Raspberry Pi and Z-wave Technology for Data Aggregation Moroccan Universities Data Centre's operations Monitoring

Zakarya BENIZZA [1], Ahmed MOUHSEN [2]
[1,2] *Laboratory of Engineering, Industrial Management and Innovation The Faculty of Sciences and Technology, Hassan 1st University, PO Box 577, Settat, Morocco.*

Abstract
The aggregation of data relating to the operating states of the critical installations of a data centre is one of the challenges faced by managers of growing data centres in Moroccan universities. Through the combination of the Raspberry Pi as a control unit, and based on Z-wave technology for interconnection and sensor management, our smart system is designed to centralise the supervision of the operation of a data centre in a Moroccan university environment. It is designed to automatically get instantaneous measurements of the power delivered by three sources of energy, also temperature inside and outside of the server room, and the temperature and power of all the IT Equipment inside each server racks. And to deduct the total consummate power and the power usage effectiveness PUE from it. The smart system can also manage operations inside the server rack by logically administrating all the IT Equipment through SSH Protocol. The measurements are collected with repetitions rate tuneable from one to ten minutes, are archived in an application Based on MySQL, Java especially developed for this system. The processing of these information's relating to the instructions configured by the operator, allowed to connect with efficiency the Data centre, according to DCIM approach.

Keywords: *Data Centre, DCIM, PUE, Raspberry Pi, Z-Wave, Sensors*

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1. Introduction

A data centre (DC) can be defined as a structure with all the physical resources necessary to store and process digital information. Data centres include the necessary infrastructure (e.g. electrical installations and devices, climate control systems, telecommunications, security, fire protection, automation systems) and IT equipment (e.g. servers for processing, data storage, switches and other network/communication equipment).

A DC now plays a key role in the booming university as the main IT infrastructure. Due to the sensitivity of the data processed, as well as the complexity of the IT equipment located in the data centre of a Moroccan university, and in accordance with standards, best practices and user requirements (Teacher-Researchers, Students, and Administration), the DC infrastructure must meet strict technical requirements in order to guarantee reliability, availability and Cybersecurity.

Most existing work on data centre availability focuses solely on the likelihood that a data centre's electrical infrastructure will support all of its IT equipment. , the use of a loading management strategy will increase the electricity supply from renewable energy and improve the sustainability of electricity supply [1]. But in general, different power infrastructure-induced failure scenarios can make various fractions of the overall IT equipment unavailable. Based on the poser distribution system's hierarchies, it is clear that the failure of a single PDU would only result in the unavailability of the associated cluster of racks, with the rest being operational, while an ATS failure would make all IT equipment unavailable. Pursuant to the rapid technology enhancements in cloud environments and data centers augmentations, power utilization in data centers is expected to grow unabated [2].

The Internet of Things is touching all spheres of life, be it in connecting cities together, making agricultural farms and health care smarter, predictable and more secure, and in industries it is set out to bring about changes that are similar to those of the industrial revolution that took place in the 19th and 20th century [3].
The objective of our study, is the improvement of the energy efficiency of the Hassan 1st university's Data center, to climb on the scale of ranking, by acting on the PUE (power usage effectiveness) of the server room, through the management of the power distribution system by a concept of a smart operations monitoring system. In line with the DCIM approach the smart system allows to monitor, verify, control and manage the energy consumption in the DC's electric sub-systems. And also, the smart system can monitor in real time, temperature, smock, luminance, and movement inside the server room and the server Racks. Traditionally, the ATS is used to switch between the two main Utility power sources and the DG diesel generator set as the second backup power source [4]. In our case study this smart system, is built using the Raspberry Pi 3 (Master) and the Z-wave dongle (coordinator), two components had been chosen owing to their very good performance, programming facilities, availability and economic advantages.

