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X'MOS-IOT: IOT BASED MOSQUITO SPRAY DISPENSER SYSTEM

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ABSTRACT

Dengue remains among the major causes of mortality worldwide. Many research and medical institutions are still investigating a treatment or vaccine and vector control that would be a key strategy for dengue fever prevention. We introduce Intelligent Mosquito Spray Dispenser system X'MOS-IOT, an innovative concept that includes IR4.0 for the cloud storage automation as well as data analytics and exchange across cyber-physical systems and cognitive computing. The X'MOS-IOT provides a solution for spray interval automation using sensor and battery optimizations with direct Wifi module technology. The device is equipped with X'MOS spray mini aerosol repellent, offering effective environmentally friendly Aedes mosquito control. This all-in-one system ensures a mosquito-free environment in your home. The implementation shows the X'MOS-IOT system is able to update the level of each X'MOS in X'MOS-IOT devices, reducing the cost of manual human checking for X'Mos refill.

2020 Mathematics Subject Classification:
2020 ACM Computing Classification Codes:

INTRODUCTION

Dengue is a virus that spreads by infected Aedes aegypti (*aegypti)* and Aedes albopictus (albopictus) mosquitoes biting humans. Symptoms develop within fourteen days of infection. Dengue can be severe and affects people including infants, young children and adults, but seldom causes death. Because of its severity, dengue remains a serious disease monitored by the World Health Organization (WHO). Many products have been introduced as the preventing and combating mechanism. In this paper, we introduce an auto-spray dispenser designed to combat the Aedes mosquito by utilising Internet of Things (IOT) technology. This is a joint effort between academic institutions and industry involved in vector-borne disease control programmes.

Many emerging domains especially in the fields of medicine, engineering, agriculture, marine and fisheries, automotive and computing and robotics require cutting-edge technologies to replace manual operation and improve cost efficiency. Section 2 of this paper explores related work on smart IOT dispensing systems, Section 3 illustrates the X'MOS-IOT project, Section 4 explains the experimentation being done, Section 5 describes and discusses the results, and Section 6 provides the conclusion and describes future works.

RELATED WORKS

Smart Dispensing System for Remote Area [1] is designed for medicines and quick diagnosis of patients during emergencies. The author used embedded microcontroller which includes global system for mobile communication (GSM), RFID reader, medicine dispenser, heartbeat sensor, temperature sensor and blood pressure sensor to control the function of each component. Agribot [2] is a smart water framework tool using IOT that is designed for agriculture. It minimizes water use and waste. The proposed tool improves water usage in a cost-effective mechanism and minimizes the effort to achieve precision agriculture. It utilizes the Arduino UNO microcontroller with the Wifi module. Other components include a DC motor (to control the wheels), stepper motor (to control the seeds), relay board (to control various activities) and a pump motor to spray and spread the fertilizer, with an automatic flush and shut-off function. The work by [3] proposed a wireless robot with multiple sensors to take the measurements of different environmental parameters. The robot is developed with Raspi 2 B hardware model. It can execute tasks such as sensing moisture, scaring away birds and animals, spraying pesticides, moving forward and backward and to switch the ON/OFF button of the electric motor. The work by [4] aims to provide an automated medical aid due to the high rate of death as the results of poor medical services by the authority. The project used components such as Raspberry Pi 3, temperature sensor (DS18B20), Load cell to measure weight, load cell amplifier (HX711), that is a 24-bit analog to digital converter (ADC), a pulse sensor to measure the heart rate, pressure sensor, servo motor for a vending machine with 360 degree rotation and SG9U SERVO that can rotate 180 degrees. The four modes of communication defined in [5] are wireless system, power cabling systems, hardwired systems and internet protocol systems. The authors developed the prototype Smart Home Controlled System (SHCS) using Arduino IDE platform (APC220 wireless module and Ethernet W5100) and sensors like ultrasonic, Passive InfraRed (PIR) sensor, gas and temperature sensor. The experimental results show SHCS was successfully tested at the prototype phase as well as in the real environment. The results indicate very low error percentage and improved manual operation in a traditional home since the SHCS can be controlled through IOT or smartphone.

