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A Study on Cooperative System between Devices to Construct Internet of Things

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Abstract

Due to the development of the network, modules can control the home appliances by using the applications on smart devices and also monitor the condition of houses by using the built-in camera in smart devices. And, power control, physical control, natural ecosystem can be controlled on the smart device applications by using the network communications. The skills to do so are implemented to technologies. But since the smart appliances use different protocols, there has been a problem in a matter of product compatibility.

In this paper, we design An XML schema on devices for collaboration between devices and implement the device manager, which defines the relationships to enable collaboration between devices. When the device's relationship is redefined by the manager, we used the compact embedded system in Arduino and OpenWRT while designed and implemented the prototype system that enables collaboration between devices through an XML schema.

Keywords: *Android, GPS, IoT, Mobile-Network, Sensor*

1. Introduction

Recently, users have a variety of smart devices, and adjusting to these phenomena, businesses have been releasing and developing products to control the appliances and electronic devices by using the smart devices [1-2]. And a number of products such as cleaning robots, refrigerator, air conditioner, computers, TV, and etc. is growing exponentially and people use these devices to implement DLNA (Digital Living Network Alliance) a system [3].

In addition, domestic and foreign leading companies are developing a more progressive system, and Qualcommon's Internet of Things (IoT) called Alljoyn is the representative technique [4-5]. But, home appliances that are being used currently have a problem since a number of products with un-installed operating system is much greater than a number of products with installed operating system [6]. In order to resolve these issues, the users have a financial burden since they should buy the newly installed electrical appliances on operating systems [7].

Therefore, in this paper, we designed XML schema for a collaboration of the devices, and by using that schema we implemented an equipment manager, which defined relationships to enable a collaboration of devices. Once the device's relationship via the manager is redefined, the compact embedded system in arduino and openwrt are used to design and implement a device collaborated system through schema.

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2. Machine Socialization Schema

This chapter describes schema for machine socialization. And, the device's information is saved, and in order to process operation, an XML document is defined. Machine socialization schemas are composed of two structures. Table 1 saves the device's basic information called DEVICE_INFO schema in which the device administrators judges the device operation permission by using the device information. The minimum value is 1 for the Device-Info element, and the number of devices can be continuously added so the maximum value is set to infinity. More detailed information is shown in Table 1.

Table 1. DEVICE_INFO Schema Description

Object	Type	Cardinality	Description
Device ID	int	only once	Device identification number
Device_Description	string	either once or not	Device description
Model	string	only once	Device Model name
Sim_Country_Code	string	either once or not	USIM Country code
Device_Network	string	only once	Network provider
Device_Board	string	either once or not	Device mainboard name
Device_Brand	string	either once or not	Device Manufacturing Corp
Work_Time	string	only once	Last total work time
Device_Platform	string	only once	Behavior-based definition of device
Device_Sensor	-	zero or more	Device sensor information
Device_Function	-	one or more	Device function information
Device_State	-	only once	Current state of device

The Work_Info of Table 2 is a structure that saves the information of the working group and must store the necessary information for the operation. The minimum value is 1 for cardinality of elements, and since a number of devices can be continuously added, the maximum value is set to infinity. Work_Info structure is an element that saves the group's information and has a sequence structure. Details are shown in Table 2.

Table 2. WORK_INFO Schema Description

Object	Type	Cardinality	Description
Work_ID	int	only once	The working group's identification number
Work_Desctiption	string	only once	Working group description
Work_Time	-	only once	Estimated hours of work
Device_Group	-	one or more	Device priority sequence notation

3. Design

The suggested system uses the sensors of android and arduino in which the devices operate through the device manager in charge of the communication between the devices.

Device manager uses the sensors and networks to analyze the behavior and devices that the user needs and also provides the contents to the use via the necessary control and operation. In this paper, suggested system configuration is shown in Figure 1.

