Design of Interoperable Module between Two Home Network Middlewares

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Abstract. In order to guarantee interoperability among home network appliances and devices using heterogeneous network technologies and different applications, alliances of worldwide major companies developed and commercialized home network middlewares. Some of them were already published as international standards, and some are still in the standardization process. However, it finally causes another interoperable problem among these home network middlewares. In this paper, the architecture of a chip that can be used in a home gateway or each home network device to provide interoperability between two heterogeneous home network middlewares, is designed and proposed.

Keywords: CCP, IGRS, home network, middleware, interoperability, home network

1 Introduction

Wired and wireless network technologies were developed and ultimately applied to home network market in accordance with their features and applicable home network services. However, it brought about coexistence of heterogeneous networks in premises without interoperability among them. With this reason, efforts of each nation's enterprise- or government-driven development of home network middlewares were made to guarantee interoperability among heterogeneous networks or applications during past few years. For example, Konnex of Europe, Echonet of Japan, IGRS and iTopHome of China and UPnP of American global leading companies are representative.

In this paper, the design of basic chip architecture interoperable with two home network middlewares, Common Communication Protocol (CCP)[1] and Intelligent Grouping Resource Sharing (IGRS)[2], is especially focused and proposed, where CCP is an international standard of IEC TC100, and IGRS is in the standardization process of ISO/IEC JTC1 SC25.

2 Features of Middlewares

From the hierarchical point of view of OSI-7 layers, most of middlewares are commonly placed on top of physical, data link, network, and transport layers and under the application layer provided with APIs from the middlewares, which offer various application services to the developers according to the features of network protocols below it. In case of HAVi, it is based on IEEE1394 and capable of transferring AV data among AV network devices. Similarly, UPnP [3] and IGRS [3] are based on IP for sharing and transferring data resources including AV files among IP devices. Whereas, compared with former two middlewares, Konnex [3], Echonet [4], and CCP [4] provide wider selection of network protocols below them such as PLC, IrDA, Bluetooth, Zigbee and so on, and also support more home network services due to their characteristics.

Even though the common feature is to provide the home network users and device manufacturers with easy accessibility to home network devices and feasible implementation methods guaranteeing interoperability among heterogeneous networks or application services, respectively, there are certainly differences among those middlewares in terms of lexicon, taxonomy, message format, data format, delivery method, addressing scheme and so forth. With these differences, it is not easy to make two or more heterogeneous home network middlewares compatible with other.

Especially, the main causes of incompatibility among them are message and data formats. For example, message formats of UPnP and IGRS are based on XML. On the other hand, in case of CCP, Echonet, and Konnex, they define their own message formats composed of several fields or arguments representing special meanings or functions, which can be referred to in their specifications.

In order to solve these problems, one-to-any middleware conversion methods were recently developed and proposed [5][6]. These define a meta-middleware above existing home network middlewares and provide one-to-any conversion modules or profiles. Each converts messages of a certain home network middleware into newly defined messages of the meta-middleware.

3 Features of CCP and IGRS

IGRS is a middleware based on TCP and UDP over IP and defines XML-based message formats, which is similar to UPnP. Also, it supports gateway-free peer-to-peer communication method through online advertisement and service discovery by using broadcast, multicast, and unicast. On the other hand, CCP is a middleware based on multiple network protocols and defines its own unique message formats. In addition, due to multiple network protocols below CCP, a home gateway is essential for physical network linkage and communication among heterogeneous networks it supports.

Fig. 1 shows differences between CCP and IGRS messages particularly related to home network management such as device registration, device discovery, device addition and deletion. Not only for difference of the network protocols CCP and

IGRS support, but also for the differences of message formats, both new interoperable home network topology based on a newly defined home gateway and its architecture are needed in order to make these two middlewares interoperable with each other, which are proposed as shown in Fig. 2, which represents a new home network topology with new home gateway architecture.

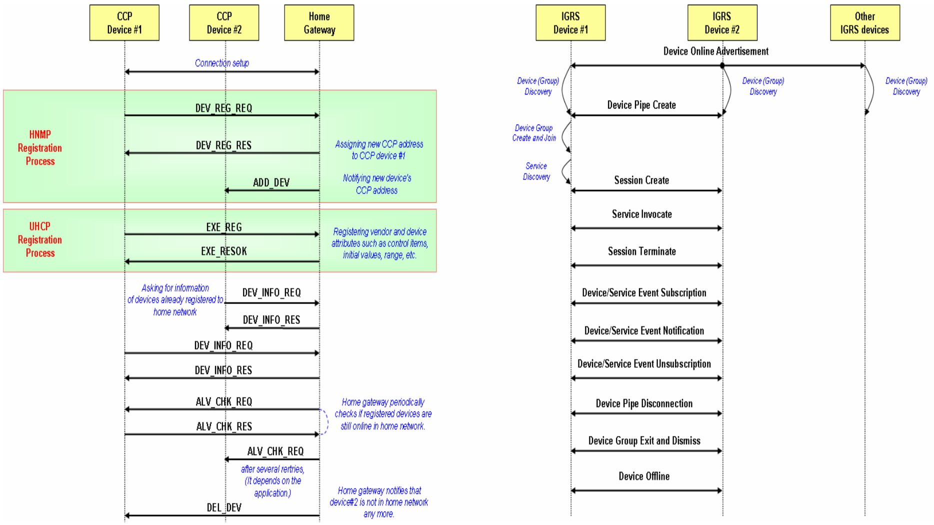

Fig. 1. Differences between CCP and IGRS messages for home network management services

