# M2M Middleware Based on OpenMTC Platform for Enabling Smart Cities Solution

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**Abstract.** M2M middleware is needed to avoid silo systems on smart city solutions. The middleware serves as an enabler for the basic process of communication between machines based on the machine type communication. This paper proposes OpenMTC platform as M2M middleware solutions for smart cities. OpenMTC is a platform that communicate data between machine-server-machine without human intervention. Some solutions are implemented on OpenMTC platform such as mobile tracking, early warning of forest fires and water pollutant monitoring systems. The result shows that OpenMTC, empirically, has capability as reliable M2M-Middleware for some smart cities applications.

**Keywords:** M2M · Middleware · OpenMTC · Smart city

## 1 Introduction

The era of human-to-human communication may soon decreased and be replaced with machine-to-machine communication. This phenomenon occurs in line with the increasing role of machines in a variety of applications that can not be done manually by humans. BTS information control process, temperature control container, tracking, are some applications that require the involvement of the machine for efficiency.

The sensor has an important role in collecting information from the environment. Through a variety of networks such as wireline and wireless, information collected from the environment to the server for further processing. Data obtained from the sensor can be used for decision making as activates particular actuator or sent to the user as information.

Technology changes the way people view the environment. Smart city is a new concept that is becoming a trend nowadays. This viewpoint is supported by many researchers from the ICT sector, in particular, the infrastructure sector Next Generation Network (NGNI), the Internet of Things (IOT) and Future Internet (FI). This development is supported also by the international standardization body in M2M communication domain, such as: (i) European Telecommunications Standards Institute (ETSI) TC M2M [1–3] on middleware. (ii) 3rd Generation Partnership Project (3GPP) [4] on Machine Type Communication (MTC). (iii) The Telecommunications Industry Association (TIA) [5] established the TR-50.1 Smart. (iv) oneM2M, a consortium of the development of standards to improve the ability of M2M solutions [6].


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Fraunhofer FOKUS has developed Open Type Machine Communication (OpenMTC) platform based on the ETSI standard [7]. This platform serves as a standard-oriented middleware for M2M applications and services oriented to facilitate research and development of M2M systems [9]. One advantage OpenMTC platform is the availability of a standard application programming interface (API) to access data and information. There are many research and implementation of OpenMTC platform in the real world [8, 9, 11–13].

Smart cities has no definite concept. In terms of information and communication, smart cities can be seen as ICT infrastructure of the city. A town called smart city characterized by an intelligent ICT infrastructure that can improve the control efficiency compared to the manual process. The city's air pollution control, fire control and tracking of vehicles are some examples of processes those would be more efficient by using an intelligent ICT infrastructure such as M2M communication.

Other issues in the smart cities are smart community development and urban planning in favor of nature. Nature is a finite resource that needs to be managed intelligently to sustain support society needs.

There are several stakeholders involved in the development of smart city those are academic, business, community and government. Each stakeholders have important role in developing smart city system.

This paper discusses the role of academic and technology as an enabler to realize smart city environment in terms of M2M communication. M2M communication has a fundamental role to realize the intelligent infrastructure related to the communication between devices. In the smart city there are a lot of devices that communicate each other without human involvement.

OpenMTC platforms need to be tested for implementing different M2M applications with topics related to smart city solution to test the reliability of middleware as M2M communication backbone in smart city.

## 2 OpenMTC Platform for Smart Cities

Smart City currently widely discussed as a standard concept and also implementation. Smart City definition refers to behavior of a region where some processes of activity are done automatically through communication machine-server-machine without human intervention [9]. M2M communication becomes key enabler to deploy smart city solutions [7, 10]. M2M is a concept that is already designed and standardize by several standard communities, such as ETSI standard for Europe region. This standard body defines M2M system specification as a standard reference for all developers of platform and application [6, 7, 10].

M2M communication has different traffic characteristics based on application needs and prioritization. A M2M platform is needed for enabling those different developments effectively [9–11]. OpenMTC is chosen as M2M platform because of its scalability and compatible with many kinds of sensor system. Figure 1 shows the OpenMTC platform architecture that is developed by Fraunhofer FOKUS based on ETSI M2M Rel. 1. [1–3]. The system is designed as a middleware platform by concerning a variety of sensors, actuators and data transmitter technologies in order to adjust to various use cases.

