

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

Chang-Su Kim<sup>1</sup>, Sang-Keun Yoo<sup>2</sup>, Young-Sic Jeong<sup>2</sup>, Yong-Woon Kim<sup>2</sup> and Hoe-Kyung Jung<sup>1\*</sup>

<sup>1</sup>*PaiChai University, 155-40, Baejae-ro, SeoGu, DaeJeon, Korea*

<sup>2</sup>*Electronics and Telecommunications Research Institute, YuseongGu, DaeJeon, Korea*

*ddoja@pcu.ac.kr, {lobbi ,jys, qkim}@etri.re.kr, hkjung@pcu.ac.kr*

### **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) system [3].

In addition, domestic and foreign leading companies are developing a more progressive system, and Qualcomm'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 an 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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\* Corresponding Author

## 2. Machine Socialization Schema

This chapter describes schema for machine socialization. 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.

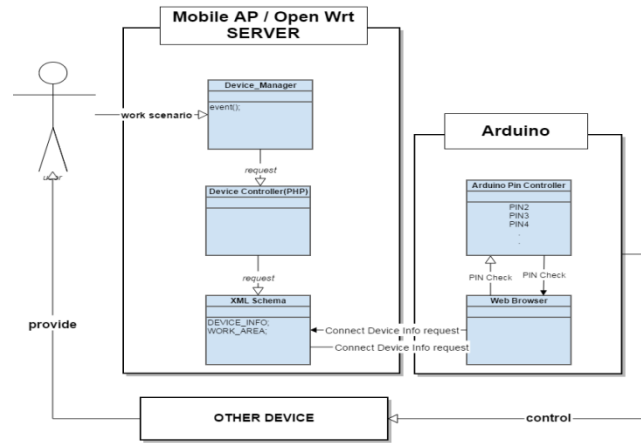
**Table 2. WORK\_INFO Schema Description**

Object	Type	Cardinality	Description
Work_ID	int	only once	The working group's identification number
Work_Description	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 user via the necessary control and operation. In this paper, suggested system configuration is shown in Figure 1.

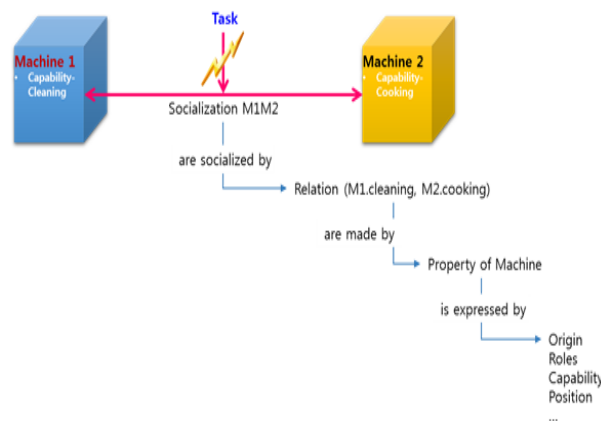


**Figure 1. System Configuration**

The Smart devices or wearable devices that have the closest ties to the users provide the first scenario. And, by using the acceleration sensors and gyro sensors, 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. Devices' manager provides 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.

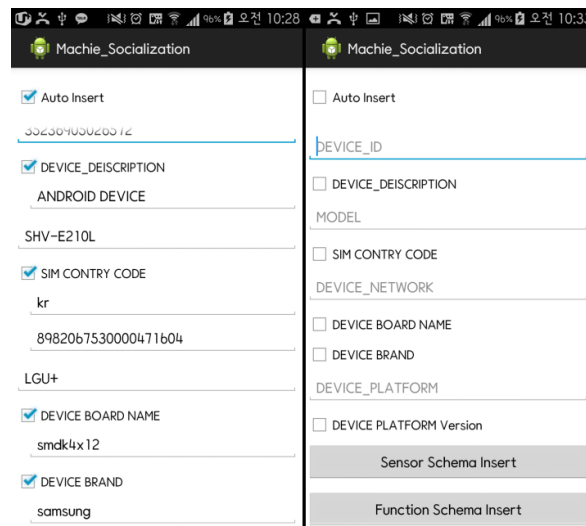
Figure 2 is constructed using the logically connected relationship of the unit M1 and M2. These relationships use each of the device attributes, and these characteristics of the devices can be represented into the device's role, usage, function, and location. When an operation occurs, the relationship is automatically generated, and it is in 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 the element that can distinguish between collaborated devices with M1 by using the function of isolated M1 and newly added sociality-based function of M1. In order to define this relationship, each schema consisting machine socialization is described in Chapter 2.



