Internet of Things for Intelligent Traffic Monitoring System: A Case Study in Denpasar

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Abstract — *This research intends to determine the design of the implementation of the Internet of Things (IoT) for intelligent traffic monitoring system (ITMS) in the Denpasar city, Bali, Indonesia. The goal was to get a monitoring system that was able to visualize the traffic on the Web-based GPS/GPRS. IoT implementation focused on three main components, namely the acquisition of traffic by leveraging the capabilities of GPS as a sensor, GPRS-based data transport, and the design of a Web/GIS-based traffic monitoring software. The results show was possible to interconnect the GPS tracker, GPRS and Internet networks as IoT scheme for building ITMS in Denpasar*

Keywords — *IoT, Intelligent traffic monitoring, GPS, GPRS, Denpasar.*

I. INTRODUCTION (SIZE 10 & BOLD)

Based on 2015 census data, the population of the city of Denpasar amounted to 880.600 inhabitants. This number increased by 2% from the previous year. Population growth is also correlated with the increase in demand for transport. This will directly affect the growing risk of growing traffic problems, such as congestion and accidents, which decrease the performance of the service road. Therefore, we need a mechanism of transport management in the Denpasar city which is able to minimize traffic problems.

Currently, some traffic information services already enjoyed by the citizens in the city of Denpasar, such as radio service broadcasting and video streaming services. In general, the information conveyed by these services are subjective, so that road users should interpret the traffic conditions. Portrait of traffic information services shows that the traffic information management in the city of Denpasar has not been integrated, and requires road users to use multiple devices to access information. Nowdays, the most crucial is no real-time traffic service.

Intelligent traffic monitoring system (ITMS) is a transport system that uses information and communication technology (ICT) to address and reduce transport and congestion problems. In general, ITMS rely on location-based information: to monitor traffic conditions, a number of sensors attached to the vehicle to get information about the estimated time of travel, driving conditions, and traffic incidents [1]. The more sensors are installed, then the information will be more quickly detected congestion. Furthermore, traffic can be redirected to other routes to reduce congestion.

There is several input information that can be used to realize intelligent traffic monitoring systems, such as digital video camera or CCTV, traffic analyser, traffic counters, and so on. All devices that can be expressed as sensors installed on roads. Furthermore, for the dissemination of the information can use a variety of alternative media, such as variable message sign (VMS) or electronic sign board, and radio broadcasts. But the incorporation of multiple technologies in ITMS requires an integration mechanism so that traffic data can be processed into traffic information.

IoT is a new paradigm in the field of information and communication technologies that allow all the sensors capture the data traffic can communicate with each other through a network such as the Internet. With a focus on the application of sensor technology, few studies have been done to implement IoT on ITMS, such as using cloud computing [2][3], communication technology machine to machine (M2M) [4], the combination of radio frequency identification (RFID) and Global Position Systems (GPS) [5]. The results of this study show it is possible to realize the ITMS in IoT framework.

This paper intends to develop a model of ITMS implementation for Denpasar city by utilizing GPS tracker devices as sensors embedded. In the scheme of IoT, GPS device can communicate with the server via the internet network, and dissemination of traffic information using Web-GIS (Geographic Information Systems) applications.

This paper is organized as follows: In Section II, we describe the key technologies of IoT for ITMS. Section III describes the developed system architecture, and Section IV describes the design of implementation. In Section V, we offer several conclusions

II. INTERNET OF THINGS (IOT) FOR INTELLIGENT TRAFFIC MONITORING SYSTEM

Internet of Things (IoT) can be expressed as a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols [6]. The basic idea of this concept is the result of a variety of devices with unique addressing scheme, such as RFID, sensors, actuators, etc., which can interact with one another to achieve certain goals. As described by [7], three-tier architecture of the IoT is shown in Figure 1.

