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IoT Based Energy Management for Residential Area

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ABSTRACT

Cities are becoming more and more of a focal point for our economies and societies at large, particularly because of on-going urbanization, and the trend towards increasingly knowledge-intensive economies as well as their growing share of resource consumption and emissions. To meet public policy objectives under these circumstances, cities need to change and develop, but in times of tight budgets this change needs to be achieved in a smart way: our cities need to become smart cities.

Keywords : IoT Based Energy Management, Urbanization, Public Policy, EU Energy, GHG, Smart Buildings

I. INTRODUCTION

In order to follow the policy of the decarbonisation today's energy usage in transport systems and infrastructures have to drastically change. There is a need to shift to sustainable production and use of energy, to sustainable mobility, and sustainable infrastructures and services. Cities and urban communities play a crucial role in this process. Three quarters of our citizens live in urban areas, consuming 70% of the overall energy consumption and emitting roughly the same share of greenhouse gases. Of that, buildings and transport represent the lion's share.

Within the worldwide perspective of energy efficiency, it is important to highlight that buildings are responsible for 40% of total EU energy consumption and generate 36% of GHG [8]. This indicates the need to achieve energy-efficient buildings to reduce their CO_2 emissions and their energy consumption. Moreover, the building environment affects the quality of life and work of all citizens. Thus, buildings must be capable of not only providing mechanisms to minimize their energy consumption (even integrating their own energy sources to ensure their energy sustainability), but also of improving occupant experience and productivity.

In this thesis, we analyse the important role that buildings represent in terms of their energy performance at city level and, even, at world level, where they represent an important factor for the energy sustainability of the planet.

Analysis of the energy efficiency of the built environment has received growing attention in the last decade [1], [7], [9]. Various approaches have addressed energy efficiency of buildings using predictive modelling of energy consumption based on usage profiles, climate data and building characteristics.

On the other hand, studies have demonstrated the impact of displaying public information to occupants and its effect in modifying individual behaviour in order to obtain energy savings [2], [4]. Nevertheless, most of the approaches proposed to date only provide partial solutions to the overall problem of energy efficiency in buildings, where different factors are involved in a holistic way, but which, until now, have been addressed separately or even neglected by previous proposals. In other words, a more integral vision is required to provide accurate models of the energy consumed in buildings [10].

In order to obtain an accurate simulation model, a detailed representation of the building structure and its subsystems is required, although it is the integration of all these pieces that requires the most significant effort.

IoT permits the interaction between smart things and the effective integration of real world information and knowledge in the digital world. Smart (mobile) things endowed with sensing and interaction capabilities or identification technologies (such as RFID) provide the means to capture information about the real world in much more detail than ever before.

II. RELATED WORK

A complete review of previous solutions from the literature was carried out during the development period of the present thesis. We tried to find ways that would enable us to propose holistic solutions to building energy management problems, which should address the relevant aspects mentioned previously, i.e. a complete monitoring phase, the efficient management of information, using automation systems and involving occupants during the system operation. Nevertheless, different proposals were found for different goals, but none was integrated all the aspects. This was the first constraint identified among previous solutions.

Consequently, we decided to review the main related work tackling each one of these aspects separately. Proposals such as those given by the manufacturer Johnson Controls3, a company that provides products, services and solutions that help increase energy efficiency and reduce the operation costs of its client's buildings.

Another well-known manufacturer is Siemens4, who offer a technical infrastructure for building automation and energy efficiency in the form of market-specific solutions in buildings and public places. The main differences between these commercial solutions and our proposal for automation and energy efficiency management in smart buildings are those related with the open and transparent character of our proposal, as well as its capability to gather data from a large number of heterogeneous sources.

As regards user involvement in building energy management, there are studios that maintain that energy usage feedback is the most successful approach, whereby users are involved in saving energy in buildings [2] [4]. However, few works have been addressed this aspect. It is important to note that energy usage feedback in building energy management systems needs to be provided to users frequently and over a long time, offering an appliance-specific breakdown, while presented in a clear and appealing way using computerized and interactive tools.

Concerning the fact that users have little awareness of the energy wastage associated with their energy consumption behaviours is due partly to the fact that most people do not know what the optimum comfort conditions are according to environmental features and their needs.

