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Research and Design for Mobile Terminal Based on Smart Home System

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Abstract: Smart Home is one of emerging application domains of The Internet of Things. It minimizes user's intervention in monitoring home settings and controlling home appliances. Mobile terminal has become an important part of Smart Home now. This paper presents an effective approach to solve the potential problems when using mobile terminal in Smart Home. In the smart home system, a kind of simple, easy to operate, and suitable for family application smart home mobile terminal software is designed, on an Android platform. The software is a combination of local and remote control to control household equipment. Moreover, this paper implements four usage scenarios to demonstrate the approach's feasibility and efficiency, *i.e.*, measuring home's environmental conditions, intelligent lighting control, remote control, and security warning. It has been proved well, that the user is able to control household appliances remotely, as well as monitoring sensor data sampled from indoor environment. The test results show the mobile terminal can work effectively.

Keywords: Android, Intelligent control, Internet of Things, Mobile terminal, Smart home.

1. INTRODUCTION

Smart Home is one of the emerging application domains of The Internet of Things, following the computer and Internet [1]. The smart home is a concept of the pervasive computing, and it is gradually becoming essential for the people living in an information age [2]. With the development of science and technology, Smart Home has been transformed from concept to physical reality. Relying on increasingly sophisticated IT technology, integrated wiring, network communication technology and other high-tech means, traditional home appliances of the family have become increasingly automated and intelligent. At present, the technology has been able to achieve that the most appliances of the family are classified as systematic management; the user can make use of a variety of terminal platform of their own home equipment for unified management [3-5].

Smart Home promises the potentials for the user to measure home conditions (*e.g.*, humidity, temperature, luminosity, *etc*.), manipulate home HVAC (heating, ventilation and air conditioning) appliances and control their status with minimum user's intervention. Researchers and practitioners have made a great deal of efforts in facilitating this concept. For example, for smart home management, Son *et al*. proposed a resource-aware management system using a domain-object hierarchical model for representing home context [6]. For efficient energy management, Han *et al*. suggested a new Smart Home Energy Management System (SHEMS) based on IEEE802.15.4 and ZigBee [7]. They designed a SHEMS-based multisensing and light control application for reducing total energy cost.

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The popularization and application of smart terminals allow people to access high-quality and high-speed data services, anytime and anywhere. Currently, mobile users strongly demand for mobility management of smart home [8, 9]. Whether the users are remotely located, as long as they can be connected to the network of the mobile terminal, by gently sliding their finger they would be able to access the real-time status of the current environment of their residence. On the basis of a comprehensive study on the current technical feasibility, this paper proposes solutions for monitoring and control of smart home based on mobile terminals.

The remainder of the paper is organized as follows: Section II presents system architecture and use case design. Section III details the technical solutions. And conclusion is drawn in Section IV.

2. SYSTEM ARCHITECTURE AND USE CASE DESIGN

2.1. System Architecture for Smart Home

The system architecture for Smart Home must fulfill the requirements of measuring home conditions, processing instrumented data, and monitoring home appliances. The system has three main modules, which consist of the low-level sensor network, application server and the mobile phone terminal. The system architecture is shown in Fig. (**1**).

In the framework of the system, the application server is the core of the service, running the IOT_SERVICE. The middleware is responsible for responding to all connection requests from mobile clients, also responsible for the information and control data that are transmitted to the low-level sensor networks and mobile phone terminals. The

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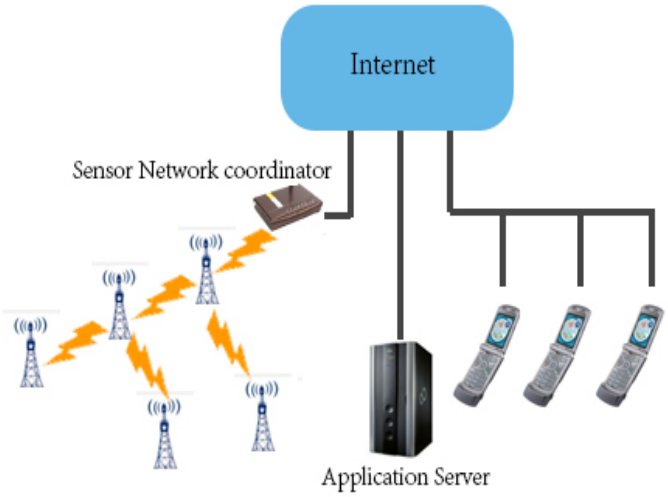


Fig. (1). System architecture.

application server also maintains the user's registration information and related user personalization setting information.