An effort is initiated to present a complete IOT conceptual approach in the development and implementation of system to enhance bathroom safety [6]. The components that are suggested are leak detection sensor to detect leakage in the floor, a digital light sensor to measure the intensity of light radiation, voice detection sensor for acoustic detection and signals of noise, pressure sensor to detect the magnitude of contact pressure that detect a person's status in the toilet or bath tub, positional sensor (GYRO/Accelerometer/Manometer) to detect tilt, pitch and inclination, motion sensor to detect movement and water flow sensor in searching for water leakage. The paper demonstrates tremendous potential IOT, especially for bathroom safety for the elderly. A smart controlling and monitoring of beehives is done in [7] using the Arduino Uno ESP8266 microcontroller board with a humidity and temperature sensor in a beehives colony.

An Aedes mosquito trap equipped with water-based sensor to detect pheromone level was an effort in [8-9] in a project named as iMHS. They developed the circuit board embedded with ESP8266 as the main microcontroller board. Finally, a system called the Intelligent Tissue Dispenser System (iTDS) [10] is proposed in detecting the status of toilet tissue located in each public toilet in one of the airport in Singapore. The next section illustrates the proposed system in detail with the components that we use during project development.

PROJECT DESCRIPTION

In this section we discuss how the X'MOS-IOT project is initiated with the collaboration of the product component from industry.

Project Brief

The X'MOS-IOT project is a combination of technologies that comprises the iMOS dispenser, a product manufactured by DrMOS Healthcare Sdn. Bhd., the X'MOS spray repellent and IOT components. The iMOS dispenser is used as a storage compartment to install the X'MOS spray. The X'MOS spray is an Aedes mosquito repellent from One Team Network Sdn. Bhd. The IOT components used are the Node MCU ESP8266 Wifi Module [11], DC geared motor [12], resistor [13] and 3V battery [14]. These components are depicted in Figure 1 to Figure 5.

Figure 1: iMOS dispenser and X'MOS spray

Figure 2: Node ESP8266

Figure 4: 3V battery

Figure 3: DC geared motor

Figure 5: Resistor

The first IOT component is Node MCU ESP8266, an Arduino microcontroller to gather sensor data and provide connectivity to the gateway for transmitting data. It has micro-USB for flashing or reprogramming via Arduino IDE and can be operated from min 3.3V and 5V power regulator to stabilize output voltage and provide more flexibility in the type of sensor to be used. It also acts as the direct Wifi module for data transmission to a cloud environment.

The second component is DC geared motor, used for pressing the spray lid. It is a combination of motor and gearbox. The gear motor can reduce speed while increasing torque output. The third component is resistor, to stabilize power by reducing the flow of current, adjusting the levels of signal, dividing the voltages, biasing the active elements and terminating transmission lines, among other uses. The fourth component is the 3V battery, which is the power source to the X'MOS-IOT circuit. The complete circuit board is shown in Figure 6.

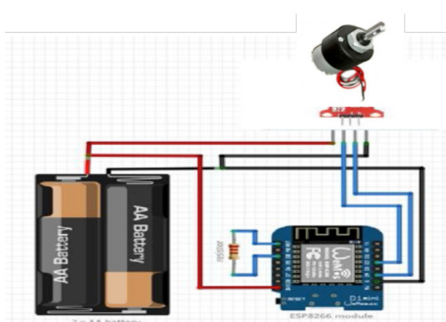

Figure 6: X'MOS-IOT circuit board

Setting Area

A feature of X'MOS is that after a period of use, many vectors, including cockroaches and ants, will stay away from areas sprayed with the solution. A 250 ml of X'MOS can cover up to 300 square ft, but it depends on spraying frequency and the use of the area (room, living room or office area). The proposed spraying intervals according to room type is given in Table 1.