Smart buildings should prevent users from having to perform routine and tedious tasks to achieve comfort, security, and effective energy management. Sensors and actuators distributed in buildings can make user life more comfortable; for example:

- ✓ room heating can be adapted to user preferences and to the weather;
- ✓ room lighting can change according to the daylight;
- ✓ domestic incidents can be avoided with appropriate monitoring and alarm systems;
- ✓ energy can be saved by automatically switching off electrical equipment when not needed, or regulating their operating power according to user needs, thus avoiding any energy overuse.

III. GENERAL ARCHITECTURE FOR MANAGEMENT SYSTEMS OF SMART BUILDINGS

The general architecture of for smart building is modelled in layers which cover the requirements of different smart environments of cities, such as intelligent transport systems, security, health assistance or, as is the case analysed in this thesis, smart buildings. This architecture promotes high-level interoperability at the communication, information and services layers and has the following layers

1) **Data Collection Layer**
2) Data Processing Layer
3) Services Layer

The general block diagram can be given as below

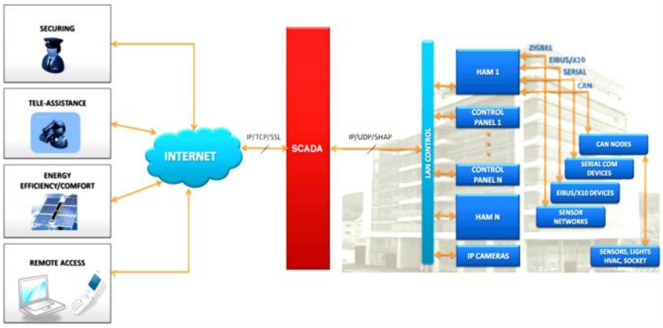

Figure 3.1 General Block Diagram of IoT-based Energy Information Management System for Energy Efficiency in Smart Buildings

IV. PROPOSED SYSTEM

4.1 BLOCK DIAGRAM:

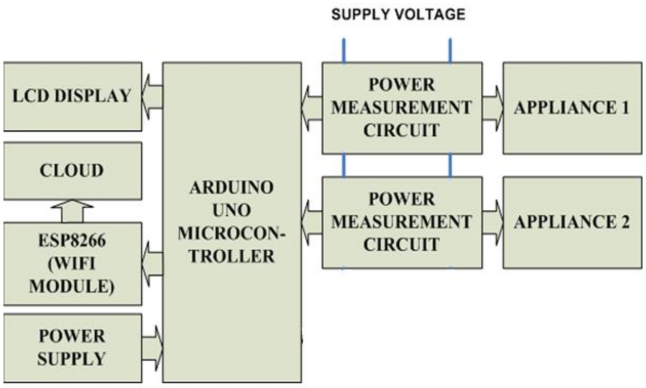

Figure 4.1 Block Diagram of the Proposed System

As seen in the system shown above it consist of the following

1. LCD Display
2. ESP8266 WI FI Module
3. Power Supply
4. Arduino Uno

Appliance are interfaced with power measurement circuts. These power measurements circuits forward the value of power obtained from the appliances to the Microcontroller.

Arduino Uno is used as a microcontroller. The value of power received from the appliances are forwarded by a wifi module onto the cloud . Cloud interface acts as a front end or a dashboard to the user. With the dashboard the user is able to view the power consumed by the particular appliance. Thus the user is bale to monitor the power consumption pattern of the particular appliance and can turn on and off any appliances from any part of the world . Thus by doing so the user is in control of the appliances and thus can play a role of an active user who tries to optimize the energy consumption by minimal wastage of power.

4.1 COMPONENT DESCRIPTION :

The following section gives the details of different components used in the projectof

4.1.1 LCD Display

LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

1) The declining prices of LCDs.
2) The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
3) Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
4) Ease of programming for characters and graphics. These components are "specialized" for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits.

Figure 4.2 LCD Display board

4.4.2. ESP8266 WI FI Module

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by manufacturer Espressif Systems in Shanghai, China.

The chip first came to the attention of western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first there was almost no English-language documentation on the chip and the commands it accepted.

The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.

