Raspberry Pi Based Energy Efficient Load Monitoring System

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Abstract -- Internet of Things (IoT) promises to be a key enabler in Smart Manufacturing and Smart Supply Chain. These systems are characterized by reliable sensing and reporting of multiple parameters within the factory floor. Industrial IoT (IIoT) systems could suffer from high and uneven energy consumption due to the nature of the network deployment. Services like Twitter, Facebook, and Weibo have established a novel information channel that constantly provides real-time observations and situation reports from a worldwide community of users. Once made accessible, data from these sources could tremendously help to support information gathering in domains like disaster response, critical infrastructure management, and general public safety. In this paper , We proposed that energy monitoring of loads can be made efficient by employing twitter, only social network which is open source one with help of Raspberry pi system. Further, we propose a heuristic and opportunistic link selection algorithm, HOLA, which not only reduces the overall energy consumption of the IoT network but also balances it across the network. HOLA achieves this energy-efficiency by opportunistically offloading the IoT device data to smart-devices being carried by the workforce in the factory settings.

I . INTRODUCTION

The IoT is the internetworking of physical devices, vehicles , buildings, and other items (smart devices) embedded with electronics , sensors and network connectivity that enable these objects to collect and exchange data. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure. It results in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

With the progress of science and technology and the continuous improvement of living standards, various electric equipments are used more and more widely. The electric power network will be overloaded so much so that result to a widespread power outage with the electrical equipments used so much. Therefore, monitoring the operation data of electric equipments is very important. House is an important place for people's daily life, work and entertainment, and the domestic use of electricity is the basic unit is of social modernized development. The monitoring of electrical equipments which helps users to know the status of household electricity load to further reasonable formulate energy-saving plan, reduce energy consumption and expenditure .

Electricity load monitoring of appliances has become an important task considering the recent economic and ecological trends. In this game, machine learning has an important part to play, allowing for energy consumption understanding, critical equipment monitoring and even human activity recognition.

Nowadays, appliances are responsible of a significant part of the electricity bill in residential and commercial buildings. For instance in U.S. residential building, lighting and appliances represent 30% of the electricity consumption . Two approaches are existing:

1) Non-Intrusive Load Monitoring - NILM consists in measuring the electricity consumption using a smart meter, typically placed at the meter panel. Relying on a single point of measure it is also called one-sensor metering. The qualification of non-intrusive means that no extra equipment is installed in the house. With NILM, the appliance signatures are superposed and, for comprehending the contribution of single appliances, they have to be separated. This operation is called disaggregation of the total electricity consumption.

2) Intrusive Load Monitoring - ILM consists in measuring the electricity consumption of one or few appliances using a low-end metering device. The term intrusive means that the meter is located in the habitation, typically close to the appliance that is monitored.

Services like Twitter, Facebook, and Weibo have established a novel information channel that constantly provides real-time observations and situation reports from a worldwide community of users. Once made accessible, data from these sources could tremendously help to support information gathering in domains like disaster response, critical infrastructure management, and general public safety .

The main components are the IoT devices, Base Station, and the Cloud service provider. The IoT devices in such deployments are typically powered by devices such as Arduino . The plug-and-play nature of the devices requires them to use batteries as a source of energy. To conserve energy, the IoT devices use a low power wireless communication protocol such as Bluetooth. The IoT devices collect data from their sensors and send it to the Base Station (BS) or Access Point (AP).

The Bluetooth protocol has a short communication range of approximately 10 m. A typical manufacturing factory has rectangular shape with typical dimensions of 1000 m * 900 m , and the BS is located at one end of the plant/factory. In order to be able to reach the BS, the IoT devices form a Peer-to-Peer (P2P) multihop network. Thus the IoT devices not only sense and report data collected from the sensors, but also the data arriving from neighboring nodes down the link that needs to be forwarded to the BS over the Bluetooth interface. The BS, for example , could typically be powered by a Raspberry Pi device . The BS collects all the sensor data from the IoT devices over Bluetooth interface and sends it to the Cloud for further proce ssing over wired Ethernet interface. The Cloud is powered by an analytics platform. Some examples of IoT platforms are the TCS Connected Universe Platform (TCUP) and the Splunk platform for machine data.