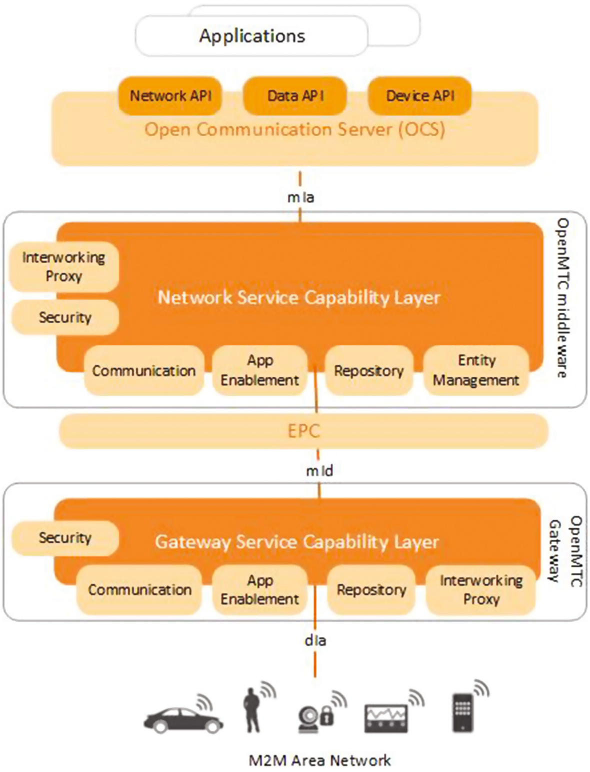


**Fig. 1.** OpenMTC platform architecture [10]

OpenMTC platform as a middleware has an ability for handling thousands of sensors and actuators rather than one M2M application [9]. The platform communicates various sensor, actuators and user application. OpenMTC Platform is divided into four parts namely M2M Network Area in which devices are located and connected through a variety of networks infrastructure such as Wire line, ZigBee, Wifi, GPRS and Bluetooth [9, 11]. The second is Gateway Service Capability Layer (GSCL) that connects between a Network Area where devices located and a server [9]. The third is Network Service Capability Layer (NSCL) were OpenMTC is implemented as a middleware platform to support user application. The fourth is user application domain [9–11].

OpenMTC platform is designed to be application agnostic, providing a middleware layer for M2M communications [9]. Figure 2 shows the message flow in OpenMTC platform that involves five parts of system namely: devices, sensors, gateway, OpenMTC server and user application. Sensors and devices connect to the system through gateway. Gateway informs OpenMTC server all devices and sensors those connect to the system. Once user applications register and search for devices, OpenMTC server will send all available devices list to them. User applications can choose one of many sensors needed to the gateway. While gateway accepts data from suitable sensors, it will sent notification data directly to application. The user application can send trigger data to actuator device to do something.

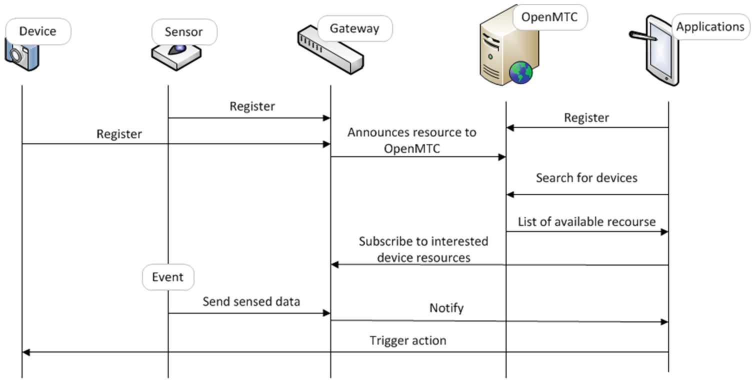


**Fig. 2.** Message flow of a simple scenario [10]

In addition to OpenMTC platform, there are many platforms those implemented as commercial goods like Axeda. In general both have the same function as an enabler for smart city application as a middleware. In detail both platform are incomparable because OpenMTC designed for laboratory and university version, meanwhile Axeda for commercial purpose.

# 3 Smart Cities Infrastructure Applications

There are many cases those need to implement as M2M application, four among of many applications are mobile tracking, nature pneumatic pressure monitoring, early warning of forest fires and water pollutant monitoring systems. All application connect to OpenMTC platform using various communication technologies. Those application have been implemented and tested based on OpenMTC platform.

