Electricity, Temperature, and Network Utilization Monitoring at University of Lampung Data Centre Using Low Cost Low Power Single Board Mini Computer

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Abstract– A service-level agreement (SLA) defined contract of service between Service Provider and Customer. Usually this document contain technical values. Customer needs monitor its services to ensure the service comply with SLA. Nowadays, energy efficiency is one of most significant issue. How to provide low cost and low power for electricity, temperature, network utilization monitoring was carried out in this paper. Raspberry Pi BCM2835 as a mini computer was used to ran the services monitoring. Testbed has been deployed in University of Lampung (Unila) data centre. The systems was built base on modified waterfall software engineering principles. The result presented that the system was running properly and provided data statistics of electricity, temperature, and network utilization through an interactive website interface that generated by python script. Any peculiar condition informed immediately to network administrator via sms or email for properly treatment. During testbed throughout a month on June 2014, peak time for daily bandwidth utilization occurred at working hours, starting from 8 am to 4 pm. Maximum temperature recorded was 38^0C and minimum was 15^0C. For a month there were accumulated total 15.456 hours for electricity black out. The usage of cpu resource show less than 20%, and memory usage average on 58%. All data from this application was used by top IT management, to evaluated electricity and internet service SLA.

Keywords: python programming, green computing, electricity monitoring, temperature monitoring, network monitoring

INTRODUCTION

Nowadays, internet become basic needs for human being. A lot of services are available to fullfill the users need. Internet availability is increasingly recognised as a serious, worldwide public concern. Unila as an academic institution should provide the internet service for thousand of users. Unila has 25.000 students, 1300 lecturer and 645 academic staff that used the internet daily. A service-level agreement (SLA) with the service provider stated that bandwidth available is 150 Mbps for Indonesia Internet Exchange (IIX) and 100 Mbps for International Exchange (IX) connection.

Monitoring the condition of electricity, temperature, and network utilization becomes an important role as a part of maintenance lifecycle to make sure internet services running well. One of the most important issue is to provide low cost and low power monitoring system. It is important not only to provide more green computing because Unila also facing on electricity problem. Located in south of Sumatera island Indonesia, some times the blackouts happens. So, it is important to provide a system that can run on low energy power consumption and make sure monitoring process still running although not supported by main power.

In this paper, solution of green network monitoring system using mini single board personal computer was investigated and built. BCM2835Raspberry Pi was used to perform the monitoring task. This paper only monitor the electricity, temperature, and network utilization, used Python programming language and MySQL as database server, sensor DS18B20 used to captured the temperature at Network Operation Center (NOC) room, any peculiar condition notified to administrator for right treatment. System development process referred to modified waterfall concept.

RELATED WORKS

Baker in Works [2] describe the used of low cost and low power mini computer for environmental monitoring. This research show that it is possible to logged the environmental parameter using sensor and stored it into database for further research using low cost mini computer.

The works in [3] show the significant issues and challenges in the field of internet monitoring and measurement. This paper describes the methodologies for internet monitoring that may changes following the the changing of scenarios and how the network operated. This paper also describe that some times it takes very high cost to develop well developed software for network monitoring. Envolve and development of application and protocol also has contibution on network or internet monitoring complexity.

The trend of green computing in Network Operation Center (NOC) also rapidly increased. Paper [4] show the trend of cloud computing for energy efficiency as one of green computing concept practices. Unila as one of the largest university in Sumatera, Indonesia also adopted this trend onto theirs NOC [5]. Paper in [6] studied the network monitoring using several open source application.

Paper [7] show the monitoring of electricity consumption base on microcontroller and C programming language, and not provide any notification to administrators.

Paper [8] show web base temperature monitoring system using EZ430, personal computer (PC), Visual Basic, and store the data into MySQL server, but still without early warning notification to administrator.

Refers on several research describe above, in this research we trying to develop a low cost system monitoring base on various open source application, stressed on real time report and fast notification to administrator by SMS Technology and E-mail.