Table 1: Proposed setting for X'MOS-IOT spray interval

Room Type (no of Imos to be Installed)	**Start Time**	**End Time**	**Spray Interval**	**Xmos Exchange Interval (Day)**
Living Room (1)	A: 6.00 am B: 5.00 pm	A: 6.12 am B: 5.12 pm	1 min (12 sprays) 1 min (12 sprays)	33 days
Kitchen (1)	A: 6.00 am B: 5.00 pm	A: 6.12 am B: 5.12 pm	1 min (12 sprays) 1 min (12 sprays)	33 days
Bed Room (1)	A: 9.00 pm	A: 9.12 am	1 min (12 sprays)	66 days
Kindergarten / day care *entrance (1) *back door (1) *each class room (1)	A: 6.00 am B: 12.00 pm	A: 6.12 am B: 12.12 pm	1 min (12 sprays) 1 min (12 sprays)	33 days
Office *entrance (1) *back door (1) *each room (1)	A: 6.00 am B: 12.00 pm	A: 6.12 am B: 12.12 pm	1 min (12 sprays) 1 min (12 sprays)	33 days

Because of the manual operation, a few precautions need to be taken to ensure the optimum effect first, record the installation date, and set X'MOS exchange date as a reminder in dealer's smart phone calendar. Second, check battery after ten months. Third, estimate the area of the premises and deploy one unit of X'MOS-IOT for every 300 square ft. Fourth, do not switch on the exhaust fan after the X'MOS-IOT has applied the solution to avoid venting out the solution. And lastly, the device should be set at the entrance (door) or near the window about 6" from the ceiling to ensure total spraying coverage. The proposed setting area is illustrated in Figure 7.

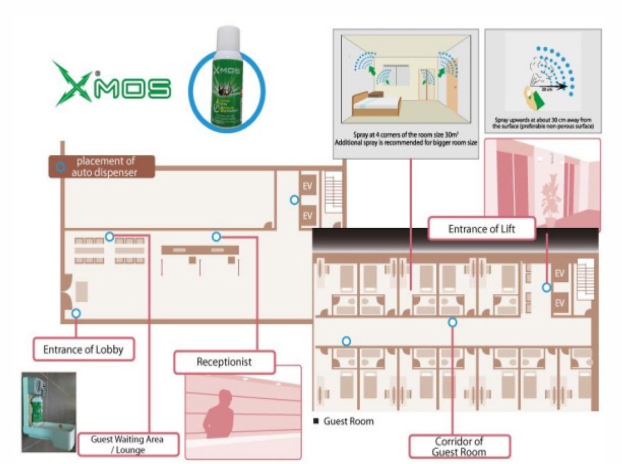

Figure 7: The illustration of X'MOS-IOT installation in a building

EXPERIMENTATION

Experimentation is done in Acer Intel Core i5 with 8GB RAM. The X'MOS-IOT system is developed with open source programming language Php and MySQL Database Management System with Xampp control engine. The address is https://mospryiot.musproject.com.

Device Setup

The internals of the iMOS dispenser is shown in Figure 8. The complete circuit board is attached to the iMOS dispenser as in Figure 9 and 10, while the resistor is connected between the battery and the DC gear motor for power stabilization, as depicted in Figure 11.

Figure 8: The internal view of iMOS dispenser with the attached X'MOS-circuit board

Figure 9: The view of X'MOS-IOT circuit board inside the upper cover

Figure 10: Closer view of X'MOS-IOT circuit board once attached with the upper cover

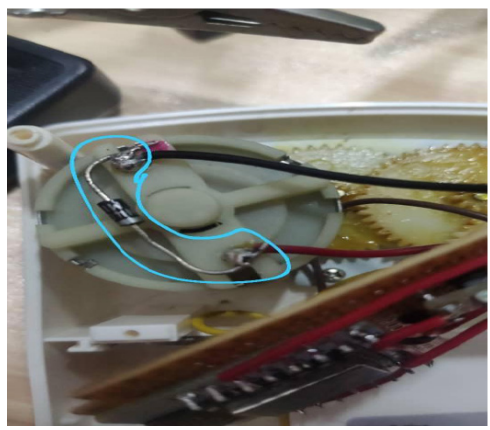

Figure 11: Connection of resistor between the battery wire and the DC gear motor wire

The X'MOS-IOT Interfaces

The X'MOS-IOT system that can be accessed through mobile apps. The interface of the mobile system are shown in Figure 12 to Figure 19.

