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POINT-N-PRESS

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Abstract—*With numerous connected devices and appliances, the smart home is one of the representative fields of Internet of Things (IOT). As the complexity of devices/appliances increase, numerous buttons (sometimes dozens) are designed on the remote controller in home spaces even if several of them are seldom used. A user may be confused with the controller even if he or she only intends to perform a simple operation. This confusion also leads to a higher probability of mal-operations. In addition, conventional methods of communication between remote controllers and connected devices, such as eXtensible Markup Language (XML) messages, are usually bandwidth-consumptive. To address these problems, an intelligent universal remote control system for home appliances named Point-n-Press is proposed. Point-n-Press addresses the directionality feature, which enables easy and intuitive control by pointing to the target device to display the target's control interface on the screen of the remote controller. By leveraging the state dependencies of home device/appliance operations, only functional buttons that are relevant to the current context are utilized. Two real prototypes are implemented to verify the feasibility of the proposed scheme. The evaluation results show that Point-n-Press is a useful and suitable control scheme for IOT-based smart homes..*

Index Terms—*Intuitive control, IOT, less bandwidth consumption, smart home, user-friendly UI.*

I. INTRODUCTION

The goal of this paper is to develop an intelligent universal remote control system for home appliances called Point-n-Press. Point-n-Press automatically detects the device (or appliance) when a user points the controller at it. Also, a user interface (UI) for controlling this device is immediately displayed on the screen of the controller. Only the functional buttons that are relevant to the current control context appear on the UI. The UI provides intuitive operations and user-friendly interfaces, which enable users to simply enable and control the target device among the increasingly complex functionalities of home devices in a shared space for IOT-based smart homes. Note that a finite state machine (FSM) is used to model all operational states of a device and dependencies among these states. Multiple bit-string formatted control codes (modeled as bit-vector forms), which represent the control operations, are also applied in the proposed scheme to decrease the bandwidth consumption. Two real prototypes are implemented in smart homes to demonstrate the feasibility of the proposed scheme. In this control prototype, Point-n-Press is implemented in a mobile phone; a fan can be directly controlled by pointing to an external control box near the fan. Note that two state dependencies are included in the control process of the fan. First, the fan can only be started by pressing the "Power" button when it is powered off, whereas pressing other buttons is useless. Second, the "wind speed" button has no effect on the fan when the fan is in sleep or natural mode, because the wind speed is automatically adjusted. Thus, by considering the state dependencies, only functional buttons that are relevant to the current context are displayed on the screen of the controller.

II. LITERATURE SURVEY

M. Javier et al, From the internet of things to the internet of people.
One of the buzzwords in the Information Technology is Internet of Things (IOT). The future is Internet of Things, which will transform the real world objects into intelligent virtual objects. The IOT aims to unify everything in our world under a common infrastructure, giving us not only control of things around us, but also keeping us informed of the state of the things. In Light of this, present study addresses IOT concepts through systematic review of scholarly research papers, corporate white papers, professional discussions with experts and online databases. Moreover this research article focuses on definitions, geneses, basic requirements, characteristics and aliases of Internet of Things. The main objective of this paper is to provide an overview of Internet of Things, architectures, and vital technologies and their usages in our daily life. However, this manuscript will give good comprehension for the new researchers, who want to do research in this field of Internet of Things (Technological GOD) and facilitate knowledge accumulation in efficiently.

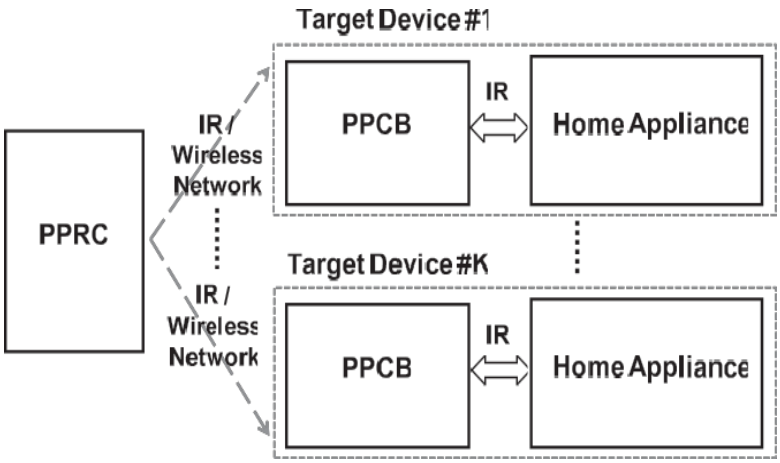
L. Zhang, L. Zheng, H. Yang, and T. J. Pan, Research of the key technologies of the smart home based on IOT. This paper mainly studies Ihome, the application of smart home, which provides a cloud service background, based on the distributed and intelligent control and a series of control terminals, smart sensors, to let the family consumers can fast, easy to build an extensible intelligent home solutions. In addition, intelligent control, control terminals, smart sensors can also be integrated in the intelligent community.

