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Research paper



Open source IOT monitoring and controlling system using raspberry Pi 3 and OpenHAB to measure and control the electricity power consuming

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Abstract

Internet of Things (IoT) is one of promised components of Industry 4.0. It is a concept of how to the technology make the life easy and smart enough to let people focus on more productive and efficient areas. The ultimate purpose of this research paper is to introduce a practical experience of adopting open source solutions which a world trend to solve daily issues quickly, efficiently and affordably. Open source initiatives believe that community is a key party to contribute with solutions' ideas, technical experience and sharing knowledge.

Keywords: *Internet of Things; Big Data; Smart City; Open Source*.

1. Introduction

The core of IOT is internet environment which is responsible to link all devices each together. Internet was commissioned by the United States federal government in the 1960s and the network was called ARPANET.
Since Web was invented, web contents grown dramatically and advanced intent technology make this happen fast. Web contents were consumed by users. Most of these contents are personal pages and static contents hosted in web servers. Web 1.0 and web 2.0 were introduced to compare the difference between the contents that has been generated in traditional web and the new era of web 2.0
Web 2.0 is not the end, Web 3.0 now is introduced as a Semantic Web, but Spivack's opinion is that the Semantic Web is just one of several converging technologies and trends that will define Web 3.0. He defined it as connective intelligence; connecting data, concepts, applications and ultimately people. Some People supposed that Web 3.0 is the blockchain technology which is "an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value" [1] . Blockchain depend on the concept of decentralization which means that the network works based on on a user-to-user (or peer-to-peer).
Another approach introduces IOE (Internet of EveryThing). It supposes that IOT connection is machine-to-machine (M2M), machine-to-person (M2P) or person-to-person (P2P). IOE includes not just the networked connection of physical objects, but also includes the links between people, process, and data (see Figure 1.3). However, the above definition is able to proof that IOT can do Everything.

2. An overview of internet of things

ITU (International Telecommunication Union) defines IoT: "A global infrastructure for the Information Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies."[2]
The IERC (IoT European Research Cluster) definition states that IOT is "A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network. [3]"
McKinsey, The research and consultancy company defines IoT as "sensors and actuators embedded in physical objects are linked through wired and wireless networks, often using the same Internet Protocol (IP) that connects the Internet. [4]"

3. Open source technologies contributions for IOT

Open Source software is a promised solution for accelerating finding solution for daily issues. Most of experimenting labs (if not all) use open source software's because it provides ability to use without restrictions according to the open source license.

3.1. IOT software

Usually any IOT solution has server and client slides. Server side software is responsible to process and visualizing data that are captured by the client side software which is a normal topology

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when the server is far from the client and a communication protocol is used like WiFi or wire. Another way is a standalone IOT system when the capturing and data processing are in the same hardware and no more actions are required like triggering a separated device like the mobile phone which has motion sensor that captured number of meters of a daily walk.

3.1.1. Software IOT-dedicated systems (servers)

The server side software is a set of files and database along with protection and performance tools that are required to read and process data provided by one or several sources named as clients. The server side software should be capable to receive data from any client that support an IOT data protocol or communication medium.
MQTT is an example of connectivity or data protocol that provide a lightweight data transportation for IOT systems when a small code footprint is required [5]. IOT software Server side can translate MQTT subscription and publishing messages that sent from the clients.

3.1.2. IOT software clients

According to client-server topology, Client should be powered by a small capturing or actuating software that can temporarily store and then send data using MQTT protocol over TCP transportation protocol. There are many Data Protocols used for IOT purposes such as CoAP, AMQP, Websocket, Node, however MQTT is selected to be most straightforward protocol supported by OpenHAB.

3.2. IOT hardware

IOT is used to characterize the ability to track and identify objects or things (Virtually or physically) within the Internet or similar IP structure [6]. There are many considerations that bring dedicated hardware characteristics either for server or client devices. These are not limited to:

- Internet connection: Ability to connect to internet or trigger an IP-switch.
- Low-power device: If anything has a chance to be connected to internet and keeping active object, more and continuous supplying power is required.
- Easiness of connection and operate: In near future, almost everything is going to be IOT-enabled.
- Minimum level of smartness: By the definition IOT things should has ability to decide and act according to a given or predefined data or self-configuration.

Open source hardware (OSHW) is hardware whose design is made publicly available so that anyone can study, modify, distribute, make, and sell the design or hardware based on that design [7].
In this paper, Raspberry Pi (RPi) is selected to host the IOT platform as a server side. Raspberry Pi is open hardware by the definition of Open Source Organization [8]. Moreover. ESP8266-based sensors and switches are used which is also considered as open source hardware where a small framework can be embedded for different purposes.