GREEN COMPUTING, NETWORK MONITORING, SOFTWARE ENGINEERING

Nowadays, world facing an energy exhausting. Most of energy sources that had been used is non renewable energy. Development in information technology contributes a large energy consumptions. Most of people nowadays use computer for a daily works. Green computing become popular buzzword and a lot of reserach has been done to meet the green computing requirement. The basic concept of green computing is minimize energy consumption, reduce undegradable and hazardous material and promote reuse of recyclability material. Therefore, information technology engineer and scientist researched a lot of possibility to made the green computing is possible.

As part of computing process is monitoring process. The computer need to stay on for 24 hours a week since it is used for monitoring purposes. Solution of computing using lower energy consumption for network monitoring is important, each of monitoring device have a standard humidity level, to keep the performance of network devices run optimally, Cisco defined that the recommended temperature at data centre room should between 18^{o}C until 27^{o}C [9]. Python programming language can be used to capturing network utilization data[10]

Modified waterfall consist of 5 phases: requirements analysis, design, implementation, testing, maintenance [11]. Data Flow Diagrams (DFD), is a graphical representation of the "flow" of each data components on information system, does not display the logical phases nor the stages of the program [12]

SINGLE BOARD MINI COMPUTER ARCHITECTURE

A lot of single board mini computer variant is available in the market. One of the most used mini computer architecture is based on ARM. BCM2835 is one of single board mini computer with ARM architecture [13]. Single board has all the computer feature to run as a computer. BCM2835 has an I/O ports (USB, HDMI, Audio and GPIO) that only need low energy (5 volt with current 700 mA).

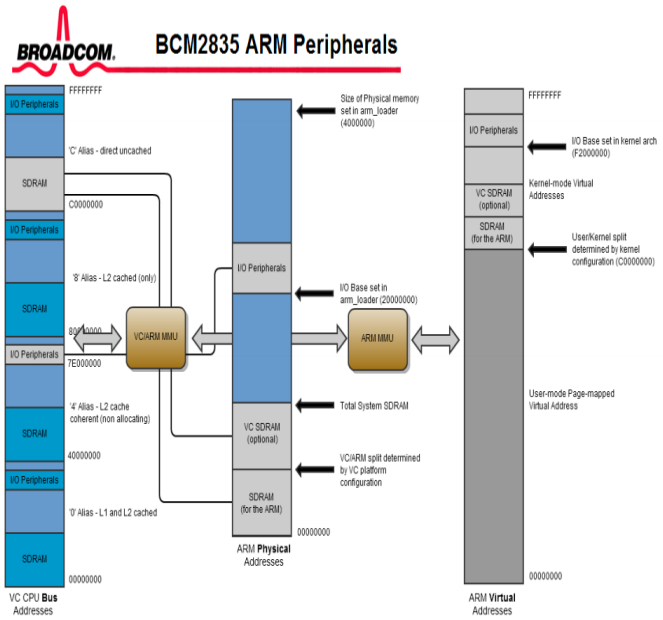

Figure 1.BCM2835 ARM peripheral [1]

Figure 1 depicts the architecture of BCM2835 that used in this paper as low cost and low power mini computer. This mini computer well known as Raspberry Pi in the market. This board become very popular and a lot of researcher used this board for their research.

SIMULATION AND RESULT

In this paper, the possibility of using low cost and low power mini computer for network utilization monitoring is studied and examined. Our testbed in figure 2 consist of server that act as internet gateway and connected with switch and BCM2835 for monitoring purposes. Since BCM2835 only need 5V power,

it is also backed up with Uninterupted Power Supply (UPS) in case of black out. Another client computer will be used as client monitoring to show the graph of electricity, temperature, network utilization chart statistics.
Raspberry Pi act as data collector and the data result will be send to database server on cloud system. Sensor Dallas ds18b20 connected to Raspberry Pi GPIO pin be used to get temperature information on data center room, there are 3 sensors that placed on different location inside the room, to find out temperature distribution.

3.3 Volt adapter also connected via Raspberry Pi GPIO to read the state of electricity supply from provider, and GSM modem is attached through USB connector on BCM to disseminate if there is any peculiar condition as soon as possible to administrator.

