Development of Power Monitoring System to Support Fair Operation of Data Center to the Customers

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This paper presents a power monitoring system to provide the information of the electricity used in the racks of data center. Our Idea to implement a context of power monitoring system is how to deliver the current electricity used and the excess power of the electricity used of a rack and its cost in data center to the data center corporation and to the customers. We implement the system that retrieves data periodically every one second for real time monitoring and one minute interval for system requirement, The one second interval only aimed to be presented in the web and will not be saved in the database but the one minute interval will be saved to be processed further. After retrieving one minute interval data, we process it to be presented into periodically graphs and process it data to get excess power from the contract agreement. We perform our proposed system to fulfill the request from XL Data Center to support fair operation of the data center.

Keywords : power monitoring system, data center, fair operation, electricity, excess power

1. Introduction

Data center can be defined as any space whose main function is to house hold servers, electronics computing, communicate with other computer networks and manage the interaction between users and server-based software and web portal. Moreover, data center is used for managing data and important operation, confidential such as email and company or government database. All this time, server reliability is measured from its ability to be functioning properly and minimum loses data. Reliability is strongly linked not only to the server characteristics but also the infrastructure as well, which include the power distribution an environmental management.

Electricity is the one of the important factors in data center business. Joko Suryana in his research said that the total the Indonesia's power consumption is 109.098 kW. Electric power consumtion reaches 40% -50% more than the total monthly operating costs [1]. Andreuw THAF also said the same thing that electrical components contribute about 40% to operating costs [2]. Rack servers are the one of electrical components of data center. The power usage of rack servers affects the operational costs as well. And the calculation of electricicy costs of the rack servers will impact the profit and loss of monthly operational costs.

Unfortunately, there is no power monitoring system that provides information when there are changes in the use of electricity while the changes can be affect the costs. The change of the costs can benefit customers but it inflicts the financial loss of the provider if the usage of the electricity is actually more than what it was declared in the contract. (In the case study at XL Data Center, the amount of electric current that is allowed is 10 Ampere).

Whereas, the real time conditions of racks in data center is customers' right. This research will develop a new way in the web-based power monitoring system to provide the information of power usage of the customers' servers directly.

2. Related Works

In [3], the amount of electricity usage for data centers around the world has doubled during the years 2000-2005. Almost entirely is the result of

the increasing the number of serves. The total powes used by IT equipment in the data cener by approximately 0.5% of world electricity consumtion in 2005. In [4], Neil describes the conventional way of describing the density of the data centers is still primitive, incomplete and ambiguous. This paper outlines the requirements for density specification and introduces a new method for density specification. In [5], the use of power in data center is much greated than in commercial office buildings in general, because of the density of computer equipment. Calculate the electricity usage of equipment with more accurate computer also can have a significant impact. In [6], the projection growth of data center in 2000 is three times each year in US. In the year 2020, it's likely to increase 4-fold. In [7], the issues discussed was the center of power distribution of adata center such as power distribution must not be interrupted, the power supply efficiency and power density in Watts / ft2.

3. Uniqueness

Most data center calculate the cost of electricity based on electricity current written in the contract agreement without calculating if there is power exceed the agreement. And few of them are calculating the excess power based on electric current exceed the agreement using AMP meter in the end of the month. Calculating electric current exceed using Power Distribution Unit integrated with this Power Monitoring System that periodically record the electric usage of data center is a new way.

4. Discussion

A. System Design

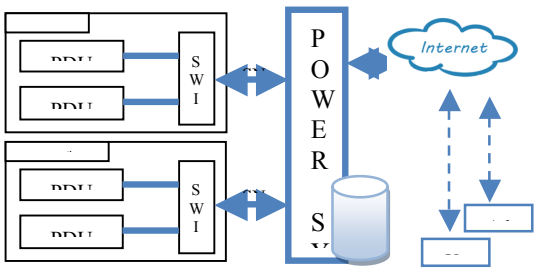

Fig 1. System Design

In the power monitoring application, the design is divided in two concepts, hardware side and application side.

1. Hardware

- There are 1000 racks in data center.
- Every rack contains 2 PDUs.
- Each PDU has one port RJ45 that used for communication.
- So there will be 2000 IP Address will be assigned in the network plus 1 more IP Address for server.
- The closest subnet type is Class B in Netmask 21. The range of the IP Address is from 255.255.248.0 ~ 255.255.255.254.
- Both PDU ports in a rack are connected to a second hierarchy switch.
- Each second hierarchy switch is connected to the main switch. In the main switch there is one server that connected to it. The scheme is on Figure 2.

