Mobile Tracking System Using OpenMTC Platform

Based on Event Driven Method

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Abstract— **Mobile tracking system is used to monitor vehicles position and in special cases there are much useful information can be monitored such as speed, cabin temperature and number of passenger. This monitoring process is done using vehicle's position data from satellite through GPS device, and sending the data to a server through GSM modem. This paper proposes new approach on managing all vehicle data using Machine-to-Machine (M2M) communication form which Open Machine Type Communication (OpenMTC) as communication platform for aggregating and processing location data. As a result, the testing showed high accuracy level in transmitting the vehicles position and it can be showed in many devices.**

Index Terms— **GPS, M2M, OpenMTC, Mobile Tracking**

I. INTRODUCTION

Machine-to-Machine (M2M) communication offers a new communication approach that enable connecting billions of sensor objects to actuators. The concept can be implemented in various domains such as logistics, smart environments, energy and asset tracking. This trend is encouraged by the fact of saturation and high competition in the mobile market, which raises the need to introduce new potential services to fulfill the revenue gap. Additionally the evolution in semiconductor industry shrinking lithography continues to reduce chipset cost and power consumption, and embeds more sensors into devices used in different aspects.

Recently, the smart city concept is becoming trend often spoken by many researchers of ICT sector, especially, sector of Next Generation Network Infrastructure (NGNI), Internet of Things (IoT) and Future Internet (FI). Recognizing the need for reliable network infrastructures and the associated challenges, various Standards Developing Organizations (SDO) have recently promoted several standardization activities in the M2M communication domain, just to mention a few: i) the European Telecommunications Standards Institute (ETSI) TC M2M [9-11] mainly focusing on the service middleware layer. ii) 3rd Generation Partnership Project (3GPP) [13] address requirements and functional architecture for Machine Type Communications (MTC). iii) Telecommunications Industry Association (TIA) [14] established the TR-50.1 Smart Device Communications Engineering Committee, aiming to develop an M2M Communications framework that can operate over different underlying transport networks. iv) oneM2M, a consortium of several standards development bodies to reduce the standardization overlap by providing ongoing standards support, and increase the ability of M2M solutions and produces to interoperate [15].

One implementation of M2M ETSI standard is the Open Machine Type Communication (OpenMTC) platform that is developed by Fraunhofer FOKUS [16]. This platform aims to provide a standard oriented middleware platform for M2M oriented applications and services to facilitate research and development of M2M systems. One pre-eminence of OpenMTC platform is the ability to access and process information through standardized application programming interfaces (APIs).

Mobile tracking system is an application for monitoring position of mobile vehicle. Big companies, which have many armadas, use such systems to track and control their vehicles. Not only location information can be aggregated and managed, but also other environmental measurements (e.g. temperature, humidity) can be aggregated to help in improving shipping patterns and assets control. Vehicle position is one piece of information that is needed in monitoring. There is further information that is able to be captured once this position data is available such as vehicle temperature, opening or closing state of the door, relative movement of the vehicle, and so on. Using M2M concepts, this information can be gathered and sent to an administration division for analysis prior to taking decisions aiming to improve the monitoring and control services. Server application has to be modified regarding variation of data types.

This paper proposes new approach by combining these two systems, mobile tracking system and M2M OpenMTC platform technology, aiming to build a scalable system that can be easily adaptable to large scale Smart Systems using M2M technology. The OpenMTC platform provides standard interfaces that assure the interoperability between applications and heterogeneous sensors networks. Data aggregated from the mobile tracking system can be accessed and reused by other services connected to the platform.

This paper presents the work of implementing mobile tracking system that utilizes M2M communication principles. The aim of the work is to verify the efficiency of using openMTC platform in supporting Smart Cities applications such as mobile tracking system. The main advances of the

978-1-4799-0540-9/13/$31.00 ©2013 IEEE

proposed system, comparing to other common fleet management systems, are its scalability and adaptability. The evaluation of the system shows its capability to handle huge amount of data. The adaptation of standard based M2M platforms ensures the adaptability of the system for future opportunity to collaborate with another M2M applications.