2. Smart DC Operations Monitoring System Overview

2.1 Raspberry Pi 3 the master of the smart System

The block diagram of Figure 1 shows that the smart system under study mainly insures the monitoring the DC operations toward two kind of missions. A Raspberry Pi Would act as a mini computer in our system [5]. First the Raspberry pi receives the resulting signals delivered by the Z-wave module, the latter, ensures the interconnexion and data collection of the signals coming from the sensors installed on each piece of the DC. The smart system can handle the immediate state information of the tree power supplies, and also the real time state of the power consumed by servers and the other It Equipment. It can also monitor the temperature and humidity in each inch of the DC, finally The Smart system can monitor in real time the stats of the doors (DC Door, Rack Doors), the movement and lightning intensity.

The second mission of the smart system, is to ensure the processing when reading data via its python program, once the temperature of an equipment (server, switch, firewall ...) exceeds the permissible threshold, the Raspberry will retrieve information on the processes of the equipment via SSH access, followed by sending an email containing information to diagnose the problem related to the operation and finally the logical and electrical shutdown of the equipment. All the data are stored in a MySQL data base and they can be displayed using Java. The smart system can calculate the power usage effectiveness PUE, generally defined as, the total electrical power supplied to the data centre divided by the total power consumed by IT equipment [6].

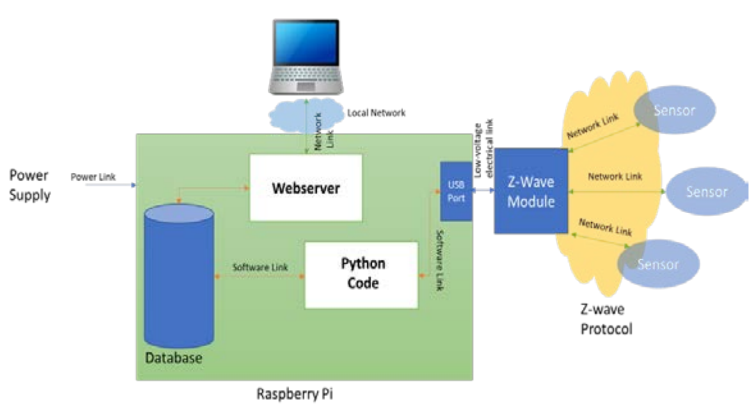

Fig. 1 Block diagram of the smart system.

The actions that can be executed by the python script are:

- Start and check the availability of the system components.
- Check logical links and networks.
- Mount and synchronies the Z-wave dongle, check link with raspberry pi.
- Detect and store data providing by the Z-wave dongle (controller) on the MySQL data base.
- SSH remote access and administration of the IT Equipment (server, switch, firewall …) to read system files and check the log and process.
- Logical remote shutdown of suspicious IT Equipment.
- Email notification to an already predefined destination by attaching system log files to get an idea of the state of the equipment.
- Physical shutdown of an IT Equipment using the Fibaro wall plug device.

2.2 Data Aggregation Using Z-wave Technologie

Data aggregation is an important aspect of any DCIM system and is usually done using a centralized device that can standardize data across multiple environments. These solutions include hardware, software or a combination of both [7]. In our system Data aggregation is insured using the Raspberry Pi as a master, which is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside of its target market for uses such as robotics. Peripherals (including keyboards, mice and cases) are not included with the Raspberry Pi. Some accessories however have been included in several official and unofficial bundles [8]. Diverse kinds of wireless technology and corresponding networks enable gadgets to address one another and to the web without cables. There are various wireless advancements out there that can be executed in hardware items for Internet of things and machine-to-machine correspondence [9]. In our system we are using a Z-wave USB dongle (slave) for data collection and sensors communication, Z-Wave is one of the key access protocols of the Internet of Things (IoT). It is highly popular in-home automation and security system applications due to its minimum power consumption, reliability, and cost effectiveness [10]. Optimized for reliable, low-latency communication of small data packets with transmission speeds of up to 100 Kbps, it operates in the Sub-GHz band and offers total resistance to interference caused by Wi-Fi and other wireless technologies in the 2.4 GHz range, such as Bluetooth or ZigBee. With the ability to control up to 232 circuits, it is highly scalable and supports full mesh networks without the need for a coordinating node. Te advantage of this topology is that it automatically finds the best path, reducing the message delay, and enhances the reliability of the system [11].

