Smart Data Centre Monitoring System Based On Internet of Things (IoT) (Study Case : Pustipanda UIN Jakarta)

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ABSTRACT

State Islamic University Syarif Hidayatullah Jakarta as rapidly growing university toward world-class university placed in the edge of Jakarta has a data center run by its unit of organization called Pustipanda (The Center of Information Technology and Database). The team has made observations during the last 1 year and found that these data center lately has an incident occurred where its hardware is found defected caused by instability of voltage and current from power supply, several uninterrupted power supply installed that should cover this problem is also unable to answer cause the current provided is insufficient for power up computers in period of time and it was verified by Mr. Nasrul Hakiem as the head of the data center through the interview team has done.
Internet of Things, based on ITU-T 2015, some objects are able to transmit data among object by using Internet connection. It means by this technology the Internet used has been widely changed, from human to machine communication now also become machine to machine communications. As the number of Internet-connected devices grows, the amount of traffic they generate is expected to rise significantly. Cisco estimates that Internet traffic generated by non-PC devices will rise from 40% in 2014 to just under 70% in 2019. Cisco also forecasts that the number of "Machine to Machine" ("M2M") connections (including in industrial, home, healthcare, automotive, and other IoT verticals) will rise from 24% of all connected devices in 2014 to 43% in 2019.[13] By using this technology a small object or device is able to implement into electrical system in data center in order to monitor abnormality of voltage and current from electrical supply and also implemented in the surroundings in order to monitor the temperature condition. Object implemented in the data center system are able to monitor and send the data into monitoring system that researchers would build with scrum methodology

Keyword :
Internet of Thing, data center

1. Background

Data center by definition is a place where collection group of computer connected build a logical server or several physical servers for servicing a request from Internet users. Many issues or problems are faced by the data center. One of the issues is electrical problem, voltage and current stability from electric power supply should constantly power up the power consumption of computers, when the power is discontinued. It causes a big problem for providing services and caused hardware damage. The other problem is a temperature issue; the air condition in data center should be kept cool in order to freeze the processor of computer after heating up by the electric current because of data processing.

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This monitoring system should run twenty four hours a day, seven days a week, and three hundreds sixty five a year, this system should record all the abnormality and send a alarm to several authorize person in real time so the potential defective hardware could be avoided.

1.1. Objectives

Objectives in this research are :

1. Build a monitoring system in order to record all abnormality in electrics supply and air temperature in data center.
2. Build early warning system to inform/alarm the authorize person instantly when the abnormality occurred.

1.2. Limitation

1. This system should record electric current consumption, humidity, and temperature issue because of data processing and send an alarm to several authorize person in real time.
2. This system able to prevent a serious damage in sever by give an early warning to administrator and authorize person to state further corrective action.
3. Monitoring reportall the abnormality is viewed through web.

2. Review of Related Literature

2.1. Interactive Device

All of the objects are built using microcontroller follow a very simple pattern that as known the "Interactive Device". The Interactive Device is an electronic circuit that is able to sense the environment using sensors (electronic components that convert real-world measurements into electrical signals). The device processes the information it gets from the sensors with behaviour that's implemented as software. The device will then be able to interact with the world using actuators, electronic components that can convert an electric signal into a physical action. [8]

2.2. Scrum Methodology

Scrum is one of software and hardware engineering methods by using AGILE approach which has strong points in team collaboration and iteration incremental product review for final results.[5]

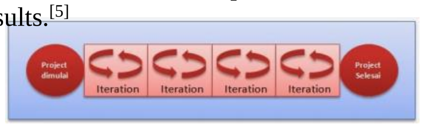


Fig 2. Scrum Methods

3. Research Methodology

Methods are used in this research are as follow:

3.1. Literature Reviews

At this step, literature review is done by collecting all books and articles that are relevant to this research. Several textbooks are used in this research in example books that contain theory about UML, Embedded System, Electronics Circuits, and Database System. Articles that has similarity with this research also is collected, some article found in Journal and some articles found in proceeding of international conference.

3.2. Observation and interview

Observation is done to research object PUSTIPANDA (a data center unit in UIN Jakarta), specially its power supply and server room from May 2016-October 2016 and in this research, interview is done by asking the chief of PUSTIPANDA Nashrul Hakiem, Ph.D as the man who responsible running the operation of Data Center.

4. Analysis and Design

system development methodology that reseracher used is SCRUM. The SCRUM methodology has several steps and iteration. The first step in this methodology is collecting all data and facts about Pustipanda condition, and then analyze the facts, observe the environtment, problem identification, design and programming, testing the system, and deployment in site.

