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QoS Analysis for Public Transportation using IoV

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Abstract
Every city manager in every nation must do with public transportation. It is envisaged that the transportation used by the community to do daily tasks will be convenient, affordable, and secure. However, the advancement of Internet of Vehicles technology offers a chance to create a system for managing public transportation. The transition to electric vehicles and the current system of transportation management provide the ideal momentum for the development of an IoV technology. Implementation is hampered by the lack of adequate communication infrastructure. To prepare the supporting infrastructure for optimum development, a thorough examination is required. The Communication Toolbox in Matlab can be used to simulate the infrastructure and assess its service quality. The goal of this research and simulation is to ascertain the service quality level to establish the minimal level of communication infrastructure required to support an IoV in public transportation.

Keywords: QoS, 4G, 5G, IoV

INTRODUCTION

In large cities, public transportation is both a problem and a solution. Transportation services that are affordable, cozy, secure, and timely are becoming more and more necessary. The dynamics of society will be substantially impacted by the effectiveness of the public transportation system. The general public mostly uses public transportation as a mode of daily transportation to get to and from the office.

Progress has been made in the development of transportation technologies on the automobile side. Progress has been made in terms of speed, comfort, and energy efficiency. One of the advancements in vehicle technology is the conversion of fossil fuels into electrical energy. Electric energy conversion for public transportation has started to be carried out in several countries, including Indonesia. This momentum is applied to enhance the entire transportation network. On the other side, information technology has undergone technological advancements. Internet of Things, particularly Internet of Vehicles, is one.

The Transportation System is using the Internet of Vehicles, a technology idea, to increase passenger amenities, ride comfort, and driving safety. With the help of Internet of Vehicle technology, vehicles can communicate with their surroundings and give the right people who require it factual information about their whereabouts. Additionally, this technology can direct the driver to choose the best route and foresee mishaps or calamities. Monitoring engine conditions is another improvement that can lessen disturbances to the engine and its support. Devices must become more complex as functions and features become more complicated. The Internet of Vehicles is a collection of several technologies for data collecting, data processing, and data communication. The integration of these several components makes it crucial to conduct a thorough examination of each component that makes up the overall system.

1. A consideration of the communication tools utilized in public transportation will be conducted in this study. The mode of public transportation mentioned is an electric-powered bus. The communication under discussion is a method of data transfer that primarily relies on cellular technology. An analysis of the EV Public Transportation System's quality of service will be done as part of this study.
2. Describe how IoV is being used in electric bus public transportation.
3. Analyze the 4G and 5G infrastructure's quality of service for public transportation buses and electric vehicles.

4. Investigate the potential system flaw

RELATED WORKS

Some studies compare the communication networks' quality of service to system requirements. The level of risk that the communication system faces when performing its duties is gauged by the quality of service. Using Quality of Service in a system with several connected and dynamic nodes will be crucial. The capacity to offer dependable resources and distinctive services within the network is known as quality of service. Its operating theory offers certain network service restrictions. Throughput, packet loss, and jitter are just a few of the variables used to gauge the quality of a service. Currently, the primary factor used to assess the dependability of computer networks is quality of service. The reliability of the computer network increases with the service value. The study examines how Call Dropping and Call Blocking might be used when 5G is implemented as a communication tool. [1]. Grid and star topology performance quality of service comparison [2]. The IoV functions included in this study include GPS tracking, driving assistance, ECU condition, and accident events. Each offers a distinct level of service quality.

Other studies talk about the delivery time, latency, and congestion that 5G cellular IoV experiences. Varied service requirements at various risk levels. The adoption of additional NOMA (non-orthogonal multiple access) components is the suggested approach. [3]. A key area of study for QoS analysis is autonomous driving technology, which is covered by formulating a QoS prediction principle. [4]. System QoS prediction also serves as a guide in determining a particular level of QoS that was generated by a particular communication infrastructure. [5] . In addition to the current QoS issue, research is currently being done that examines SLA levels for QoS telecommunications infrastructure and edge computing [6]. Related to QoS parameter, it has been more thoroughly classified at level QoS. (T. Manivannan et al., 2020).

There has been a lot of study on cellular technology using 4G or its advancement of 5G as the primary framework in the Communication system in the Internet of Vehicles. One of them is setting up a 5G network for a high-data-rate Internet of Vehicles working environment. [8]. It has also been discussed how well the communication network infrastructure utilized in vehicles performs. [9]. A more thorough explanation of how 5G is being implemented in the Internet of Vehicles. This study describes how connection loss in 5G technologies can happen. [10]

INTERNET OF VEHICLE

Transportation or the automotive industry is one area that gains from IoT. In addition to the health industry, the transportation sector is one of those that uses IoT the most. The Internet of Vehicles, a new phrase for IoT application in the transportation industry, is establishing specifications and becoming more commonly used (IoV). The idea behind the Internet of Vehicles is how to connect vehicles with other entities that can affect or influence how they behave. The driver, passenger, and unit all have ubiquitous access thanks to IoV implementation. [11]. Increased comfort, safety, and effectiveness are results of this accessibility. Similar to IoT, chances for service development are provided by device development and communication capability. An increase in the volume of data flowing has other effects. Vehicles produce and consume massive quantities of various kinds of data. [12].

