ECHONET Lite Framework based on Embedded Component Systems with Visual Programming

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Abstract: Internet of Things (IoT) devices can improve the efficiency of daily life. In smart home systems, with the increase of devices, the maintainability of the software of IoT devices decreases. This paper proposes a framework to develop smart home software using the embedded component system to componentize the devices and separate the communication part and the control part. When controlling smart homes, visual programming is regarded as a simple method. A block-based programming framework is proposed for controlling devices. For the proposed framework, a code generator is developed to generate component description languages, application programs, and a visual block library which are based on the description of ECHONET Lite devices.

Keywords: Internet of Things, smart home, component-based embedded software, visual programming

1. Introduction

Smart homes are systems that can provide comfortable, safe, convenient, and efficient living environments. With an increase in smart home devices, the connections and interactions between devices have become more complex. With the introduction of Internet of Things technology, the existing software development in smart homes has the following limitations. First of all, network modules and device drivers are mixed, resulting in a decrease in the maintainability of the software. Secondly, for smart homes, the complexity and diversity of device functions lead to reduced software reusability. Finally, in order to cope with the devices produced by different manufacturers, the development of the application efficiency is affected.

To solve the problems, this paper proposes a smart home framework for developing IoT software using embedded component systems and controlling devices through a block-based programming approach. By parsing the description of the devices, a code generator is developed to generate the code for each part of the proposed framework.

The remainder of this paper is structured as follows. Section 2 introduces the system model used in this paper. Section 3 introduces the design of the proposed framework, and Section 4 presents a use case of creating a smart home application using a visual programming language. Section 5 presents the conclusions of this paper.

2. System model

This section describes the proposed system model and introduces TECS, ECHONET Lite, and Blockly. The architecture of the system model is presented in **Fig. 1**. The orange arrow indicates plugin, called ECNL Code Generator automatically generates the component description language (CDL), smart home software, and visual blocks by parsing ECHONET Lite devices description. In addition, the blue arrow indicates that the end user defines the properties of the devices in the block editor, and the editor generates a command. The command is received by the application and parsed through the middleware. Finally, the interface defined in TECS is called to the real-time operating system.

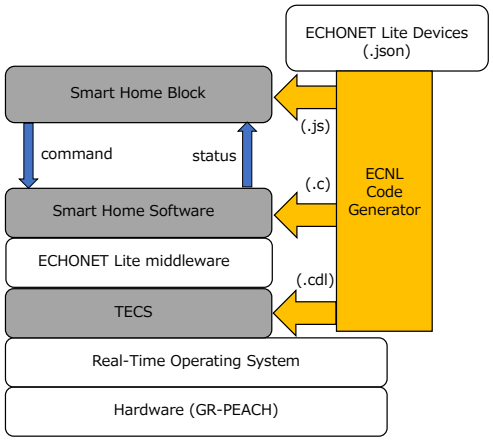

Fig. 1 System model

2.1 TECS

TOPPERS embedded component system (TECS) [1–4] can develop complex, large-scale software systems using component-based techniques. TECS can automatically generate static application programming interface (API) code for kernel objects. TECS divides projects into components and subsystems, and can improve embedded software reusability, enhance productivity, and reduce development costs.

2.2 ECHONET Lite

ECHONET Lite is a simplified version of ECHONET, a pro-

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```
"0x0290":{
 "validRelease":{"from":"A", "to":"latest"},
 "className":{"en":"General_lighting"},
 "elProperties":{
 "0x80":{
 "validRelease":{"from":"A", "to":"latest"},
 "propertyName":{"en":"Operating_status"},
 "accessRule":{"get":"required", "set":"optional", "inf":"
      required"},
 "data":{"$ref":"#/definitions/state_ON-OFF-3031"}
   }
  }
 }
```

Fig. 2 GeneralLighting specification

tocol for smart homes, that is intended for home network system builders and service system developers [5]. ECHONET Lite has passed the certification of ISO standards [6] and IEC standards [7]. ECHONET Lite is also recognized as the standard protocol of HEMS (Home Energy Management System).

2.3 Blockly

Blockly is a block-based visual programming tool that provides a user interface and framework for block editors to generate code in text-based languages. The Blockly editor uses visual blocks to represent elements such as variables, and loops, making it easy for users with no programming experience to use. Blockly allows users to complete a series of logical commands through puzzles.

3. Design and implementation

The ECNL Code Generator parses the specific information in the device description, for example, **Fig. 2** is the property definition of general lighting class, and generates the component description language, the block definition, the template code of the callback function, and the main task in the application.

3.1 Component Design

The properties of device are defined as the component interfaces. The component description language can generate a template file with the TECS generator. The developer describes in the template file how to control the properties according to the specifications of devices.

3.2 Application Design

The application includes a main task and callback functions. The main task is a template code used to start the ECHONET Lite middleware and wait to process messages. The callback functions are used to call the components of the smart home devices.

3.3 Block Design

The Javascript code generated by extracting the JSON information defines the shape of the visual block, the device name, properties, and control options. Finally, the block is represented by a browser in the form of a list.

4. Case Study

According to the design process described in Section 3, a complete smart home should include multiple controllers. Each controller is responsible for controlling one or more smart home devices, and acts as a node to form one. The prototype used for the case study is illustrated in **Fig. 3**. The exchange of ECHONET Lite Data is completed through a network switch, and the relay is controlled by GR-Peach as the switch of a smart home device.

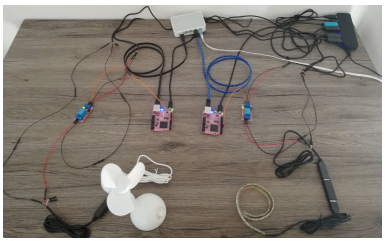

Fig. 3 Prototype of smart home devices for the case study

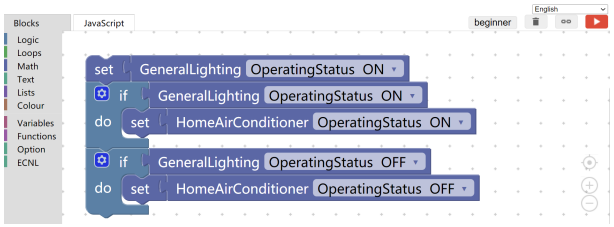

Fig. 4 Case in Blockly

In the case shown in **Fig. 4**, first turn on the light, and then control the air conditioner according to the state of the light. A demonstration video of the adaptation of the proposed virtual programming framework can be seen at: `https://youtu.be/-l31MFus9c4`.

5. Conclusion

This paper proposed an ECHONET Lite framework developed by an embedded component system, and the hardware could be controlled through visual programming. Visual block, smart home software, and component description language are automatically generated by reading the description of the devices. The smart home software, which is developed using component-based technology, improves the maintainability and reusability. Through the use cases, the current visual programming environment realized the custom control of multiple devices.

In future work, the ease of use of the block editor is planned to be improved by modifying the user interface and code generator.

References

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