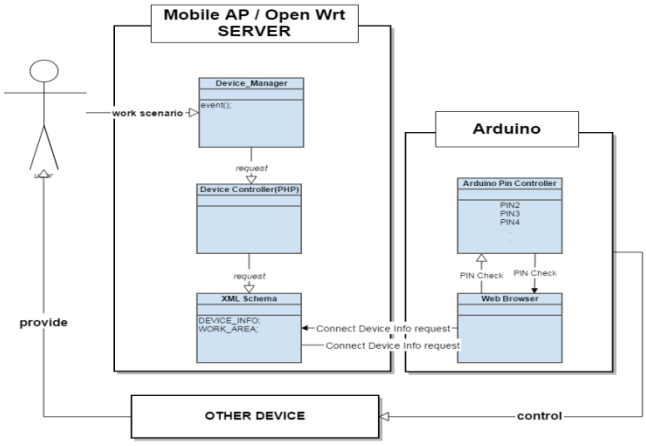

Figure 1. System Configuration

The Smart devices or wearable ones that have the closest tides to the users provide the first scenario. By using the acceleration sensor, gyro sensor, and illuminance sensors, one collects the user's surrounding information, recognizes the user's current situation, and sends that information to the device administrator in the server. Device managers provide the users by controlling the devices after managing the process based on the received data. Since the devices have different characteristics depending on the type, a link that logically connects the different attributes of those devices is defined as the standard. Figure 2 shows the overview of the socialization between two devices when a task is given to the devices with different functions.

Figure 2 is constructed using the logically connected relationship of the unit M1 and M2. These relationships use each of the device attributes, and these characteristics of the devices can be represented into the device's role, usage, function, and location. When an operation occurs, the relationship is automatically generated, and it is transit to the corresponding task.

In the socialization, M1's sociality has the unique features of M2 in addition to its own characteristic features so that when an outside request or a task is created, it can support collaboration in the form of M2's function. This is an element that can distinguish between collaborated devices with M1 by using the function of isolated M1 and newly added socially-based function of M1. In order to define this relationship, each schema consisting of machine socialization is described in chapter 2.

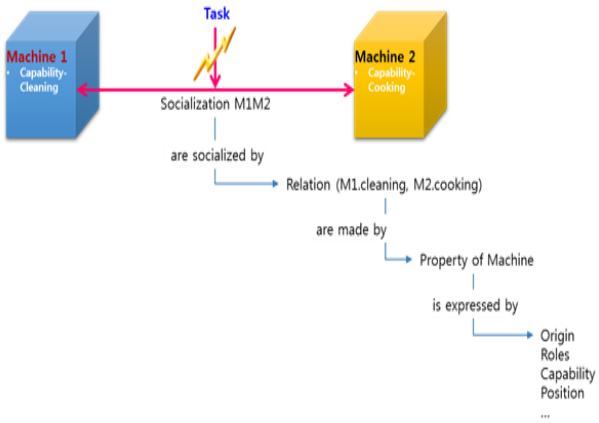

Figure 2. Definition of City Rail and Rail Car Using Virtual Markers

4. System Implementation

In this chapter, we describe the system that is implemented by using the devices' collaboration system designed in chapter 3 and Arduino and OpenWRT. For this, one uses information of an android mobile device, a mobile server, OpenWRT, Arduino, and a Wi-Fi Shield, and the device manager is in control in order to give intelligence to each device.

Servers are classified into OpenWRT and mobile server. OpenWRT is installed in the fixed space for the communication among devices with no movement, and mobile servicer is installed in the flow-type space. The two servers all operate in the same form, and in the case of a mobile server, the device becomes dormant when there is no server. In addition, it becomes dormant by the power control of arduino. When mobile server operates, Arduino receives the signal of the mobile server and waits for the power supply. When an event occurs, the device manager operates in the same form with OpenWRT. Figure 3 shows the process of module type tasks in sequence diagram.

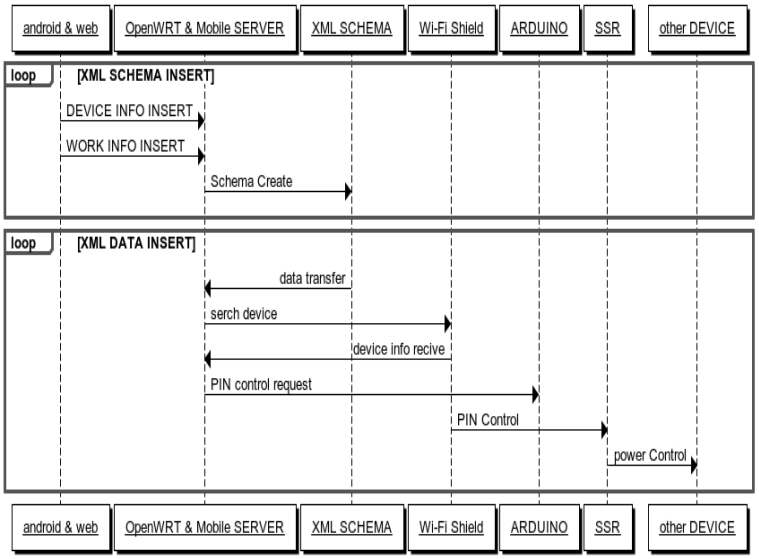

Figure 3. Sequence Diagram of the System

All operations form relationships with XML schema by a device manager. DEVICE_INFO will be stored with basic information of device and previous task information, and task manager records the operation time needed to calculate the device's current status and estimated end time. WORK_INFO will be responsible for the device relationships that can process the task and corresponding work. And then device information will be passed on to the device manager, and the device manager enters the device information onto the schema to check each device's connectivity as well as simultaneously redefines the relationship on XML schema.