Low-level sensor network provides the sensor data sources and control for the system. The low-level sensor networks consist of sensor nodes and coordinator, networking in ZigBee multihop way, data sources of the low-level sensor network are eventually aggregated and packaged in coordinator, which after converting to the IP packet, is sent to the application server in the network. Sensor networks include a variety of sensors (*e.g.*, temperature, humidity, light *etc*.), and the same kind of sensors may be multiple; in order to effectively distinguish each sensor, they will have their own unique physical address.

In the case of mobile client connecting to the network, the user opens the application. The application server will request data services by the way of the socket, after the server identifies the customer data, it will provide directional data service information. After obtaining permission, the mobile client can view a variety of data information collected by the sensor network that it manages and can also be remotely controlled.

In the system, communication between the various main modules uses TCP/IP datagrams for interactive data and control information. In the communication environment, the application server has SERVER role, processing connection requests from each client. The coordinators in mobile phone clients and sensor networks have CLIENT role, responsible for initiating the connection requests, enjoying data services provided by the server.

2.2. Use Case Design

The rapid development of networking technology and its applications on smart home and smart family for maintaining traditional residence functions, continues to develop towards the goal of providing comfort, safety, and high-grade living space for the people. In this paper, the designed system will change as dynamic wisdom tools for the original passive stationary appliances and provide comfort, convenience, and safety for people's lives.

This design of smart home system can provide users with a number of services, as shown in Fig. (**2**). By using the mobile terminal user will be able to understand the details of various kinds of home situations, and they are remotely controlled.

In light of the above system architecture, we design the following four usage cases.

- *Environmental monitoring*. The users are able to view, in real-time, the current temperature, humidity, light and other basic information in the system. Taking into account the energy-efficiency, user can set the sensor working status through mobile terminals, such as the collection work, collection frequency and other indicators, in order to provide personalized services for users.
- *Intelligent lighting control*. Users can preset the desired interior lighting degree through mobile terminals. When the light sensor perceives that the room

Fig. (2). Smart home features.

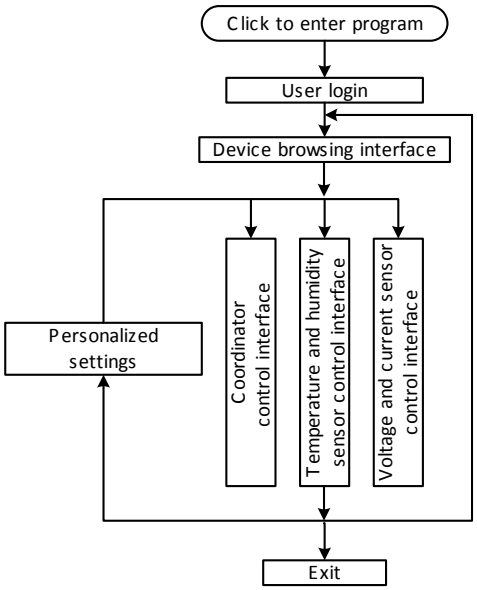


Fig. (3). Software flowchart of the mobile client.

lighting is too bright or too dim, the system will prompt the user to adjust through the handset.

- *Remote control*. In smart home, the remote control is significant. End-user will be able to complete the traditional home appliance operation through the mobile phone. In this system, users simply click on schematic icon in the phone interface and will be able to complete the appliance control, such as activating the bedroom light switches, living room fan start or stops *etc*.
- *Security warning*. In smart home application system, on the one hand, the user can monitor, in real-time, all kinds of electrical usage of current household, and on the other hand, the system can provide the function of early warning report for users. The user can bind some data monitoring services, such as, when the temperature is above or below the temperature desired by the user, the system can alert the user by means of a buzzer alarm to manually adjust the setting.