The structure of this paper is as follows: Section II presents the principles of mobile tracking system and briefly reviews related work in this area, Section III presents the use of OpenMTC platform as Smart City enabler. Section IV states our implementation of a mobile tacking system using OpenMTC as communication platform. Finally the paper is concluded in Section V.

II. Mobile Tracking System

Monitoring application has been widely implemented like Intelligent Mobile Health Monitoring System (IMHMS) [1] for monitoring public health vehicle movement system. Also, there are several distance monitoring applications like Monitoring system of cyclist and pedestrians [2], Eastern Interconnection Phasor Projects (EIPP) [3], mobile phone location tracking [4], [5], and anti-thief mobile tracking [6] [7]. These applications usually use different communication models and not intended to be used across variety of needs.

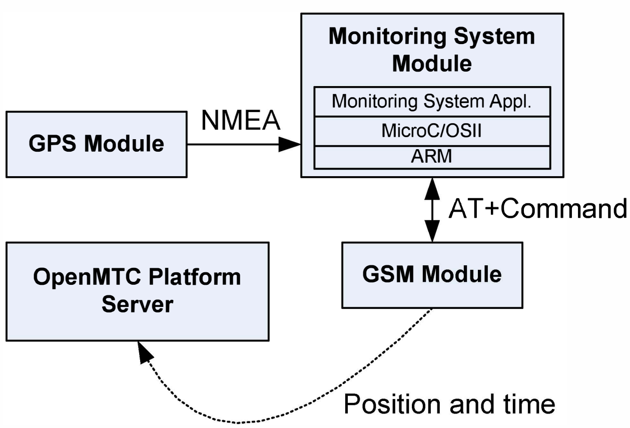

Fig. 1. Mobile Tracking Module

Mobile tracking system can use M2M platform for the implementation. The benefits of employing M2M platform are to increase the automation degree of the system and reduce the errors caused by human-machine interaction. Fig. 1 shows the devices those are used in the system consist of several components such as embedded monitoring system module, GSM and GPS modules.

Embedded monitoring system is hardware with a microprocessor in it. The microprocessor used in this mobile advice is µC Cortex-M4 that consists of three parts namely ARM microprocessor, MicroC OS/II-operating system, and monitoring application.

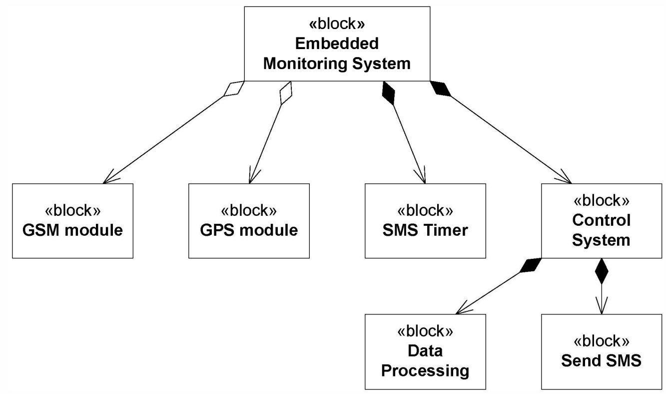

Fig. 2. Module diagram of embedded monitoring system[4]

Monitoring application is supported by seven main modules in embedded monitoring system as in Fig.2, they are GSM and GPS modules, SMS timer, and control system consisting of two sub modules namely data processing and SMS sending.

Operating principle in monitoring modules is event driven method. This method is used for system efficiency that waits for event influenced by GPS module. When position data is received by the system, timer will start for determining time of sending. Then, counter's value is set up by user accord with needs. Module control system works to process data and send SMS. The system with event driven method can operate more effective because it just works after influenced by event from outside.

III. OpenMTC Platform For Smart City

Smart City concepts and implementations are currently widely discussed. Definition of Smart City refers to behavior of a region where some processes of activity are done automatically through communication from M2M. Here, M2M becomes enabler to develop smart city solutions. M2M itself is a standard concept that is already designed by several standard communities, one of them is ETSI. This community defines specification of M2M system as a standard reference for all developers of platform and application.