## 3.1 Mobile Tracking System

First application is mobile tracking system. Figure 3 shows message flow of this application from sensor to gateway, OpenMTC server, and application. Sensors of mobile tracking located on vehicular will register to GSCL gateway and then GSCL will send these data to OpenMTC NSCL. The user application, map application, can search the devices that connected to OpenMTC GSCL [9].

The core server will send information of resources availability that meet the search criteria [9]. The user application sends a request to the GSCL to access required information from the available resource, or subscribe to them, and get notification when sensor data is received by gateway [9]. Sensors send position and time data to gateway. Gateway notifies sensor positions and time to application.

On sensor side, there is one device that collect raw data from sensors and send it the gateway. Figure 4 shows the mobile tracking module that connect to GPS module and GSM module. Mobile tracking system module consists of hardware and software parts.

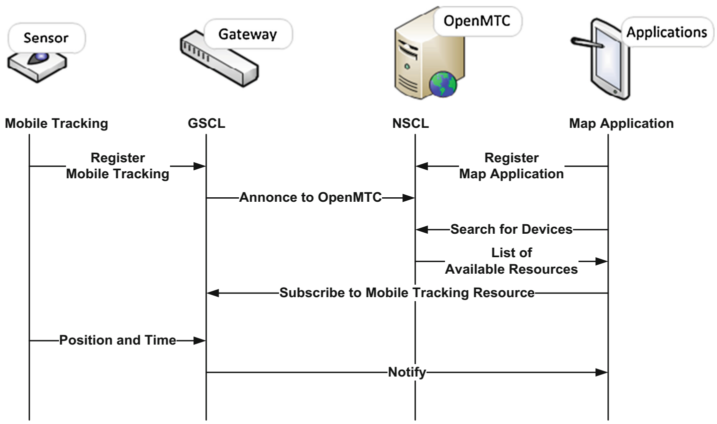


**Fig. 3.** Message flow of mobile tracking system [9, 11]

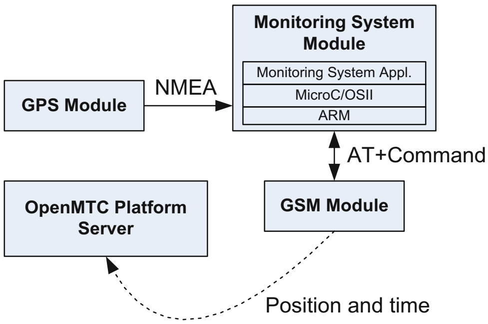


**Fig. 4.** Mobile tracking module [9, 11]

The microprocessor used in this mobile device is ARM microprocessor with MicroC OS/II-operating system and monitoring application [9]. Figure 5 shows the software modules of tracking system such as GSM and GPS modules, SMS timer, and data processing and SMS sending modules.

GPS module will send longitude, latitude and time data to monitoring system device periodically. Device will send those data to server gateway periodically regarding SMS Timer. Gateway notifies map application and data will showed in the map application that can be accessed by any devices.

### 3.2 Early Warning Forest Fire System

Early warning forest fire system is a system that monitor and control to avoid forest fire. This system connects many sensors in the forest to monitoring application (Fig. 6) [12].

The system divided into three parts, namely Device app, OpenMTC platforms, and devices other app that allows you to display the data. Device app is a set of sensor networks and gateways are connected to GSCL [12].