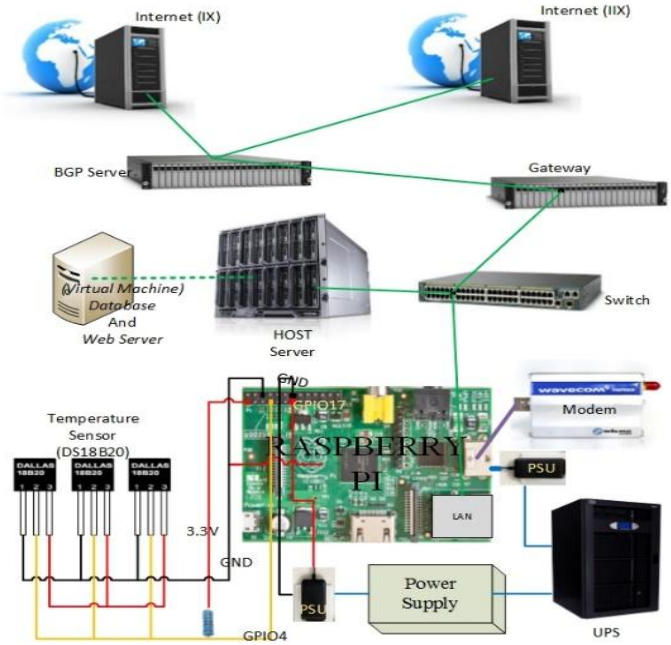

Figure 2. Testbed Architecture

MODIFIED WATERFALL PHASE

Phase requirement analysis
Base on observations and interviews to Top IT management Unila that the general overview need of system monitoring should be able to show a real time report and can be access through website, the data is also stored on to database, and system automatically generate report and able to send early warning report via sms or email if there is any abnormal condition.

Phase design
At this stage, continuing from phase design we already identify necessary outputs, inputs, processes, internal and external controls for monitoring system. Software design using conceptual design that visualize by Context Diagram and DFD.

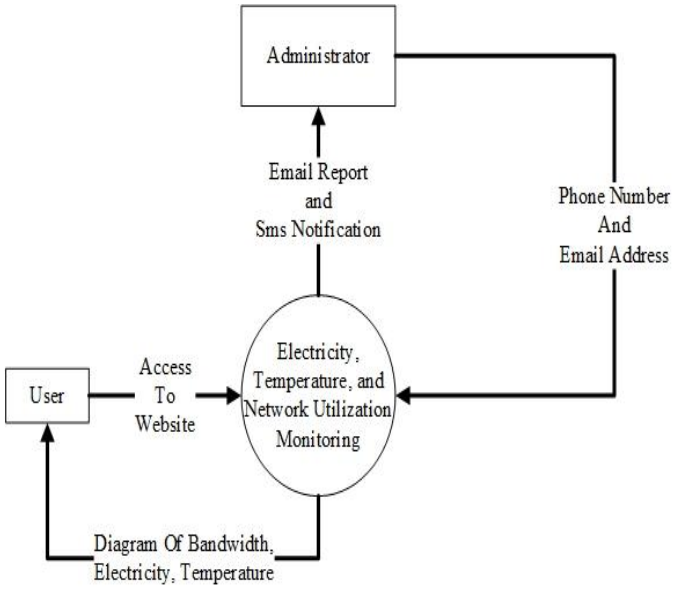

Figure 3. Context Diagram System Monitoring

Figure 3 shows Context Diagrams (CD) plan. CD is used to represent all external entities that may interact with monitoring system, in this paper there are 2 entities that is user and administrator. Administrator should give phone number and email address to get information of electrical, temperature, and network utilization from system monitoring. Information consist of real time notification, weekly and monthly report. User is the second entity, that should gave date time parameter to system and will receive monitoring information,

For more detail of graphical representation the "flow" of each data components on information system for administrator entities describe on figure 4.