M2M communications have different traffic characteristics depending on application needs and prioritization. A M2M platform is needed for enabling those different developments effectively. OpenMTC is chosen as M2M platform with this mobile tracking system, for its scalability and ease of development. Fig. 3 shows the OpenMTC architecture. OpenMTC platform that is developed by Fraunhofer FOKUS based on ETSI M2M Rel. 1 specification [9][10][11]. The system is designed by concerning a variety of sensor and actuators technologies in order to be suitable for various use cases.

M2M platform is necessity for handling thousands of sensors and actuators rather than one application for one machine to machine communication. The platform roles as template for various sensor and actuators types.

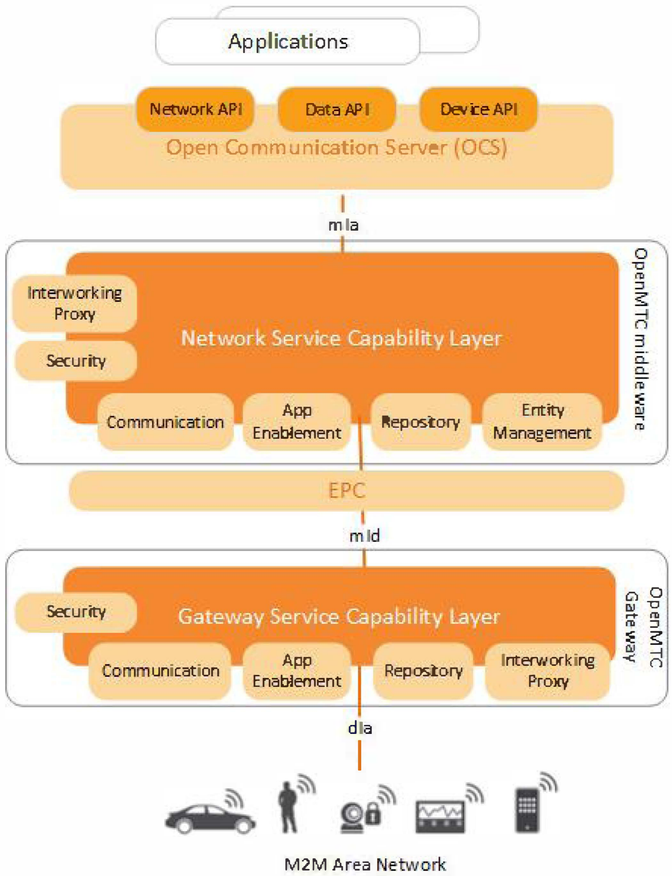

Fig. 3. OpenMTC Architecture

In the Open MTC Platform, a system is divided into four parts namely M2M Network Area in which user's device is located and may be connected through a variety of networks such as ZigBee, Wifi, BlueTooth, etc.

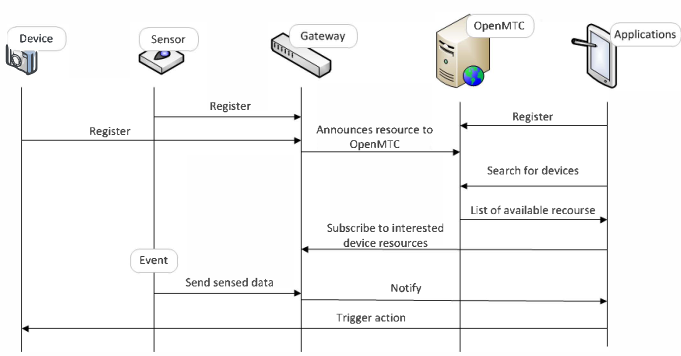

Fig. 4. Message flow of a simple scenario [12]

The second part is Gateway Service Capability Layer (GSCL) that connects between a network and a server. The third part is Network Service Capability Layer (NSCL) in which OpenMTC is implemented.

This part is a middleware that connects between a network and application of user. The fourth part is application domain. OpenMTC platform is designed to be application agnostic, providing a service middleware layer for M2M communications and enable various use cases. Fig. 4. Shows the general message flow in OpenMTC platform and Fig.5. shows the Mobile Tracking System message flow.