Figure 12:
X'MOS-IOT main menu

Figure 13:
Username and password entered

Figure 14:
Status of battery

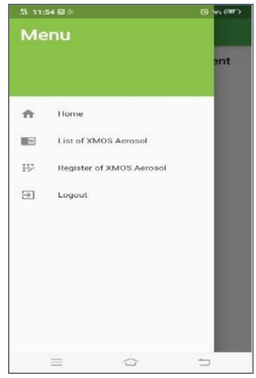

Figure 15:
Other menus in X'MOS-IOT

Figure 16: Register of new device of X'MOS-IOT

Figure 17: Select the location of device to be installed

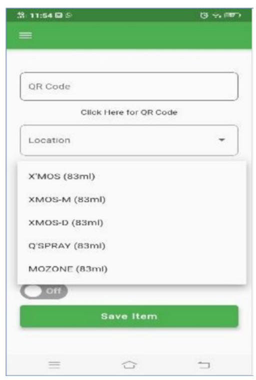

Figure 18: Select the type of the X'MOS spray

Figure 19: Status of X'MOS-IOT devices at different location

RESULT AND DISCUSSION

From the experimentation, we collect data of X'MOS spray in one bedroom (pilot location) from 01/01/2021 until 10/2/2021. Data is collected from spray ID (DISP001) in two measurement i.e. spray level and battery level. The results are tabulated in Table 2.

Table 2: Proposed setting for X'MOS-IOT spray interval

DISP-ID	Location	Date	SP-Level	Bat-Level
DISP001	BEDROOM	1/1/2021	800	3.000
DISP001	BEDROOM	2/1/2021	780	2.996
DISP001	BEDROOM	3/1/2021	760	2.992
DISP001	BEDROOM	4/1/2021	740	2.988
DISP001	BEDROOM	5/1/2021	720	2.984
DISP001	BEDROOM	6/1/2021	700	2.980
DISP001	BEDROOM	7/1/2021	680	2.976
DISP001	BEDROOM	8/1/2021	660	2.972
DISP001	BEDROOM	9/1/2021	640	2.968
DISP001	BEDROOM	10/1/2021	620	2.964
DISP001	BEDROOM	11/1/2021	600	2.960
DISP001	BEDROOM	12/1/2021	580	2.956
DISP001	BEDROOM	13/1/2021	560	2.952
DISP001	BEDROOM	14/1/2021	540	2.948
DISP001	BEDROOM	15/1/2021	520	2.944
DISP001	BEDROOM	16/1/2021	500	2.940
DISP001	BEDROOM	17/1/2021	480	2.936
DISP001	BEDROOM	18/1/2021	460	2.932
DISP001	BEDROOM	19/1/2021	440	2.928
DISP001	BEDROOM	20/1/2021	420	2.924
DISP001	BEDROOM	21/1/2021	400	2.920
DISP001	BEDROOM	22/1/2021	380	2.916
DISP001	BEDROOM	23/1/2021	360	2.912
DISP001	BEDROOM	24/1/2021	340	2.908
DISP001	BEDROOM	25/1/2021	320	2.904
DISP001	BEDROOM	26/1/2021	300	2.900
DISP001	BEDROOM	27/1/2021	280	2.896
DISP001	BEDROOM	28/1/2021	260	2.892
DISP001	BEDROOM	29/1/2021	240	2.888
DISP001	BEDROOM	30/1/2021	220	2.884
DISP001	BEDROOM	31/1/2021	200	2.880
DISP001	BEDROOM	1/2/2021	180	2.876
DISP001	BEDROOM	2/2/2021	160	2.872
DISP001	BEDROOM	3/2/2021	140	2.868
DISP001	BEDROOM	4/2/2021	120	2.864
DISP001	BEDROOM	5/2/2021	100	2.860
DISP001	BEDROOM	6/2/2021	80	2.856

DISP001	BEDROOM	7/2/2021	60	2.852
DISP001	BEDROOM	8/2/2021	40	2.848
DISP001	BEDROOM	9/2/2021	20	2.844
DISP001	BEDROOM	10/2/2021	0	2.840

The graphs (Figure 20 and Figure 21) are plotted based upon two measurement i.e. spray level and battery level. The spray level is reduced by 20 while the battery power (in volts) is reduced by 0.004. The status of spray is then emptied by a month and ten days by 10/02/2021, but the battery voltage remains at 2.840V.

