Reliability Analysis Of Communication Network Service Quality For Internet Of Vehicles (Iov)

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Abstract.
The development of the Internet of Vehicle (IoV) is overgrowing toward driving comfort, safety, and efficiency. Autopilot or a car without a driver is one implementation of IoT. To run the full function of IoV, a reliable communication network is needed because the risk will be substantial due to the low quality of network infrastructure services. In this research, we will analyze the quality of network infrastructure services. The analysis can be done through two approaches: direct measurement in the field using a GPS Tracker-based system and modeling using the mathematical function of transmit power of mobile communication transmitting devices. The test is carried out in a specific area with a sample of high traffic and low-density areas. This method was chosen to find the right pattern in measuring the quality of communication network services. The tests carried out produce dynamic data on service quality in certain areas. For areas of low density, the service quality tends to be below as well, and many areas without signal are found, while for areas with high density, the quality of service is found to be good, but network overload conditions often occur.

Keywords: *Internet of Vehicle (IoV), Quality of Service (QoS), Network Infrastructure.*

I. INTRODUCTION

Competition in the field of public transportation is a must. The need for comfort, security, and punctuality is an important point in capturing consumers. The implementation of the internet of things will be a solution for transportation units in increasing competitiveness. However, before various Internet of Things-based services can be implemented, a communication network condition with a minimum standard or a certain level of Quality of Service is required. One of the important functions of the communication network is to act as a liaison between the devices installed in the vehicle unit and the data center. Disconnection (loss connection) will result in data loss, and the function does not run. Referring to the needs above, before building the need for transportation facilities in providing technology-based plus services, it is necessary to first make sure of the quality of the communication system. The problems that arise from the data communication system in transportation are:

a) The limited coverage of BTS and the mobility of vehicles make the potential for loss of connection increase.

b) The movement of vehicles will pass through high-rise buildings and large buildings, which are very likely to block communication signals.
c) The accumulation of vehicles at a point due to traffic jams, crossroads, accidents, or other activities will cause an overload of the communication network so that connection loss will occur.

With these conditions, it is necessary to research the extent to which loss connection conditions can occur and the risks that will arise. This identification will be the basis for building a solution. First, the service quality parameters are defined. In this case, the parameter is

a) Availability: the extent to which the communication network infrastructure is available when the vehicle unit will send or receive data to/from the server/data center.
b) Reliability: the extent to which the system is able to guarantee the delivery of data from the unit to the server/data center.

Furthermore, mapping of the signal coverage condition of the communication system and the pattern of traffic density and potential congestion is carried out. From this data, an analysis is carried out that underlies the development of an IoT-based data communication system with a Quality of Service level that meets the needs.

II. METHODS LITERATURE REVIEW

Along with the increasing number of vehicles connected to the internet, IoT in vehicles or transportation is becoming a field that is widely researched. There are many definitions and historical approaches to IoV. The development of IoT combined with the Intelligent Transportation System is the beginning of the emergence of IoV. Another approach is that Vehicular Ad-hoc networks (VANETs) are being transformed into a new concept called the Internet of Vehicles (IoV). The transformation that occurs is the addition of a wider connection range [1].

From several references, the Vehicle Internet sub-components can be grouped. IoV includes five types of vehicle communication, namely vehicle-to-vehicle, vehicle-to-roadside, vehicle-to-mobile network infrastructure, vehicle-to-personal device, and vehicle-to-sensor [2] ('Integrating in-vehicle, vehicle-to-vehicle, and intelligent roadway systems' define the term 'neighborhood' as the area around a vehicle; 'infrastructure' as a local area, such as a nearby municipality or countryside; 'ecosystem' as a distant facility, such as the Internet, Cloud, and call center.) [3]. There are still many groupings of IoV subcomponents. In general, the grouping can be described as follows:

Vehicle to Vehicle (V2V)

This sub-component connects between vehicles. The purpose of this connection is to share bandwidth, transfer position, and movement data to minimize collisions. Communication infrastructure can use Short Range Communication technology such as a Blue tooth, RFID [4][5][6]

Vehicle to Internet/Infrastructure (V2I)