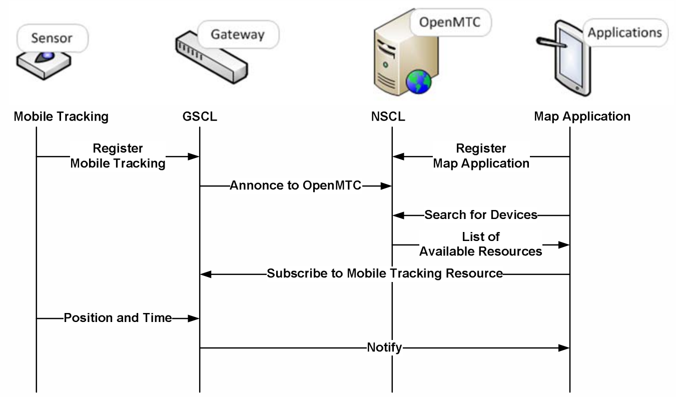

Fig. 5. Message flow of Mobile Tracking System

The strength of OpenMTC Platform is the ability to handle implementation for a variety of sensor and user's application. Flow of messages in of the mobile tracking application is showed in Fig.5. Device and sensor connected to the mobile vehicle are registered into a gateway. Then, gateway informs the OpenMTC core about registered applications and sensors. On the client side, user's application registers them to OpenMTC, in order to be able to get data and updates from sensors thorough the system.

The application can search for devices connected to OpenMTC, and the core server will send information about available resources that meet the search criteria. The application sends a request to the gateway to access required information from the available resource, or subscribe to them, and get notifications when sensor data is received by gateway. If needed, the application will trigger actuator advice to do something according to position of the tracked vehicle.

Since mobile tracking is a real time system, a robust platform which can support real time data transfer among sensors is needed. Real time data generated from mobile tracking system is longitude, magnitude, and time sent from sensors to OpenMTC platform. OpenMTC will process and store input data, and enable the access to them by authorized client's devices via APIs. In the implemented mobile tracking system, the client application has a user friendly graphical interface that shows moving tracked objects on a map according to their position. The location information is received form the OpenMTC platform via notifications.

IV. Implementation and Analysis

Implementing system involves several hardware and software. On the side of moving tracked objects, it consists of hardware of monitoring system, GPS and GSM modules and application of monitoring system.

```
$GPGSV,3,2,12,12,33,104,24,24,24,027,15,14,22,300
,38,18,22,358,29*7B
$GPGSV,3,3,12,31,19,219,32,05,09,108,,22,03,330,,
09,01,030,*76
$GPRMC,090905.000,A,0653.4311,S,10736.6264,E,0.00
,269.11,070113,,,A*7D
$GPVTG,269.11,T,,M,0.00,N,0.00,K,A*30
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89,786.9,M,3.3,M,,*7C
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0.89*03
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7,29,34,185,17*74
$GPGSV,3,2,12,12,33,104,23,24,24,027,15,14,22,300
,38,18,22,358,29*7C
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09,01,030,*75
$GPRMC,090906.000,A,0653.4311,S,10736.6264,E,0.00
,269.11,070113,,,A*7E
$GPVTG,269.11,T,,M,0.00,N,0.00,K,A*30
```
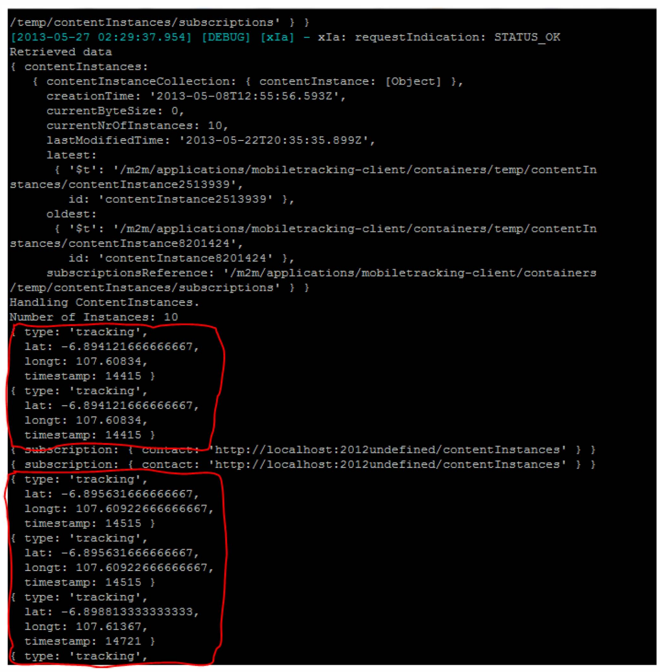


