Stakeholders.
The system has been improved by including gadgets for car usage and methods to connect them to the vehicle's sensors.
The system's performance was evaluated by applying its algorithms to the OMNeT++ simulation system using GPS photos of the study area, which is the Amman/Jordan airport road.

3. Methodologies

All cars on the local road are required to have mandatory service devices.
The gadget inside the car exchanges data with the RSUs, traffic circuit mechanisms, and other vehicles.
In-vehicle gadgets are outfitted with GPS services to assist in determining directions and areas and improve the accuracy of the data provided in the proposed system.
The gadget allows the car's driver to view the data without modifying it and enables the traffic police official to access it to take appropriate action.
In the event of a vehicle collision or any other form of accident, a long-distance emergency message is sent, and an emergency call with the number 911 is sent to assess the extent of the emergency that has happened. The severity of the emergency scenario and the necessary actions are decided for the call with the driver.
When approaching another vehicle or model, a warning message is sent to the driver based on the safety distance criterion defined by the Traffic Department, which is based on the following equation: The safe distance between two vehicles is supposed to be (police department safety distance (sd) minimum safety distance (min sd) for two cars.
Some cameras located on public roads are used to verify the received data with the car plate number. If the vehicle's data does not match the plate, the security services are notified to take the necessary action.
Warning messages are displayed based on safety parameters to avoid potential vehicle crashes.
The region sets the vehicle's speed restriction, and through warning signs (school, village, work area...), and in the event of a speed infringement, an electronic violation is given, the driver and traffic police are notified, and the data is saved in the cloud storage.
Figure 3 depicts the fundamental components for assessing the performance of the proposed system

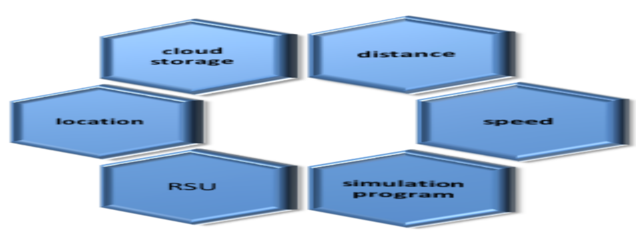

Fig. 3: The fundamental components for assessing the performance of the proposed system.

Table 1 depicts the interchange of vehicle data between vehicles, RSUs, cloud storage, and traffic departments.

Table 1: Vehicle data exchange with other system components

Vehicle plate number
Type of vehicle.
Date of manufacture
The country of origin
Color of the car.
Name of the vehicle's owner.
Date of vehicle license expiration
Fines is automatically imposed for dangerous driving.

Table 2 depicts the data transferred between the vehicles.

Table 2: Data exchange between V2V

Vehicle Location
Warning messages
Awareness messages

Algorithm 1: Monitoring vehicle speed based on safe speed

The safe speed was determined through the traffic signs on the side of the road that were placed by the traffic departments and through the warning messages that appear on the screen on the system through the positioning service and the distance traveled according to time. It also shows the warning messages related to the safe distance between vehicles.

The structure of the first algorithm

1) while
2) broadcasting of the current location of the car
3) receive a message about the safe speed
4) if (car speed > safe speed)
5) Receiving a message from the Traffic Department system about issuing a speeding ticket

Algorithm 2: Determine the level of emergency in the event of an accident

A long-range emergency message is sent to the security services in an accident. A direct call is made to 911. If the driver responds to the call, the driver is asked directly about the level of the accident, and accordingly, support is sent. If the call is not answered, the nearest police patrol and an ambulance will be sent. And a fire engine for the site.

The structure of the second algorithm

6) while
7) if (accident)
8) a long-range emergency message is sent to the security services
9) A direct call is made to 911
10) if (the driver responds to the ring)
    a. the driver is asked directly about the level of the accident
    b. if (Simple accident level)
    c. send a police car
    d. else if (The accident level is medium severity)
    e. Send a police car and ambulance
    f. Elseif (Accident level advanced)
    g. Sending a police car, ambulance, and civil defense
11) else
    h. Sending a police car, ambulance, and civil defense

Algorithm 3: The safe distance between two vehicles

When approaching another car, warning messages are sent after calculating the safe distance between the two vehicles based on the law of the distance between two points.

