Cloud Enhanced Smart Home Technologies

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***Abstract*-- Cloud computing is making its way towards use at home. This paper presents a cloud for smart home. We present review of technologies for smart home and give an integrated cloud-based energy- and carbon-efficient architecture.**

I. INTRODUCTION

In the recent years, cloud computing has emerged as a powerful alternative model for enabling on-demand access to a shared pool of configurable computing devices. It works on a client-server basis, using web browser protocols, providing computation, software, data access and storage services. It provides server-based applications and data services to the client, with the result being presented on the client device. Various devices may log into the cloud – personal computers, mobile phones, tablets, servers, etc.

According to the recent study, cloud computing can reduce the energy consumption [1]. It may also lead to massive carbon emission savings – predicted to be 85.7 million tons annually by year 2020. Cloud computing could lead to a 38 percent reduction in worldwide data center energy use by year 2020. Carbon profit may be reduced as much as 90 percent for the smallest and least efficient businesses.

There are some reasonable doubts in energy efficiency of cloud computing. Baliga, Ayre, Hintor and Tucker [2] gave an analysis of energy consumption in cloud computing. They considered both public and private clouds and included energy consumption in switching and transmission as well as data processing and data storage. They showed that cloud computing can enable more energy-efficient use of computing power. However, under some circumstances cloud computing can consume more energy than conventional computing on the personal computer (PC).

Zhu, Luo, Wang and Li [3] presented the principal concepts of multimedia cloud computing. They addressed cloud computing from multimedia-aware cloud and cloud-aware multimedia perspectives. To achieve a high quality of service for multimedia services, they proposed a media-edge cloud in which storage, central processing unit and graphics processing unit provide distributed parallel processing.

Even though it started as a commercial solution offering computing resources and services for renting, cloud computing is slowly making its way towards private use at home. Encouraged by the results of volunteer computing projects and the flexibility of the cloud, Cunsolo, Distefano, Puliafito and Scarpa [4] developed a computing paradigm they named Cloud@Home. They see it as a generalization knocking down the barriers of volunteer computing, as well as the enhancement of the grid-utility vision of cloud computing.

Clouds mostly offer storage and multimedia services. We believe that the services cloud can offer may be extended to offer control and storage services to the smart home. In that context, we propose cloud-enhanced smart home system. We present the review of some of the current technologies used in the smart home and give a proposal for an integrated cloud-based architecture which would offer cloud services to all the mentioned technologies working together in a more energy- and carbon-efficient system for home use.

The rest of the paper is organized as follows: section 2 presents the overview of the proposed home cloud. Section 3 explains cloud components in more detail. Section 4 gives some concluding remarks.

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II. CLOUD OVERVIEW

Fig. 1 presents the overview of the proposed smart-home cloud model. The proposed cloud consists of the following servers:

- Smart lighting and electric outlets,
- Intelligent home networking system,
- Smart home control through digital TV,
- Audio and video communication system,
- Entertainment devices.

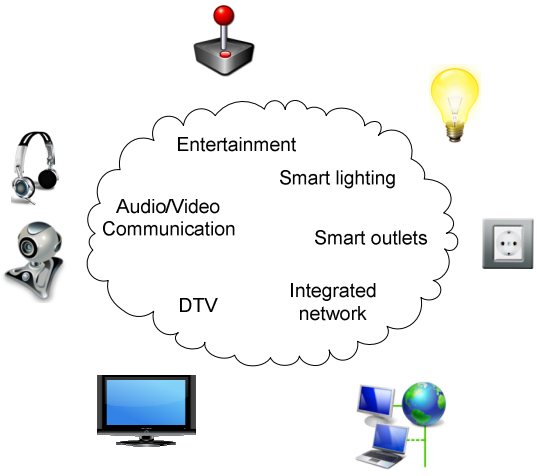

Figure 1. Cloud overview

III. CLOUD COMPONENTS

A. Smart Lighting and Outlets

Smart lighting and outlet solutions bring additional functionality and comfort compared to standard on/off switches and potentiometers [5]. In a smart home, users can

control lights using the remote control and select the desired light intensity for each light bulb. Furthermore, it is possible to program lights to be at a desired intensity at a given time in the future. The servers for smart lighting can be accessed over the internet to provide remote control even outside the home. The same can be achieved with other simple home appliances through the use of smart outlets. Cloud services for smart lighting and outlets may include storage of lighting profiles and history of device operations for devices connected to smart outlets, as well as centralized control as discussed later.

B. Intelligent Home Networking System

An intelligent home networking system [6] provides monitoring and controlling of residential energy. It consists of wirelessly-controlled smart power extension cords, remote controllers, wireless PIR sensors and home energy controller. The system is based on ZigBee 2.4 GHz wireless network protocol and is easily configured and managed as a residential smart grid. This system can be integrated in the cloud which would offer storage of energy consumption in the home and control for wirelessly-controlled home devices. In such way the system will be able to follow energy consumption in real-time and share the data with a smart meter installed in the home. There are initiatives [7] to connect smart meters at national level and use secured cloud for storing energy usage of each home. Contrary to this macro level, the intelligent home networking system provides the micro smart grid option, supporting further energy savings reported in [1].

C. Smart Home Control

Digital television and set-top boxes can be extended to provide control over home appliances in a smart home. References [8]-[9] provide examples of such systems. Remote control which was used to control television set or set-top box can now be used to control all home appliances. Intelligence and awareness is achieved with a support for execution of recipes - prepared scripts that define timely actions and respond to triggers obtained from sensors. The main aim is to allow the interaction between interactive TV applications and the controllers of the in-home appliances in a natural way. This unit would offer centralized control for the whole cloud. Cloud may also offer storage services for digital TV and other multimedia data available in a home.

D. Audio and Video Communication System

An integrated audio and video communication system can be connected to the cloud to add full-duplex hands-free videophone functionality in the smart home [10]. It consists of a digital camera and microphone array which are connected to the TV set through the High Definition Multimedia Interface (HDMI). It provides excellent sound quality via TV loudspeakers and simultaneous watch of the TV broadcast. Microphone array allows for suppression of the existing sound from the TV broadcast. Storage of the history of audio/video communications can be offered by the cloud as well as access to the unified contact list.

E. Entertainment

Entertainment devices can also be incorporated in a cloud as the storage needs for games increases at a high rate. User awareness kit [11] can be used as an add-on device with a variety of consumer electronics devices. As a result, host device would be able to anticipate user actions and adapt accordingly. It combines sensor inputs (passive infrared sensor, microphone array, time of flight camera) with behavior models based on system attentiveness and user-system interference concepts, to provide information about the users to its host. Gaming devices can be added to the cloud through PC or a console connected to the digital TV set and gaming experience can be improved with the use of the aforementioned user awareness kit and gaming accessories.

IV. CONCLUSION

This paper presented a review of cloud-enhanced smart home technologies. The proposed cloud covers basic requirements of a smart home – smart lighting and outlets, intelligent network, digital television, audio and video communication and entertainment. Servers for each of these applications work in a cloud environment, therefore saving energy and providing a more ecological-friendly solution. Cloud is just beginning to enter private use in homes and provides an efficient alternative to integration of all technologies in a smart home.

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