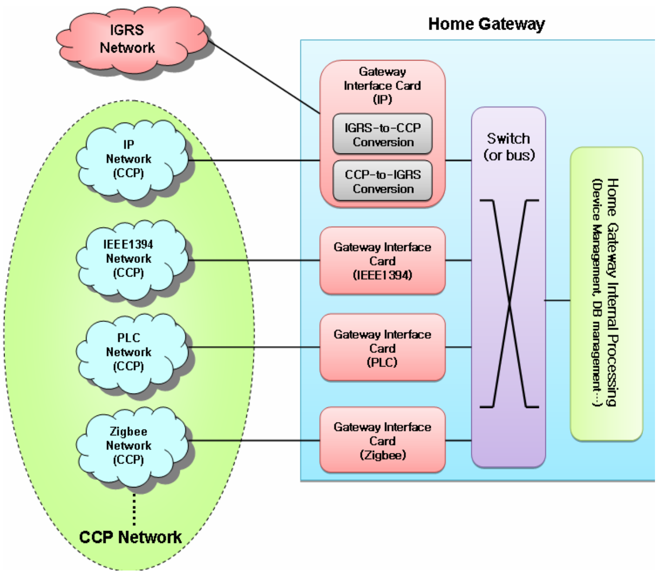

Fig. 2. Interoperable home network topology and home gateway architecture

4 Conversion Module

4.1 S/W Implementation

Above all, message-based classification of common functions provided by both middlewares and extraction of common and mutually exclusive parameter lists essential to form common messages are needed in order to implement conversion module. The next thing to be considered is the difference between message delivery methods. For example, in order to provide a specific function, some middleware use unidirectional messages such as indication, notification, and broadcasting messages. However, some use bidirectional messages such as pairs of request and response messages. Thus, in case of common messages of which parameters are mutually exclusive and of which delivery method is different from each other, the conversion module should compensate for variance.

Table 1. Analyzed common messages related to home network management services

Functions	CCP messages	IGRS messages
Registration (or discovery)	DEV_REG_REQ, DEV_REG_RES, EXE_REG, EXE_RESOK, EXE_RESNOK, ADD_DEV	DFVICE_ONLINE _ADVERTISEMENT, SERVICE_ONLINE_ADVERTISEMENT SEARCH_DEVICE_REQUEST, SEARCH_DEVICE_RESPONSE
Service invoke (or information retrieval)	DEV_INFO_REQ, DEV_INFO_RES, QUE_REGSTAT, QUE_CTRLSTAT, QUE_ALLSTAT, QUE_RESOK, QUE_RESNOK	INVOKE_SERVICE_REQUEST, INVOKE_SERVICE_RESPONSE, CREATE_SESSION_REQUEST, CREATE_SESSION_RESPONSE, GET_DEVICE_DESCRIPTION_REQUEST, GET_DEVICE_DESCRIPTION_RESPONSE, GET_SERVICE_DESCRIPTION_REQUEST, GET_SERVICE_DESCRIPTION_RESPONSE
Check existence of device	ALV_CHK_REQ, ALV_CHK_RES	DEVICE_ONLINE_DETECTION_REQUEST, DEVICE_ONLINE_DETECTION_RESPONSE
Termination	DEL_DEV	DESTROY_SESSION_NOTIFY, DEVICE_OFFLINE_ADVERTISEMET, SERVICE_OFFLINE_ADVERTISEMET

Table 1 shows common messages especially related to device management such as registration (or discovery), maintenance, status query, and termination. Even though these messages can be classified according to their supporting functions, there is no pair that perfectly corresponds to each other. To conclude, the common functions of these two middlewares are as follows:

– Home network management including discovery (or registration) of devices, addition (or deletion) of devices, checking existence of devices, device status retrieval, and so on
– Data services such as directories and files retrieval, attribute retrieval, upload (or download) of files, and instant messaging service
– Multimedia services such as locating multimedia files and real-time streaming services

From the derived common message list, a conceptual model of S/W conversion module is designed as shown in Fig. 3, which especially depicts the mutual registration processes. S/W conversion modules are designed as follows.

Remark 1. In Fig. 3, upper figure shows a case of an IGRS device's registration to CCP network, and lower one represents a case of a CCP device's registration to IGRS network.