4.1. Collecting All Data

The researcher tries to collect all data and facts about pustipanda ‘s data center, starting with reading the log system and history provided. Several incidents are found in the log system. Few months ago the power of electricity is black out about an hour and causes the storage server dysfunction. Three from eight hard drive from storage server found to be defect. The service level agreement from pustipanda is disrupted. From here the officials from pustipanda decided to monitor the electricity power supplies from the electricity company in order to avoid this kind of incident is occurred again

4.2. Analyze the Facts.

4.2.1. Scope

The first thing should be done in determining the all elements needed by the system is define the scope. The scope that the researcher do in this research is in Pustipanda data center. The researcher need to monitor all the electricity power from the electric company. This electricity monitoring system use sensor that captured data and send the data to a server automatically and periodically updated. The monitoring system should be real-time and stored to the server. Afterwards the system able to show and visualize the graph of power used remotely and locally.

4.2.2. The Hardware Requirement Analysis

Designing a prototype power monitoring system, researcher used several hardware and software for build a complete system. The Hardware uses microcontroller components, sensors for read current, temperature, and humidity. The specification for each component choose is also important to make sure the system working perfectly. Following is list of component used in this power monitoring system :

Table 1 Hardware Analysis

No.	Components	Qty	Function
1.	Raspberry Pi 3	8	As center of computation and processing in the system.
2.	Arduino Uno	8	Acting as Analogue digital Converter from current sensor
3.	SCT 013 100A	4	Current Sensor
4.	DHT-22	4	Temperature and Humiditiy Sensor
5.	*Power Source USB* 5 V 2.0 A	8	Giving Power for Raspberry Pi

4.3. Current System Analysis

The power system that uses in pustipanda is using UPS and GENSET for interuption in power network from electric company. The monitoring system that Pustipanda uses only using a panel with led monitoring system. More advanced and reliable system for monitoring a eletricity problem is needed for preventing a further damage and defection in the server working in pustipanda data centre. By this condtion the researcher design and build a power monitoring system based IoT. This system able to capture current, temperature, and humidity and stored in database, and show the graphic as visualisation for further analysis. By this system, abnormalities in power also detected completely by the system.

4.3.1. Requirement Analysis

Requirement will be divided into two section, the first section is the fucntional requirements, the definition of functional requirements is activity and services that the system should provide in order to make the system working. The second section is Non-functional requirements, by the definition the non-functional requirements is featerus that the system has in order to make the system more easy to used, more advanced to operate.

4.3.1.1. Functional Requirements

The system build should have fucntional requirements as follow :

1. Able to monitor and capture the current, temperature and humidity from the environetment.
2. Stored the data into database.
3. Visual the data into graph and digital meter

4.3.1.2. Nonfunctional Requirements

Nonfunctional Requirementsfrom the system build as follow as shown in Table 3

Table 2 Nonfunctional requirement

Jenis kebutuhan	Penjelasan
1. Graphical User Interface	a. Graphical user interface using graphic and digital meter.
2. Database	b. Giving relational and high capacity of data
3. Historical Data	c. Able to giving a historical data

4.3.2. Design system

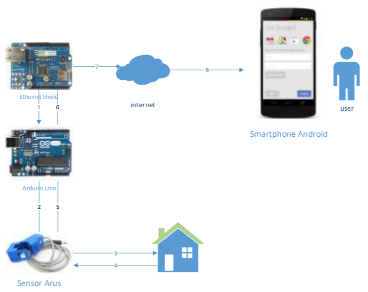


Fig 3. Design System

At figure 3 explained about the system power monitoring system based on IoT. Those monitoring system monitor the power abnormality from PLN by using SCT 013 and also the deviation of chamber temperature following is the explaination from the system:

1. Raspbery Pi3 use as processing unit and wifi connection from arduino and database server.
2. SCT 013 sensor, current from the PLN cable is measured and digitalize by using arduino.
3. Arduino using as analogue digital converter and send the data as serial data.
4. DHT-22 temperature and humidity sensor is used for capturing the temperature in the server room.
5. Raspberry pi send the data into database server.
6. Database server send the data to web server and visualize the data.
7. User able to monitor the power and the temperature.

From data forwarded to database server and database server will push to web server. By using webbrowser the data are viewed to user in realtime.

4.4. Workshop Design

Design or designing a system could be define as task that focus on detail specsification of solution based on computer.