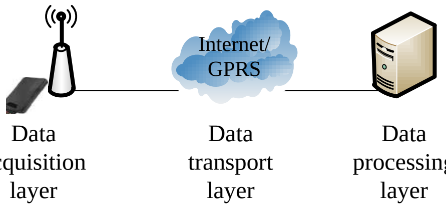

Fig. 1 Three-tier architecture of Internet of Things

A. *Data Acquisition Layer*

The basic data used to realize the ITMS is information about the movement of vehicles, including vehicle location, speed, and direction. The condition of the current state of the vehicle can be received with some integrated sensors such as environmental mapping and location of vehicles simultaneously through GPS technology. Another technology that can be used is RFID. This device can identify the vehicle, read data and write vehicle label. By examining the data position and speed of vehicle, the traffic information can be realized.

Techniques for collecting road information can use the contact traffic detection technology such as sensors toroid, geomagnetic vehicle detection (GVD), and the piezoelectric detection technology. Moreover, it can also use the technology of non-contact detection of traffic such as networked surveillance cameras (CCTV). With the support of mobile technology, many mobile devices are already implanted sensor technologies, such as GPS tracker and image processing capability, so as to perform image segmentation procedures for the classification of the object vehicle the vehicle.

B. *Data Transport Layer*

When traffic data is obtained, layer 2 of the architecture IoT will perform transmission mechanism to transport data to the server. There are two schemes of transport traffic data that can be used: wired and wireless technologies. On wired technology, fiber optic communications network has been used as a backbone network infrastructure for wide area network (WAN), making it possible to build high-speed internet network for data transmission. Wireless network technology, communication system includes an FM radio, satellite and mobile. FM communication technologies including radio broadcast, radio data system (RDS), and digital audio broadcasting (DAB), and digital multimedia broadcasting (DMB).

GPS satellite communications technology is widely used for location-based traffic monitoring. As shown in Figure 2, the GPS technology consists of three parts: satellites, ground stations and users. Satellites in orbit for 24 hours, and there are 4 satellites of 21 satellites visible from the earth station. Four satellites will provide vertical and horizontal position data for each station in the form of coordinates (x, y, z). In function of vehicle speed information (dx/dt, dy/dt, dz/dt) can also be obtained in all weather conditions [5].

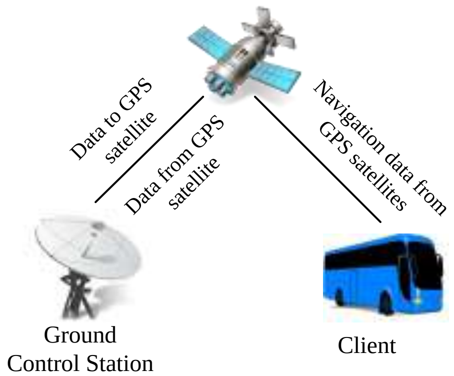

Fig. 2 GPS satellite communication system

Mobile telecommunications technology that is already implemented today are GSM, GPRS, 3G, and 4G, and will be followed by the standard 5G. General packet radio service (GPRS) is a packet data communication features on GSM technology, which makes it possible to transmit high-speed data via terminals / mobile phone devices. GPRS provides a wireless IP connectivity in a large area for GSM users. As shown in Figure 3, GPRS fully supports TCP / IP, dynamic IP address allocation, and provide mobile internet services via the GGSN.

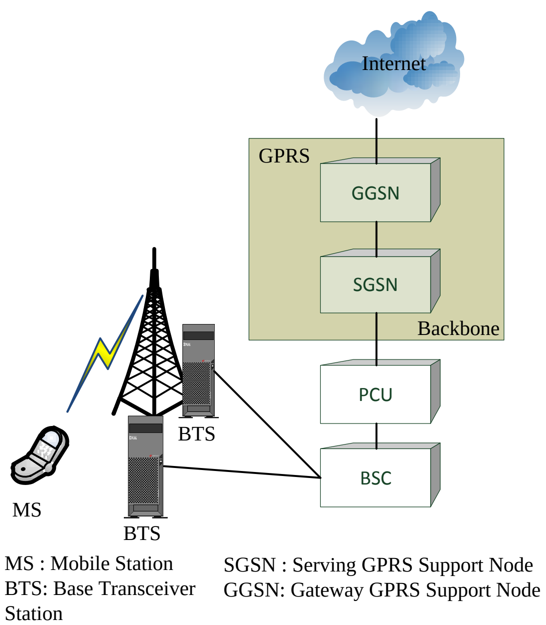

Fig. 3 GPRS architecture

C. *Data Processing Layer*

Data processing layer in the architecture of IoT serves for the exchange, processing, and data storage. Traffic behaviour can be understood as an issue of classification of data that vary over time. Currently, some research has implemented several methods to understand the characteristics of the traffic, such as