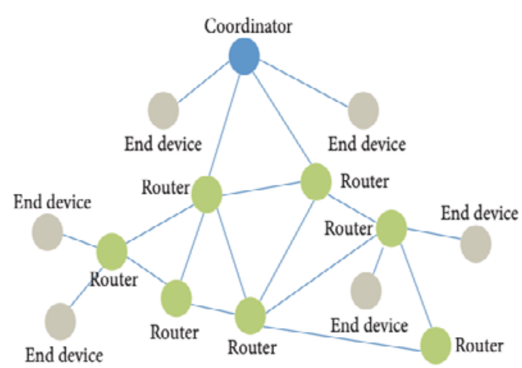

Fig. 2 Mesh Topology used by the smart system

2.3 Z-Wave Sensors deployment

1) Power measurement: The power consumed by the IT Equipment (Servers, Switch, Router, Firewall,.) is measured using the Fibaro Wall Plug, Z-Wave compatible, relay switch in the form of a socket adapter. The Plug may be used to operate any device up to 2,500W power output. The Plug features power consumption measuring and uses a crystal LED ring to visualize the current load by colour changing illumination. Fibaro Wall Plug may be operated using the service button located on its casing, or via any Z-Wave compatible controller [12].

2) Server Room Temperature Measurement: The temperature measurement and fire detection in the server room is insured by The Fibaro Smoke Sensor, which is a universal optical smoke detector compatible with the Z-Wave standard. A fire detection is signalled by a sound, a light signal and the sending of a Z-Wave command. The optical detector detects smoke at the start of a fire, sometimes even before the flames appear and the temperature rises quickly. This detector also has a temperature sensor, which allows to detect a too important increase of this one [13]. In our case we used four of these sensors placed in the four corners of the DC.

Fig. 3 Fibaro Fire detection status

3) Server Rack Monitoring: For the server Racks monitoring, the smart system is using the Philio 4 in 1 Sensor as home automation device, it has PIR and door detection function insuring the security access to the rack, also by using this kind of sensor it allows to measure the temperature inside each rack, this device send report about the four parameters measurement using Z-wave protocol to the central controller, this message reports include 4 headers : Motion Report, Door Report, Temperature Report, and Illumination Report when detecting a change in the luminance inside the rack [14].

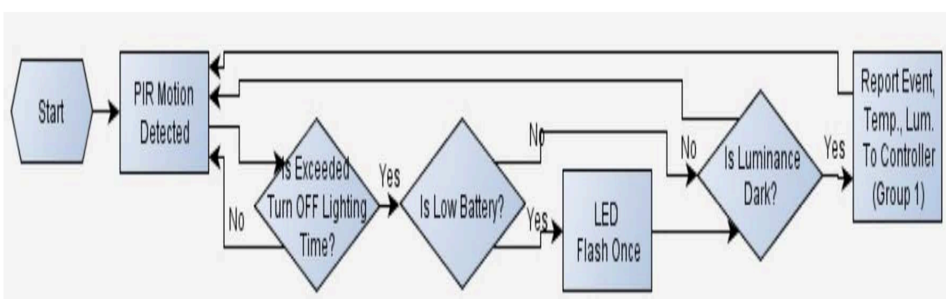

Fig. 4 Philio 4 in 1 used as home automation sensor

3. Results and Discussion

The reporting function of the DC's operations remains the most important objective toward this study; we conceived an intelligent system, which ensures the archiving information about powers input/output temperature inside/outside a rack, PIR, and fire detection, and calculate the PUE of the DC, data are displayed using a special java application developed especially for the smart monitoring system.

3.1 Power Delivered by the tree Utilities

The smart system can monitor the instantaneous values of the power delivered by the tree utilities: The Normal Utility S1, the emergency utility source 1, and the second one S2. The DC manager can keep a clear vision about each utility performances, and can evaluate the solar system efficiency by monitoring the power delivered and comparing the values every season during a year, by generating reports.

