A COMPETITIVE MODEL FOR APARTMENT COMPLEXES ENERGY MANAGEMENT WITH THE AIM OF CREATING THE INFRASTRUCTURE OF SMART CITY

Hashem GHORBANPANAH
MEEDC – Iran
hashem.gh2007@gmail.com

Ali SAEEDI
MEEDC – Iran
a.saeedi@meedc.net

Saeed ALISHAHI
MEEDC – Iran
s.alishahi@meedc.net

Naser NAKHODCHI
MEEDC - Iran
nnakhodchi@gmail.com

ABSTRACT

This paper presents a competitive model for energy managment at the residential complexes in a city.This model includes cultural patterns and technical models together.The combination of culture and technology is improved energy managment at consumers side and decreased problems at utility side for energy supply. The consumer owned smart meter shared data with a control and monitoring center(CMC) through wire or wireless platform and on the other side, a data analyst application is enabled on the server and after analyzing and processing data received from the customers, the information are transmitted to a database(SQLite). A web application also uses the information stored in the database. The smart meters integrate different types of information coming from several electric or electronic devices present in buildings via ZigBee or WiFi platform.This information are shown to the building residents through graphical forms, tables and charts via web programming methods.

INTRODUCTION

The iran's electrical grid was originally designed to deliver power from power generators to customers and according to the information received from multiple grid segments, today's electricity system is more reliable than before but it's not enough and and needs more improvement.Also, over the last few decades, peak demand for electricity has been tremendously increased due to population growth, more electronic appliance reliance and global warming, which may cause massive blackouts[1].

Creating smart city infrastructure is one of the most important methods for improve reliability of electical network. If we want to have a smart city, we need to have an accurate and complete infrastructure in this city therefore, each smart cities usually have the main components that shown in Fig. 1.

To implement a smart city, the current electricity grid has to be fledged with the information and communication technology(ICT). Smart city will establish a multi-directional flow between citizens and other segments via the information and communication technologies and in this modern city, apartment complexes known as one of the important zones in the field of energy management in areas with high population density. If we implement energy management at the best level for apartment complexes then, we can expand this approach to other parts of the city only by eliminating the surplus units.

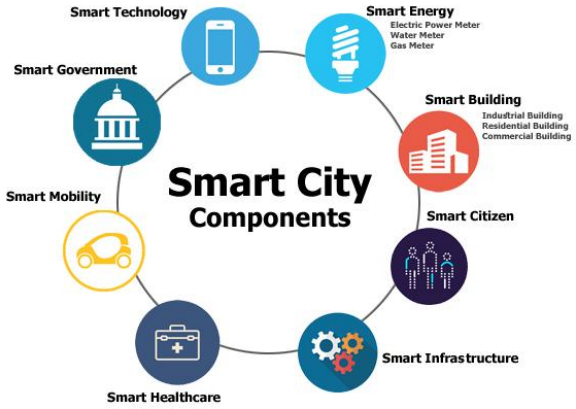

Fig.1. The basic components that define a Smart City

An intelligent controller methodology providing information about consumption energy patterns is useful to raise energy consumption awareness and to persuade consumers to real energy savings.

IMPLEMENTATION STRATEGY

We used some of smart city components (citizen, building, energy and smart technology) to implement competitive model. As a special form of smart building, a competitive system is proposed for cost sensitive energy management based on the energy implications and electricity consumption characteristics of apartment complexes.

In this method, we want to change the pattern of energy consumption in residential apartment complex side by data aggregation from all zones of the apartment complex and compare the energy consumption of each residential units with others and provide a database for collecting and organizing information about the pattern of energy consumption for residents.

Perhaps ask this question, why we need energy management methods in apartment complex? the following items are proposed in response to this question:

1. During the past decade, peak demand for electricity has been tremendously increased in cities but energy generation is not growing at the same rate.
2. Increased uses of electrical and electronic equipment in daily life
3. The high cost of power generation, transfer and distribution energy
4. Lack of a culture and full policy for energy management
5. High population density in residential apartment complexes

6. Existence of different types of electrical loads (water pumps, lighting, elevators, home appliances and etc.)

These and many other items, may cause massive blackouts. To reduce the impact of the limitations of energy supply, the information and communication technology has come to help us.