This sub-component connects the Vehicle to the internet or wider network infrastructure. The benefit of this connection is the exchange of data or information. The data or information can be used by passengers or drivers for various purposes. Communication infrastructure can use cellular networks (2G, 3G, 4G), WiFi, and others. This connection makes it easier for V2I to provide any service. [6]

Vehicles for People (V2P)

This sub-component connects People with Vehicles. The person in question is the driver, passenger, or person outside. The benefit of this connection is to provide passengers with internet connection services for entertainment or information purposes. For outsiders, you can use this connection for the purposes of tracking position or sending information to the driver. Communication infrastructure varies according to need, it can use Short Range or Medium Range. The ease with which passengers can get internet services while in the Vehicle without being hindered by the mobility of the device is a key factor one of the benefits of vehicles for society. The consequence is massive data exchange to and from the Vehicle. [7][8]

Roadside Vehicle (V2R)

This sub-component connects the Vehicle with the surrounding environment, such as traffic lights, road boundaries, and the surrounding environment (road texture, road conditions, and others). The benefits of this connection extend to driving safety. Information on environmental conditions will assist the driver in operating the Vehicle safely and comfortably. This sub-component leads to the development of Autonomous Vehicles. [9]. This concept also makes the Vehicle able to determine its position on the road automatically, able to handle collisions with the surrounding environment.[3]

Vehicle to Sensor (V2S)

This sub-component is how to capture information related to vehicle behavior and status. These sensors can retrieve engine data such as engine conditions (temperature, NVH levels, fuel consumption), braking conditions, and others. All information is sent to the data center or server. The information obtained then becomes big data and can be used as a reference by various parties. Among the information that may be collected includes:

a) Vehicle movement history information
b) Vehicle condition information

This information can then be used for further analysis, such as benchmarking of vehicle brands and types, distribution of vehicle spare parts needs, distribution of technician needs, and others [10][11]. This information is very much needed and useful for many parties such as the general public, vehicle users, spare parts and workshop vendors, car manufacturers and distributors, and the government as policymakers. The availability of this information provides many benefits ranging from the efficiency of vehicle maintenance, optimization of spare parts stock, analysis of load factors on the road, and others. This information can also lead to the creation of a self-diagnostic module. With this concept, the durability and safety of the Vehicle will be better maintained. [12][13]The information entered can also be used as material for predictive maintenance [13].

The essence of IoV is the relationship between entities that have relevance to the Vehicle. Connections can be near or far as needed. Trials and research are being carried out by many organizations like Huawei and Google, but IoV is still in an evolutionary stage and will take some time to become a reality. IoV is still in an evolutionary stage, so it needs more attention to reliability issues. A simple error or failure of data transmission can wreak havoc and lead to catastrophic loss of human life and economic loss due to damage to vehicles, roads, and city infrastructure. Each application has some special characteristics required for its function, which also applies to the vehicle network or Internet of Vehicles (IoV). These are the special characteristics for IoV:

a) High Scalability and Heterogeneity: In a big city, there may be millions of vehicles, and to create a network of these vehicles and related sensors, platforms, etc. requires a large-scale network, and such a network must also be highly scalable to accommodate the increasing number of vehicles[2][14]

b) Dynamic Topology: Many different heterogeneous components of IoV interact with each other, and those components (mainly vehicles) move at high speed, which changes the network topology rapidly. Therefore dynamic topology is the main characteristic of IoV..[15][10][5]

c) Complex Communications: IoV network density varies from scenario to scenario. In a city environment, vehicles move close to each other but relatively slowly compared to a highway environment where vehicles are at a distance but travel at high speed. Therefore interference from other vehicles is possible in a city environment and in terms of the location of the highway traffic vehicles and their respective distances varies at high speeds, which requires high communication speeds with minimal delays. IoV requires a very complex but highly reliable communication network. [16], [17][15]

d) Energy and Processing Capacity: Unlike IoT, a vehicle network or IoV does not lack energy, processing power, or memory capacity. A node is a vehicle or platform that has sufficient energy and sufficient space to include processing power and memory, which is not possible in the case of IoT[2][10]

With such characteristics, problems and challenges arise in developing IoV. There are various challenges for IoV systems that need to be addressed in order for their implementation to be successful.