For cooperation between devices, device information is described on DEVICE_INFO and the device equipped with operating system is connected to a server. And, schema is generated automatically while device information is handled to a device manager. As shown in Figure 4, schema generation automatically brings the device information, generates schema, and enters schema manually.

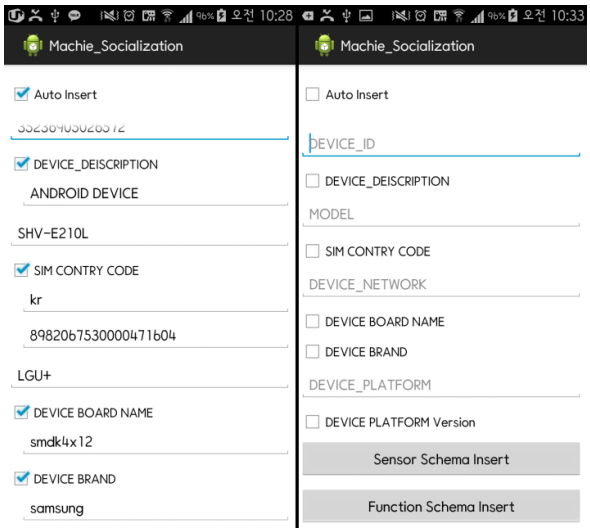

Figure 4. Generator of Device Information Schema

Device manager transmits the current status depending on the presence or absence of a power supply by using PIN control of Arduino. The current state of the device will be stored on DEVICE_STATE in sub-elements of DEVICE_INFO element. Depending on the presence or absence of the GPS, current latitude, longitude, height, and probability of whether or not it works are calculated.

Depending on whether or not power control of Arduino is controlled, the relationship between device 1 and device 2 should be newly matched and new schema value should be newly defined according to the relational data. And, for exchanging the data among devices, DEVICE_MANAGER browses the schema to define the relationship. Figure 5 shows the schema of DEVICE_INFO before DEVICE_MANAGER defines the relationship.

```
<DEVICE_INFO>
    <DEVICE_ID>35236905026572</DEVICE_ID>
    <DEVICE_DESCRIPTION>ANDROID DEVICE</DEVICE_DESCRIPTION>
    <MODEL>SHV-E210L</MODEL>
    <DEVICE_NETWORK>LGU+</DEVICE_NETWORK>
    <DEVICE_BOARD>smdk4x12</DEVICE_BOARD>
    <DEVICE_BRAND>samsung</DEVICE_BRAND>
    <WORK_TIME>20</WORK_TIME>
    <DEVICE_PLATFORM>ANDROID</DEVICE_PLATFORM>
    <VERSION>4.4.4</VERSION>
    <DEVICE_FUNCTION>
        <FUNC_ID>5000</FUNC_ID>
        <FUNC_DESC>=</FUNC_DESC>
        <ORDER>1</ORDER>
        <FUNC_NAME>Cleaning</FUNC_NAME>
    </DEVICE_FUNCTION>
    <DEVICE_STATE>
        <STATE>1</STATE>
        <STATE_WORK>5000</STATE_WORK>
    </DEVICE_STATE>
</DEVICE_INFO>
```

Figure 5. DEVICE_INFO Before Defining the Relationship

But before the relationship is defined, android devices that have first priority do not have the defined relationships. So that when they are run for the first time, DEVICE_MANAGER defines the relationship of the devices for job processing.

WORK_ID number controls power in device 1 and events in order to run 5000 CLEAN task while FUNCTION_ID connects the relationship WORK_ID and Device 2, the same task.