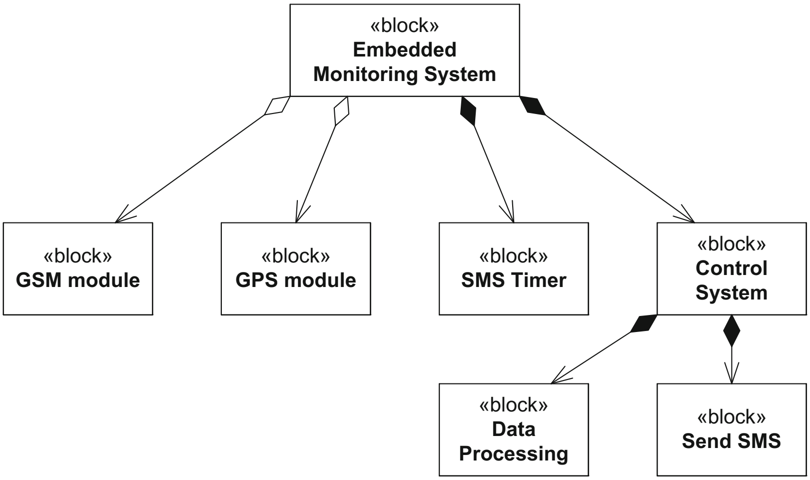


**Fig. 5.** Module diagram of tracking system [11]

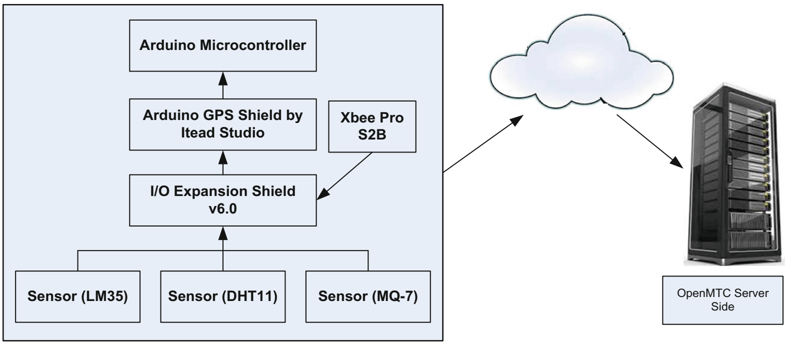


**Fig. 6.** Diagram of early warning of forest fires system [12]

The sensor network consists of several sensors, microcontrollers, XBee Pro S2B, GPS module, power supply, and I/O expansion shield [12]. The sensor is used to acquire the data early warning of forest fires surrounding environment is processed by the microcontroller and transmitted using XBee Pro S2B module to the gateway. Gateway on device app consists of modules XBee Pro S2B and a computer that acts as the coordinator node for receiving data to be entered into the application on the computer of the sensor device via a ZigBee network [12].

On the other side OpenMTC platform collect the information and send to early warning forest fire system. These information updated periodically regarding the need of user by configuring the timer parameter [12].

### 3.3 Air Pollution Control System

Air pollution Control System is a system that control number of pollution on the air. Air pollution detection system is divided into 4 parts: M2M Devices, M2M Gateway, M2M and M2M Application Server [13]. M2M Device is a combination device consisting of two sensors (PM and CO), microcontroller, power supply, XBee as an End Node, and Expansion Shield [13]. Expansion Shield is used to connect sensors and XBee with microcontroller (Fig. 7) [13].

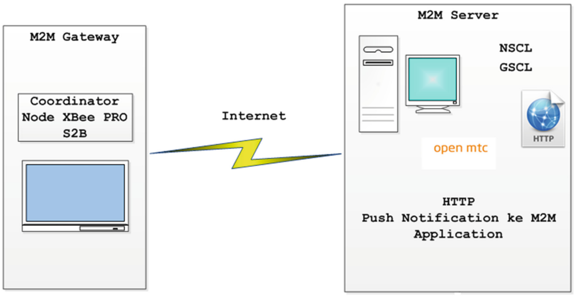


**Fig. 7.** Diagram of air pollution detection system [13]

M2M Gateway consists of Coordinator NodeXBee and computer. Data sent by the M2M Device through ZigBee networks [13]. The computer will perform the data conversion to XML format base64 to be received by the M2M Server. M2M Server consists of a computer equipped with M2M platform OpenMTC. Air pollution monitoring data into the server will be processed in order to be able to do a push notification to the M2M Application and displayed through the website.

## 4 Result and Analysis

These analysis to the experiment results have done for evaluating the reliability of OpenMTC as M2M platform on handling the various data coming from various sensors with different types of vendors and communication networks. OpenMTC gateway collects those data in the same way and compatible with various device standards (Fig. 8).

These analysis focusing on evaluation the final result of application on the top of OpenMTC platform those captured at user interface.

These experiments will show the empirical prove and analysis of implementation some application on the top of the OpenMTC platform. All experiments show OpenMTC performance for handling various data from various devices.