a) Delay Limitation: IoV applications require very hard delay constraints where there should be no delays or very low service delays. Setting up such a highly efficient network is impossible with this level of communication infrastructure current and in need of improvement. IoV Network System often loses signal, disconnects. Under certain conditions, there will be fatal consequences. The delay in sending data resulted in a critical condition.)[18][19]

b) Poor Network Connectivity: In many areas, especially in remote locations, network connectivity is still poor, which will hinder IoV operation in remote locations and needs to be resolved. This network offers various types of safety and infotainment services and provides comfort and safety for passengers and drivers. Due to the high mobility of nodes, nodes go out of their communication range, and information becomes obsolete and causes link breaks and packet drops[20]

c) Continuous Service: Providing a smart as well as user-friendly system is a challenging task. IoV is in the development stage, and it is a big challenge to design a smart and user-friendly continuous service network. [21], [22][10].

d) Lack of standards: Lack of standards makes effective V2V (vehicle-to-vehicle) communications and connections difficult and hinders ease of scaling. Only by adopting open standards can the current system, closed and one-way, be integrated into an effective system for the smooth sharing of information. IoT devices are still not secure and cannot defend themselves. The development of standard IoT devices is also immature. The emergence of IoT devices from various factories without being followed by standards is an obstacle to the development of IoT itself. [23][24]

e) Fault Tolerance: Transport services require highly reliable network communication, which can provide real-time communication. [8][25]

f) Precise vehicle positioning: Assisted Global Positioning System (GPS), the de-facto industry standard for vehicle positioning, is not completely secure and can provide precise vehicle location up to 5-10 meters which is not enough for secure and reliable IoV networks and it requires long-term planning.[19][26][10]

g) Security and Privacy: Security and privacy are one of the main considerations of any network. Vehicle identification is needed to create an ad-hoc network; at the same time, it is also necessary to secure user data. Otherwise, anyone can track your Vehicle, which will be a security hazard for users. Data can be misused to discover user travel interests and places visited, which can cause serious problems. Even vehicles can be hacked to stop them permanently. Therefore security and privacy is one of the main challenges that need to be addressed. This issue is the main concern of this research paper and has been discussed in detail in the next section. More and more devices of various types and brands are connected to the IoT network. Develop services and interconnections. Also, constructors and hackers improved. The release of human involvement for a long time will open the opportunity for attacks or misuse of data. Security will be the reason for IoT implementation. [27][28].

The literature review shows that there are many things needed by the internet of Vehicle (IoV) in terms of Availability and QoS Level. The impact or risk is experienced if the connection is interrupted or the QoS level drops. There is a need for a mechanism for measuring the QoS level of the network infrastructure as a benchmark for;

a) Development of network infrastructure for a minimum level of QoS for IoV implementation in certain areas.

b) Prediction for the IoV unit that will move through a certain path related to its QoS level. This prediction is necessary to minimize failure and risk

III. RESULT AND DISCUSSION

The data collected in this study are the quality of the availability of Network Infrastructure (Network Availability) in the vehicle unit line from start to finish. To obtain this data, it is done in two ways or approaches, namely:

a) Develop a graphical and mathematical model of the signal strength at the location of the vehicle line. Signal strength measurement is based on BTS signal propagation analysis.[29]. The analysis uses the concept of GSM 900 and 1800 signal propagation, using the Okumura Hatta and Walfish Ikegami method [30].

b) Conduct direct testing using GPS Tracker installed in several vehicles. The pattern of data stored on the server is used as a reference in measuring the availability of network infrastructure in the vehicle lane.

The data taken were sampled in 3 public transport routes or routes in Bandung and Makassar. Graphical and mathematical models are derived by taking BTS data from the cell mapper site and drawing signal propagation according to the technical specifications of the transmitter used (Antenna Direction and Strength / Transmittance). An example of graphical modeling is as follows:

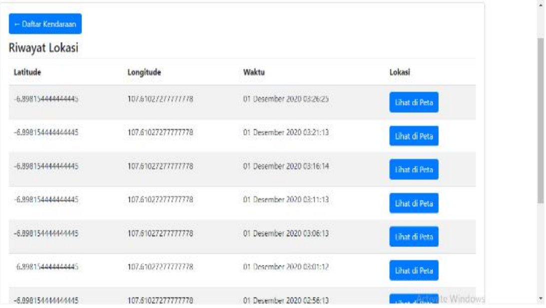
Fig 1. Position of BTS Provider Indosat Oreedoo in Cicaheum Area

The mapping is carried out along the road or area traversed by the selected path or route. In this case, observations were made on the Cicaheum Ledeng and Kebon Kelapa – Dago public transportation routes. BTS observations are carried out by taking into account the following limitations:

a) Transmitter Technology used (2G, 3G, 4G or LTE)

b) Pay attention to buildings with a certain height.

