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DESIGN AND PERFORMANCE OF DATA COMMUNICATION PROTOCOL BETWEEN TRAFFIC MANAGEMENT CENTER AND ON BOARD UNIT CLOUD SERVER FOR SUPPORTING INTELLIGENT TRANSPORT SYSTEM SERVICES

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ABSTRACT

Intelligent Transport System (ITS) is an information and communication technologies (ICT) that can be used to support smart mobility on a smart city. ITS is expected to be able to optimize the current public transport condition that has not been integrated through an ICT networks. In this paper is proposed a traffic management center (TMC) development used to monitor the fleet's movement and soon will be developed to control the fleet's movement. In this paper discusses from design to its performance of data communication protocol algorithm for communication between OBU cloud server as OBUs data collector and the TMC.

Keywords: smart mobility, intelligent transport, vehicle monitoring, traffic management center.

INTRODUCTION

Intelligent Transport System (ITS) is a part that can support smart mobility. Smart mobility aims to decrease congestion, speed up movement, decrease the transportation cost and more environmentally friendly [1]. ITS also aims to improve the transportation users's safety [2]. Generally, ITS needs a wireless data communication line for delivering message from a

On board unit (OBU) device carried by a vehicle to a Traffic Management Center (TMC). The data communication line is also used for sending information to the road users. If seen from the needs, then the data communication protocol in ITS needed also diverse.

The vehicles in Indonesia are currently still connected neither to each other (vehicle-to-vehicle, V2V) nor to a traffic controller (vehicle-to-infrastructure, V2I). This condition applies as well to public transportation in Indonesian big cities.

As a result, the distance between public transport fleets are not optimized -- either they are to close or too far from each other. At the moment, public transportation in Indonesia actually has a periodic schedule, but because of the unpredictable traffic, the estimated time of arrival is often unpunctual. In order to fix this problem, a fleet movement monitoring system through existing wireless communication network is proposed in this paper. By monitoring locations of public transportation in a control center, an optimized public transport movement is expected to be achieved.

To move digital information from one device to another, a protocol is needed. The protocol used in a communication data within the ITS system works above the communication data protocols that have been commonly used, so that the finishing process goes faster. The communication data protocols that are commonly used at the moment are communication data protocols based on Internet Protocol (IP).

The problem description of this paper as follows:

a) How is the system architecture to monitor the location of a vehicle that is moving in a TMC space?

b) How is the optimal protocol on a communication system between OBU and TMC through a cloud server located on data center?

In order to maintain the reliability of data communications between the OBU and the TMC, a reliable cloud server is introduced between them. This server takes main responsibility to acquire such a data transaction from many OBUs, as well as a main data center in the point of view of the introduced ITS concept. In addition, the cloud server serves data collector from distributed OBUs' data. The TMC server finally can be consider as a user of data center server to run critical function of monitoring the vehicle through On Board Unit.

Using such architecture, the Communication Division operators or technicians in the TMC may concentrate to their function to manage the traffic condition and public transport vehicles.

METHODOLOGY

ITS is a system with all the information technology and communication within vehicle, between vehicles (V2V) as well as between vehicle and the existing infrastructure (V2I). ETSI have also published Cooperative ITS (C-ITS) which connects various transportation modes [3]. Cooperative ITS promises a lot of convenience which can improve efficiency in both time and money. Willke *et al* in his publication has categorised ITS application especially to V2V that can be used to control the movement of fleet and also as information delivery media like data service, advertisement, street data and warning for traffic situations [4].

Because ITS is a part of smart mobility in a smart city, the communication system used can also refer to the architecture of Internet of Things (IoT) that is used a lot in smart cities. Jin *et, al* illustrates the communication relationship within smart city as three different domains [5]. In that research, the author describes that the smart city system uses some layers of sub-systems compared to other architecture references. Smart city works based on the result of sensors that are connected through the WAN network whose result will be saved and processed by the cloud computing system in a data center. Cirani *et. al* pictures architecture gateway IoT with caching capability and resource directories (RD) [6]. In the paper, the practice of data communication on smart city through many kinds of existing data communication protocols is described as well.

Figure-1 shows the architecture designed to overcome the system. This system consists of OBU, TMC and VMS (Variable Messaging System) supported by multi platforms communication networks.

Communication from OBU to server is done by using a private wireless communication network and a public network. The protocol used in this research is TCP/IP, on the layer of transportation and network as well as the application layer of HTTP.

These protocols are chosen due to their common used as communication data, so that no new protocol should be made in this research. This research prioritize the function of the already built ITS application more than the existing wireless communication network protocol.