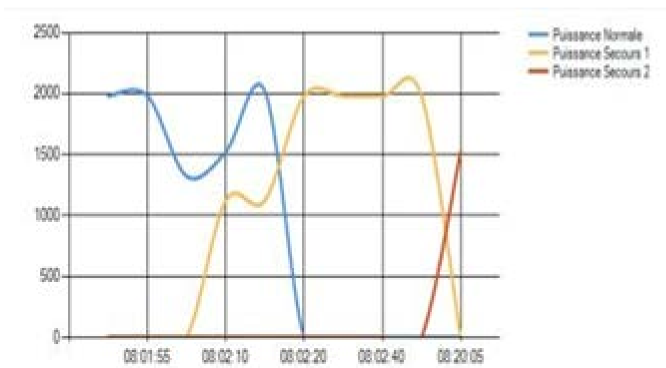

Fig. 5 Power delivered by the 3 Utilities: Normal Source, DG, and Solar utility

3.2 Temperature Inside/Outside The server Rack

The smart system can monitor the instantaneous values of the temperature inside and outside the server room, all the data are stored and dynamically archived, the DC manager have to deal with one and only central monitoring application, also can generate report about the cooling system performances.

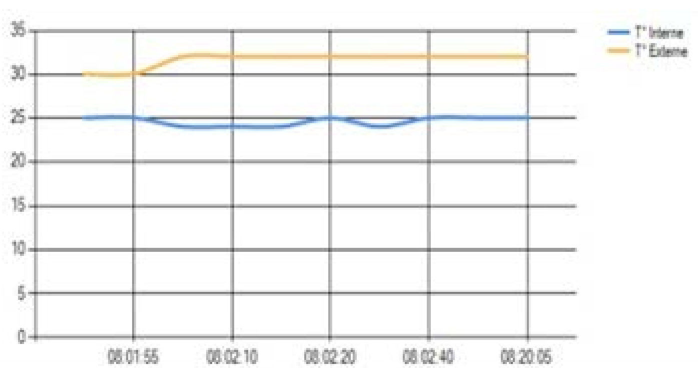

Fig. 6 Temperature Inside/Outside the Server Rack

3.2 Power Usage Effectiveness monitoring

The Power Usage Effectiveness metric PUE was introduced by the Green Grid, an association of IT professionals that focuses on the development of energy efficiency in data centres [15]. It is a synthetic, efficient and internationally recognized indicator allowing a rapid assessment of the energy efficiency of a data centre. It also enables data centres to be compared with each other and to determine whether energy efficiency improvements are needed.

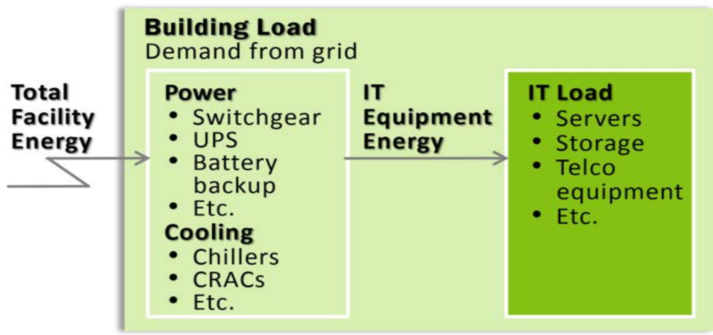

Fig. 7 PUE as defined by the Green Grid institution

The smart system, allows an advanced deduction of the PUE. the Fibaro wall plug device give a continuous measurement of the power at the level of the IT Equipment input, the measurement is collected with repetitions rate tuneable from one to ten minutes. The measurement not require human activity to gather and record data; data will be collected by automated smart system in real-time and support extensive trending and analysis. The Green Grid–recommended approach for obtaining the data necessary to calculate PUE is to measure actual energy usage for the entire data centre and IT equipment. By Moving the monitoring location closer to the devices that are consuming the energy enables further isolation of distribution component losses [16].