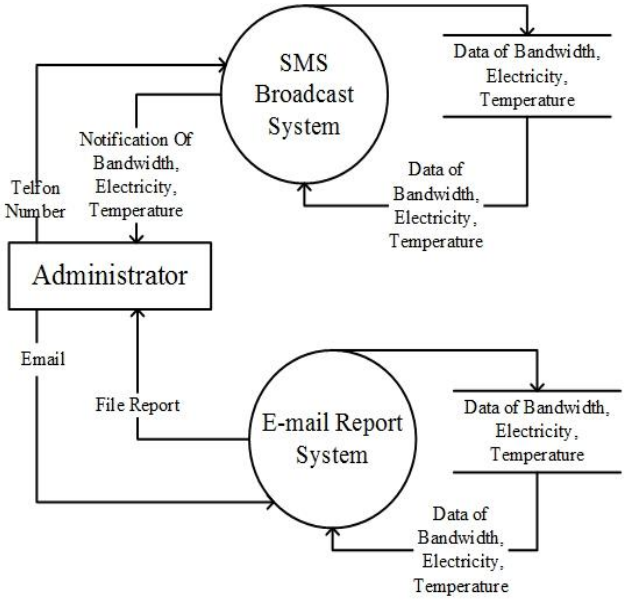

Figure 4. DFD administrator (level 1)

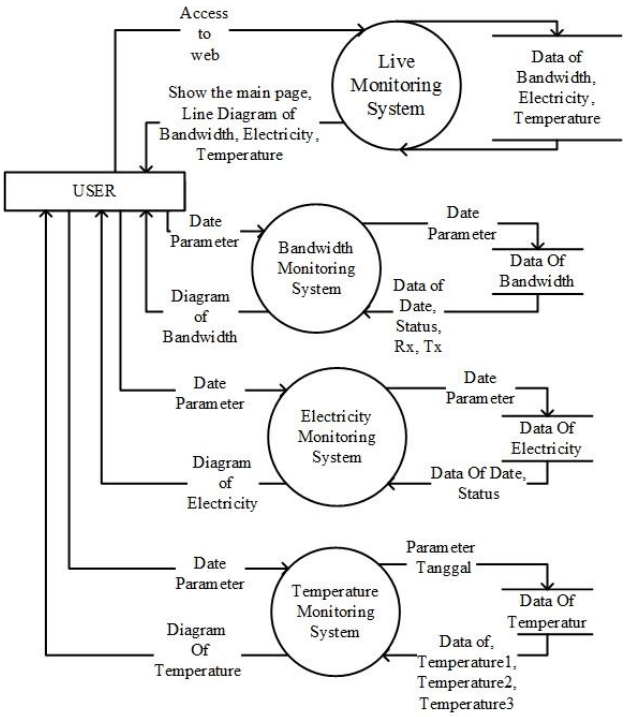

Figure 5. DFD User (Level 1)

Figure 5 shown DFD level 1 for user entity, user can access the main system, the data flow components is electricity, temperature, and bandwidth utilization that generated from database, and possible to read it online. User is also can retrieve specific data by set date time parameter to system, system will give responds for this request and as line diagram or Pie Chart diagram.

Phase implementation

Live Monitoring Implementation

Web base live monitoring was created using python programming language, javascript, and html. The system collecting information of electricity state, temperature, and bandwidth atUnila's data centre. Data charts showing on application will be updated every 2 seconds. Live monitoring screen captureshow on figure 6.

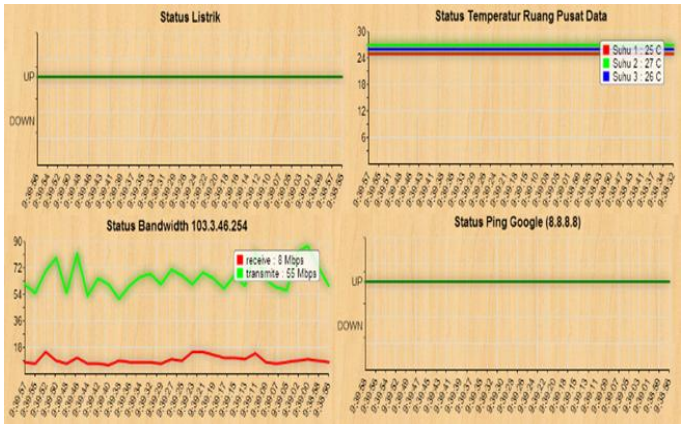

Figure 6. Life Web Base Report for electricity, temperature, network utilization

Bandwidth Monitoring Implementation

Figure 7. is a picture of BGP server bandwidth utilization graphs taken on June 29, 2014. In this figure present that bandwidth usage start increase at 8 am to 4 pm during Unila working hours. After 4pm bandwidth usage began to decline and reach its lowest condition on 4 am until 8 am.