On the early design, the TMC server is placed on the server located in the same building as the TMC server. However, because of the complex server maintenance, on this early research a cloud-server rented from a web hosting service provider is used. In the TMC building, a PC as information view regulator on video walls and a PC to operate the TMC are provided.

Wall display (video wall) is used to show information to operator generally. The function of the CC-rom is to monitor the movement of the fleets as well as to deliver message to OBU and VMS. Next to that, CC-rom can also be used to control the traffic signal (TL). Cloud-based server is a server located in a data center on an internet network. The server on the data center is the server functioning as a bridge of information from several OBU devices to computer devices on the TMC. Figure-2 below shows the communication between the TMC and cloud server.

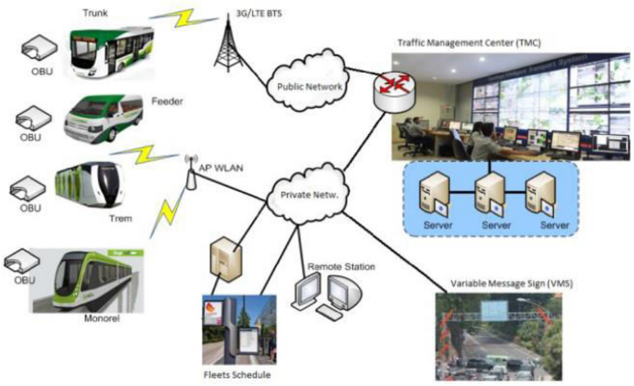

Figure-1. Design of ITS architecture to be developed.

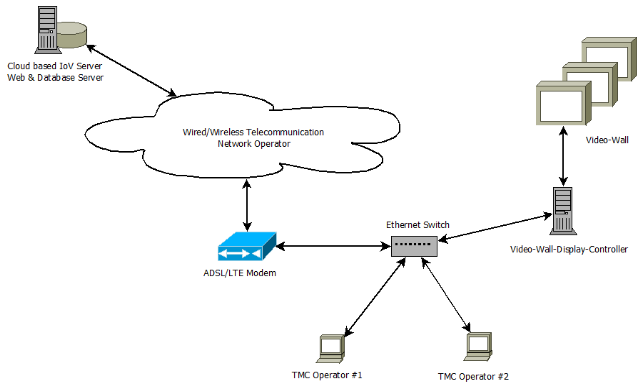

Figure-2. Communication between the TMC and server.

In order to communicate and carry out data transaction with the OBU, some applications such as database server, HTTP server and other software server are provided. Such applications support to serve the programmer modifying its script for developing the system in the future. The server is picked using the cloud system located in a data center, due to many considerations like existing network operator on data center, human resource during blackouts, etc.

Program code on the side of this server consists of several parts: script to take data from OBU, script to send data to the TMC and script for messaging system between OBU and the TMC in case of emergency message or so. Because this system of HTTP server is passive, the client side has to actively send triggers.

The earliest PHP programming script is the PHP code script to receive data from OBU. Such a code is applied to acquire data from OBU, i.e. geo-position coordinate, and other required data; into data base server. The Table-1 shows data structure transmitted from OBU to the cloud server. While Table-2 shows the replied data format from the cloud server to OBU.

Table-1. Data from OBU to cloud-Server

Field	Description
Header	ID_Sender, Type_of_message, Urgency_level
Payload1	Periodic information (location coordinate from the GPS and other data from sensors connected to OBU, time stamp)
Payload2	Text Message (direction and content)

Table-2. Reply data format from server to OBU

Field	Description
Header	Server Identity, Type of Message
Payload1	Information posting status to database server
Payload2	Text message (optional)

The algorithm of application supporting such data transaction from OBU and cloud server is described in the Figure-3. This instruction maintains the acquired data and continuously updated in the data base server.

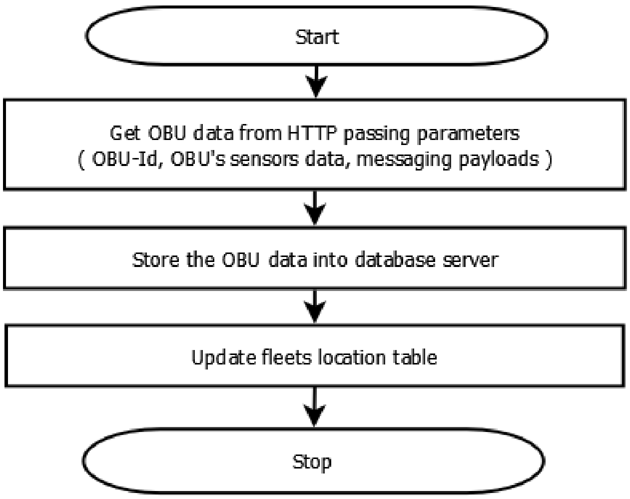

Figure-3. Data transaction from OBU flowchart.