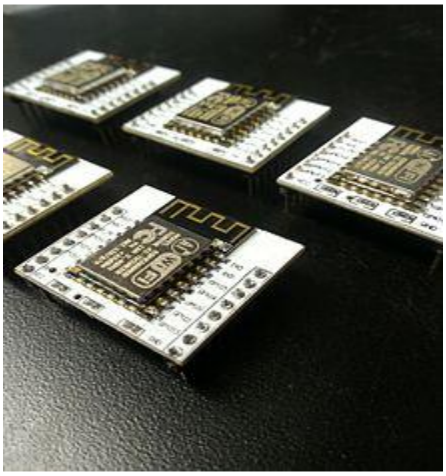

Figure 4.6 Ai-Thinker modules

4.1.3 Power Supply

4.1.3.1 Block Diagram

Figure 4.7. Block diagram (Power supply)

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

4.3.4.1 Arduino UNO R3

This is the **Arduino Uno R3**. In addition to all the features of the previous board, the Uno now uses an ATmega16U2 instead of the 8U2 found on the Uno (or the FTDI found on previous generations). This allows for faster transfer rates and more memory. No drivers needed for Linux or Mac (inf file for Windows is needed and included in the Arduino IDE), and the ability to have the Uno show up as a keyboard, mouse, joystick, etc.

The Uno R3 also adds SDA and SCL pins next to the AREF. In addition, there are two new pins placed near the RESET pin. One is the IOREF that allow the shields to adapt to the voltage provided from the board. The other is a not connected and is reserved for future purposes. The Uno R3 works with all existing shields but can adapt to new shields which use these additional pins.

V. RESULTS AND DISCUSSION

In this work we have been able to develop a system in which appliances are interfaced with power measurement circuts. These power measurements circuits forward the value of power obtained from the appliances to the Microcontroller.

The figures below shows the screen shots of the implemented module along with the screen shots of the cloud interface.

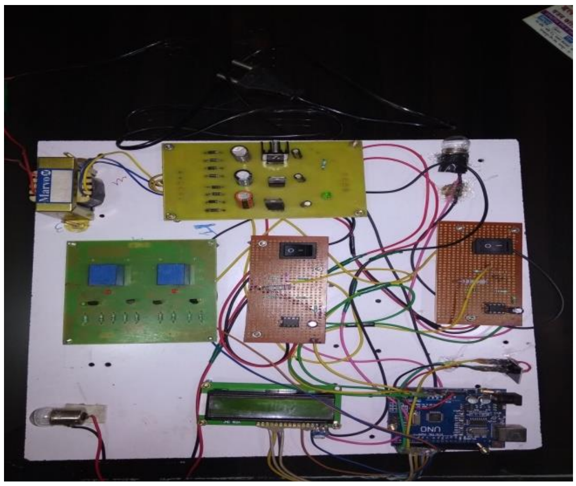

Figure 5.1 The implemented system

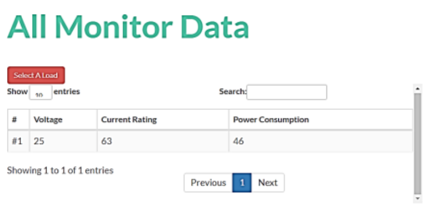

Figure 5.2 Data of Appliance 1

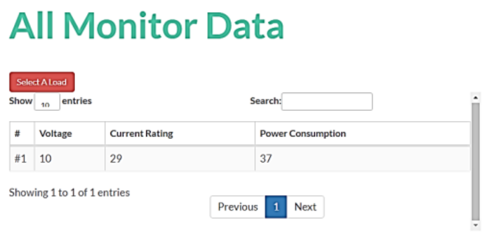

Figure 5.3 Data of Appliance 1

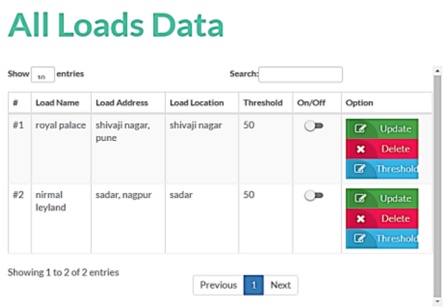

Figure 5.4 Screen shot of Dashboard at cloud to turn load on or off

VI. CONCLUSION

We have been able to design and develop a system which gathers the value of power consumed by appliances in real time on the cloud. A user can get the access to all the appliances which have been integrated with the cloud and can have the idea of the appliances as to whether they are on or off. Through the cloud he can turn the appliance on as well as off.

With the user being able to access the appliances in terms of their power consumption and turning them on or off, it provides the basic platform to carry on with the energy management.

VII. FUTURE WORK

With the profile of appliances being available to the user customized power solutions can be designed and proposed.

The system can be integrated to provide

High Comfort level, Air quality control, Automated Heating and Cooling system, Automated lightning system.

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