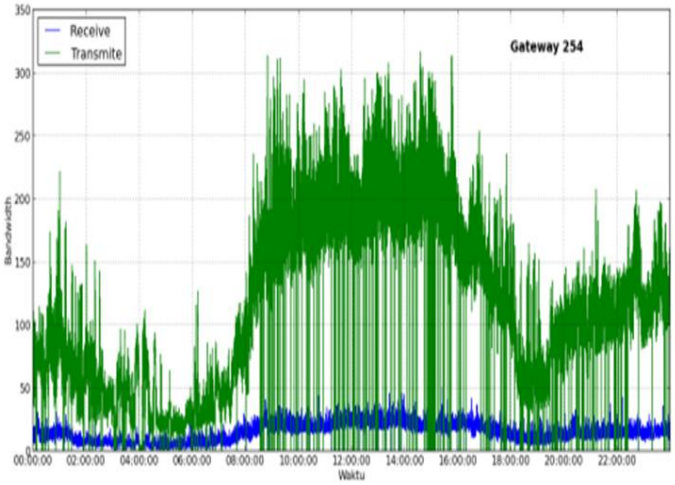

Figure 7. Daily Bandwidth Usage Statistic

Figure 8. describe total Byte data usage each day for a month on June 2014, described below

MByte data IN:

Max: Wednesday-6/18/2014(working day)**334,598.10** Mbyte

Min: Saturday-6/28/2014 (non working day) **87,509.53** Mbyte

MByte data OUT:

Max:Friday-6/6/2014 (working day) **1,502,366.93** Mbyte

Min: Saturday-6/28/2014 (non working day) **549,153.67** Mbyte

MByte data SUMMARY:

Max:Friday-6/6/2014 (working day) **1,714,652.51** Mbyte

Min: Saturday-6/28/2014 (non working day) **636,663.20** Mbyte

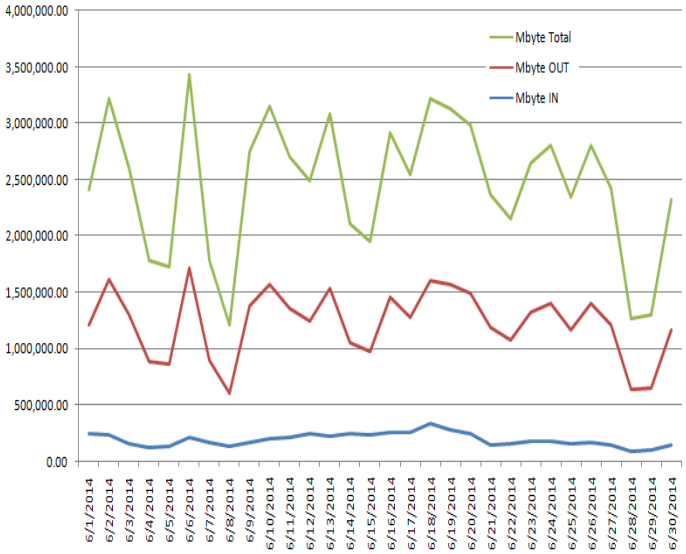

Figure 8. Data Usage on June 2014

Figure 9 shown daily bandwidth utilization report during June 2014, maximum bandwidth summary occurs on **Friday-6/6/2014(working day) 164.02** Mbps, Minimum on **Saturday-6/28/2014(non working day) 60.46** Mbps.