The structure of the third algorithm

1) while
2) If (the first vehicle approaches the second vehicle)
3) Warning messages and alarms are received for both cars from the same system to exceed the safe distance between them
4) Send simulation software to RSU devices and cloud storage

Algorithm 4: Vehicle data validation

The vehicle number and speed received by RSU are verified and matched with the surveillance cameras to determine the vehicle number and speed. In the event of tampering, the security services are informed.

5) while
6) If (Vehicle number and speed from the RSU ≠ vehicle number and speed from the surveillance camera)
7) Inform the security agencies

Hardware Design

In this section, the study will discuss the unique model of the device as shown below in figure 4, as well as how the algorithms operate on it as seen in figure 5. A microcontroller-based system with a radio and a GPS receiver will be created. Additionally, it will include fixed random memory, 2 gigabytes of random-access memory (RAM), a CPU, and Bluetooth. The gadget has a one-of-a-kind identification number corresponding to the license plate number.

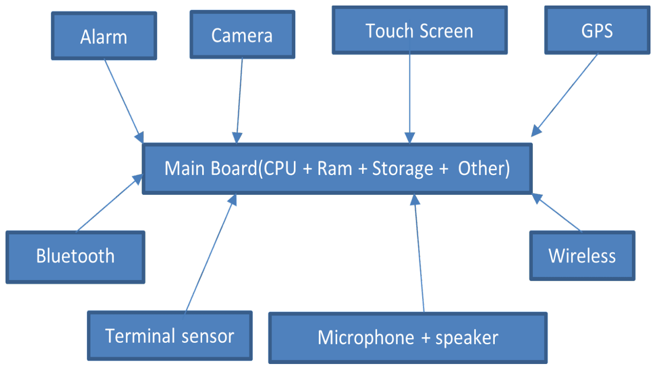

Fig. 4: A Sample Hardware Diagram

Fig. 5: VANETs' level design

Case studies will be discussed depend on figure 6,

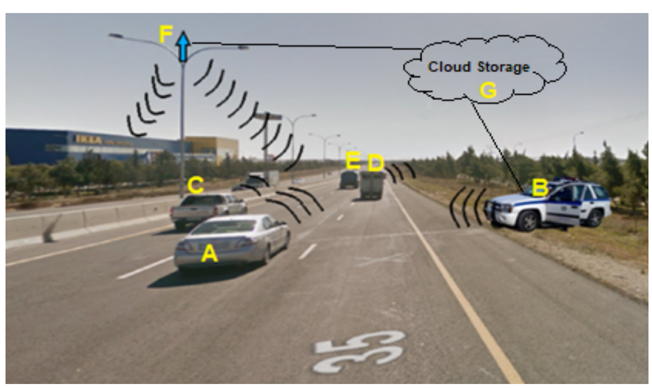

Fig. 6: VANET level design case study

Case study 1 (NODE A WITH NODE B) Information exchange between the vehicle (A) and police vehicle (B) if the vehicle (A license)'s has expired and a speeding citation has been issued in a particular location. Here, the police car (B) gets the data, verifies the car number, and transfers it to the cloud storage node (G).
Second case study (NODE A WITH NODE C)
Car (A) and Car (C) exchange information by getting warning messages about exceeding the required space between vehicles on the road.
Third case study (NODE C WITH NODE F)
The information exchange between the vehicle (C) and the transmitting and receiving unit (RSU) denoted with the symbol (F) is complete, as shown in Table (1), and the car is receiving weather and traffic alert messages.
4th Case Study (NODE G WITH NODE F AND B)
Node G stores all data collected by nodes F and B and all information requests are routed through node G.