4.4.1. Application Design

4.4.1.1. Identification of User

The actors is something that act outside the system. For detail explanation will be given in the table 4

Tabel 4 Requirement Actor dan Use Case

Requirement	Actor	*Use Case*
1. Microcontroller send data to server	Mikrokontroler	Send data to database server
2. User/Staff monitorize the graph	User	Monitor and has information from the graph

4.4.1.4. Class Diagram

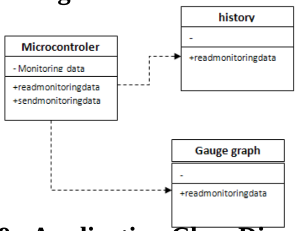


Figure 9. Application Class Diagram

4.4.1.7. Design of Database

The system needs database to store the information captured by sensor. The Desgin of database should support the information system wich based on web. Database is obtained by integrated all data which is connecting each other, mapping and entity class.

1. Information Table Current, Power, Temperature and Humidity

   Namatabel : info

   Primary key: id

   Foreign key : -

No	Nama Field	Tipe/lebar	keterangan
1	Id	Int(10)	Id server
2	Server	Varchar(30)	IP Server
3	Arus	Float	Data arus
4	Suhu	Float	Data suhu
5	Kelembaban	Float	Data kelembaban
6	Tanggal	Date	Tanggal monitoring
7	waktu	Time	Jam monitoring

4.4.2. Interface Design

In this step, interface is made by rules of human computer interation. By using this rule, the outlook and interface are operated easyly by user for monitoring the server with graphic visualization

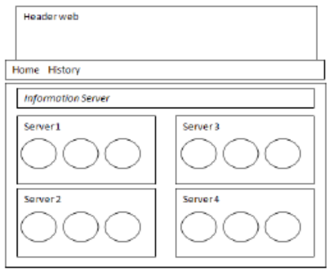
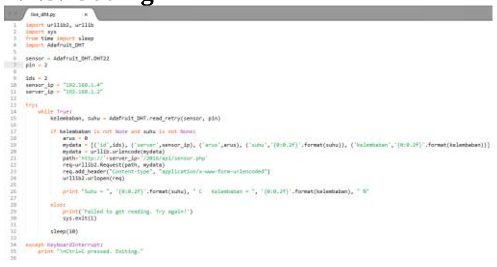


Figure 10. Application Main Page

4.4.3. Coding



```
import urllib2, urllib
import sys
from time import sleep
import Adafruit_DHT

sensor = Adafruit_DHT.DHT22
pin = 2

ids = 2
sensor_ip = "192.168.1.4"
server_ip = "192.168.1.2"

try:
    while True:
        kelembaban, suhu = Adafruit_DHT.read_retry(sensor, pin)

        if kelembaban is not None and suhu is not None:
            arus = 0
            mydata = [('id',ids), ('server',sensor_ip), ('arus',arus), ('suhu','{0:0.2f}'.format(suhu)), ('kelembaban','{0:0.2f}'.format(kelembaban))]
            mydata = urllib.urlencode(mydata)
            path='http://'+server_ip+'/2016/api/sensor.php'
            req=urllib2.Request(path, mydata)
            req.add_header("Content-type", "application/x-www-form-urlencoded")
            urllib2.urlopen(req)

            print "Suhu = ", '{0:0.2f}'.format(suhu), " C   Kelembaban = ", '{0:0.2f}'.format(kelembaban), " %"

        else:
            print('Failed to get reading. Try again!')
            sys.exit(1)

        sleep(10)

except KeyboardInterrupt:
    print "\nCtrl+C pressed. Exiting."
```

Figure 12. Coding

In python code there are several import code which contain module using by the python itself in order to make the system running as expected. One of the module used is AdaFruit DHT which run as module to convert the result taken by the temperature and humidity sensor DHT – 22. And the next step the sensor need to be initialized by Adafruit code. Next process read the data from sensor DHT 22 and send it to server by using php file.

4.4.4. Implementation

The Power monitoring system used a current sensor and temperature sensor. The current sensor works with capturing the electro magnetic fields exist in the power cable. This electro magnetic field will inducted to ferrit coil inside the sensor. Afterwards the fluks magnet exist inside the sensor will be convert to current that can be measrude by coil. With little help from resistor components the sensor will give the voltage value linearly with the current measured. The schematic diagram at current sensor, arduino and microcontroller is as follow. The microcontroller change the data from analogue to digital.