M. R. Alam, M. B. I. Reaz, and M. A. M. Ali, A review of smart homes-past, present, and future**.** A smart home is an application of ubiquitous computing in which the home environment is monitored by ambient intelligence to provide context-aware services and facilitate remote home control. This paper presents an overview of previous smart home research as well as the associated technologies. A brief discussion on the building blocks of smart homes and their interrelationships is presented. It describes collective information about sensors, multimedia devices, communication protocols, and systems, which are widely used in smart home implementation. Special algorithms from different fields and their significance are explained according to their scope of use in smart homes. This paper also presents a concrete guideline for future researchers to follow in developing a practical and sustainable smart home.

III. Proposed System

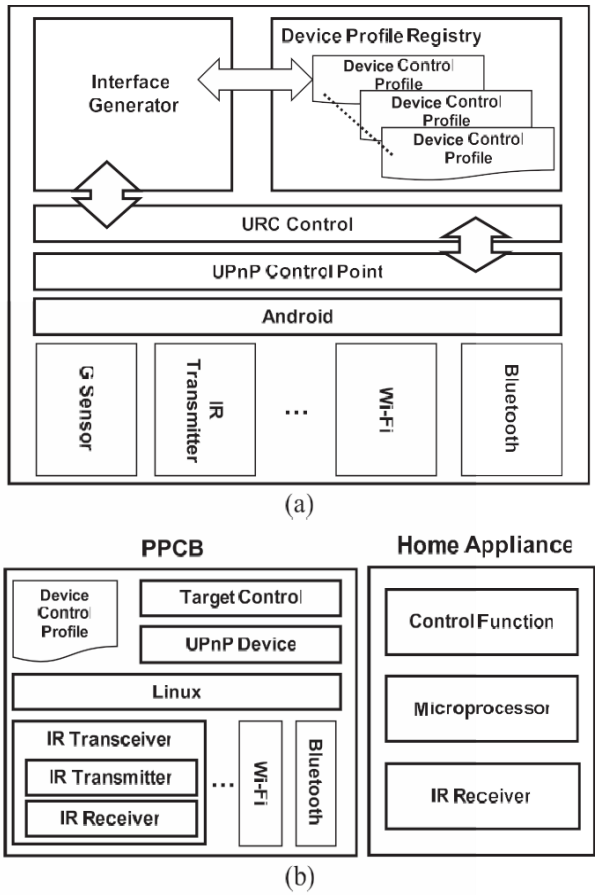
With numerous connected devices and appliances, the smart home is one of the representative fields of Internet of Things (IOT). As the complexity of devices/appliances increase, numerous buttons (sometimes dozens) are designed on the remote controller in home spaces even if several of them are seldom used. A user may be confused with the controller even if he or she only intends to perform a simple operation. This confusion also leads to a higher probability of mal-operations. In addition, conventional methods of communication between remote controllers and connected devices, such as extensible Markup Language (XML) messages, are usually bandwidth-consumptive. To address these problems, an intelligent universal remote control system for home appliances named Point-n-Press is proposed. Point-n-Press addresses the directionality feature, which enables easy and intuitive control by pointing to the target device to display the target's control interface on the screen of the remote controller. By lever- aging the state dependencies of home device/appliance operations, only functional buttons that are relevant to the current context are utilized. Two real prototypes are implemented to verify the feasibility of the proposed scheme. The evaluation results show that Point-n-Press is a useful and suitable control scheme for IOT- based smart homes.

Block Diagram



Methodology:

Here, the comprehensive system architecture and its primary components are discussed and the detailed workflows of the proposed Point-n-Press. The key features of the reutilized as the communication interfaces between the PPRC and the target devices.



The architecture of Point-n-Press consists of two parts:

1) The Point-n-Press remote controller (PPRC) and 2) a number of target devices, which embed in the Point-n-Press control box (PPCB) for interacting with the PPRC, as shown in Fig.

2) The detailed architectures of the PPRC and target devices are illustrated in Fig.

The functions of the components in the PPRC are described as follows.

- **Interface Generator** creates a UI according to the properties and descriptions of the target device and its current state.
- **Device Profile Registry** stores the information of the current target device, such as its current state and dependency between each state.
- **URC Control** is the main component of the PPRC, which is responsible for receiving DCPs from target devices. The URC Control subsequently analyzes the DCP and the cur- rent state of the target device to perform additional control operations.
- **UPnP Control Point** is a set of network protocols that enables networked devices to seamlessly discover each other in the network and establishes functional network services for communication. The UPnP Control Point is applied to transmit the control commands to target devices.
- **Android platform** is the operating platform of the PPRC, which is Linux-based.
- **Underlying communication interfaces** are used between the PPRC and the target devices, including IR, ZigBee, Wi- Fi, and Bluetooth. A gravity sensor (G sensor) is utilized to detect the movement of the PPRC. An IR transceiver is used to detect and identify a certain target device as the PPRC is pointed to a specific target device.