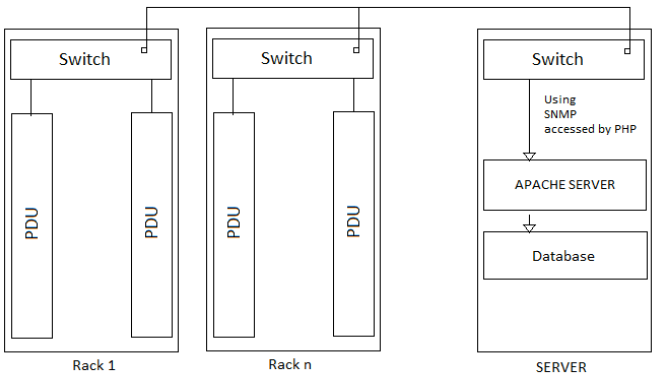

Fig 2. Network Scheme

2. Application

In application side, the process is performed by power monitoring system application. In the application, there are 2 roles:

- *Admin role*

  Admin is the ones who manage the entire system. Admin has privileged to monitor

the entire PDUs. Admin also can add, edit, and delete data.

- *Users role*

  Users are the customers who rent the rack. Users have privileged to monitor their own rack. Monitor the real time electric current and monitor the power usage by time.

The data are obtained and need to be processed to get the average electric current every 5 minutes, 30 minutes, 1 hour, 2 hours and 1 day. The one hour average of electric current are saved in the database for further process and the others are not purposed to be saved and it just saved in the database for temporary time because it just proposed to be showing in the graph for a temporary time. The one hour average of electric current is used for analytic purpose and for calculating the excess power of the rack. The process of calculating the excess power is passing through these following steps:

1. Each rack has 2 PDU, the sum of the one hour electric current average of both PDUs are the total current of the rack every one hour.
2. The total current of the rack every one hour will be processed to get the electric power and power hour. The formula to get the electric power and power hour are explained below :

$$Q = V.I.\cos\theta/1000 \quad (3.1)$$

$$W = Q.t \quad (3.2)$$

W = Power hour

t = Time (number of hours in a month)

Q = the reactive power

V = Voltage (220V)

I = Electric Current

Cosθ = Power Factor (known to be 0.92)

From formula 3.1 and 3.2, where the electric current is known to be 10 A, the power threshold can be calculated.

3. To get the power used in a month, the electric current is knows to be the average current of every one hour in a month. The formula can be derived as follows:

$$W = \sum_{i=1}^{n} V.I_i.\cos\theta/1000$$

Where n = the number of hours of a month.

4. The formula to get the excess power can be derived as follows:

   EP=Power used - Power threshold (3.4)

   Where EP > 0

   EP = Excess Power
5. After excess power calculated, the electric current that actually used in one month can be obtained by divide excess power with power usage of 1 A.

   Excess current = excess power/$W_{of\ 1Amp}$ (3.5)

4.1. Experiment and Analysis

The purpose of this experiment is to determine whether the system is running well and working properly. The experimentand analysis focus on data retrieval, excess power calculation, and presenting the data.

A. The Experiment

1. Retrieving Data from the PDUs

1.1. Periodic retrieval system for system requirements

There are many PDUs to be retrieved its data and data should be retrieved at the same time. It means, there should be no waiting time for each process. For this reason, PHP-Forking is used to answer this problem. This retrieving data function saved in a single PHP file and it run by crontab every minute interval. Processes inside are divided into different child of process and run together at the same time without waiting each process to be done. This system has been implemented in server of Politeknik Elektronika Negeri Surabaya (PENS) and in server of XL Data Center Jakarta. In PENS, one rack is registered in the

system, the rack has 2 PDUs which the id are 45 and 46. Look at table 2, the table shows the both PDUs have the data retrieved in the same time.

Table 1. Realtime Electric Current Data Of PENS

	id	circuit	nilai	waktu	id_device
	20150702031001463	C3	4.9	2015-07-02 02:10:01	46
	20150702031101453	C3	0.7	2015-07-02 02:11:01	45
	20150702031101463	C3	4.9	2015-07-02 02:11:01	46
	20150702031201453	C3	0.6	2015-07-02 02:12:01	45
	20150702031201463	C3	4.9	2015-07-02 02:12:01	46
	20150702031302453	C3	0.6	2015-07-02 02:13:02	45
	20150702031302463	C3	4.9	2015-07-02 02:13:02	46
	20150702031401453	C3	0.6	2015-07-02 02:14:01	45
	20150702031401463	C3	4.9	2015-07-02 02:14:01	46

In XL Data Center Jakarta, one rack is registered as well, the id of the PDU are 47 and 48. The result are the same as in server of PENS, the both PDUs have the data retrieved in the same time. The result is on table 1.