Fig. 6. GPS data example

On the server side there is M2M platform to handle process of receiving information and giving services to application, as depicted in Fig.8 and on the side of user, the system has a web application to show vehicle's position that moves on Google maps, presenting real time movement of the tracked objects.



```
/temp/contentInstances/subscriptions' } }
[2013-05-27 02:29:37.954] [DEBUG] [xIa] - xIa: requestIndication: STATUS_OK
Retrieved data
{ contentInstances:
   { contentInstanceCollection: { contentInstance: [Object] },
     creationTime: '2013-05-08T12:55:56.593Z',
     currentByteSize: 0,
     currentNrOfInstances: 10,
     lastModifiedTime: '2013-05-22T20:35:35.899Z',
     latest:
      { '$t': '/m2m/applications/mobiletracking-client/containers/temp/contentIn
stances/contentInstance2513939',
        id: 'contentInstance2513939' },
     oldest:
      { '$t': '/m2m/applications/mobiletracking-client/containers/temp/contentIn
stances/contentInstance8201424',
        id: 'contentInstance8201424' },
     subscriptionsReference: '/m2m/applications/mobiletracking-client/containers
/temp/contentInstances/subscriptions' } }
Handling ContentInstances.
Number of Instances: 10
{ type: 'tracking',
  lat: -6.894121666666667,
  longt: 107.60834,
  timestamp: 14415 }
{ type: 'tracking',
  lat: -6.894121666666667,
  longt: 107.60834,
  timestamp: 14415 }
{ subscription: { contact: 'http://localhost:2012undefined/contentInstances' } }
{ subscription: { contact: 'http://localhost:2012undefined/contentInstances' } }
{ type: 'tracking',
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  longt: 107.60922666666667,
  timestamp: 14515 }
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  timestamp: 14515 }
{ type: 'tracking',
  lat: -6.898813333333333,
  longt: 107.61367,
  timestamp: 14721 }
{ type: 'tracking',
```


Fig. 7. Position data in base64 coding form

A vehicle's position is detected by taking information from satellite data received by GPS module. The data received by system is still crude. Position data received by monitoring system is processed by concerning timer, furthermore sent to OpenMTC using SMS media. This sending process is periodically done and determined by user. Fig.6. shows GPS data example.

Information received by OpenMTC gateway will be forwarded to the user application, which has previously subscribed to it using the OpenMTC APIs. Fig.7. shows encoded data in base64. The data is processed and adapted by Google map format then displayed in form of Google map.

Fig. 6 shows an example of data received from the GPS module as event that triggers the process in the system. This crude data is processed becoming information that consists of three parts namely longitude, latitude and time position. This information is sent from monitoring module to OpenMTC platform gateway.