The network topology in the Bluetooth System leads to reduced energy efficiency of the IoT devices. Specifically, we observe that the nature of the network topology leads to increased energy consumption and geo-physically skewed energy consumption within the IoT devices. The IoT devices at one end of the network sense and transmit only their sensor data. This results in low congestion and low energy consumption in these IoT devices. However the IoT devices at the center of the network are not only sensing and reporting their sensor data, but al so that of the IoT devices from down the link. This leads to moderate congestion and energy consumption. The IoT devices closer to the BS have to sense and transmit their own sensor data and also transmit the sensor data arriving from the rest o f the network. This leads to high congestion and energy consum ption in these IoT devices. These additional transmission responsibilities result in the IoT device operating its Bluetooth antenna for long durations. This, in turn, increases the energy consumption of the IoT device.

The drawback of existing system is that it has a very low range due to the use of a Bluetooth module. As the Bluetooth module has a very low bandwidth it cannot be used to transmit large amount of information over long distances.

II. PROPOSED SYSTEM

High energy consumption in I T devices in an Industrial Internet setting is not desirable since it results in reduced network lifetime, and increased ca rbon footprint. Skewed or uneven energy consumption is n ot desirable as it makes planned maintenance of IoT devices for battery replacement challenging and increases the over all down time. With this in mind, a Heuristic and Opportunistic Link selection Algorithm (HOLA), for IoT systems that improves the energy-efficiency of IoT systems by reducing the overall energy consumption and balancing it across the network. HOLA achieves this energy-efficiency by opportunistically offloading the IoT device data to smart-devices (e.g., smart phones, tablets, etc.) being carried by the workforce in factory settings.

Wireless Protocol	Range (m)	Ba ndwidth	Energy-Efficiency
Bluetooth	**~10**	**Low**	**High**
Wi-Fi	**~100**	**High**	**Medium**
3G/4G LTE	**~5000**	**Me dium to High**	**Low to Medium**

Table 1 Comparison of various Wireless radio interfaces

Further, these smart-devices with multiple radio links such as Bluetooth, Wi-Fi, and 3G/4G LTE heuristically determine the best link to transmit the data to the cloud based on the quality and energy cost of the link. HOLA can improve the energy efficiency of II oT systems by reducing the overall energy consumption and balancing it across the network.

The proposed system uses the HOLA concept, which not only reduces the overall energy consumption of the IoT network but also balances it across the network. Proposed system achieves this energy-efficiency by opportunistically offloading the IoT device data to smart-devices by using Wi-fi module. In this method, compared to the existing system, congestion level is very low. This method performs offloading the data in a fraction of second to the web server, so this way reduces the congestion level.

Internet of Things (IoT) promises to be a key enabler in Smart Manufacturing and Smart Supply Chain. The IoT systems are responsible for enabling and improving the operational efficiencies of factories, plant floors, including assembly plants. These systems are characterized by reliable sensing and reporting of multiple parameters within the factory floor. Such sensing activities offer safe, efficient and optimized performance of not only the machines manufacturing the products, but also the workforce operating them.

In recent years, research on social media analytics for crisis intelligence has seen exponential growth in the areas of information mining and data visualization. Services like Twitter, Facebook, and Weibo have established a novel information channel that constantly provides real-time observations and situation reports from a worldwide community of users. Once made accessible, data from these sources could tremendously help to support information gathering in domains like disaster response, critical infrastructure management, and general public safety. Recent visual analytics (VA) approaches have demonstrated how the tight coupling of machine learning, language processing, and highly interactive graphical interfaces can be utilized to cope with social media data volumes and identify relevant entities, trends, and anomalies in this data.

Energy management has become one urgent research issue. Regarding the home environment, an energy management cloud can collect home consumption usage and then supports remote control and schedule the status of home appliances. In order to increase the interoperability we use a universal smart energy management gateway based on an open source Internet of Things (IoT) platform called Iotivity. Therefore, the energy management cloud can be extended to monitor and manage Iotivity-compatible devices.

The IoT is the internetworking of physical devices, vehicles , buildings, and other items (smart devices) embedded with electronics , sensors and network connectivity that enable these objects to collect and exchange data.The IoT allows objects to be sensed and controlled remotely across existing network infrastructure. It results in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

“Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring or field operation devices that assist firefighters in search and rescue operations. Legal scholars suggest to look at "Things" as an "inextricable mixture of hardware, software, data and service". These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices. Current market examples include home automation (also known as smart home devices) such as the control and automation of lighting, heating (like smart thermostat), ventilation, air conditioning (HVAC) systems, and appliances such as washer/dryers, robotic vacuums, air purifiers, ovens or refrigerators/freezers that use Wi-Fi for remote monitoring.