Table 2. Realtime electric current data of XL

	id	circuit	nilai	waktu	id_device
Edit Inline Edit Copy Delete	20150702021501473	C3	1.5	2015-07-02 02:15:01	47
Edit Inline Edit Copy Delete	20150702021501483	C3	0.3	2015-07-02 02:15:01	48
Edit Inline Edit Copy Delete	20150702021601483	C3	1.6	2015-07-02 02:16:01	48
Edit Inline Edit Copy Delete	20150702021601473	C3	2	2015-07-02 02:16:01	47
Edit Inline Edit Copy Delete	20150702021701483	C3	0.3	2015-07-02 02:17:01	48
Edit Inline Edit Copy Delete	20150702021701473	C3	1.5	2015-07-02 02:17:01	47

1.2. Data Retrieval by Customers and Admin

Data retrieved by customers and admin is performed when monitoring page is opened in browser. This is performed by using a PHP script which is run by AJAX in JavaScript according to target of the PDU. To get the data, it requires IP Address of the PDU and its OID. The purpose of retrieving real time data is to be shown in the graph and not to be saved in the database. The experiment of running this system in the server of PENS shows that real time data retrieval run well without problem, the status of the process return 200 means the processes are complete. The figure of the real time data retrieval in PENS is in figure 3:

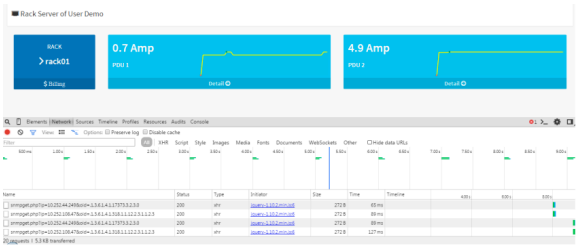

Fig 3. Monitoring Page (PENS)

In XL Data Center Jakarta, the real time data retrieval also run well without problem. The real time data retrieval in XL is in figure 4:

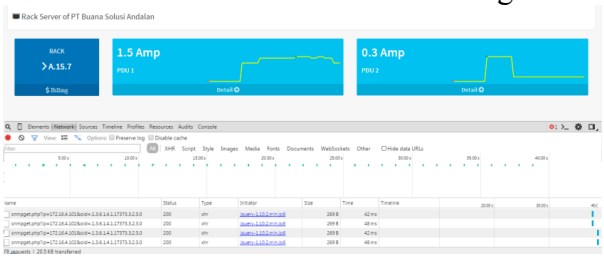

Fig 4. Monitoring Page of PT. BSA (customer of XL Data Center)

1.3. Presenting Data

The presentation of data are divided into 3 categories:

1.3.1. Real time Data Presentation

In this category, the data is presented into real time every one second interval, 5 minutes average, 30 minutes average, 2 hours average and 1 day average for each PDU. The figure of real time every one second interval is shown in the figure 5 and 6.

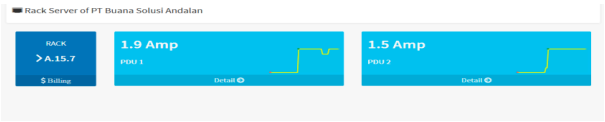

Fig 5. Real time one second interval

The data presentation for 5 minutes average, 30 minutes average, 2 hours average and 1 day average is shown in the figure 4.8 to 4.11. In 5 minutes average, each point in the graph presents the average of electric current usage in 5 minutes. Figure 7 shows the electric current usage of the day is far below the electric current threshold.

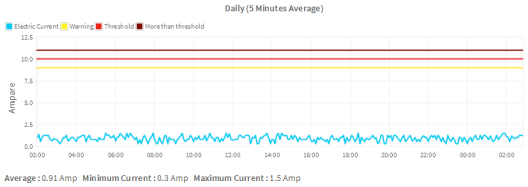

Fig 6. The daily graph (5 minutes average)

In 30 minutes average, each point in the graph presents the average of electric current usage in 30 minutes. Figure 7 shows the electric current usage of the week is far below the electric current threshold.

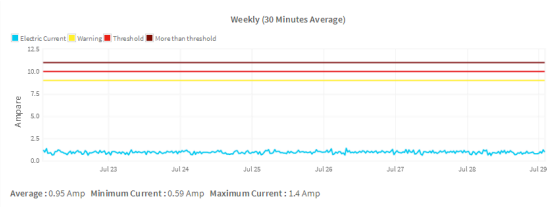

Fig 7. The weekly graph (30 minutes average)

In 2 hours average, each point in the graph presents the average of electric current usage in 2 hours. Figure 8 shows the electric current usage of the month is far below the electric current threshold.