Then data stored in the cloud server will be sent to the TMC server. To send data from the cloud server to the TMC server, a simple script is needed to take the last position data of from the OBU and send it to the TMC (Figure-4). A batch of the OBU location data is sent at once in a transaction, in order to save the use of transmission bandwidth. The format of the information data request from the TMC to server can be seen on Table 3 and table 4.

In order to display the OBU data to the TMC screen display, the recorded data base in the cloud server should be transferred to the TMC server. The flowchart of such a data processing in the TMC can be seen on the Figure-5. Because the location information on the TMC display should always be shown up, the process has to be performed periodically and keep tracked by the timer on the computer.

Table-3. Data from the TMC to cloud-Server.

Field	Description
Header	ID_Client_the TMC, ID_Authentication
Payload 1	1.First row of required message (based on ID_message)
Payload 2	2. Messaging data from the TMC operator to the OBU (if any)

Table-4. Reply data from cloud-Server to TMC.

Field	Description
Header	ID_Server, Message_Class
Payload1	Fleets location data (multi-rows)
Payload2	Text message from OBU (optional, multi-rows)

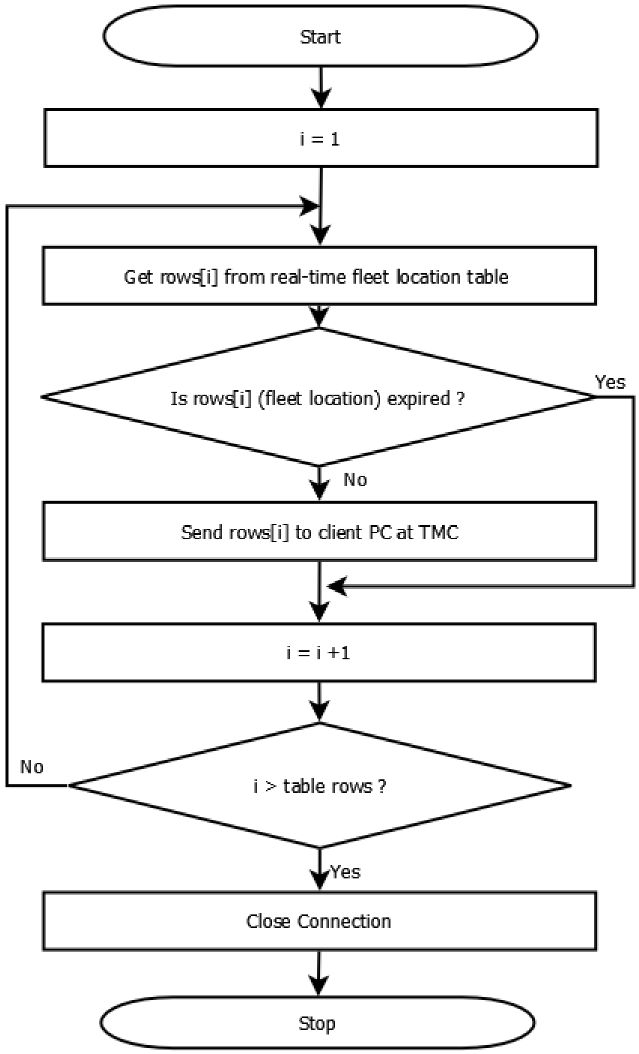

Figure-4. Chart of data transmission from Server to TMC.

The steps of the algorithm start from the sending request to cloud server to take the last posted data from some OBUs. Then the received data coming from multiple OBUs are stored to the TMC buffer. The next step is to take the first row of the data from the buffer, and then the

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data is parsed to get information containing such as vehicle location coordinate and other attribute data. After that, we put each coordinate data as an object on a basic map. Thus, we may show the position of OBU in the map of such the first data. The next process continues to get the data from the following row; the data from the first row must be erased from the processed data, so that the second row will move up to the first row. This process is done over and over until the last data row in the buffer is processed. Thus, such a displaying data activity in the TMC has been processed instantaneously.

For the vehicle management purpose, the received data in the TMC will be stored permanently as a backup of main cloud server. Such a recorded data base will be resource for more data analytic for traffic and vehicle management purpose in the public transport management in the TMC.