The creation of sensor and actuator technology promotes automation, driverless cars, and unmanned vehicles . [13]. The factory or service center can keep an eye on everything that happens in the car thanks to the ease of connection and data transmission. It is simple to anticipate vehicle maintenance thanks to accurate, quick, and valid monitoring. (Murugadass et al., 2018). Enhancing the system's capabilities will lead to the creation of new service concepts or advantages. Although there is little to no connectivity between servers and automobiles, there is communication with the immediate environment and the larger environment. The availability of numerous data will be impacted by this. The dynamics of IoV pose numerous additional issues in addition to boosting the benefits for humans. [15] There will be issues due to the growing volume of data, human expectations, and system dependence. The level of service quality rises as expectations rise. Data loss, bottlenecks, and time delays are examples of system failures that will diminish system reliability and present a risky situation.

The distinguishing feature of IoV in contrast to other IoT is the device's movement. More research has to be done on this quality because it has a big impact on so many different things [16], [17] IoT in automobiles or transportation is a field that has received a lot of attention due to the rise in the number of connected vehicles. IoV has been defined in a variety of ways throughout history. The emergence of IoV begins with the development of the IoT and the Intelligent Transportation System. The Vehicular Ad-hoc networks (VANETs), a different approach, are being developed into a new idea called the Internet of Vehicles (IoV).

The metamorphosis takes the form of expanding the variety of connections that are added. [11] The sub-components of the Internet of Vehicles can be categorized from a number of publications. The Internet of Vehicles (IoV) consists of five different kinds of vehicular communications: vehicle-to-vehicle, vehicle-to-roadside, vehicle-to-cellular network infrastructure, vehicle-to-personal devices, and vehicle-to-sensors. The phrase "surroundings" refers to the area immediately around a vehicle; "infrastructure" refers to the local region, such as a municipality or neighboring countryside; and "ecosystem" refers to distant facilities, such as the Internet, the Cloud, and contact centers. [18]

IOV FOR EV PUBLIC BUS

One of the transportation options that is commonly used as public transportation in many places throughout the world, including Indonesia, is the public bus. One of the causes is that the initial investment is negligible. This means of transportation is immediately operational and can be created in phases. It can utilise the current road infrastructure. The acquisition of the bus fleet—the technological conversion of resources or energy from fuel to electricity—is the main asset. An important task that the public bus operator must perform is the desire for service improvements for this transportation to continue to be a favorite of the general public as well as cost and energy optimization. One of the answers could be the use of Internet of Vehicles technology. The secret lies in enhancing safety and comfort while reducing disruptions that raise costs.

The following structure can be used to implement IoV technology for public transportation.

Table 1: Implementation of IoV for Public Bus.

Function	Description	Technology
Passenger Comfort	Bus passengers can use the internet connection to access entertainment, information, work-related needs, and smartphone-based communication	WiFi technology is used by passengers to connect their laptops or smartphones to the internet.
Information for Public Entities	Information on the Bus' location, speed, and anticipated arrival at a certain area are available to the general public.	The installation of sensors using V2S technology allows the position of the vehicle to be determined and sent to a server using V2Server technology.
Driver's Guide	Drivers receive instructions for stopping points as well as information about the route to be traveled entirely under unusual circumstances (according to the needs of passengers and prospective passengers).	Using V2Server technology, the bus's environmental parameters and the intended route are transmitted to the driver. Additionally, the system leverages V2Roadside technology to gather stop or turn point data.
Vehicle Condition Monitoring	A vehicle with a high utilization load is the public bus. It must be monitored by the control center and the engine condition must be monitored. Data on the engine, cabin, and other statuses will be retrieved by the system and sent to the data center for additional analysis.	Bus condition data is collected using V2Sensor technology and sent to the data center via V2Server.

Technology is employed in many of these implementations, including V2Server. Most functions make use of the line. Because node mobility is essentially non-existent and data rate/data volume can be expected because it is often static, V2Sensor technology is less dangerous for data transmission. Additionally, V2Roadside technology carries some reduced risk. The V2Server connection will serve as the IoV bus system's primary structural support. The dynamics of changes in the number of nodes, their volume, and their positions will all be dynamic (buses). From 2G to the most recent 5G, the cellular family of communication technologies is a commonly used one. We'll talk more about this research, particularly how 5G technology and its variations will serve as the primary means of data connection in public buses.