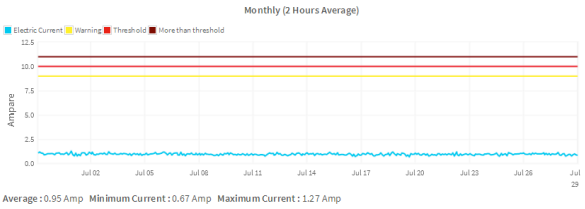

Fig 8. The monthly graph (2 hours average)

In 1 day average, each point in the graph presents the average of electric current usage in 1 day. Figure 9 shows the electric current usage of the year is far below the electric current threshold.

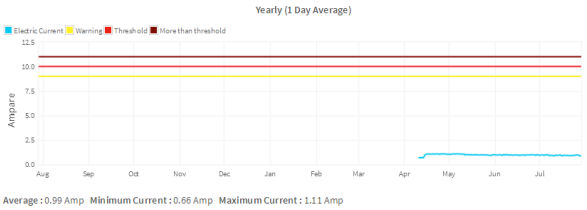

Fig 9. The yearly graph (1 day average)

The data presented for analytic purpose is presented in histogram graph. There are 4 histogram, daily histogram, weekly histogram, monthly histogram and yearly histogram. From those graphs admin or user can see the trend of power usage.

The daily histogram present the electric current usage in 24 hours point graph. Each point present the average of electric current usage of same hour in a month. Figure 10 shows the electric current usage of June 2015. None of the point reach the threshold.

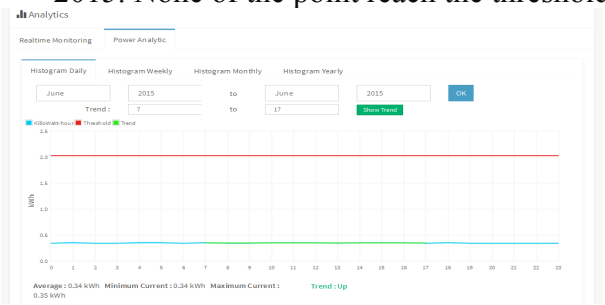

Fig 10. Daily Histogram

The weekly histogram present the electric current usage in 7 days of the week point graph. Each point present the average of electric current usage of same day in a month. Fig 13 shows the electric current usage of June 2015. None of the point reach the threshold.

1.4. Excess Power Calculation

The system has been implemented since April 2015 in XL Data Center Jakarta but there are no data above the threshold. So for testing the cost calculation, the dummy data is used. For example the power usage in June is 2025,012 kWh with power limit according to the contract for 10A is 1350,008 kWh. The excess power is 675,004 kWh with electric current exceed is 5A above the threshold. The exceed electricity cost is 5 multiple by cos per Ampere. The result of the calculation is shown in the figure 11:

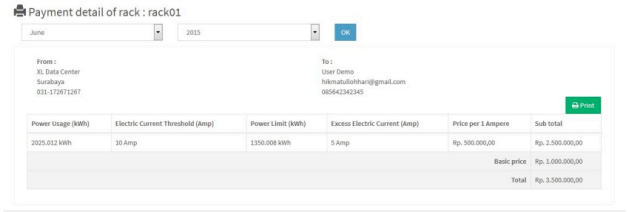

Fig 11. Billing from June 2015

The basic cost is Rp. 1.000.000,00 and the excess power excess is Rp. 2.500.000, 00 so the total cost is Rp. 3.500.000,00.

The following are real the billing information of PT. Buana Solution Andalan, customer of XL Data Center Jakarta, on April shown in figure 12:

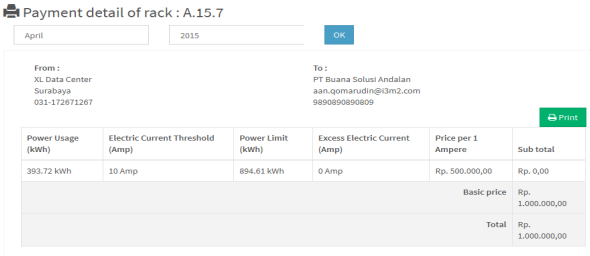

Fig 12. Billing from April 2015

5. Conclusion

Based on experiments and analysis can be concluded that:

- With this power monitoring system, the power usage of a rack and the excess power usage cost can be calculated using the method of this research. The data retrieve from PDU is the same as the data retrieved from conventional power meter because PDU is also an industry standard. So the calculation using this method by utilizing the PDU is a new way compared to the conventional way.
- Realtime monitoring presented in graph provide the information more readable and easy to understand.
- All the data retrieved from PDU is presented in the graph, so both provider and customer can analyze it or compare the data to the billing calculation.
- Data center from small scale to big scale can use this system to provide tranparency electricity infomation of each rack in data center.

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