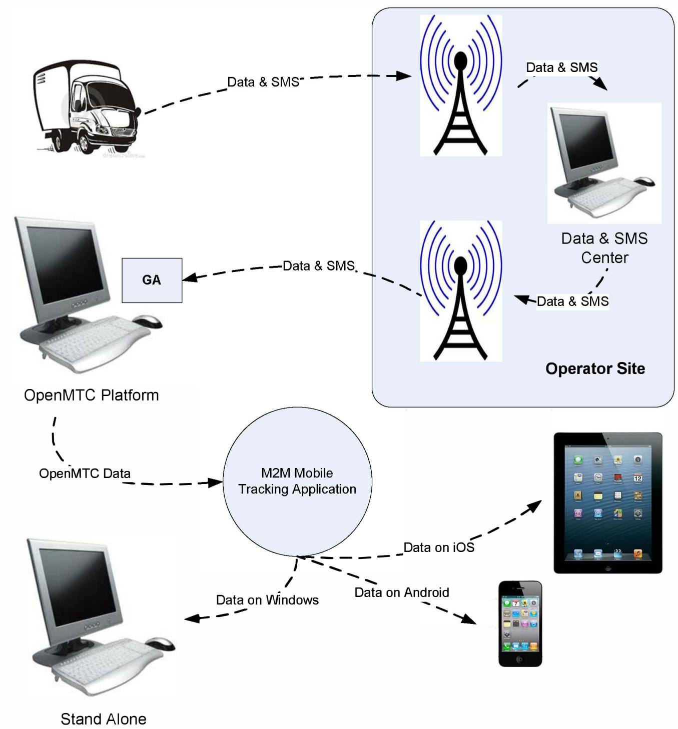

Fig. 8. Monitoring System on OpenMTC Platform Architecture

AT-Command standard is used to control GSM module. It is sent to GSM module and its reply uses interval interface. Sending data is done by using SMS. These are the following steps of sending SMS:

1. The sent SMS format is text, AT+CMGF = 1.
2. Send SMS, AT+CMGS="<+DestinationNumber>".
3. SMS content.
4. Send character as the last limit of SMS, 0x1A.

Information received in the side of OpenMTC platform is data text with base64 code that is processed in OpenMTC module.

Information from gateway is continued by system and then captured by web application to be converted into world map and showed it. Overall monitoring system is showed in Fig.8.

The data are presented in Google map showing points of vehicle's position, which has been captured from OpenMTC server. The data of the position is showed up and collaborated with Google map. The result of this implementation shows that using OpenMTC platform as middleware that connects data from outside to the application has worked effectively. Fig. 9 shows the final view in Google map.

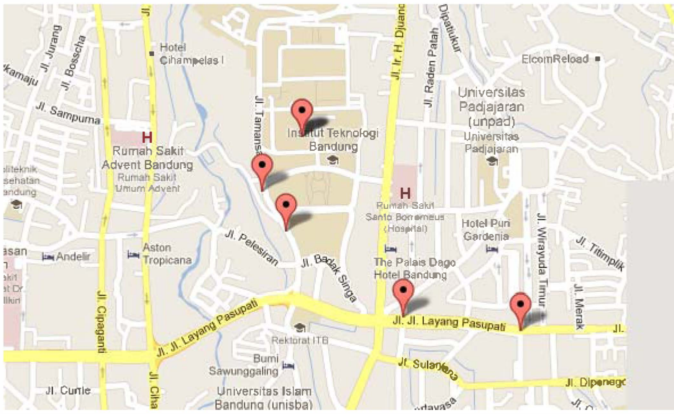

Fig. 9. Vehicles location presented on Google map

V. Conclusion

This paper shows the result of implementation a mobile tracking application using M2M communication technology. The system has been successfully implemented on the OpenMTC platform. The result of the implementation shows high accuracy of the system in monitoring the position of tracked objects. More information such as speed, cabin temperature and number of passenger can be gathered from the tracked devices, to enable further processing and improvement of the monitoring and controlling service. The proposed approach offers scalable and adaptable mobile tracking system. Scalable means M2M communication can handle numbers of objects and they can communicate with another M2M environment.

ETSI M2M provides a sound foundation to address the entire M2M eco-system and to accelerate the development and re-use of services not just only by specifying common service capabilities but also by smoothly integrating existing solutions into the platform through interworking proxies.

Acknowledgment

Maman Abdurohman thanks to Universitas Telkom, Fraunhofer FOKUS and Lab ELKA STEI ITB that have supported financially and laboratory resources in this research . Also thanks to Sidik Prabowo and Ricky Henry Rawung for helping in implementation. This research fully funded by Universitas Telkom in the Kemitraan Research Scheme.

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