We need ICT for implementing competitive method, through the creation of a hierarchical system includes of various hardwares,user application and a good telecommunications platform for example ZigBee, WiFi or a wired connection. In this method ,we try to reach the following specific goals:

1. Communication with power meters for reading power quality parameters
2. Disaggregated data at three levels: each customers, apartments, apartment complexes
3. Data analysis and data archive in a SQLite database
4. Data transmission to electricity distribution company
5. Energy usage comparison at three levels: a residential unit to other units, apartment to apartment and devices level

COMPETITIVE MODEL

The competitive model is conceptually designed based not only on available on-line energy consumption status of different parts of the apartment complexes but also based on consumer roles to reduce energy loss and improve energy management.

Energy management policies of an apartment complex are fully investigated and analyzed to make the concept of competitive model that be desirable for all the residents living in apartment complexes. To take advantage of the competitive model, the proposed system includes both hardware and software modules that each module connected to other parts of the system via a special platform to implement advanced monitoring.

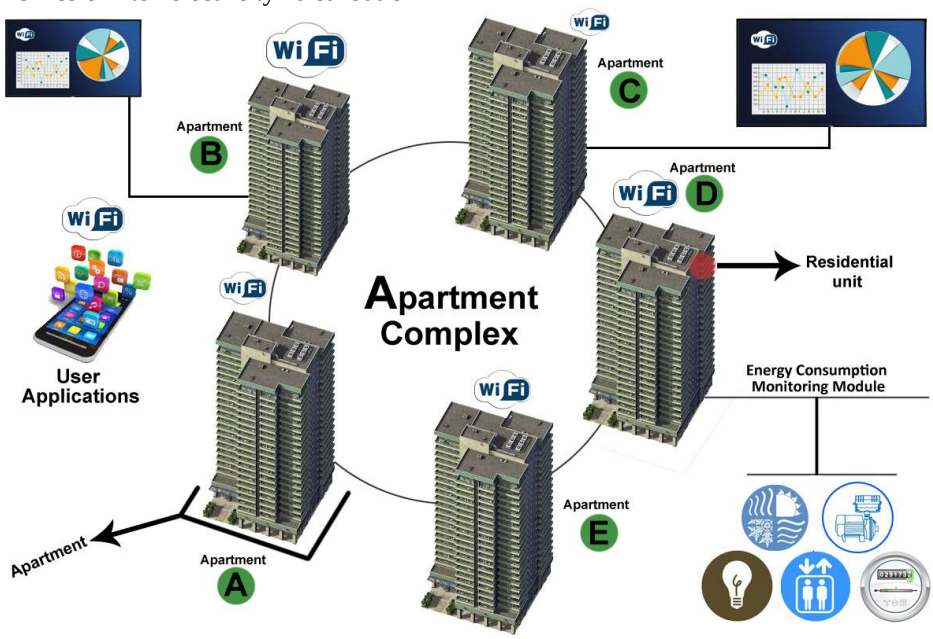

Fig.2. The schematic of ICT infrastructure for competitive model of energy management in the apartment complexes

Competitive model components

Competitive model is aiming at intelligent energy management in an apartment complex through comparing and coordinating data received from the system modules and finally presents the results to the occupants of the building and Distribution System Operator (DSO). The concept here developed for building automation allows multi-users to interact with the building control unit, which has an intelligent controller with time-varying references that accommodates advanced strategies of control[2]. Competitive model components could be divided into three groups: measurement equipment for power quality data collection and environmental data, communication infrastructure for data communication between equipments with Apartment Complexes Control Unit(ACCU) and SCADA application for hierarchical control and monitoring energy flow in various parts of apartment complex.

The most important energy loads in the apartment complexes could be: general electrical loads from household appliances, water pumps, elevators, lighting fixtures for the stairs and public places, surveillance cameras[1], electric doors as well as heating and cooling systems.