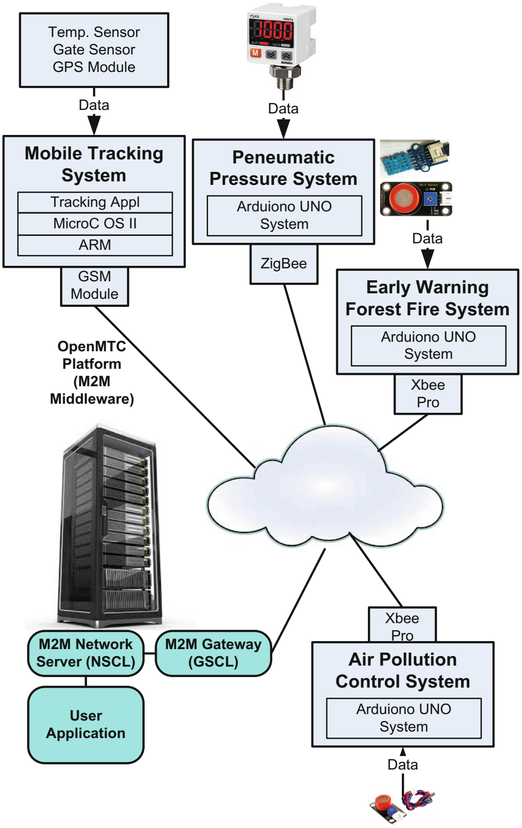


**Fig. 8.** OpenMTC - M2M middleware implementation

### 4.1 Mobile Tracking System

On a mobile tracking system: vehicle position obtained from the GPS module. This data is processed in order to obtain the position of the vehicle which is then sent via a GSM module to the server OpenMTC. The data accepted on server side consist of longitude and latitude position and also time stamp when the data captured.

Longitude and latitude position will get as coordinate of the vehicles. The data is displayed in the Google Map. Data taken periodically to show the tracking of vehicles time to time. Figure 9 shows the five points that show the vehicle position in Bandung City, Indonesia.

### 4.2 Early Warning Forest Fire System

In early forest fire system, the humidity sensor accuracy compared with hygrometer HTC-2 has a difference of $\pm$ 0.6435 %. This difference is still within the tolerance value that indicates measuring DHT11 sensor has worked well.

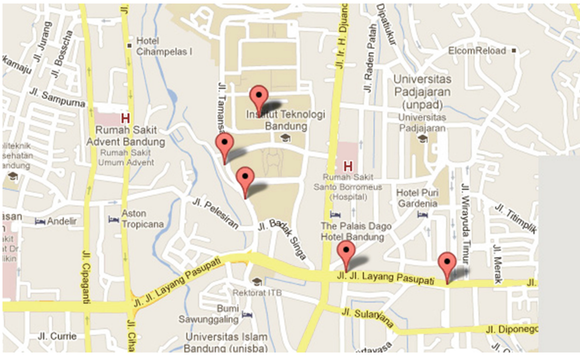


**Fig. 9.** Map of Mobile Tracking System [9, 11]

Accuracy of temperature sensor is shown by comparison of the infrared thermometer with low temperature difference between the results and the room temperature by 0.9 ° C. The temperature difference is within the tolerance limits indicated temperature sensor LM 35 has worked well.

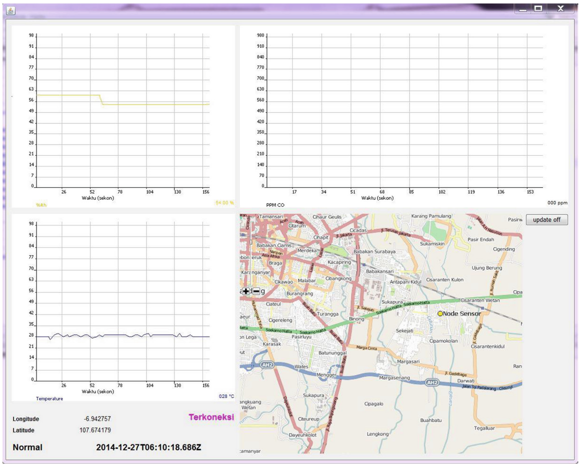


**Fig. 10.** Early warning forest fire system [12]

Figure 10 shows the result of early warning forest fire system that located on Kamojang forest, Garut, West Java, Indonesia. The sensors put on the tree regarding the safety position, quite high from the land. Monitoring system application will show the forest condition temperature to avoid the overheat temperature of the forest. Once overheat temperature captured by the system, this application will show in the application.