4. Analysis and results

The simulation was conducted using OMNeT++ version 5.7, Debian 11, Linux 5, and GNOME 3 [23]. SUMO version 1.11.0 [24] has been integrated as a road traffic simulator because it is an open-source application approved for use in scientific research as a network simulator and has been the subject of numerous studies and initiatives. Asdepicted in Figure 7, we employ an exclusive, realistic OpenStreetMap map of a portion of Jordan and a specific sector in Amman, the Queen Alia International Airport area. The simulation program was developed, and the code was deployed to evaluate the functioning of the VANET network, enhance the security protection system, control the movement of vehicles, and decrease the response time to emergencies. The system was evaluated in a particular operational setting with various cars and RSUs (11, 20, 60, 110). In this simulation, ten routes and ten journeys comprise the simulation region and configurated as seen in table 3.
The outcomes were utilized to emphasize the significance of the proposed system and the topics it addressed. The system's benefits will be discussed later.

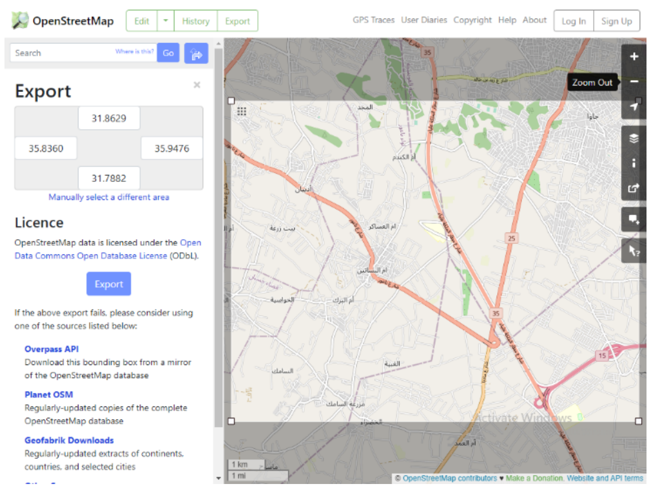

Fig. 7: Amman Airport-Jordan Highway

Table 3: Configuration of Simulation

Parameters	Value or Protocol
Simulation modules	Veins 5.2 INET Framework 4.2.8 Simulate 1.2.0 (plus a backported patch, 23c0936e31) Veins_INET included with Veins 5.2

Software	OMNeT++ V 5.7 SUMO 1.11.0 Cookiecutter 1.7.3 for cookiecutter-veins-project
Operating system	Debian 11, Linux 5, GNOME 3
Number of Vehicles and RSU	110, 60 , 20, 11
Simulation area	(X,Y,Z) =(21025,18367,50)m
Simulation Time	6000 Seconds
Trips	10
Routes	10

1- TotalLostPackets:

TotalLostPackets is the rate of difference between data bits sent and received, showing the proportion of lost data bits.

Figure 8 depicts a direct relationship between the rate of rise in missing bits and the increase in the number of compounds in the site.

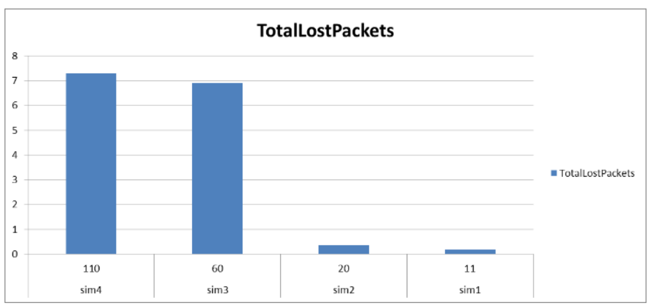

Fig 8: TotalLostPackets vs. Number of Vehicles

Table 4 displays the outcomes of the various simulation situations, where different results were produced by varying the number of vehicles.

Table 4: Total Lost Packets Simulation Parameters

Simulation	No. of Nodes	TotalLostPackets	*.nic.mac1609_4
sim4	110	7.3	*.nic.mac1609_4
sim3	60	6.916666667	*.nic.mac1609_4
sim2	20	0.35	*.nic.mac1609_4
sim1	11	0.181818182	*.nic.mac1609_4

The previous results demonstrated that by altering the maximum and minimum speeds in a specific path while controlling the movement and flow of data, we get better results since it improves the security system and allows security personnel to control traffic flow in certain locations.