DEVICE_MANAGER is redefined by a relationship by the device function and task's unique number.

```
<DEVICE_INFO>
    <DEVICE_ID>35236905026572</DEVICE_ID>
    <DEVICE_DESCRIPTION>ANDROID DEVICE</DEVICE_DESCRIPTION>
    <MODEL>SHV-E210L</MODEL>
    <DEVICE_NETWORK>LGU+</DEVICE_NETWORK>
    <DEVICE_BOARD>smdk4x12</DEVICE_BOARD>
    <DEVICE_BRAND>samsung</DEVICE_BRAND>
    <WORK_TIME>20</WORK_TIME>
    <DEVICE_PLATFORM>ANDROID</DEVICE_PLATFORM>
    <VERSION>4.4.4</VERSION>
    <DEVICE_FUNCTION>
        <FUNC_ID>5000</FUNC_ID>
        <FUNC_DESC>=</FUNC_DESC>
        <ORDER>1</ORDER>
        <FUNC_NAME>Cleaning</FUNC_NAME>
    </DEVICE_FUNCTION>
    <DEVICE_STATE>
        <STATE>1</STATE>
        <STATE_WORK>5000</STATE_WORK>
    </DEVICE_STATE>
    <DEVICE_RELATION>
        <RELATION_NAME>CLEANING</RELATION_NAME>
        <RELATION_ID>201501191015</RELATION_ID>
        <WORK_DEVICE_ID>02</WORK_DEVICE_ID>
        <WORK_GROUP_ID>5000</WORK_GROUP_ID>
    </DEVICE_RELATION>
    <DEVICE_RELATION>
        <RELATION_NAME>CLEANING</RELATION_NAME>
        <RELATION_ID>201501191015</RELATION_ID>
        <WORK_DEVICE_ID>01</WORK_DEVICE_ID>
        <WORK_GROUP_ID>5000</WORK_GROUP_ID>
    </DEVICE_RELATION>
</DEVICE_INFO>
```

Figure 6. A Schema of Financial Relations DEVICE_INFO

It analyzes each device registered in schema, matches unique number of DEVICE_FUNCTION and FUNCTION_ID, ORDER, and redefines the relationship with device 1.

Figure 6 shows a part of DEVICE_INFO schema showing the redefined relationships of 1 device by DEVICE_MANAGER.

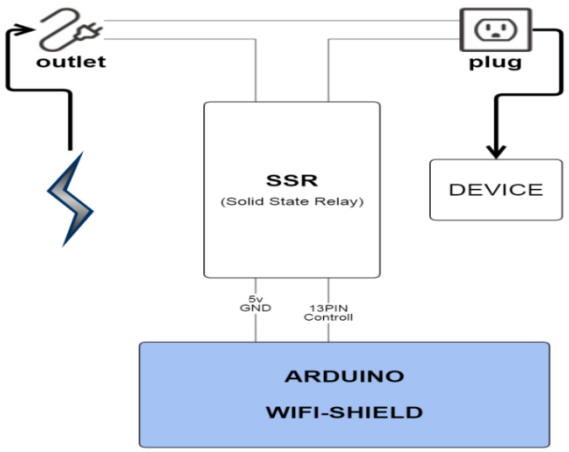

Figure 7. A Schema of Financial Rlations DEVICE_INFO

Arduino, which controls using the suggested schema, receives the 220V electric current as shown in Figure 7, and SSR supplies one of the electric current 220V to the 5V electric current of Arduino. When SSR connects to Switch ON, electric current supplies power to the plugged home appliances, which makes sure the device normally operates.

5. Conclusion

Recently, the issue of IT industry is IoT, and IoT means the environment which shares information by connecting the network on objects in life. By using IoT, not only home appliances and electronic devices, but also health care, remote meter reading, smart home, and smart car can be used to share information through a network. The standard research

group is doing a standardization work for Internet of Things. Although currently many IoT systems are released, there are certain problems in a matter of compatibility because only the communication among devices equipped with their own company's system is possible. Also, existing devices released with analog methods are excluded from IoT service. ‘

In order to solve the existing problems, in this paper, one uses XML creates schema, and provides the base for IoT system using that schema. This possibly solves the compatibility problem in the existing service, communication module, and limitations of the operating system. The suggested system defines the relationship among devices by a device manager, and when a relationship is defined, arduino is used to implement the prototype system, which confirms the excellent portability as the cooperation among devices is described by the schema. Regardless of the device model, XML is used to manage the operating condition of each device and the relational work between devices, and DEVICE MANAGER manages schema recorded on OPENWRT.

For the future research challenge, based on this paper's schema, we can create and implement H2M (Human to Machine) so that people and machines can communicate. The research about the system where humans and machines can communicate is necessary.

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