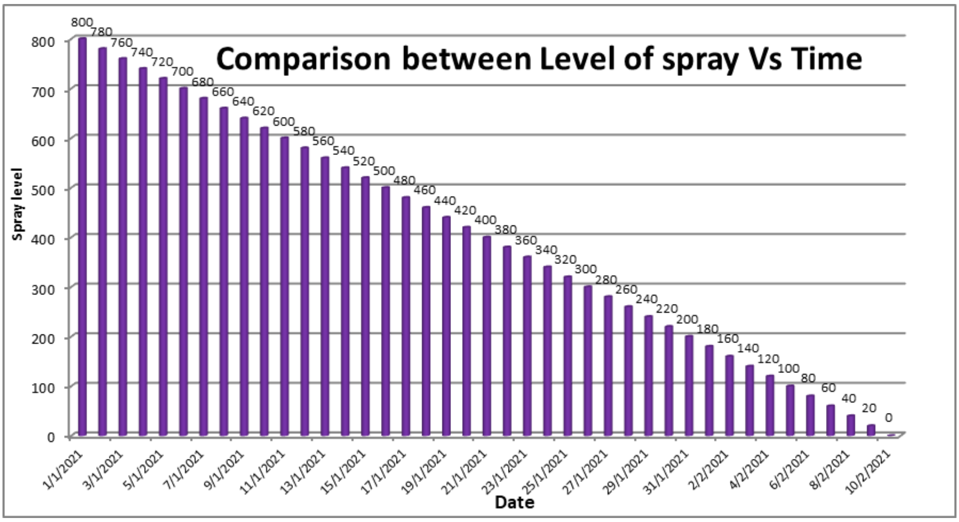

Figure 20: Different level of spray towards specific date

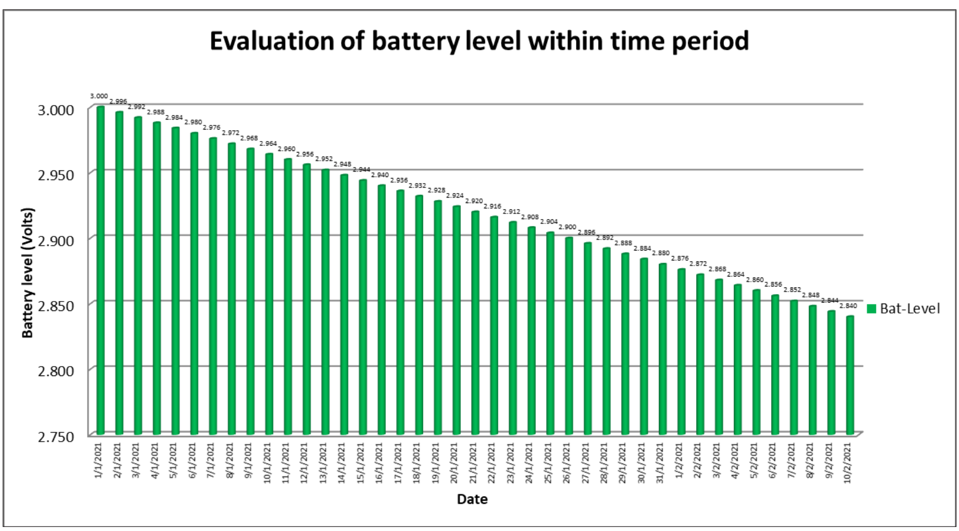

Figure 21: Different level of battery (Volts) towards specific date

The X'MOS-IOT aims to combat Aedes mosquito to reduce the transmission of dengue, which is a disease with serious cause of mortality with no vaccine formulated to date. The clinical testing of X'MOS spray has been undertaken through the matching grants between several higher academic institutions and industry such as UMT, UniSZA, One Team Network Sdn. Bhd., Dr MOS Healthcare Sdn. Bhd., Institute for Medical Research (IMR) and UPM. The use of this Aedes mosquito repellent is improved by embedding IR4.0 technology. Our X'MOS-IOT is a complete package where the controlling and monitoring of the spray is done remotely through Internet connection. The spray and battery levels of each X'MOS-IOT device can monitored remotely using IR4 technologies.