using license plate recognition (LPR) algorithm [8] and enumeration method [9].
Furthermore, traffic information disseminated using a wide variety of media. Several models have been proposed dissemination of traffic such as Web-GIS-based applications [10] and Android-based applications developed by [11].

III. PROPOSED METHOD

The main target of this research on ITMS Denpasar has developed a traffic management centre with the ability to: (i) to process traffic data from GPS tracker device into a real-time traffic information system based on Google Map API, (ii) providing a web-based traffic information services / GIS. Related to the above, this research proposes a network architecture model of IoT, as shown in Figure 4. This model is adapted from the proposed model of network architecture IOT of [5].

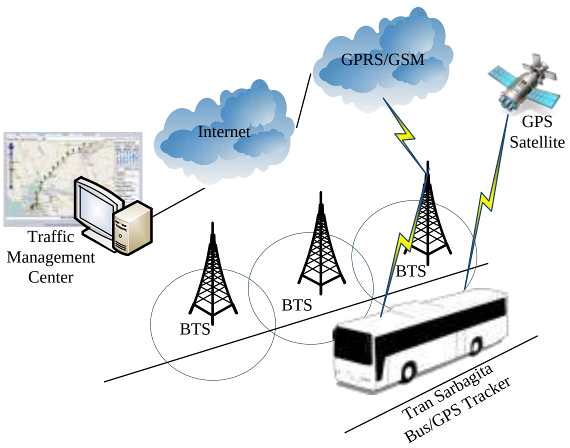

Fig. 4 Network architecture model of IOT for ITMS Denpasar

In the data acquisition, the data traffic in the form of coordinates and velocity obtained from the GPS tracker. Data format of this standard will facilitate the integration of data in the process of making traffic information on spatial map Google Map API. To get a real time traffic information, the application must be supported by continuous data acquisition. Therefore, the data acquisition was done by placing GPS devices on the vehicle bus Trans Sarbagita. Trans Sarbagita bus is Denpasar city mass transportation services run by the provincial government of Bali.

For data transport, the proposed model used GPRS technology for Internet access. GPRS provides a wireless IP connectivity in a large area for GSM users, so as to support client-server based applications. GPS tracker sent the coordinates and speed of data to the server using the IP network.

In the data processing, the server processed the GPS coordinates and the speed of data into traffic information, and visualized on Google maps. Coordinate data used to visualize the position of the vehicle, while the speed of the data used for the visualization of traffic categories, as well, being, dense and jammed. Further, traffic information disseminated to the public using Web-based media.

IV. IMPLEMENTATION

A. GPS Traffic Flow Diagram to ITMS

Based on Figure 4, this research used bidirectional communication scheme between the GPS tracker device with GPRS/GSM. In this scheme, the GPS tracker and GPRS/GSM can hold information about the position and speed of the Trans Sarbagita bus at any time, and send that information to a web server, as shown in Figure 5. The data sent to the web server used a fixed IP address and port which had been set. Therefore, the GPS tracker that was located at the Trans Sarbagita bus must have an interface with functions: (i) communicates with GPS satellites to get the data position and velocity, (ii) transmit position data and speed to the server GPS via a data communication GPRS / GSM.

For data collection, research used Trans Sarbagita bus travel route as shown in Figure 6. Along this route, the vehicle position and speed can be monitored from the GPS tracker device through GPS satellites.