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





**Figure 4. Generator of Device Information Schema**

Device manager transmits the current status depending on the presence or absence of 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 Define the Relationship**

But before the relationship is defined, android devices that have a 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 to relationship by the device function and task's unique number.

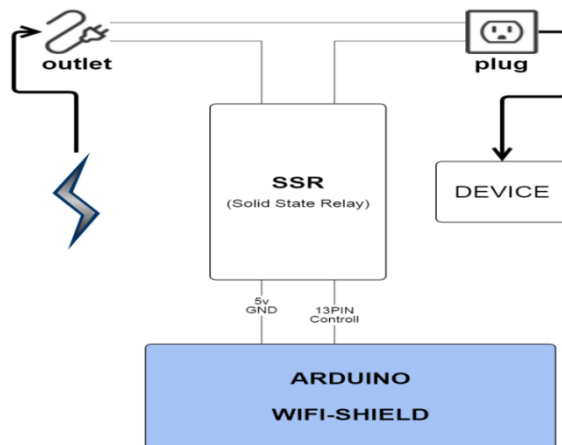
```

<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 Relations 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 Switch ON, the 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 method 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 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 devices 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.

## Acknowledgments

This research was supported by the ICT Standardization program of MSIP (Ministry of Science, ICT & Future Planning).

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## Authors



**Chang Su Kim**, he received the B.S., M.S., and Ph.D. degrees from the Department of Computer Engineering of Paichai University, Korea, in 1996, 1998, and 2002, respectively. From 2005 to 2012, he worked for the Department of Internet at Chungwoon University as a professor. Since 2013, he has worked in the Department of Computer Engineering at Paichai University, where he now works as a professor. His current research interests include multimedia document architecture modeling, web 2.0, and the semantic web.



**Sang Keun Yoo**, he received the M.S degrees from Chungnam National University, Korea in 1999. He developed micro payment systems in start-up from 1999 to 2000. Since 2001, he has worked for ETRI in areas of information security, RFID, sensor networks and IoT. He is a Convener of ISO/IEC JTC 1/WG 10 (Working Group on Internet of Things).



**Young Sic Jeong**, he received the B.S. degrees in Electronics Engineering from Yeungnam University, Gyeongsan, South Korea in 1991 and the M.S. degree in communication and signal processing from Pohang University of science and technology, Pohang, South Korea in 1993 and the PH.D. in communication and signal processing, Daejeon, South Korea in 2006. He is currently a principal member with Protocol Engineering Center, Electronics and Telecommunications Research Institute, Daejeon, South Korea. He is an editor of question 25/SG16 of ITU-T. His research interests include number portability, dualband RFID/NFC, High speed RFID, machine socialization and international standardization.



**Yong Woon Kim**, he studied electronics engineering at Dong-A Univ. and majored in computer networks and communication for the MS degree at POSTECH. He is currently a principal research engineer at the Protocol Engineering Center, Electronics and Telecommunications Research Institute (ETRI), Daejeon, South Korea. His research interests include IoT applications and services in the fields of smart city, smart factory, smart grid and smart water grid, and also IT sustainability works in terms of standardization. His research results have been contributed to ITU-T and ISO/IEC JTC 1 for development of relevant standards where he is a vice chairman of ITU-T SG 5 WP 3 (ICT and Climate Change) and the convener of ISO/IEC JTC 1/SC 39(Sustainability for and by IT)/WG 2(Green ICT).



**Hoe Kyung Jung**, he received the B.S degree in 1987 and Ph. D. degree in 1993 from the Department of Computer Engineering of Kwangwoon University, Korea. From 1994 to 2005, he worked for ETRI as a researcher. Since 1994, he has worked in the Department of Computer Engineering at Paichai University, where he now works as a professor. His current research interests include multimedia document architecture modeling, information processing, information retrieval, and databases.