CONCLUSION AND FUTURE RECOMMENDATION

The implementation of Internet of Things (IOT) in IR4 reduces wasting of energy, improves efficiency and most importantly, combats Aedes with green technology and in an environmentally friendly manner. Monitoring the real-time data exchange is crucial for big data analytics initiatives (15-16). In future, we would like test the X'MOS-IOT mechanism to spray hand sanitizer liquid to improve the standard operating procedure (SOP) in combating COVID-19.

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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REFERENCES

[1] P. R. Prasad, N. Narayan, S. Gayathri & S. Ganna. (2018). An efficient E-Health monitoring with smart dispensing system for remote areas. In *3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)*, pp. 2120-2124.

[2] K. A. Kumar. (2020). An Internet of Thing based Agribot (IOT-Agribot) for precision agriculture and farm monitoring. *Int. J. Educ. Manag. Eng*, *10*(4), 33-39.

[3] J. Krishna, K. Lokesh, O. Silver, W. F. Malende & K. Anuradha. (2017). Internet of things application for implementation of smart agriculture system. In *International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), IEEE*, pp. 54-59.

[4] R. Kumar & M. P. Rajasekaran. (2016). An IoT based patient monitoring system using raspberry Pi. In *International Conference on Computing Technologies and Intelligent Data Engineering (ICCTIDE'16), IEEE*, pp. 1-4.

[5] T. S. Gunawan, I. R. H. Yaldi, M. Kartiwi & H. Mansor. (2018). Performance evaluation of smart home system using internet of things. *International Journal of Electrical and Computer Engineering*, *8*(1), 400.

[6] D. D. Koo, J. J. Lee, A. Sebastiani & J. Kim. (2016). An Internet-of-Things (IoT) system development and implementation for bathroom safety enhancement. *Procedia Engineering*, *145*, 396-403.

[7] M. Man, W. A. W. A. Bakar & M. A. B. A. Razak. (2020). MUS-Tracker: An IoT based system in controlling and monitoring of beehives. *International Journal*, *8*(6).

[8] W. A. W. A. Bakar, M. Man, B. A. Talip, L. C. Hwa & M. I. H. M. Noor. (2019). iMHS: An IOT Embedded for Aedes Mosquito Home System.

[9] M. Man, W. A. W. A. Bakar, L. C. Hwa, W. N. J. W. M. Yusoff, M. Affendi & M. I. H. M. Noor. (2020). Dengue innovation: A sustainability approach for preventing and controlling of dengue diseases outbreaks via IoT technology. In *IOP Conference Series: Materials Science and Engineering*, *769*(1), 012012. IOP Publishing.

[10] M. Man, W. A. B. W. A. Bakar, M. I. H. B. M. Noor. (2019). ITDS: An intelligent tissue dispenser system. *International Journal of Recent Technology and Engineering*, *8*(3), 2613-2619.

[11] S. Himanshu, V. Pallagani, V. Khandelwal & U. Venkanna. (2018). IoT based smart home automation system using sensor node. In *4th International Conference on Recent Advances in Information Technology (RAIT), IEEE*, pp. 1-5.

[12] N. Ayadi, M. Turki, R. Ghribi & N. Derbel. (2017). Identification and development of a real-time motion control for a mobile robot's DC gear motor. *International Journal of Computer Applications in Technology*, *55*(1), 61-69.

[13] Z. Wang, S. Ambrogio, S. Balatti & D. (2015). Ielmini. A 2-transistor/1-resistor artificial synapse capable of communication and stochastic learning in neuromorphic systems. *Frontiers in Neuroscience*, *8*, 438.

[14] S. Q. Liu, S. C. Li, K. L. Huang & B. L. Gong. (2007). Lithium-ion battery cathode material Li~ 3V~ 2 (PO~ 4)~ 3 prepared by sol-gel procedure. *Chinese Journal of Power Sources*, *31*(2), 123.

[15] M. K. Yusof & M. Man. (2017). Efficiency of JSON for data retrieval in big data. *Indonesian Journal of Electrical Engineering and Computer Science*, *7*(1), 250-262.

[16] M. Man, W. A. W. A. Bakar, Z. Abdullah, M. A. Jalil & T. Herawan. (2016). Mining association rules: A case study on benchmark dense data. *Indonesian Journal of Electrical Engineering and Computer Science*, *3*(3), 546-553.