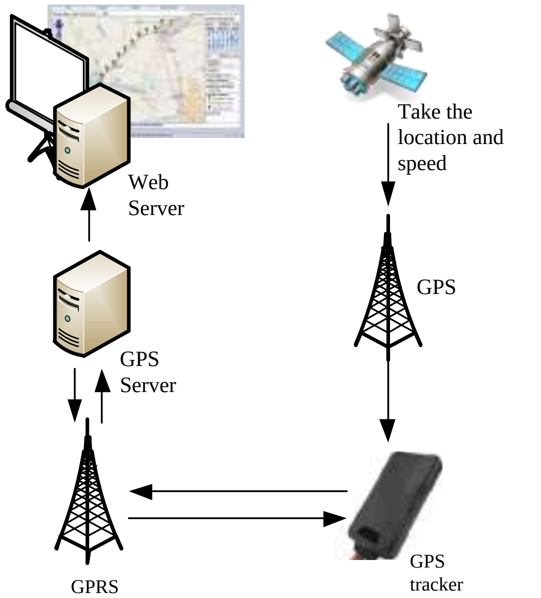

Fig.5 Traffic flow diagram of GPS based ITMS

B. Design of Software

Development of ITMS for the Denpasar city requires two softwares design, respectively for the GPS server, and to the monitoring center.

Fig. 6 Trans Sarbagita bus route map

*1) **GPS server software design:*** In general, GPS server has the primary function of reading the data sent by the GPS tracker, and sent that data to a Web server for the visualization of data traffic. In the GPS server, TCP / IP was responsible for receiving data from the National Marine Electronics Association (NMEA) sent by the GPS tracker device via GPRS to a specific port and IP addresses that have been specified. This data contains the identification number (id) of a GPS device, wherein each GPS device has a unique ID number. As shown in Figure 7, when the GPS tracker was set active (on), he sent a position in NMEA format to the GPS server. Furthermore, the server parses the NMEA data, and extract the latitude / longitude and speed data, and save them to a database.

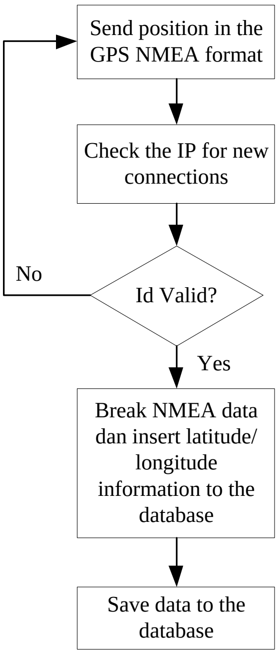

Fig 7. Flow diagram software for GPS server

Further processing of this data can be done, like categorizing road density. To get the appropriate conversion related to the definition of the category of traffic, this paper used speed range proposed by [testifying], as shown in Table 1

TABLE I

CATEGORIES ROAD TRAFFIC DENSITY

Speed (Km/h)	Road density category	Colour
40 – 57	Fluent	Blue
26 – < 40	Medium	Green
17 – < 26	Heavy	Orange
< 17	Jammed	Red

*2) **Designing software for the application interface:*** Figure 8 define the client-server interaction design at the application interface to display the visualization of information on the ITMS. The concept was a GPS server always update the data reading coordinate and speed, and sends it to the Web-GIS server periodically. With this scheme, the visual display of traffic can be displayed according to the traffic category of traffic and updated during Trans Sarbagita bus kept going.

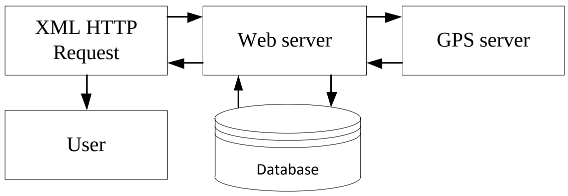

Fig. 8 The client-server interaction design

V. CONCLUSION

This research has proposed the implementation of IoT for ITMS of Denpasar city. Network architecture based GPS/GPRS proposed has the ability to process traffic data into traffic information, such as road density category. Furthermore, visualization of road density category will be displayed to the public through a Web/GIS-based media. With this media, road user will have accurate information about traffic, so as to manage adventures.

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