Computers and Electrical Engineering 52 (2016) 208–222

Contents lists available at ScienceDirect

Computers and Electrical Engineering

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

Context-aware low power intelligent SmartHome based on the Internet of things☆

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ARTICLE INFO

Article history:
Received 31 July 2015
Revised 12 April 2016
Accepted 12 April 2016
Available online 28 April 2016

Index Terms:
IoT
Smarthome
Communication model
Application
Analysis
Visualization

ABSTRACT

Constructing a smart home is not a task without intricate challenges due to involvement of various tools and technologies. Therefore, this research work presents a concept of context-aware low power intelligent SmartHome (CLP*i*SmartHome). For CLP*i*SmartHome, we propose a communication model, which provides a common medium for communication, i.e., same communication language. Moreover, an architecture is also proposed that welcomes all the electronic devices to communicate with each other using a single platform service. The proposed architecture describes the application, analysis and visualization aspects of the CLP*i*SmartHome. Furthermore, the feasibility and efficiency of the proposed system are implemented on Hadoop single node setup on UBUNTU 14.04 LTS core™i5 machine with 3.2 GHz processor and 4 GB memory. Sample medical sensory data sets and fire detection datasets are tested on the proposed system. Finally, the results show that the proposed system architecture efficiently processes, analyzes, and integrates different datasets and triggers actions to provide safety measurements for elderly age people, patients, and others.

1. Introduction

The rapid growth of Wireless Sensor Network (WSN) enabled devices constitute IoT and may generate an enormous amount of data. Similarly, enabling seamless connectivity with existing networks and proactive operation based on different factors (context aware computation) are mandatory in IoT. Its goal is to let the computer identify information without human interaction. However, it depends on three factors i.e. 1) understanding users and its appliances 2) architecture and communication, and 3) analytical tools to support smart behavior. IoT and cloud computing can be considered as two major technologies which have been developed in order to extend ubiquitous computing. The ubiquitous computing integrates different technologies with the daily life. One example is of WSN whose nodes have the ability to act as ubiquitous-sensors

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. J. Kim.

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http://dx.doi.org/10.1016/j.compeleceng.2016.04.014
0045-7906/

using MEMS and wireless communication. Another example of Cloud computing that uses the internet to provide scalable, and reliable ubiquitous computing by acting as a receiver of data from ubiquitous sensors.

So far as the definition of IoT is concerned, it has been defined in multiple ways by various interest groups. From one perspective, IoT is a combination of middleware, sensors and knowledge [1]. While according to Radio-Frequency Identification (RFID) group, IoT is a network of objects accessible uniquely via standard protocols [2]. Another definition states that IoT's Things are participants who share information that is sensed from the environment with or without human interaction. Finally, the researchers define the IoT as an interconnection of devices, which share information among platforms via a unified framework. This can be achieved via ubiquitous sensing, data analytics, etc. Some of the major entities in an IoT environment are given below.

- *RFID:* It is a wireless microchips for wireless data communication. It allows automatic identification of thing that is attached to it.
- *WSN:* The shared sensor data are sent to a centralized or a distributed system for analytics. WSN hardware is a node with a sensor, which acts as the gateway to the WSN subnet and the Internet. WSN middleware provides access to different sensors by combining cyber infrastructure with Service Oriented Architecture (SOA) and sensor network. The reliable data collection and extending lifetime are ensured by secure data aggregation.
- *Addressing Schemes:* Every connected element needs to be identified uniquely. However, the variation of wireless nodes have worsened the problem even after using IPv6 addressing. WSN is on a stack except Internet, hence it uses subnet with a gateway having URN is used to uniquely identify within the network.
- *Data storage and analytics:* This forms the middle layer of IoT. These systems allow interoperability, integration, and adaptive communication. Centralized infrastructure is mandatory to support storage and analytics.
- *Visualization:* Provides interaction with environment and user. This holds both event detection and visualization of raw and modeled data.

IoT can be internet-centric or thing-centric. The conceptual framework was developed with the perspective of internet-centric by connecting ubiquites applications with sensor devices via the cloud. The cloud is responsible for storage, computing, visualization, and analytics. This is flexible in dividing costs logically, and highly scalable. The service providers can upload their tools such as analytical tools, data mining and machine learning tools, and visualization tools. So that, people can use them as a service on cloud. The cloud connects all endpoints of ubiquites computing. The framework describes the cloud platform using Aneka [3] and Azure [4]. The public and private cloud interaction is very important to bring sensed information, analytics and visualization to a single smooth framework. Developing IoT using low-level cloud programming is complex. To create IoT applications faster, the proposed framework was mapped to cloud APIs by Aneka platform. Similarly, every new framework should have following three characteristics; 1) Reads sensor data or fetch from database, 2) Process data transparently and in a scalable manner, and 3) Output if it detects any events of interest.

Other than that, to make the IoT more appealing, a traditional application can be considered i.e., the Smart Home where embedded devices, such as sensors and actuators are self-configurable and can be controlled remotely with the help of Web technology. Such kind of technology is used to enable a large variety of security, as well as monitoring applications. The involved devices sense user's activities and transmit these data to the remote station (any community services) where it can be processed, analyzed, and predicted or give response to the user for his/her convenience based on the received data. In the literature, extensive research work has been performed on the Smart Home technology [5] but their major focus is on individual homes. Similarly, the idea of smart home is also extended towards the smart community where home domain, community domain, and service domain are integrated to provide benefits to the mankind. However, such technology is lacking of various factors; how to connect vehicles, roadside units, Global Positioning System (GPS), and other to the same infrastructure, i.e., the central web.

The concept of Smart Home is further extended towards the Smart Community where a multi-hop network of smart homes is interconnected with the help of radio frequency [6]. Furthermore, it can also be noticed that the designed smart home (under the domain of IoT) work under multifunctional sensors, continuously monitoring physical environment (such as security, safety, healthcare, and emergency) for its improvement. However, given the variety of smart home and smart community contributions, several challenges need to be tackled in developing such systems.

Firstly, how to integrate various embedded systems under a single umbrella, i.e., requires a virtual or physical platform for the exploitation of the smart community. The next is how to integrate various systems since each specific system has its assumptions and strategies to control world physical variables without much knowledge of the other system. This generates conflict when these systems are integrated without careful consideration.

Having understood the feasibility and potential of the IoT, in this paper, we drive the concept of smart home to a further extent and introduce a notion of context-aware Low Power based intelligent Smart Home. The *CLPiSmartHome* is comprised of IoT and the community where they can share information using a same communication medium, i.e., the internet. The shared medium is supported by the web server where a variety of devices are interconnected with each other to form an *i*SmartHome. The nature of these devices is heterogeneous, which requires a unique platform to exchange useful information. Such a facility is provided by the proposed *CLPiSmartHome*. Moreover, *CLPiSmartHome* architecture is also proposed that could efficiently communicate with each other to assist users in a home based on the contextual information. It can be viewed that these devices (such as, smart watch, healthcare, KINECT XBOX 360, Internet of Vehicles, GPS, and so on so forth), continuously monitoring the physical entities, and when required, automatic or controlled physical system gives alert