For data from observations using GPS Tracking, transportation movements are obtained with changes in longitude and latitude data. An example of the data capture is



Riwayat Lokasi

Latitude	Longitude	Waktu	Lokasi
-6.898154444444445	107.61027277777778	01 Desember 2020 03:26:25	Lihat di Peta
-6.898154444444445	107.61027277777778	01 Desember 2020 03:21:13	Lihat di Peta
-6.898154444444445	107.61027277777778	01 Desember 2020 03:16:14	Lihat di Peta
-6.898154444444445	107.61027277777778	01 Desember 2020 03:11:13	Lihat di Peta
-6.898154444444445	107.61027277777778	01 Desember 2020 03:06:13	Lihat di Peta
6.898154444444445	107.61027277777778	01 Desember 2020 03:01:12	Lihat di Peta
-6.898154444444445	107.61027277777778	01 Desember 2020 02:56:13	

Fig 2. GPS Capture data

From this data set, we get the position of the position where there is signal availability (by looking at the data coming into the server) and the blank spot position where there is a disconnected line (the position where it is not recorded on the server). Using the results of the data from the two sources above, it can be obtained (example for the Cicaheum Ledeng route).

Table 1. Coverage and Track Categories

Numbers	Category	Radius (Km)	Line Length (Km)
1	Strong	3	6
2	Medium	5	4
3	Weak	8	3
4	Very Weak / No Signal	10	2
5	Blank Spots		2

The classification is calculated by referring to the distance from the point of the vehicle unit to the BTS [29]. Network reliability in anticipating traffic conditions such as congestion, vehicle assembly areas. The relationship with network reliability is carried out by collecting data in the form of:

a) Potential for network overload caused by the number of vehicles exceeding the communication channel capacity of BTS in the area. This overload may occur in areas where there are congestion, such as road junctions, accidents, road narrowing and others [31].

b) The potential for overload in places that are gathering points for vehicle units such as in Terminals, Markets and others.

The search for data related to traffic conditions was carried out by looking at the potential for congestion in the area passed by the tested public transport (in this case, the Cicaheum Ledeng and Kelapa Dago routes). Congestion data is taken from Google Map with time variations. Some examples of such data are:

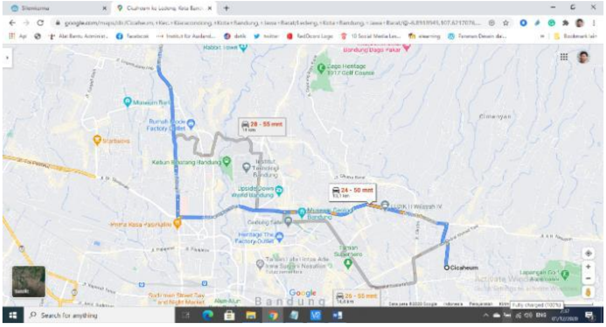


Fig 3. Potential Congestion of Cicaheum – Ledeng 08.00 hours

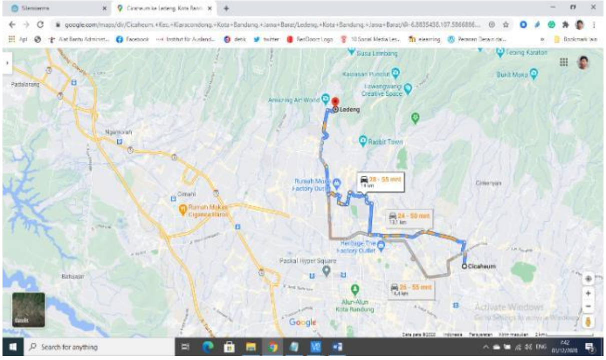


Fig 4. Potential Congestion of Cicaheum – Ledeng 16.00 hours

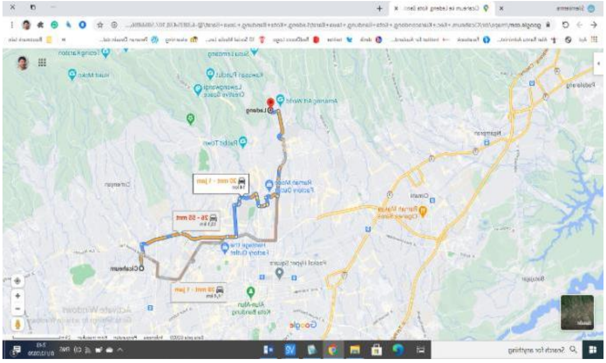


Fig 5. Potential Congestion of Cicaheum – Ledeng 12.00 hours

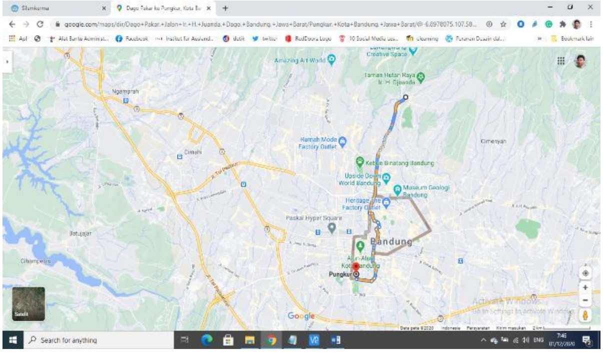


Fig 6. Potential Congestion of Dago – Kebon Kelapa 08.00 hours

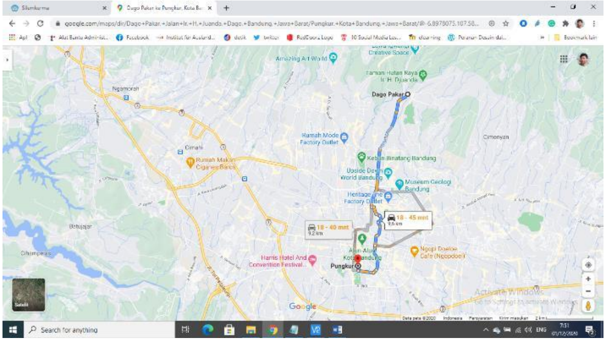


Fig 7. Potential Congestion of Dago – Kebon Kelapa 12.00 hours

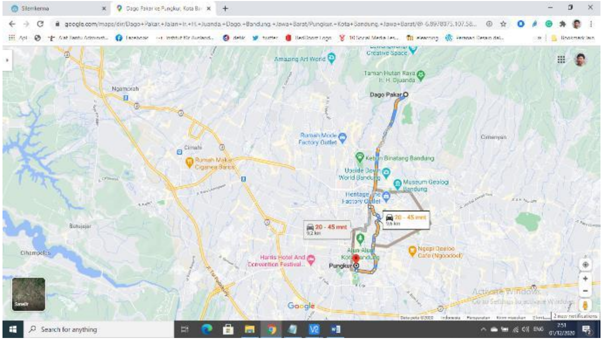


Fig 8. Potential Congestion of Dago – Kebon Kelapa 16.00 hours

From these data, the potential network overload conditions are obtained at several points [32]. From the stages of data collection, data recapitulation is obtained as follows:

a) The percentage of the area that has a level of network infrastructure availability refers to the signal strength.
b) Percentage of potential network overload due to congestion.

The combination of the two conditions above (availability and reliability) results in data recapitulation for 3 vehicle routes (2 in Bandung City and 1 in Makassar (not recorded)). The results of the data recapitulation obtained conditions.

a) QoS (Quality of Service) for Availability is below 50%, which means that almost half of the public transport routes (for 2 routes) have a potential loss of connection of up to 50 percent more.

b) QoS (Quality of Service) for Reliability will have problems in certain areas with less than 10% of public transport routes (for 2 routes). The potential for overload will occur at some point at certain hours. In general, it has not interfered with communication services.

IV. CONCLUSION

The quality of network infrastructure services is still uneven. Some areas have blank spots where the connection will be lost. This condition is very risky for the implementation of the Internet of Things which relies on important information for the movement of vehicle units.

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