2- Received Broadcasts

Received Broadcasts represent the average of broadcasts received by the vehicles and RSU (VANET NETWORK).
Figure 9 depicts the Received Broadcasts vs. Number of Vehicles graph; as the number of vehicles on site increases, so does the rate of data receipt.

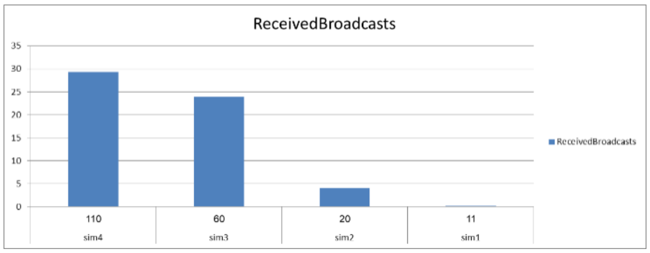

Fig 9: Received Broadcasts vs. Number of Vehicles

Table 5 demonstrates that the outcomes of receiving data improve when the number of cars in the relevant site increases.

Table 5: Received Broadcasts Simulation Parameters

Simulation	No. of Nodes	Received Broadcasts	*.nic.mac1609_4
sim4	110	29.4	*.nic.mac1609_4
sim3	60	23.93333333	*.nic.mac1609_4
sim2	20	4.1	*.nic.mac1609_4
sim1	11	0.181818182	*.nic.mac1609_4

3- Channel Busy Time (CBT) Average

CBT denotes using a statistic such as average channel occupancy time when the access layer considers the channel occupied or channel load.
Figure 10 indicates that the average occupancy duration of the channel grows as the number of cars in the same area increases.

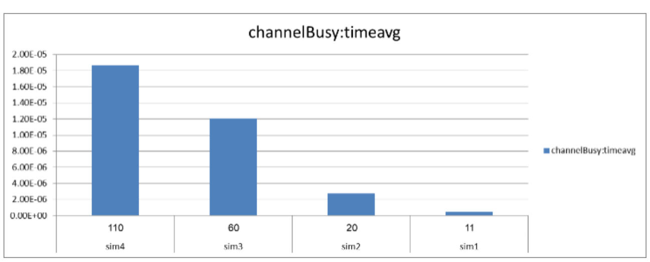

Fig. 10: Channel Busy: timeavg vs. Number of Vehicles

Table 6 indicates that the CBT Average outcomes grow with the number of nodes in the area in different simulation situations.

Table 6: CBT Average Simulation Parameters

Simulation	No. of Nodes	channelBusy:timeavg	Module
sim4	110	1.87E-05	*.nic.mac1609_4
sim3	60	1.21E-05	*.nic.mac1609_4
sim2	20	2.81E-06	*.nic.mac1609_4
sim1	11	4.54E-07	*.nic.mac1609_4

The system's significance

1. Reducing excessive speed using the existing deterrent of electronically issuing fines by documenting the movement of the vehicle and its speed during traffic for two years, reducing accidents.
2. We are reducing automobile theft by tracking cars and persons in them in a record based on the date and time for two years.
3. The speed with which the cause of the accident is determined if the accident occurs.
4. It strengthens the security system, emergency services, ambulances, and civil defense by transmitting data on the vehicle, driver, and passengers to the appropriate public security department.

5. Conclusion and Future Work:

This paper presents a project proposal for the use of VANET technology based on the Internet of things for safer driving by requiring car drivers to follow the Traffic Department's rules and instructions and by relying on the license plate number for approval to retrieve all data related to the car and its behavior on the road.
It is envisaged that implementing this project will help traffic management, lower the number of accidents and deaths, and improve Jordan's security system in general.
In the future, we will improve the security system by detecting the data of people inside the vehicle using magnetic ID cards and monitoring their security status. If any person is sought by security, the nearest police vehicle will be notified to take appropriate action.
A plan will be developed to implement the system regionally. Then the system will be formed by establishing fixed protocols and instructions for legal adoption through a global organization specialized in the field to improve the security system, reduce road accidents, and track down vehicle thieves and wanted persons.

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