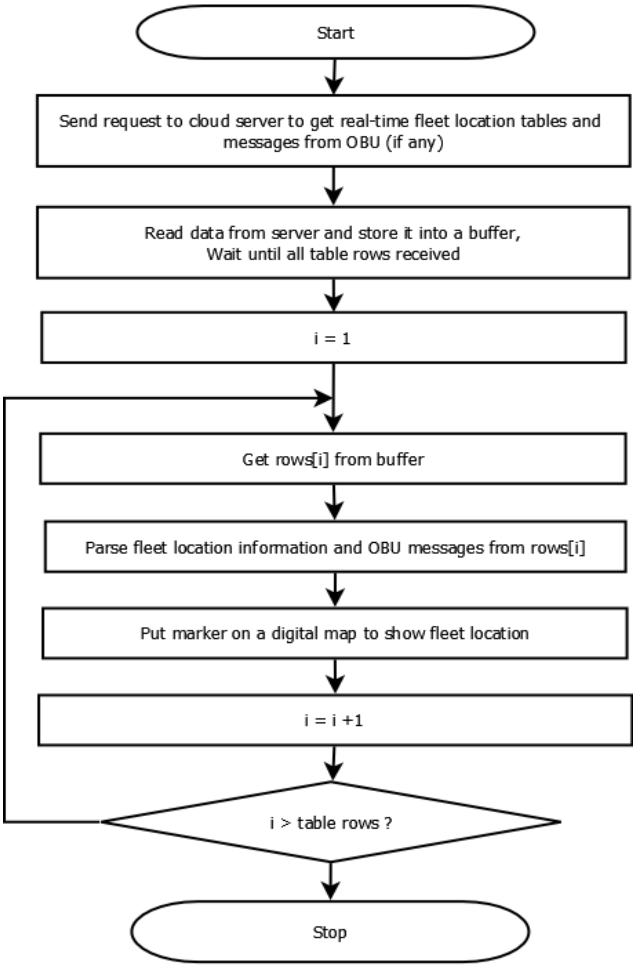

Figure-5. Flowchart of data processing at the TMC.

RESULTS AND DISCUSSIONS

The early TMC prototype that has been realized at the moment consists of a 40-inches sized ultra high definition TV and displays of standard sized monitors. Such a prototype is shown in the Figure-6 as one big screen and two screens located in both left and right sides. The main UHD TV displays the main map view, and the two small screens on the sides shows the graphical user interface of the controller and manager the items displayed on the main screen.

Besides the view of the map, the software that has been built is used as well to observe the performance of communication network between the TMC and the cloud server. In the Figure-7, it is shown that communication data takes different duration each time (communication's delay). This is probably caused by the queue on the router on the operator network whose system is 'store-and-forward' and its propagation delay.

The testing of the communication link performance between the TMC and the server on the cloud is using the existing ADSL network through some router devices. As the packet TTL (Time To Live) is 54 second, the data bundle through 11 routers (3x@local, 4x@Telco-Opr, 2x@IIX, 2x@DataCenter).

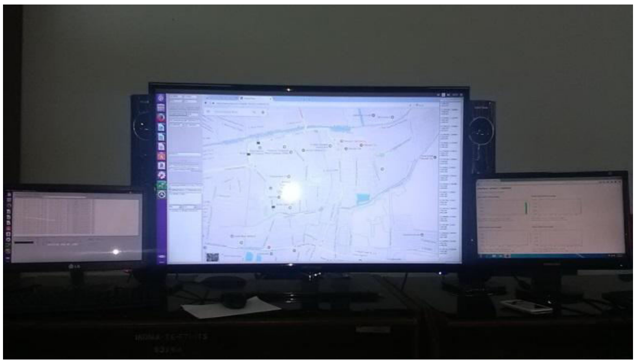

Figure-6. Presentation of video wall TMC display.

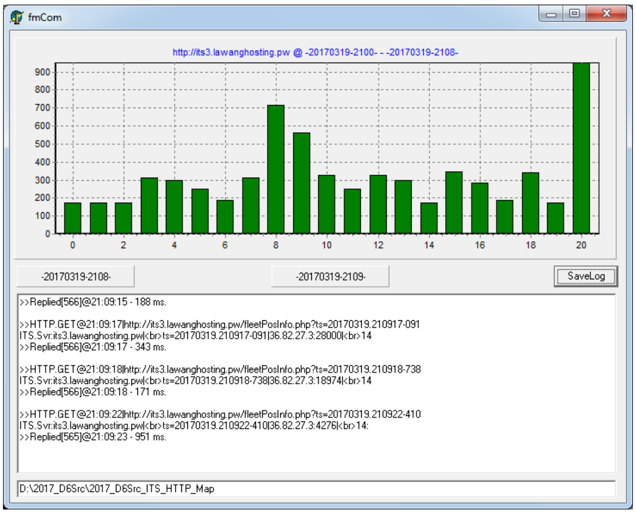

Figure-7. Communication link performance of the TMC.