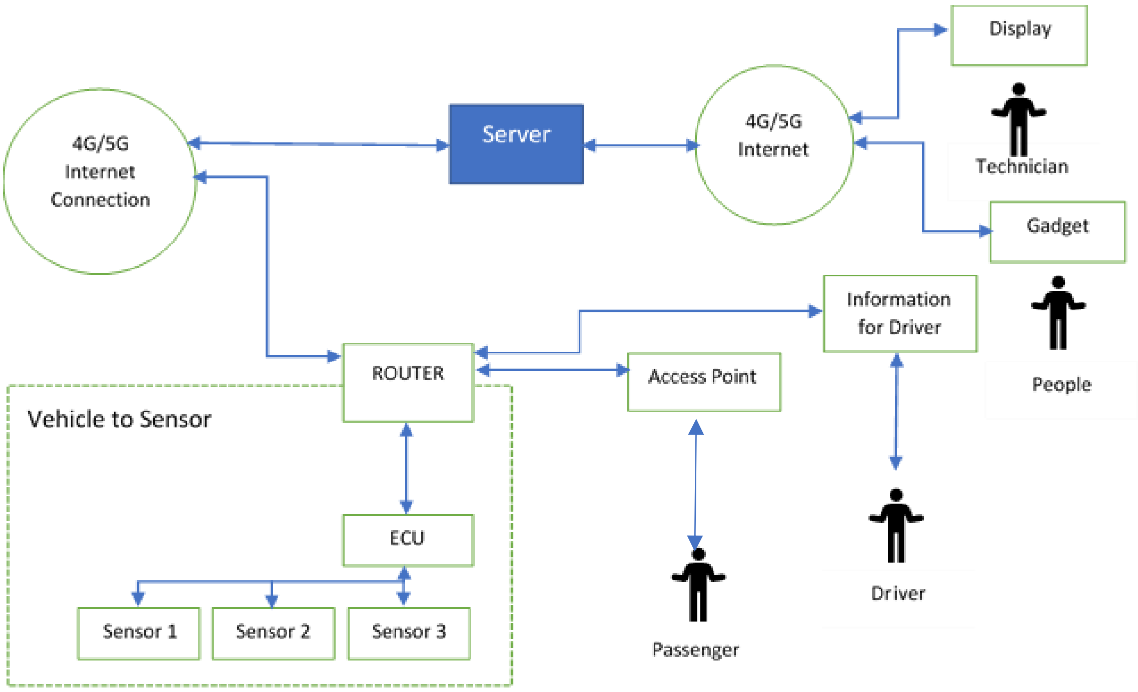

Figure 1. IoV Configuration for Public Transportation System

Since 1980, when cellular network technology was first utilized, it has advanced quickly. From the first generation (1G) to the fifth generation, the speed and level of data transfer support are becoming more advanced and contemporary (5G). Table 2 depicts the evolution of technology from 1G to 5G.

Table 2. Cellular Technology Development

Generation	Technology	Speed	Data
1G	AMPS, NMT, HICAP	Rendah	Voice
2G	GSM, CDMA, GPRS	14,4 kbps	Text & Voice
2.5 G	EDGE	384 kbps	Text, Image, Voice
3G	WCDMA	2 Mbps	Broadband
3.5 G	HSDPA	5 Mbps	Broadband
4G	LTE	50 Mbps	Broadband
5G	LTE	10 Gbps	Broadband + New Technology

1. Urban locations where EV buses are used for public transportation already have communication networks that use 4G technology and are upgrading to 5G. Because a third party (a telecommunication provider)

is already prepared to offer connection services, the adoption of this technology is substantially more affordable and accessible. We are currently in the transition from 4G to 5G. Nearly all telecommunications companies have begun to transition to 5G technology. Issues that could occur include:

2. Due to the small position and number of BTS that must be distributed evenly, the coverage area is still just a small portion of the total.
3. If there is a congestion of connected nodes and the volume of data delivered, each BTS's channel is still limited and cannot support connection requests.
4. High-speed public transportation can make it difficult for the connection to remain stable.

Following is a comparison of the features of 4G and 5G technology:

Table 3. Characteristics of 4G and 5G Technology

Karakteristik	4G	5G
Latency	10 ms	1 ms
Data Traffic	7,5 Exabytes/Month	50 Exabytes/Month
Data Rates	1 Gb/s	20 Gb/s
Spectrum	3 GHz	30 Ghz
Connection Density	100 Thousand/Km2	1 Million Connection/Km2

QOS LEVEL (DESIGN AND DISCUSSION)

To assess the communication infrastructure's quality of service, tests are conducted on call blocking and call dropping. These two factors are frequently used to gauge how well a 4G or 5G connection is performing. (Ray et al., n.d.) The terms Availability (Call Blocking) and Reliability can be used to compare these factors (Call Dropping). The following technique is used to test these two parameters:

Table 4: Testing

Indicator	Description	Testing	Limit
Availability	The percentage of failed attempts compared to the number of successful attempts with the following formula (1-F/T)*100%.	Pinging data to the destination address for 10 tries	98%
Reliability	Packet Loss: The number of packets that failed to be delivered		3%
	Download Rate of receiving data from the server	1 MB	1 menit
	Upload The rate for sending data	2 MB data	1 menit

Testing is conducted using Matlab's Communication Toolbox and takes into account the aforementioned steps for cell size, vehicle speed, and communication device channel count. Testing is conducted under the assumption that BTS positions are dispersed at random within the same coverage region. the continuous speed of a vehicle. 80 automobiles were used in the tests, and 10 BTS were installed.

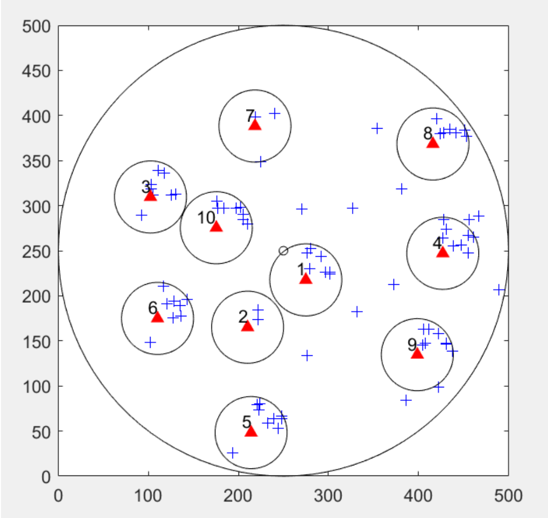

Figure 2. Simulation for 80 vehicles and 10 BTS

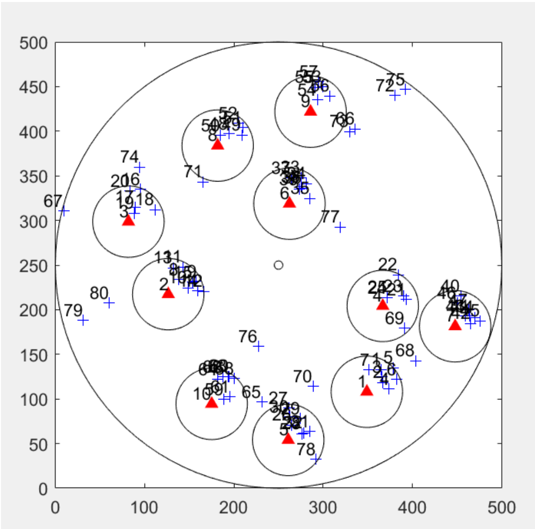

Figure 2. Simulation for 160 vehicles and 10 BTS

The test results are obtained as follows:

Table 5: Testing Result

No	Item Test	Average (80 Vehicle)	Average (160 Vehicle)	Average (200 Vehicle)
1	Average Packet Loss	0,12%	0,21%	0,34%
2	Download Data Rate	5,231 Mbps	4,763 Mbps	3,994 Mbps
3	Upload Data Rate	6,102 Mbps	5,231 Mbps	4,654 Mbps
4	Potential Connection Failure	12.5 %	15,4 %	19, 7 %

Changing the amount of vehicles that need a link allows for simulation. The test findings demonstrate that there have been considerable changes in the factors that can cause an increase in packet loss, data rate, and probable connection failures. The following happens as the number of connected vehicles rises:

1. Decrease in Data Rate to Slow Down Data Transmission Quality and Speed (Upload and Download)

2. The availability parameter lowers as potential connection failures rise. It will become more and more challenging for vehicles to connect.
3. The likelihood of missing packets increasing.

All findings indicate that more capacity will be required if there is a growth in the number of connected vehicles to maintain the quality of service level of the 5G infrastructure for data communication.

CONCLUSION

The communication infrastructure is one of the key components of the Internet of Vehicles system. For the system to fail as little as possible, this component needs quality assurance. The goal of the research is to model a router-server link utilizing 5G media. The connection is created from a moving car that is moving continuously. There is a clear correlation between the number of linked vehicles and the data rate, availability, and reliability of the network infrastructure, which further influences the quality of the Internet of Vehicles, according to experiments conducted under various assumptions.

This research has to be conducted in more depth. A more realistic simulation should be performed, primarily to examine Quality of Service, by adding additional speed fluctuations, improving the precision of telecommunication signal distribution, and talking about all IoV components. The spread of telecommunication signals needs to be described in greater detail, taking into account the type of device being used, the installation height, and the surrounding environment. The accuracy of each vehicle's bandwidth needs and the state of the road need to be improved by additional research.

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