Computers and Electrical Engineering 43 (2015) 112–128

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

A cloud based and Android supported scalable home automation system ☆

Ilker Korkmaz *, Senem Kumova Metin, Alper Gurek, Caner Gur, Cagri Gurakin, Mustafa Akdeniz

Izmir University of Economics, Faculty of Engineering and Computer Science, Sakarya Cd., No. 156, Balcova, Izmir, Turkey

ARTICLE INFO

Article history:
Received 15 May 2014
Received in revised form 28 November 2014
Accepted 28 November 2014
Available online 30 December 2014

Keywords:
Home automation system
Cloud
Google Cloud Platform
Google Cloud Messaging
Android

ABSTRACT

In this paper, an Android based home automation system that allows multiple users to control the appliances by an Android application or through a web site is presented. The system has three hardware components: a local device to transfer signals to home appliances, a web server to store customer records and support services to the other components, and a mobile smart device running Android application. Distributed cloud platforms and Google services are used to support messaging between the components. The prototype implementation of the proposed system is evaluated based on the criteria considered after the requirement analysis for an adequate home automation system. The paper presents the outcomes of a survey carried out regarding the properties of home automation systems, and also the evaluation results of the experimental tests conducted with volunteers on running prototype.

1. Introduction

Home automation is the introduction of technology within home to enhance the quality of life of its occupants, through the provision of different services, such as tele-health, multimedia entertainment and energy conservation. In other words, home automation aims at the orchestration of digital devices for the convenience of users together with security and the capability to monitor multiple dwellings [1]. Traditional home automation systems involve the control of digital devices which provide functions such as heating, lighting and shading. Due to the rapid growth of information technology and modern entertainment systems in recent years, these primary functions are required to be enriched with additional services (i.e., music system volume reduction when the telephone rings [1]). In [2], the benefits of home automation systems (the smart house systems) are listed as safety, comfort, power saving and communications. In order to provide these benefits, some technical requirements must be also respected, such as low cost, plug and play, flexibility, ease of use and reliability [2]. In the study by Piyare and Tazil [3], the requirements are itemized in detail:

- The wireless home automation systems should be scalable to facilitate the integration of new devices.
- The system should provide a user-friendly interface on the host side, so that the devices can be easily setup, monitored and controlled. The system interface should also provide some diagnostics services to track potential problems.

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Associate Editor Dr. Ziya Arnavut.
* Corresponding author. Tel.: +90 2324888258.
E-mail address: ilker.korkmaz@ieu.edu.tr (I. Korkmaz).

http://dx.doi.org/10.1016/j.compeleceng.2014.11.010
0045-7906/

- The overall system should be fast enough to exploit the full potential of wireless technology.
- The system should be cost effective in order to justify its application in home automation.

In our study, a home automation system, which provides two alternative user friendly interfaces, an Android application and a web application, is presented. The system is built to serve multiple users, using up-to-date and emerging technologies, such as Google Cloud Platform, in order to support the communication between the main hardware components of the system.

One of our two main motivations for developing the proposed system is the increasing popularity of smart homes. Although ready to use home automation systems exist, nevertheless there is a need for a new system which considers networked smart homes, rather than the systems based on individual homes. Our second motivation is to decrease the cost of such pervasive systems by using free and open tools provided by emerging technologies. In addition, we prefer to use enabling infrastructures (i.e. cloud) to build Internet based connected home-networking. To support ease of use, it was decided to select an Android interface at the end point of each system.

We believe that an important feature of the system that would make it prominent in the field is its cloud based distributed architecture. The distributed infrastructure of the system is designed to be deployed and managed pervasively by an organization (either an owner company or the system builders). The local components of the homes connected in the system together with related system services could be managed by particular mobile users of those homes anywhere.

We propose that the key internal strength in our distributed networking based and Android supported home automation implementation is its optional and flexible structure. For example, the system has a profile infrastructure that gives different authorization rights to its different types of users. The system is open to new, optionally chosen devices. Moreover, the system is designed to offer different types of pricing services: i. free, ii. pay-per-usage on demand, iii. discounted cost for a number of different users, iv. fixed cost with full rights with any number of users.

This article extends the work in [4] and dissects the design, analysis and implementation of the proposed cloud based and Android supported home automation system.

In the following sections, the related works in the literature are first discussed and then the enabling technologies used in the proposed system are introduced. Following this, the details of the system architecture are given. After listing the analysis and evaluation criteria for an adequate home automation system, the paper describes the surveys and experiments conducted with volunteers on prototype implementation of the proposed system. A discussion of the proposed system regarding the outcomes of the experiments and the comments gathered from the volunteers is also given. Finally, the paper is summarized in Section 6.

2. Related work

There has been a significant amount of research and numerous approaches to the home automation systems. Although the idea of controlling home appliances via different methods is not new, there is a need to reconsider the management of smart homes. We believe that the proposed system contributes to the research in smart home automation by merging different advanced networking technologies with its Android-enabled and cloud-based structure.

The number of published works on home automation may indicate an evidence of trends in a certain field. To this end, we searched the terms "Smart Home/House" or "Home/House Automation" in three renowned scientific databases; Web of Science, Scopus and ScienceDirect. When dissecting the returned records, we observed that not every returned record focuses on the home automation concept. Nevertheless, the number of records returned can be considered evidence for the significance of this area and highlight its importance in the future. The number of records returned from the related queries in August 2014 is 2445 from Web of Science, 13,158 from Scopus, 2258 from ScienceDirect. These records include all available material in the databases (e.g., conference proceedings, book chapters, journal articles) covering all years.

Table 1 shows the percent of academic research including some technological terms (e.g., web, cloud, Android) and the concept "home automation". In order to obtain the given values, the set of records that include the terms "Smart Home/House" or "Home/House Automation" is intersected with the set of the records of terms in each column. For example, 2445 records in Web of Science include the union of terms "Smart Home", "Smart House", "Home Automation" or "House Automation". When this set is refined with the term "web", the size of the new set is reduced to 176; in other words the

Table 1
The percent (%) of academic research including the technological terms; web, cloud, Android; and the concept "home automation".

		Web	Cloud	Android	Web AND Cloud	Web AND Android	Cloud AND Android	Web AND Cloud AND Android
Smart home/house	Web of science	7.20	1.27	0.70	0.29	0.12	0.04	0.04
OR	ScienceDirect	43.98	11.12	4.38	7.71	3.41	1.73	1.59
Home/house automation	Scopus	23.43	4.18	2.61	1.88	0.90	0.47	0.24