Before conducting the protocol testing on this application layer, a testing on the network layer first need to be carried out. Figure-8 shows the result of the test on network performance, i.e. the Cummulative Distribution Function (CDF) curve of ping test results. Ping time indicates round trip time (RTT) of the launched packet. The graph indicates the ping test has average ping time as 45 milliseconds.

After testing with Ping test (using an Internet Control Message Protocol, ICMP packet), the following

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testing is live testing using HTTP packet. This probability density function (PDF) graph testing result (Figure-9) shows that the propagation time probability is mostly at around 300 milliseconds. However, in order to guarantee of communication reliability, we learn from its CDF curve (Figure-10) and table V, it can be concluded that 95% of data bundle can be delivered completely within less than 2 seconds.

In addition, Table-5 also shows some important points from the CDF graph, and it shows the value of time propagation with probability on 90% (1.17 s), 95% (1.28s) and 99% (3.54s)

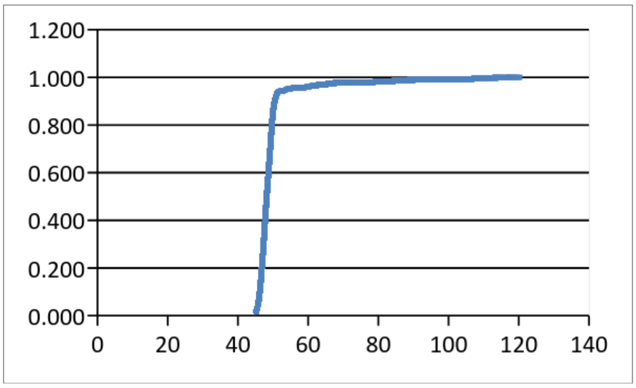

Figure-8. CDF RTT delay using Ping test between the TMC and the Cloud Server.

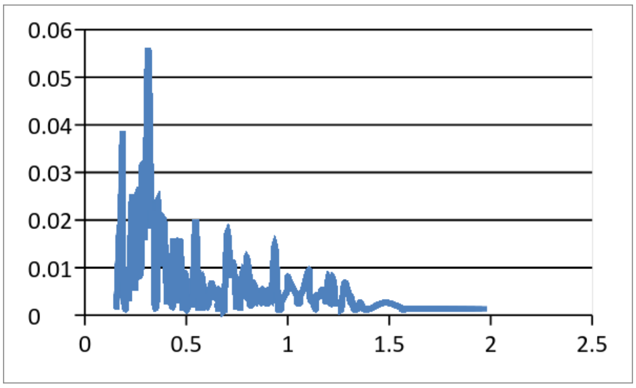

Figure-9. PDF of HTTP packet delivery latency between the TMC and the Cloud Server. (seconds).

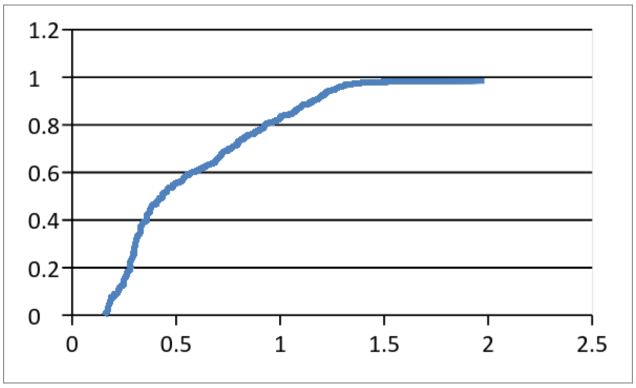

Figure-10. CDF of HTTP communication latency from the TMC to Server (seconds)/

Table-5. CDF data source.

Samples	RTT packet delay	CDF
674	1.16	89.99%
678	1.17	90.52%
711	1.26	94.93%
716	1.28	95.59%
741	3.45	98.93%
742	3.54	99.07%
748	4.23	99.87%
749	5.38	100.00%

CONCLUSIONS

The conclusion from the conducted experiment in this paper is as follows:

a) Packet data from any OBUs are periodically sent to the cloud server. Then, data communication protocol between cloud server and the TMC applies data transmission by batch from a number of OBUs data (multi-rows).

b) From a number of multi-row data using HTTP communication between the TMC and the cloud server through a public cellular network (LTE) requires average 300 miliseconds. In addition, the delay will be considered increase up to 1.17 second when we want to improve 90% reliability of connection.

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