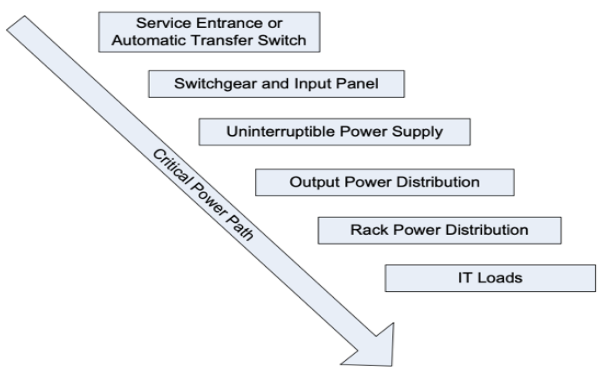

Fig. 8 Hierarchy of critical power path measurement points

In our Case study the Power Usage Effectiveness PUE, is calculated using the following equation:

$$PUE = \text{Total Facility Power}/\text{IT Equipment Power} \quad (1)$$

Where the Total Facility power is the sum of the power energy delivered from the tree utilities Normal source Utility, the DG, and the power delivered from the solar system as the first emergency source utility, added to the power consumed by the cooling system, the lightning, UPSs, control access system. And the IT Equipment power is the sum of the power consumed by different IT device (servers, storage and telecom device, …).

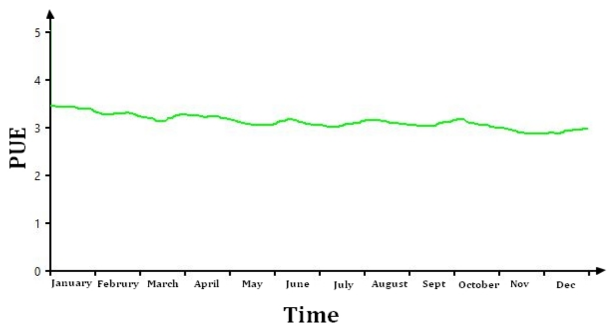

Fig. 9 University Hassan 1st PUE Monthly Monitoring

The person in charge of the Data centre can easily viewed these information's and generate various kind of reports: snapshot state, daily, monthly, yearly reports). During the design of the smart system, we have taken into consideration the homogeneity, flexibility and adaptability of the system to the Data Centre in the Moroccan university environment.

4. Conclusions

The testing and simulation phase of the smart system conducted at Hassan 1st University Settat, give us such a fascinating result about the energy consumption of the data centre. Also, the instrumentation of electric functioning, make the electrical feed operations more efficient and redundant. The processing of this data allows the Data centre manager to visually and automatically manage the Data Centre's power supplies changes, the use of this smart system in the Moroccan Higher education Institution's DCs, can reduce the power consumed by the IT Equipment, towards a logical shutdown of the servers during off-peack hours, and also check the performances (HDDR, Memory, Process, …) by launching top -b -n 1 > /home/pi/top.txt using SSH secured Tunnel. The availability of electrical installations is improved by receiving information on the power level and capacity of current air-conditioning systems. Operational costs will be reduced by improving overall efficiency.

Acknowledgments

The authors are very much thankful to the unanimous reviewers of the paper and editors of the journal for their constructive and helpful comments that improved the quality of the paper. Many thanks to Dr. Khadija ESSAFI the president of Hassan 1st University Settat, and his team for the total access to the Data Centre and the other building in relation with, which helped us in our studies, Tests and simulations.

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Zakarya BENIZZA Was born in KENITRA, Morocco, in 1985. He is Ph.D. candidate in the Faculty of Sciences and Technology, Hassan first University, Morocco. He is the Data Centre responsible in university Hassan1st Settat Morocco since 2010, he received the Master degree in System and Network from University Hassan first, Settat, Morocco. Member of Engineering, Industrial Management and Innovation (IMII) Laboratory.

Ahmed MOUHSEN Was born in May 1960. He received the Ph.D. degree in electronics from the University of Bordeaux I, France. He is currently a Professor of Electronics in Faculty of sciences and technology university Hassan1st Settat Morocco. He is involved in the design of hybrid, active, and passive microwave electronic circuits, digital systems and IoT. Member of Engineering, Industrial Management and Innovation (IMII) Laboratory.