III BLOCK DIAGRAM

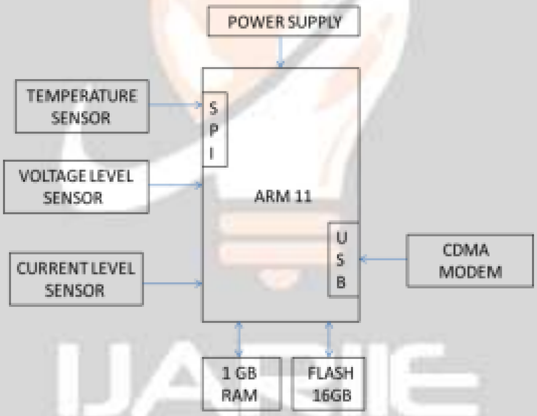

Figure 1 Block Diagram

The system configuration consists of gadgets connected across a sensors and CDMA Modem to the Raspberry pi , As shown in the figure 1 . The sensors are used to monitor the industrial situation, if the sensor value is abnormal immediately alert signals are sent to the user’s twitter account. A Modulator Demodulator (MODEM) component helps to send the signals to energy management twitter account accordingly using the python algorithm implemented in the raspberry pi. So we can easily improve the energy efficiency of the industrial equipments.

IV. HARDWARE COMPONENTS

A.Raspberry pi 3

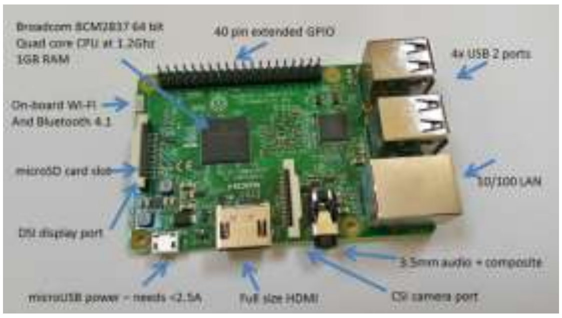

Figure 2 raspberry pi circuit

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processor, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs . Through SPI (Serial Peripheral Interface), it gets value from the sensors and sends it to twitter account through Wi-fi module.

B.MCP 3008

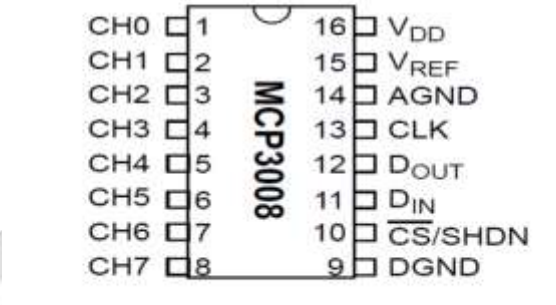

Figure 3 MCP 3008 Pin Diagram

The Microchip Technology Inc. MCP3004/3008 devices are successive approximation 10-bit Analog- to-Digital (A/D) converters with on-board sample and hold circuitry. The MCP3004 is programmable to provide two pseudo-differential input pairs or four single-ended inputs. The MCP3008 is programmable to provide four pseudo-differential input pairs or eight single-ended inputs. Differential Nonlinearity (DNL) and Integral Nonlinearity (INL) are specified at ±1 LSB. Communication with the devices is accomplished using a simple serial interface compatible with the SPI protocol. The devices are capable of conversion rates of up to 200 ksps. The MCP3004/3008 devices operate over a broad voltage range (2.7V - 5.5V). Low-current design permits operation with typical standby currents of only 5 nA and typical active currents of 320 µA. The MCP3004 is offered in 14-pin PDIP, 150 mil SOIC and TSSOP packages, while the MCP3008 is offered in 16-pin PDIP and SOIC packages.