Measurement equipment

At the reading information step, the operations are performed by LinkIt ONE module. The LinkIt ONE development board is an open source, high performance board for prototyping Wearables and IoT devices[3]. It's

combined with high performance Wi-Fi (MT5931) and GPS (MT3332) chipsets, Bluetooth and SD card slot for local record and archive data on the device. It also provides serial port and external pins to connect to various sensors and peripherals in their surroundings. The LinkIt ONE module is shown in Fig. 3.

Fig.3. The LinkIt ONE module includes ARM7 EJ-S core

The communication flow between the central SCADA application and the measurement devices (LinkIt ONE) is performed on a wireless ethernet communication infrastructure.The standard ethernet communication allows the relationship with other common networks namely: ModBus, S-BUS and M-BUS.

Due to existence of multiple device nodes in each residential tower and increase network traffic, the communication flow is not peer to peer therefore a local concentrator is employed in each tower. In the concentrator unit, all received data from each node is decoded and then will be sent to ACCU[5]. The proposed hardware module will be installed at critical points of buildings namely: water pumps room, elevator control room, power supply route lighting of public places and etc.

Each device has a virtual memory mapping that can be configured and managed via ACCU. Memory mapping is a common concept in POSIX and Windows systems. It enables a process to map disk files to its address space, treating them as memory blocks rather than files[4].

Communication infrastructure

The used wireless module was MT5931 chipset according to the WiFi network protocol, following IEEE 802.11 b/g/n. The MT5931 chipset implements advanced and sophisticated radio coexistence algorithms and hardware mechanisms. WiFi infrastructure is used for data exchange with ACCU and concentrators but we used bluetooth, I2C, SPI and UART for communication data between local sensors and actuators with Linkit ONE module that installed at critical points of apartment complexes.

To improve the level of security in communication network, All data are encrypted before sending to wireless network through a hash code that is specific for each node and defined by system administrator. This key is stored in part of the virtual memory map through a special algorithm.

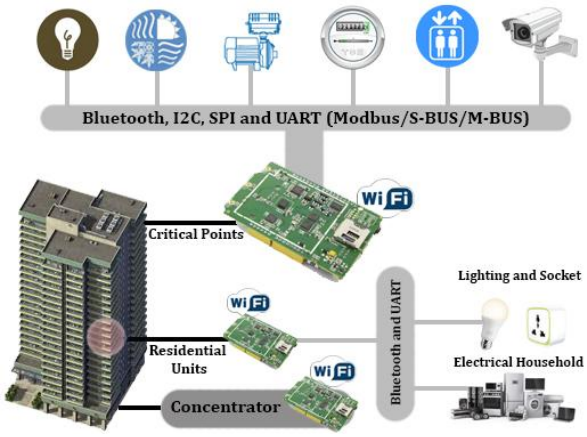

Fig.4. Multiple communication levels in the residential tower at three levels: critical points, residential units and concentrators

SCADA application

In the competitive energy management strategy,server side applications perform the high level operation and communicate with concentrators via an interactive model. The proposed application is defined on two levels (device management and user web application). In the device management level, the used communication channel between the server application and concentrators is JavaScript Object Notation (JSON). Each concentrator is connected to the server via a dedicated network socket and building data is written as name/value pairs in the temporary memory concentrator according to the JSON syntax.All data on the server will be extracted and transferred to the database tables.

After this step, a data analysis application will be launched and new information will be generated and offered to the residents in the apartment complex to manage their energy consumption.

One of the main feature of the SCADA system at user web application level is its ability to communicate with user through a standar web platform and therefore it is capable of rapid development.Data analysis core at the SCADA application comparison at three levels (self assessment, building-to-building and tower-to-tower).

Self Assessment

Each residential unit has a history in the database that will be collected over time. The data analysis core uses this information and then produces the pattern of online, weekly, monthly and yearly of energy consumption and offers them to residents.

Building-to-Building

Each building in a residential complex will be separated through a unique identifier which includes tower number, floor number and residential unit number from other buildings. The data analysis core uses this ID to create different categories of energy consumers (floors, towers,

critical points and etc.)

Tower-to-Tower

The application can access to the information of each tower via unique IDs and finally, the results of data analysis will be shared between residents through web pages in the special form of charts, tables and notification messages.The schematic of SCADA application layers is shown in Figure 5.