B. Primary Workflows

With the G sensor in the PPRC, the system can detect that the PPRC has been shaken (i.e., preparing to perform some con-trol operations) and may be used for controlling appliances. The PPRC then sends a “Be Ready” signal to the PPCB in the vicinity via a Bluetooth or Wi-Fi wireless network. When a PPCB receives the “Be Ready” signal, the PPCB initializes and enables its internal IR receiver. Once the PPRC is fixed on and pointed to a specific PPCB, the IR receiver of the PPCB subsequently receives the signal that was transmitted from the IR transmitter of the PPRC using

directionality of the IR char-acteristic. During this time, the Target Control component of the PPCB simultaneously transmits the DCP to the URC Con-trol component of the PPRC via a Bluetooth or Wi-Fi wireless network. After registering the received DCP to the Device Pro-file Registry component, the URC Control component generates a control UI via the Interface Generator component according to the DCP and state dependencies of the FSM. At this point, the PPRC can issue control commands using the corresponding control UI via the UPnP Control Point component. The PPRC then transmits control commands to the UPnP Device compo-nent of the PPCB to control the specific target device. Last, the PPCB transmits the received control commands from the PPRC to the appliance to generate the corresponding control opera-tions via an IR transmitter. The home appliance performs the corresponding operations issued by the PPRC.

C. Device Control Profile

A remote controller controls appliances by the transmission of messages. Fig. 4 shows an example of an XML message [18] (i.e., the DCP) for a fan with three buttons. Although the XML message increases the convenience of discovering and control-ling appliances, the complicated control formats and sizes con-sume significant bandwidth, produce heavy loads and create bottlenecks in the network transmission.

```
<stategroups>
  <stategroup id="0" name="speed" icon="/device/images/speed.jpg" value="0-0">
    <state id="0-0" name="off" icon="/device/images/off.jpg">
    <rule disablegroup="1,2" />
    <state id="0-1" name="low_speed" icon="/device/images/low.jpg" />
    <state id="0-2" name="medium_speed" icon="/device/images/medium.jpg" />
    <state id="0-3" name="high_speed" icon="/device/images/high.jpg" />
</stategroup>
  <stategroup id="1" name="mode" icon="/device/images/mode.jpg" value="1-0">
    <state id="1-0" name="normal" icon="/device/images/normal.jpg" />
    <state id="1-1" name="sleep" icon="/device/images/sleep.jpg" />
    <rule disablestate="0-1,0-2,0-3" />
    <state id="1-2" name="natural" icon="/device/images/natural.jpg" />
    <rule disablestate="0-1,0-2,0-3" />
  </stategroup>
</stategroups>
```

Fig. 4. Conventional XML example of a DCP message for a fan.

```
f <Wind-speed Mode Power >
S <Gentle Moderate Strong Natural Sleep Normal ON OFF>
C  S  N
01 01 46
46 01 01
46 02 0A
46 04 26
0A 01 01
0A 02 12
12 01 01
12 02 46
26 01 01
26 02 0A
26 04 86
86 01 01
86 02 0A
86 04 46
```

Fig. 5. Example of a DCP message for a fan.

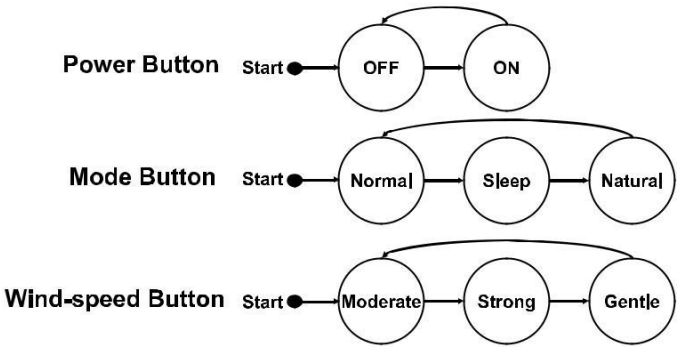


Fig. 6. Finite states of a fan's control functions.

reduce the bandwidth consumption. Thus, the design of the DCP includes: 1) a finite state machine that represents the depen-dencies of every operational state of the appliance and 2) mul-tiple bit-string formatted control codes that represent the con-trol operations. Fig. 5 shows a DCP message for our previous fan example.

