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Design, Specification and Implementation of a Distributed Home Automation System

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Abstract

This work presents the design and model implementation of a novel home automation system applying the Internet of Things (IoT) technology. It seeks simplified design protocols for developing a robust home automation system to deal with the problems of complexity, multiple incompatible standards and the resulting expenses in the existing systems. The embedded system features the ubiquitous low-cost 32-bit ESP8266 System-on-chip (SoC) module interfaced to some sensors and actuators for interaction in the home. Flexibility in the remote access, operation and management is achieved through HTML5 based intuitive mobile and web GUI applications. Web Application Messaging Protocol (WAMP) is deployed to ensure that individual applications and systems seamlessly communicate with a relatively high level of security using robust web service security protocol. This system offers a cost-effective and efficient solution, because the costs of a dedicated public IP address and a high-end computer are excluded, which are present mostly in other solutions.

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Keywords: Internet of Things; Websocket; ESP866 SoC; HTML5; Distributed System

1. Introduction

The use of smart devices in daily activities increases the quality of life and offers high productivity in turn. This has led to the increased calls for benefits such as comfort, centralized control of appliances, cost reduction, energy

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saving, security and safety which are basically the driver of the growth of automation technology in both homes and industries. As a result, the intelligence of such devices is developing exponentially while offering much higher affordability and simplicity through their connectivity[1]. The interconnectivity of virtually every object is now possible through the Internet; human social networks and machine-to-machine communications. The concept of the "Internet of Things", tied closely with the popularization of home automation[2], is an evolving technology which has received quite a lot of attentions from researchers following the vision of a global infrastructure of networked physical objects. While this vision is enthralling, no consensus exists about its realization[3].

IoT involves integrating smart objects; embedded devices with sensors and actuators connected to the Internet. These devices are intelligently interconnected thereby necessitating new forms of communication between things and people, and between things themselves[4]. It is noted in[5] that with increased device processing power and storage capabilities, their sizes tend to be smaller making them suitable to be equipped with different type of sensors and actuators. The greater power and capabilities of such embedded devices further enable them to be stacked up with the desired network protocols for seamless communication. Home automation started long ago with labour-saving machines and the term “smart house” was first coined by the American Association of House Builders in 1984[6]. However, early smart homes suffered poor performance, high cost of ownership, complicated set-up and operation, poor management and maintenance, and in many cases, the need to rewire the home[7]. While novel home automation is fast evolving, consequently, there have been different procedures with vast of them based on the wireless and Internet technologies relating to the concept of “Internet of Things”.

This work addresses the problems of complexity, multiple incompatible standards and the resulting expenses in these recent systems by providing a simplified design protocol and developing a robust distributed home automation system. The system’s independent computing units collaborate together in order to achieve the desired automation functionalities by exchanging only terse messages as opposed to human-human communication[8], to synchronize their current states in addition to the input and output data operation of the individual systems and applications[9].

2. Related works

Several works have been done with various approaches deployed towards realizing home automation. Bluetooth based solutions were explored in[10,12] for the home automation technology using Bluetooth enabled devices to provide the control without internet connectivity. Here, the appliances which are wired to the embedded controller are accessed and controlled by devices with built-in Bluetooth connectivity. However, Bluetooth has a maximum range of operation of about 100 m and this limitation renders the systems incapable of coping with long distance mobility and by this means restricting the system control to within the neighbourhood. Also, Global System for Mobile (GSM) based solutions for the communication and control of home appliances have also been offered in[13,14] where a mobile phone (or GSM modem) is incorporated to the home controller and receives different AT commands for the control. These systems suffer lack of graphical user interface (GUI) for supple operation. Thus, the users have to remember different short codes for different operations. Also, a message can be delayed due to failure of mobile network operators; hence, the solution is not suitable for real-time monitoring as well as long distance data logging (telemetry).

With the popularity of Internet gateways at homes such as broadband modem and mobile hotspot, remote access to control home appliances is becoming practicable. In[15,16], Wi-Fi based home automation solutions utilizing localized systems which manage the connected appliances were presented. Such arrangements usually pose a resource bottleneck as they require complicated network traffic routing for remote operations. Similar architectures were offered in [7,17] where local web servers are deployed at home with applications developed to manage the devices over the Internet. The drawbacks of these setups are that, deployment of a high-end computer will not only increase the cost of installation but also the energy consumption and space by the virtue of its size. The developed interface applications running on the home servers are not easily upgradable and the data communication protocols employed are not robust and scalable to support the future demands.

While there are no dedicated severs at the client premises in [4,18], the allotment of a public IP address makes the