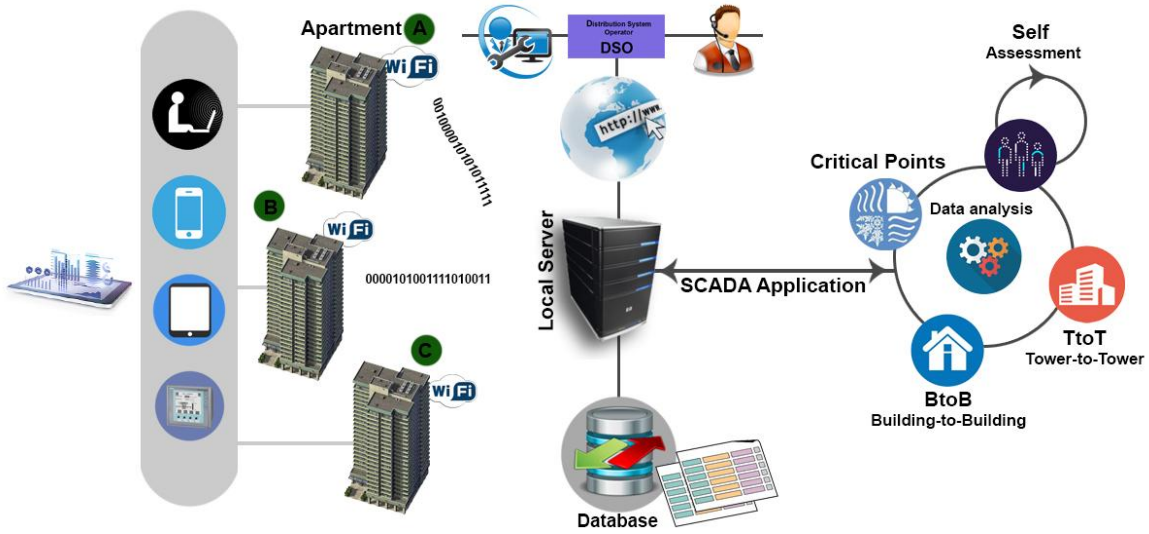

Fig .5 .Schematic of conceptual model for energy management at apartment complexes

CHALLENGES AND LIMITATIONS

To implement this model, there are some obstacles and limitations that needs more research in the following fields.

1. Privacy building occupants
2. Data warehousing and big data analysis methods
3. Cyber-attacks and hacking
4. WiFi network Restrictions (network coverage, number of nodes in the network, information security, etc.)
5. Remote calibration methods for sensors and actuators

CONCLUSIONS

This article offers a competitive model for improving energy management in an apartment complex. The integration of three levels of monitoring and control : (1) self assessment, (2) Building-to-Building and (3) Tower-to-Tower. The monitoring modules (LinkIT ONE) are connected to the server side applications through coordinators that installed at each apartment. By implementing this intelligence network, the following results can be achieved by providing a comparison of different patterns of energy consumption in apartment complexes.

1. Improving energy management in buildings
2. Data transmission between customers and DSO through of GPRS network with ability of remote control[5]
3. Create an integrated database in the DSO level for better analysis of energy consumption pattern
4. Possibility to predict the status of power grid according to the information received from end user side in the electricity network[5]
5. Better maintenance services through analysis of working pattern of equipment
6. Peak shaving

REFERENCES

[1] Nah-Oak Song, 2015, "Apartment to grid (A2G) paradigm for demand and cost sensitiveresidential complex energy management", *Energy and Buildings*, ELSEVIER, vol. 107, 191–203.

[2] R. Pereira, 2015, "Consumer energy management system with integration of smart meters", *Energy Reports*, ELSEVIER, vol. 1, 22–29.

[3] http://www.seeedstudio.com/depot/LinkIt-ONE-p-2017.html.

[4] http://www.informit.com/guides/content.aspx?=cplus plus&seqNum=213

[5] H. Ghorbanpanah, M. H. Y. Moghaddam, A. Saeedi and S. Alishahi, "Design and implementation of building energy monitoring system using wireless sensor networks," Electricity Distribution (CIRED 2013), 22nd International Conference and Exhibition on, Stockholm, 2013, pp. 1-4.