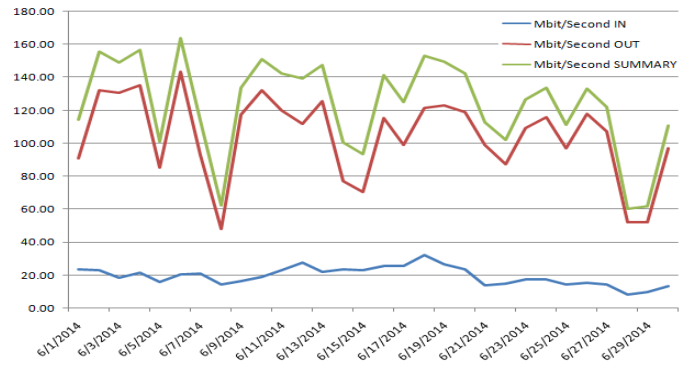

Figure 9. Bandwidth Utilization on June 2014

Electricity State Monitoring Implementation.

The workings of this electricity state monitoring is, voltage output of 3.3V adapter is connected to GPIO27 pin on the Raspberry Pi is set as an input. if GPIO27 pin receive any voltage from adapter, the program will initialize the voltage variable with state = 1, state value and capturing time will saved into database. If GPIO27 pin not receive any voltage from adapter, then program will initialize the voltage variable with state = 0, state 0 mean that data centre electricity not supplied by provider. On table 1 shown that total blackout time **9.2%** equal to **15.456 hours**

Table 1. Percentage of electricity state on June 2014

Status	**Week 1** (%)	**Week 2** (%)	**Week 3** (%)	**Week 4** (%)
Connected	94.6	96.2	100	100
Cut off	5.4	3.8	0	0

Temperature Monitoring Implementation

Dallas sensor DS18B20 was used to get temperature data, consist of 3 units IC that placed on different place on NOC room. Each pin data of sensor only connected with one GPIO pin on the Raspberry Pi. The workings of temperature program, Pi will enabling communication 1 wire protocols. If 1 wire protocol has been activated, the system will read the data from sensors that already connected via Pi GPIO and save the data and date time attribute to database.

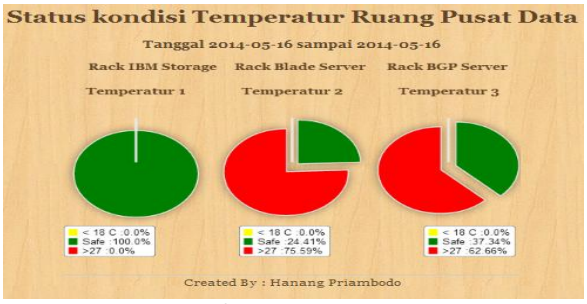

Figure10. Temperature Report

On Figure 10. showing there are 3 kind of pie chart images. Representation of different position of sensor in NOC room, the placement of each sensor :

- Sensor 1, in rack with containing switching devices.
- Sensor 2, in rack containing several servers.
- Sensor 3, in rack containing several blade server.

In Figure 11, the maximum temperature is above 38^{o}C , and the lowest temperature of 15^{o}C the data captured on 18 June 8 2014 . Maximum temperature recorded on this date was happen because all of Air Conditioner (AC) on NOC room didn't work as well.

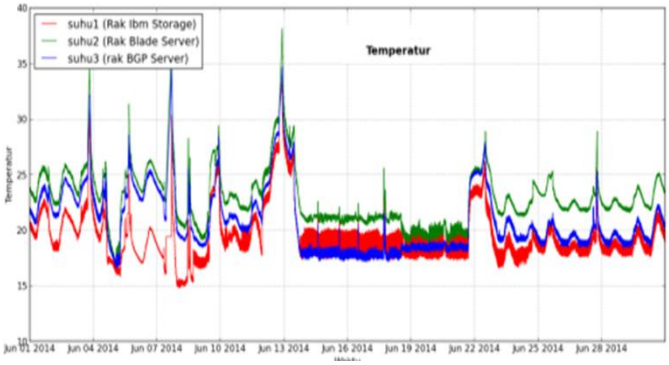

Figure 11. Temperature Report for 3 sensor on 6/18/2014

Sms Notification Implementation

In this paper, sms technology used for sending notification to administrator when electricity from provider broken off, when the room temperature exceed the maximum limit of tolerance value, and when internal network could not reach to global internet. This message is also send via email to administrator, this early warning notification is needed to be analyzed for proper treatment. SMS notification to admin mobile phone shown on figure 12.