### 4.3 Air Pollution Control System

Air pollution control system experiment places some sensors in Buah Batu Area, Bandung, West Java, Indonesia. Those sensor set to sense in the morning and afternoon. Those experiment done many times to get the average values or constant condition. Figure 11 shows the result of the experiments.

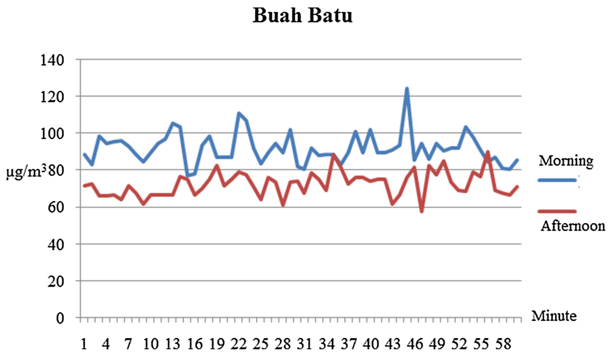


**Fig. 11.** Pollution control system [13]

Pollution control system placed on Buah Batu area, Bandung, Indonesia and the data will show in the application as Fig. 11 shows. There are two data shown in the user interface application, the data those captured in the morning and in the afternoon. The data shows constants differences between morning data and afternoon data. The results of pollution measurement system shows that the system has detected accurately pollution. Data is sent to OpenMTC and displayed in the user's application.

## 5 Conclusion

Based on several empirical experiments, the results show that OpenMTC platform can handle all the M2M data well according to data on sensor side. As long as experiments the server gateway could interacts with various sensors. OpenMTC can act as middleware that communicates M2M data from sensors side to user application. Data received on the user side shows the level of accuracy in accordance with the conditions on the ground. These experiments show the proven of OpenMTC as a platform that has good performance in handling the various data M2M. As a discussion, it needs to prove the robustness of OpenMTC platform regarding abundant of smart city data those should be collected from a lot of sensors in the city and communicate it to many user applications.

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## References

1. ETSI TS 102 689 V1.1.2: Machine-to-Machine communications (M2M); M2M service requirements (2011)
2. ETSI TS 102 690 v1.1.1: Machine-to-Machine communications (M2M); Functional architecture (2011)
3. ETSI TS 102 921 v1.1.1: Machine-to-Machine communications (M2M); mIa, dIa and mId interfaces (2012)
4. 3GPP: System Improvements for Machine-Type Communications, TR 23.888 V0.5.1., July 2010
5. Telecommunications Industry Association. http://www.tiaonline.org/tags/m2m
6. OneM2M. http://www.onem2m.org/
7. OpenMTC. http://www.open-mtc.org
8. Suryani, V., Rizal, A., Herutomo, A., Abdurohman, M., Magedanz, T., Elmangoush, A.: Electrocardiagram monitoring on OpenMTC platform. In: 2013 IEEE 38th Conference on Local Computer Networks Workshops (LCN Workshops), pp. 843–847, 21–24 October 2013
9. Abdurohman, M., Herutomo, A., Suryani, V., Elmangoush, A., Magedanz, T.: Mobile tracking system using OpenMTC platform based on event driven method. In: 2013 IEEE 38th Conference on Local Computer Networks Workshops (LCN Workshops), pp. 856–860, 21–24 October 2013
10. Elmagoush, A., Coskun, H., Wahle, S., Magedanz, T.: Design aspects for a reference M2M communication platform for smart cities. In: 9th International Conference on Innovations in Information Technology, Innovations 2013, Al Ain, UAE, 17–19 March 2013
11. Abdurohman, M., Sasongko, A., Rawung, R.: Mobile tracking system based on event driven method. Appl. Mech. Mater. **321–324**, 536–540 (2013)
12. Herutomo, A., Abdurohman, M., Suwastika, N.A., Prabowo, S., Wijiutomo, C.W.: Forest fire detection system reliability test using wireless sensor network and OpenMTC communication platform. In: 2015 3rd International Conference on, Information and Communication Technology (ICoICT), pp. 87–91, 27–29 May 2015
13. Besari, P.A.L., Abdurohman, M., Rakhmatsyah, A.: Application of M2M to detect the air pollution. In: 2015 3rd International Conference on Information and Communication Technology (ICoICT), pp. 87–91, 27–29 May 2015