3. TECHNICAL SOLUTIONS

Several technologies are involved to realize our design. These technologies include: mobile terminal software design, and interface design. The following subsections describe each technology in details.

3.1. Platform Development Overview

The mobile clients designed by the system are based on Android operating system, for Android 2.2 or later. Currently, devices activated by Android have reached 900 million units worldwide, out of which China accounts for 70% of the market share of the mobile terminal, which has a very broad potential application space.

Design and implementation of software is based on Eclipse integrated development environment, using Java programming language. In support of the basic libraries of Java, the program also relies on the API calls of Android SDK (Android Software Development Kit).

3.2. Mobile Terminal Software Design

Mobile client enables users to view, control, and personalize settings and many other tasks, Fig. (**3**) shows the process of using the mobile client software. When click to enter the program, users are first asked to enter the user's personal registration information in order to complete the user authentication, which will provide specific services to the users. Once the authentication is successfully completed, the user can view the currently managed network equipment. All network equipments will be presented in the list to the user; the user can see all the basic information of the network equipment through this interface. By clicking on one of the list columns, access to the corresponding sensors is gained to control the browser interface. The figure schematically shows the registered devices, including coordination, temperature and humidity sensors and voltage and current sensors. There are different controls and display resources on different sensors and the user can personalize each of the sensor. For example, we want to set the indoor temperature within a certain range. The user can do associated operations in the interface of temperature and humidity sensors. When the environmental conditions do not meet the user expectations, the buzzer alarm will alert the user to do management control.

Program NetService class that inherits the features of Service, is responsible for the content of all network communication in the back-end. NetService is the core of the client software and responsible for communication with the server directly (Fig. **4**). The content that NetService is responsible for can be divided into four categories: the net recognized, data information, control information and the network topology information. In order to inform the server that the mobile client is currently active in network, con-

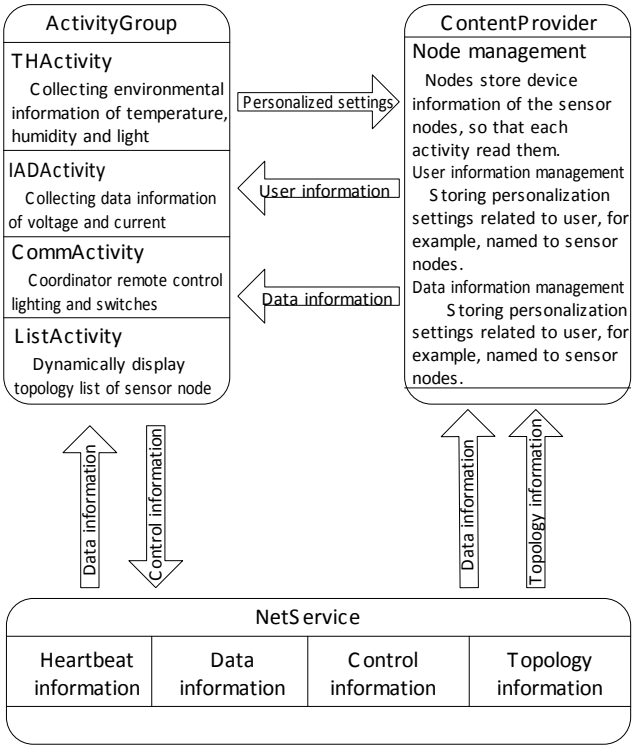


Fig. (4). Software framework.