3.2.1. IOT-dedicated hardware systems

Client-server methodology still easy way to build any system where one central server managing and gives instructions to clients. Systems usually are consisting of hardware and software to be the central part of control and monitoring of all other client unites which are also can be hardware and software.
To end up with comprehensive and complete IOT system, a dedicated open source software called OpenHAB [9] platform is hosted by the raspberry Pi. OpenHAB is well structured platform designed as home automation hub (HAB) to manage IOT items with readymade plugins and friendly interface. Since OpenHAB is opensource, hundreds of developers could contribute to connect almost most of items that considered as IOT things such as D-Link Smart Home devices, The Amazon Dash Button, Philips Hue Lighting system, LG TV, etc. Consumers only need few easy steps to plug and play their items with OpenHAB.

3.2.2. IOT hardware unites

ESP8266 is the selected client hardware which is the terminal unit to be the first line to capture and send data or to receive instruction according to system configuration. ESP8266 is a chip equipped by wifi, TCP/IP stack and MCU capabilities. cheap cost of ESP8266 make it feasible to be used for affordable IOT terminal for any number of things.

4. Implementation

According to actual power reading records (By assuming two Air Conditioners with 2 kwh and 50 rooms.
), the average energy (KWH) for one year consumed by each school is 950 kwh/day. So if this amount multiplied by 1100 school building, almost 1.045 mwh (for 1 day) is consumed enough to energize 17400 houses (for 1 day).
This research select one school to implement an energy monitoring system. The project simply focus on measuring energy consumed on the time. Building has internet connection and local wireless network. There are more than 150 Air conditioner and other devices like ceiling fans and tubelights.Consumption records are collected 24/7 hours but most usage is started from 7:00 AM to 2:00 PM, 5 day a week.

4.1. The proposed open source solution monitoring (EMON)

EmonBase is a Raspberry Pi with a pre-installed emonCMS and openHAB and equipped with RFM69Pi receiver board fixed in GPIO ports. Emon system has straight forward setup way. In fact, a pre-built emonSD file is used which is available in Github [10].
emonCMS is web-based software, so it can be accessed using internet browser. For first configuration, emonBase (fig.1) is equipped with WiFi communication that can work as a router by giving access point (AP). This means that it can be accessed directly using PC or mobile phone once it connected.
emonCMS is an open source software dedicated for OEM system. It has many features including user creation, data storing and conversion, dashboard building and so many features that help to monitor the power consumption either for stored data or real-time data. It also has the ability to manage selection of WiFi networks to for ability to access it in the local network or remotely by www.emoncms.org.
The set was installed in a government school in Muscat to measure the electricity consumption for one month (fig. 2 and 3).



Fig. 1: Proposed Open Source Solution Monitoring (EMON).



Fig. 2: Measure the Electricity Consumption.

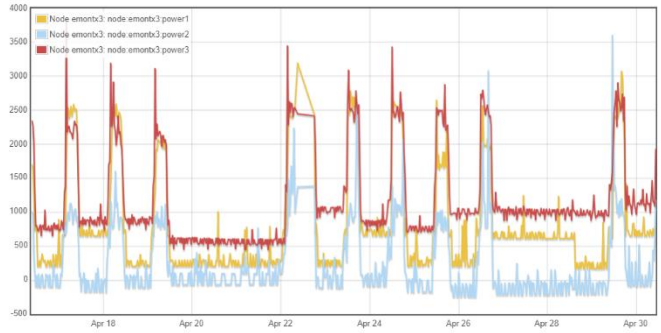


Fig. 3: Measure the Electricity Consumption.

4.2. Controlling

Open hardware and open software are used from iTead. The open hardware is RPI and ESP8266 and the open software is OpenHABian which is a light version of Raspbian where OpenHAB is built-in with.

4.2.1. The proposed opensource solution monitoring (OpenHAB)

OpenHAB stands for open "Home Automation Bus". It works as center of your smart home! It is built to connect anything that can communication via network. Thing abbreviation used in OpenHAB that tell which physical entities (devices, web services, information sources, etc.) are to be managed by the system.

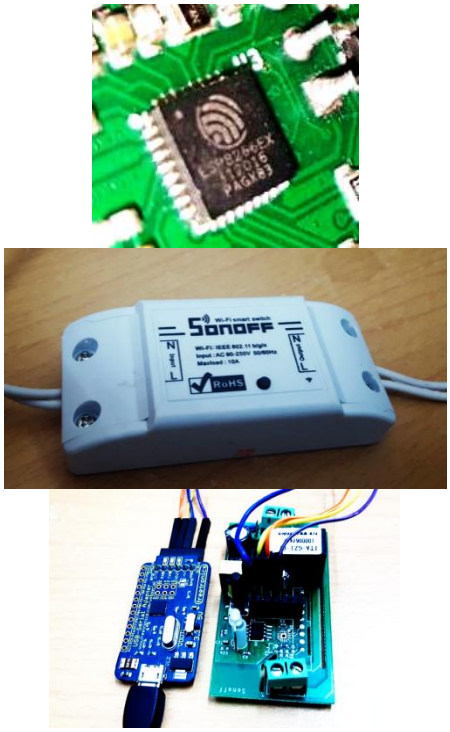


Fig. 4: Control Devices.