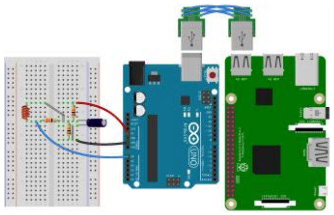


Figure 12. Schematic Diagram

Alternating Current is measured by sensor with maximum range up to 30 Ampere. 30 Ampere is the RMS value from maximum value obtained by sensor. We could calculate th I max with following formula :

i(max) = √2 * i(rms_current) = 1.414 * 30A = 42.42 A

Imax current sensor = 42.42 A.

i(sensor) = i(measured) / nb_turns = 42.42 A / 2000 = 0.02121A

calibration_value = (i(measured) / i(sensor)) / R(burden)
calibration_value = (42.42 A / 0.02121A) / 33Ω
calibration_value = 2000/33Ω = 60.6

From formula we have obtained calibration value to get a normalization value is 60,6. This value used in arduino microcontroller to normalize the current value.

Data sent by arduino will be taken by raspberry pi with serial mode data transfer. And the raspberry will be sent to database server by using wireless connection.

In temperature and humidity measurement using DHT-22 sensor will be more easier because data obtained from the sensore is already in digital form and without any normalization or calibration applied in this type of sensor.

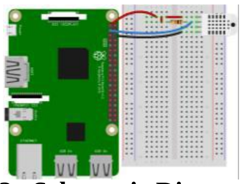
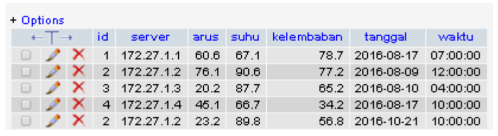


Figure 13. Schematic Diagram of DHT-22

Following is the database design and the database will be automatically will be write by raspberry pi trough php code in order to insert the table.


+ Options

←T→	id	server	arus	suhu	kelembaban	tanggal	waktu
☐ ✎ ✕	1	172.27.1.1	60.6	67.1	78.7	2016-08-17	07:00:00
☐ ✎ ✕	2	172.27.1.2	76.1	90.6	77.2	2016-08-09	12:00:00
☐ ✎ ✕	3	172.27.1.3	20.2	87.7	65.2	2016-08-10	04:00:00
☐ ✎ ✕	4	172.27.1.4	45.1	66.7	34.2	2016-08-17	10:00:00
☐ ✎ ✕	2	172.27.1.2	23.2	89.8	56.8	2016-10-21	10:00:00

Figure 14. Info Table

Infor Table consist of the condition of all rack server inside data center with information of current, temperature and humidity.

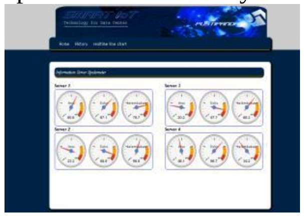


Figure 15. Main Page

The screen at main page use to monitorize the condition of the four server in data center Pustipanda. This condition tells us information about temperature and humidity inside the server room. This information also can be retrieved based on specific date or time or within a certain range of time as beautifull graphic on computer screen.

Historical view/mode tells information about temperature, humidity and current for specific previous date or time. Information system of power monitoring will be implemented by public network. Th topology from network implementation is used based on Local Area Network.

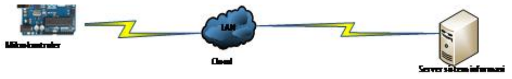


Figure 17. Network Implementation

Figure 17 explained the implementation pllaning will be use a Local Area Network to communicate with a server.

4.4.5. Black Box Testing

At this phase will be conduct a testing for application functionality. This kind of testing is done to make sure that programm could be running well without any disturbance when it operating. For every test that is running there possibility erorr occured however by doing kind of testing erorr will be minimized.

Table 8 Black Box Testing

No	Link	Output	Result
1	Send Data From Microcontroller to Server	Data is sent	Success
2	Showing a recent condition of rack server with updated data in graphically user interface	New Information in graphical form	Success
3	Showing Historical data in table form	Historical server in table form	Success

5. Result

5.1. Monitoring System

The author has developed a system for monitoring the use of current, temperatur and humidity. The author also used the technology so that the security system is becoming increasingly effective and efficient. In its development the author using various technologies, such as Embedded systems, Database Technology and Web.

Authors use ArduinoUno and raspberry pi equipped with wireless as a tool or the brain of the system developed. This tool is in charge to process all the necessary activities in monitoring the flow of electricity. ArduinoUno requires a current sensor for monitoring against the electric current and the data captured by the sensor current is sent through a cloud service. In the manufacture of the system can be accessed online. Power source micro USB with 5V 2.0 Amps needed to provide power at ArduinoUno so it can be turned on and the monitoring of the well as required. Furthermore the data generated by the ArduinoUno developed into the application monitoring system.

5.2. Data Storage

Data is stored into a MySQL-based database of current sensor and processed using the Arduino. Arduino send data to Raspberry Pi using serial data and the Raspberry pi will send tha data and store the data on database server.

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