(a)Node topology list (b) Remote Control

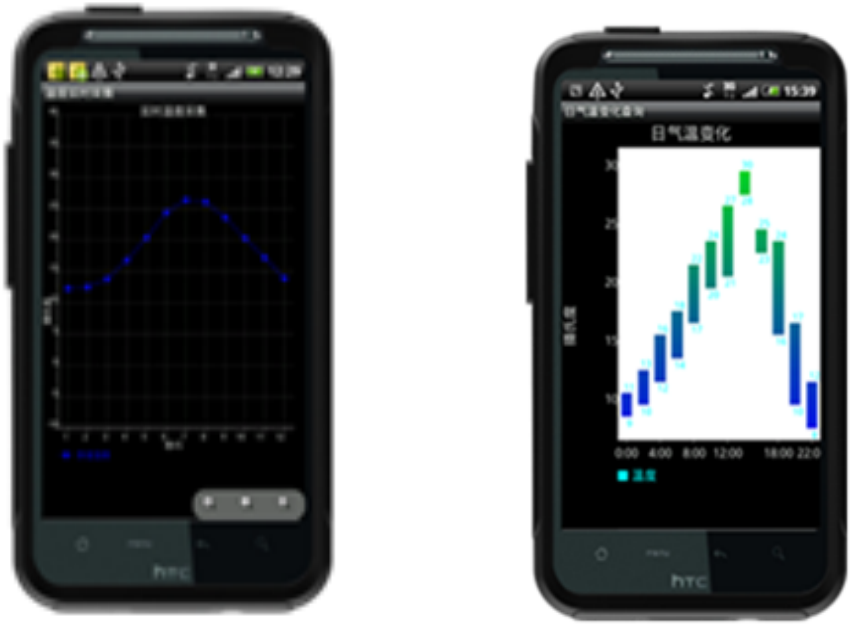
Fig. (5). Mobile terminal interface.

firm the information on the Web. The client and server will send information to each other by frequency of two seconds in the system. Transmission and access to data and control information helps mobile client to view, in real-time, a variety of data information collected by sensors. Network topology information helps mobile clients to get the number of nodes that exist in the current sensor networks.

3.3. Interface Design

Mobile device has its own unique characteristics: the limited screen size and easy operation. When the design is used in mobile client of smart home, taking into account the user's habits and ease of use, the Interface style should be kept simple. Users without professional training can quickly familiarize with the interface and the workings of the client. Design interface is shown in Fig. (**5**).

After the user is entered the personal login information, the system will receive individual family nodes within the current network topology information list. The user can see if each sensor node is working properly in the family. Also the user can name each node. In Fig. (**5a**), there are three nodes module in the network: Environmental monitoring of



(a) Real-time collection temperature (b) Look over history

Fig. (6). Mobile terminal interface.

bedroom, electrical control of kitchen and lighting control of living room. By clicking on a different action bar, the user can make the appropriate monitoring and control. Fig. (**5b**) shows the interface effect of the living room control; the user can change the state of the living room appliance switch to achieve the desired effect. Operation is very simple, the current state of home appliances will be described by a dynamic map, which the users can easily understand and use.

Mobile clients are also able to remotely monitor, when the user clicks into the environment acquisition module interface, and will be able to monitor, in real-time, the current environmental information. Fig. (**6a**) shows the real-time renderings of collection of the bedroom temperature, refreshed once every one second. The user can easily view the current temperature and by simply pinching sliding the fingers on screen they will be able to achieve the effect of zooming in and out. Meanwhile, the mobile client also allows the user to view historical data, as shown in Fig. (**6b**). Users can view the time of day and the temperature for each time period, in order to see whether the control to regulate the environment is achieved as per the user's expectations. According to the historical information, the system dynamically adjusts future operations to achieve better control purposes.

CONCLUSION

This paper presents an approach for effectively installing mobile terminals for smart home. Data exchange between the sensor network and the client is transmitted *via* the Internet. Users are able to remotely notify home electronic equipment by using a mobile intelligent terminal anytime and anywhere. Also, the user can monitor the information of the environmental quality of the home. Meanwhile, the mobile client uses a design, focusing on the user experience with a beautiful interface which is easy to use. This approach was successfully used for demonstrating services for measuring the home conditions, monitoring appliances, and controlling access.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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