iTead Sonoff (fig. 3) smart switch equipped with ESP8266 electronic chip that has the DNS capability and WiFi communication. But the factory setting let users communicate with the smart switch using a mobile app called eWeLink. In order to use this device to work with openHAB, a customized framework has been embedded, available in GitHub called Sonoff-Tasmota [11]. The factory default firmware has been replaced by a new firmware that will help configuring the smart switch to communicate with openHAB. New Firmware allows OpenHAB (fig. 4) to control Sonoff switch by using MQTT protocol which is one of data exchange standard between M2M and it's fast and does not overload resources.

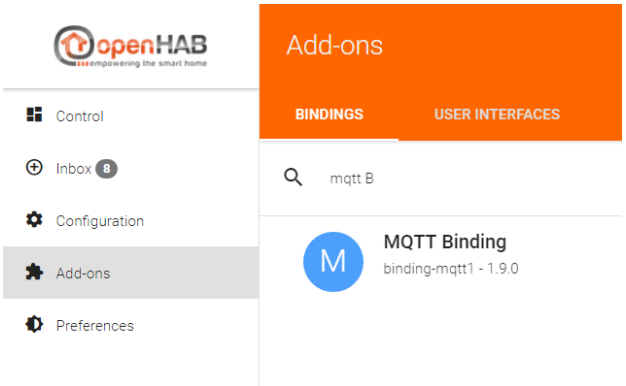


Fig. 5: OpenHAB.

OpenHAB is built by Java and most of Java application reached by port number 8080. Once the Raspbian is connected with the network, Openhabian can be a reached by using local IP like http://192.168.100.6:8080 . OpenHAB have good interactive user interface capabilities. There are two default screens: Setting and dashboard. Settings screen for binding and scanning new clients (or things). The dashboard is customizable to control or monitor the items.

Sonoff smart has been programmed to publish to the topic (say /sonoff/bluelamp/). To let openHAB subscribe to the same topic, simply one file under (items) folder is required with extension (. items). The required code as following [12]:

```
Switch bluelamp "Living Room Light" <light> (LR,gLight)
                { mqtt=">[broker:/sonoff/bluelamp/cmd:command:ON:ON],>[
broker:/sonoff/bluelamp/cmd:command:OFF:OFF],
                                <[bro-
ker:/sonoff/bluelamp:state:ON:1],<[broker:/sonoff/bluelamp:state:OFF:0]"
                }
```

Explanation of the first code line:

- Switch: used for ON/OFF function
- "Living Room Light" is nothing but item label.
- <light>: icon name to be displayed in the controlling dashboard.
- (LR,gLight) : Groups' names. Any item can belong to unlimited number of groups for organizing purpose and flexible group controlling.

The second code line is responsible to subscribe to the topic (/sonoff/bluelamp/)

The third code line is reporting the status of the item either ON or OFF. This is important to confirm and display the status in the controlling dashboard.

5. Evaluation of open source solution adoption

Open source solutions usually are easy to adopt from technical point of view with little bit practice and reading some documentations. Selection of open source software and hardware must be a smart decision. There many aspects make the adoption success:

- Cost effective: Either the adopted solution is being used for testing or production purpose, it should be logical and with-in a ROI.
- The solution should has well organized and enough documentation of installation, troubleshooting, configuration, tutorials etc.
- No restriction of number of users or server licenses in the code level however it could possible for maintenance and support services. No restriction of how to use and what type of license the solution belongs such as GPL or MIT as examples. This subject to how far the period of investment is.
- System Security is highly considered where the level of security is subject to the investor using policies.
- The selected solution shall have a clear and

Such adoption of open source gives a chance to learn new technical skills not limited to coding, installing, troubleshooting or customizing. The community support is the key mean of open source where everyone can find a solution for any issue and it provided usually for free. Dealing with hardware required minimum of understanding how such physical things are working. Software issue often are visible and can be debugged with handy tools however hardware issues are headache, unexpected fails and need the right procedures for troubleshooting.

6. Conclusion

The new era of internet is the access almost to anything using same existing internet infrastructure to collect more real-time or stored data and generating more values using algorithms or processing tools conventionally called AI (Artificial Intelligence) to analyzing huge quantity of data which is called (BigData).
Values are information generated by AI from BigData should give decision makers a clear vision for what is going in real-time and what is expected both in short and long period.
Operational Efficiency and revenue generation are two primary areas of monetizing the IoT. IoT allow us how data are organized and used, consequently it help to prevent unexpected or unplanned shutdown. On the other hand, companies are interested and see great opportunities to embed digital services along with their products [13].

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