C.Temperature Sensor

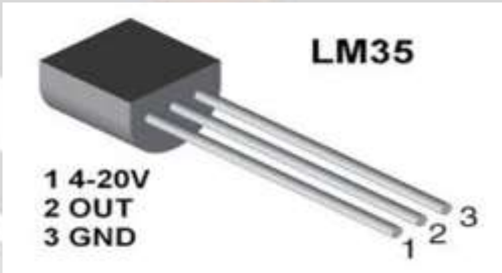

Figure 4 LM35 Sensor

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air. The LM35 device is rated to operate over a −55°C to 150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy). The LM35-series devices are available packaged in hermetic TO transistor packages, while the LM35C, LM35CA, and LM35D devices are available in the plastic TO-92 transistor package. The LM35D device is available in an 8-lead surface-mount small-outline package and a plastic TO-220 package.

LM35 is a precision IC temperature sensor with its output proportional to the temperature (in oC). The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self heating and does not cause more than 0.1 oC temperature rise in still air.

D.Current Sensor

Figure 5 Current Sensor

The 10A AC Current Sensor is a self powered AC current transducer that provides a 0-5V dc analog signal proportional to the AC current flowing through the device wire window. It is ideal for load monitoring without the need for an external power supply. Factory calibrated, fixed ranges ensure superior accuracy and eliminate configuration and adjustments in the field, saving time and avoiding confusion. The 14.5mm (0.570") wire window accommodates a conductor up to AWG #2. Multiple turns of the primary wire may be used to alter the input range. Output voltage is clamped at 6.5V, and the unit delivers a linear output up to 120% overload (6V). Mounting hardware for flexible surface mounting included.

E.Trimpot

A trimpot or trimmer potentiometer is a small potentiometer which is used for adjustment, tuning and calibration in circuits. When they are used as a variable resistance (wired as a rheostat) they are called preset resistors. Trimpots or presets are normally mounted on printed circuit boards and adjusted by using a screwdriver. The material they use as a resistive track is varying, but the most common is either carbon composition or cermet. Trimpots are designed for occasional adjustment and can often achieve a high resolution when using multi-turn setting screws. When trimmer potentiometers are used as a replacement for normal potentiometers, care should be taken as their designed lifespan is often only 200 cycles

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Figure 6 Trimpot

V OUTPUT

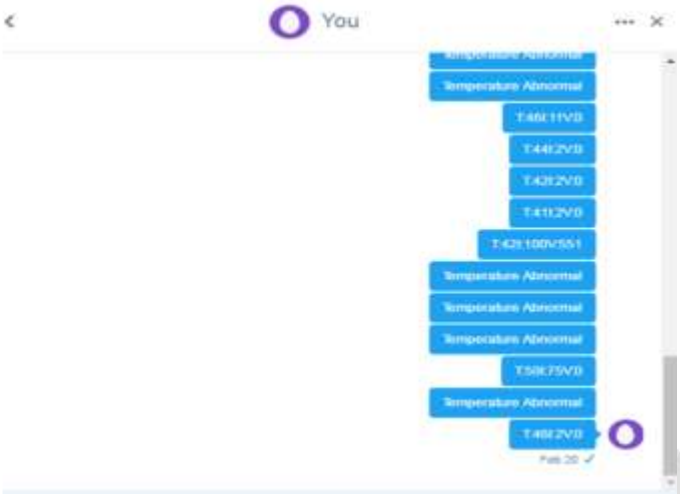

Figure 7 Output of the project

The figure 7, which is shown above represents the output of the project . The ratings (voltage , temperature , current ,etc.) may vary depending on the load. The values are specified in the program source code . When the kit is turned on and on opening the twitter account , the user get messages with the prescribed time interval (10 seconds) . So for 10 seconds once , we get messages from the kit . When the value goes beyond this rated value , then the user gets the value as abnormal . Here with reference to the above figure , the user can able to know that the temperature is abnormal . Thus the user monitors and when he gets an abnormal message , He starts to take necessary action to prevent the load from getting damaged .

VI CONCLUSION

We have proposed HOLA along with Twitter that improves the energy efficiency of IoT systems by reducing overall energy consumption and balancing it across the network. HOLA achieves this energy-efficiency by opportunistically offloading the IoT device data to smart-devices being carried by the workforce to monitor the loads successfully. Thus the IoT devices along with twitter , acts as a good enabler in monitoring the loads and the workforce can able to monitor the loads , just with successive and successful log-in with twitter . Through practical experiments, we have measured the energy consumption of the loads.

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BIOGRAPHIES (Not Essential)

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