Fig. 6 illustrates an example of using a finite state diagram to represent the state transitions for controlling a fan with three buttons. By transforming the control flow of an appliance into a FSM, the UI only needs to show the states that are relevant to the current state (i.e., candidates of subsequent states). Note that two state dependencies are included in the control process of this fan. First, when the fan is powered off, it can only be started by pressing the "Power" button, whereas pressing other buttons is useless. Second, when the fan is in sleep or natural mode, the wind speed is automatically adjusted, which indicates that the "wind speed" button exerts no effect on the fan.

IV. SYSTEM IMPLEMENTATION

Demonstration With Two Real Prototypes Two control prototypes have been launched in IOT-based smart homes. The first prototype is a fan, as shown in Fig. 1. The PPRC is implemented on the platform of a commercial smartphone, which is equipped with 1.2GHz, 1Gbytes random access memory (RAM), 16 Gbytes read only memory (ROM), a Bluetooth communication, a Wi-Fi communication, a G sensor, and a micro-universal serial bus(micro-USB)interface.

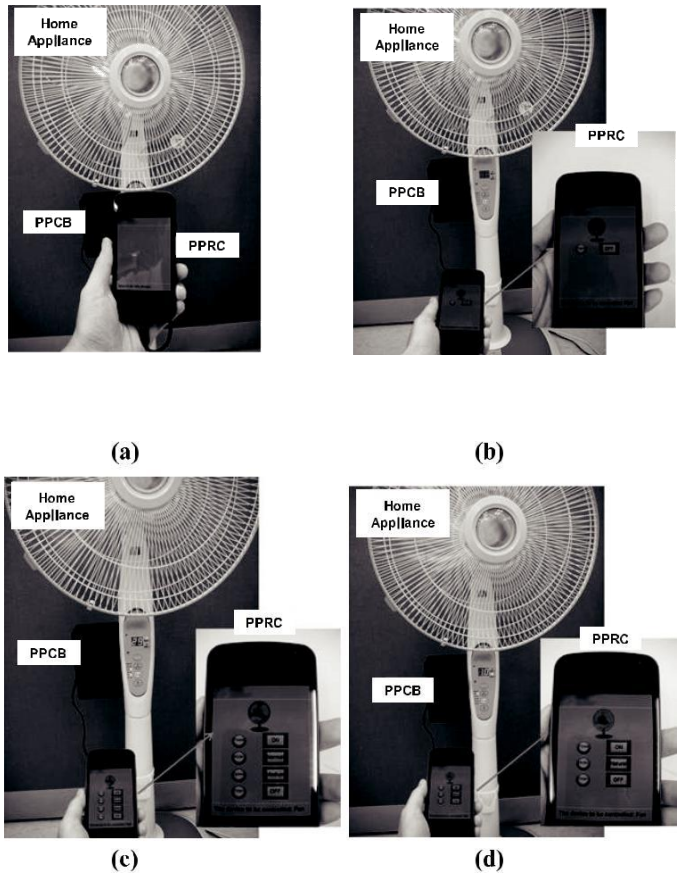


Fig. System operations and UI demonstration for controlling a fan. (a) Search for appliances (not yet pointing to the PPCB of the fan and nothing is displayed on the screen). (b) Pointing to the PPCB of the fan (at this point, the state of the fan is powered off). (c) Pointing to the PPCB of the fan and pressing the "Power" button (at this point, the state of the fan is powered on in normal mode and a moderate wind speed). (d) Pointing to the PPCB of the fan and pressing the "Mode" button (at this point, the state of the fan is powered on in natural mode with no wind speed control available).

Conclusion:

An intuitive control system with a set of user-friendly operations, called Point-n-Press, is proposed for controlling connected devices/appliances in IOT-based smart homes. The proposed scheme leverages the directionality characteristic of IR to enable easy and intuitive control of devices (i.e., controlling an appliance in smart homes by pointing to it). A

user- friendly UI is designed by considering the state dependencies between each control operation. This design disables buttons that are irrelevant to the current context to prevent users from performing mal-operations. With the demonstration of two real prototypes with controlling appliances in smart homes, the feasibility of an intelligent universal remote control system for home appliances with intuitive and user-friendly features is verified. In the designs of the FSM and bit-string formatted control codes, the communication between remote controllers and appliances requires less bandwidth consumption. Compared with previous studies that employ conventional XML and the RF4CE-based approaches, the proposed control system significantly reduces the bandwidth consumption while multiple users simultaneously control numerous appliances. Consequently, the proposed Point-n-Press control system not only enhances the features of intuition and user-friendliness but also establishes a less bandwidth-consumptive control system. Nevertheless, the implementation of the proposed control system is currently limited to IR sensors. Moreover, state dependencies of devices/appliances must be manually identified. Therefore, to control devices/appliances with a more precise pointing mechanism, and to support an auto discovery mechanism of state dependencies are two possible directions for future research.

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