Figure 12. Sms Notification Content on Admin Mobile Phone

Average time delay between the message sent from server and time the message received by admin is **6.**7 seconds, which mean is system provide early warning notification if there any weird condition

Report via email Implementation

Beside sms, email technology is also provided by system to notify administrator. All summary report such as daily, weekly, and monthly information will be sent by email to admin,

reported document are on compressed pdf format for easy to read, sample mail report showing on Figure 13.

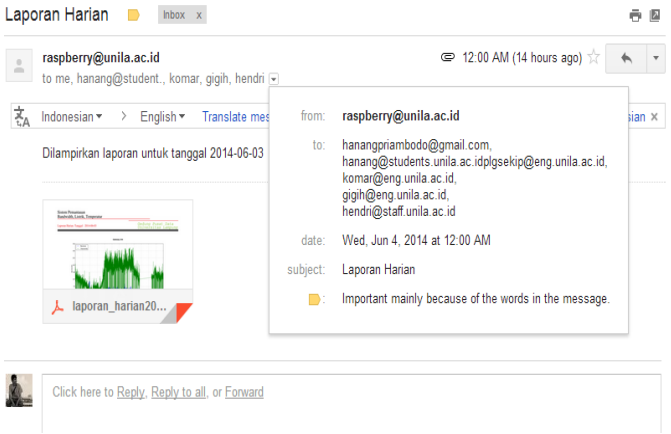

Figure 13. Mail Report Screenshot

Phase testing

Testbed was also made a reliability testing to analyze the performance of Raspberry Pi, the method is by measuring CPU and Memory usage during the program is running. VMSTAT tools used to retrieved those information that already installed on Pi and save the recorded into database.

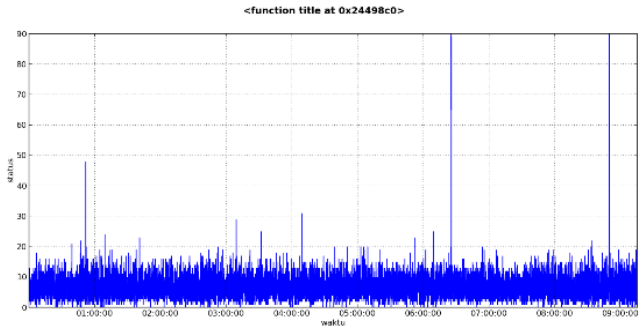

Figure 14.Persentage of CPU Usage

Figure 14. shown that CPU usage average below 20% of all resource, while Memory usage average below 50% show on Figure 15, it show that monitoring application can be run normally on Raspberry Pi with low energy consumption.

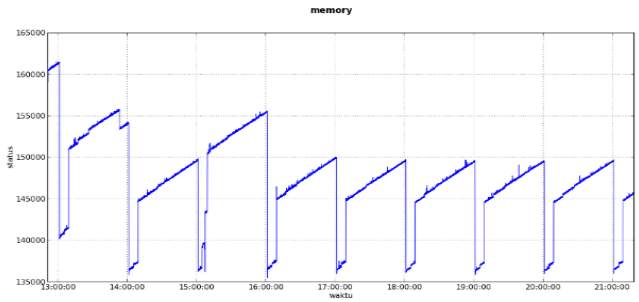

Figure 15. Total Memory Usage

CONCLUSION AND FUTURE WORK

This paper shows that electricity, temperature, and network utilization monitoring using low cost and low power computer ran properly. System monitoring provided interactive live report to helped Unila top IT management analyzed and evaluated the electricity and internet connection SLA. Testbed of BCM 2835 as monitoring system accomplished smoothly with CPU usage average below 20% and percentage memory usage around 50%. System had an early warning notification for abnormal detection used sms and email technology to informed administrator as soon as possible.

Future work should consider to extend the monitoring ability such as automatic smart responds if there were any failure detection, system could identify the power level of UPS and to make sure if state on low level, the system will automatically execute normal shutdown to all server to avoid data loses and damage if server suddenly shutdown. Extend the ability to control temperature room automatically by direct access to air conditioning (AC) system. Also a good feature if system monitoring can read the current and voltage value, and doing any action to prevent those value exceed the normal threshold.

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