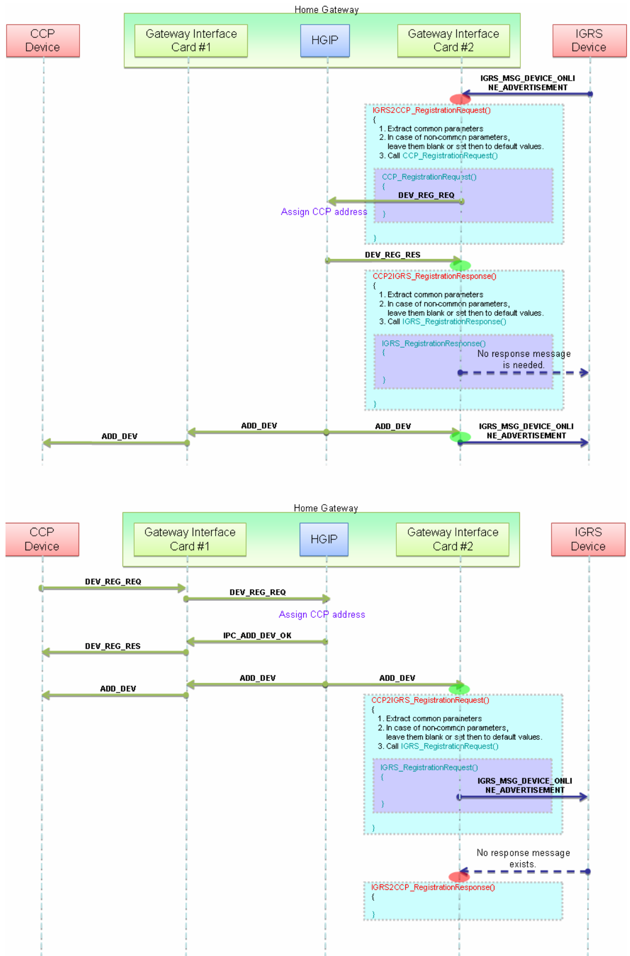

Fig. 3. Mutual Registration (or discovery) of CCP and IGRS devices

For example, *functionname* here can be RegistrationRequest, RegistrationResponse, and so forth. And both CCP_*functionname* and IGRS_*functionname* make CCP and IGRS messages, respectively with extracted common parameters and can also be implemented easily by using existing CCP and IGRS APIs. This modularization of each function is for the easy implementation of H/W conversion module.

```
CCP2IGRS_functionname (*CCP_packet)
{
   CCP_message_classify (*CCP_packet, *packet_type);
   extract_common_parameters_from_CCP (*CCP_packet,
          packet_type);
   process_CCP_uncommon_parameters (*CCP_packet,
          packet_type);
   IGRS_functionname (packet_type, parameters);
}

IGRS2CCP_functionname (* IGRS_packet)
{
   IGRS_message_classify (*IGRS_packet, *packet_type);
   extract_common_parameters_from_IGRS (*IGRS_packet,
          packet_type);
   process_IGRS_uncommon_parameters (*IGRS_packet,
          packet_type);
   CCP_functionname (packet_type, parameters);
}
```

4.2 H/W Implementation

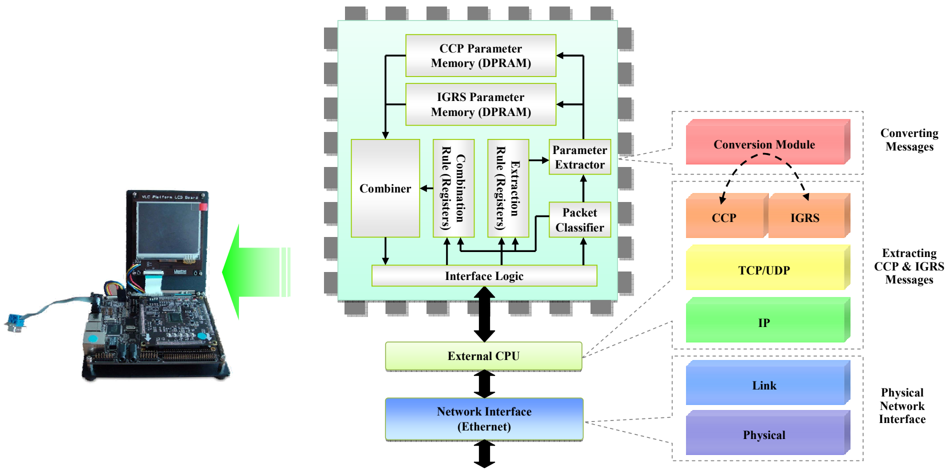

Fig. 4. H/W Design of Conversion Module

Fig. 4 depicts the designed H/W module mainly composed of network interface, external CPU and FPGA, which converts messages between CCP and IGRS networks. For functional verification, it is designed to support only IP network. This H/W module is linked to one of various interfaces provided by a home gateway. Accordingly, when a home gateway detects messages going from CCP network to IGRS network and vice versa, it passes them to the H/W conversion module through IP network.

Network interface is for exchanging CCP and IGRS messages with a home gateway. And, external CPU is responsible for processing TCP or UDP over IP protocols and decapsulating CCP and IGRS messages from IP packets.

Front-end part of FPGA classifies incoming messages into CCP and IGRS messages, identifies message name, extracts common parameters, and finally stores them to internal dual-port memories according to the identified message name. In this case, parameters and their formats are subject to change according to modification or upgrade of specification. Therefore, every rule required for classification, identification, and extraction is designed to be stored in volatile memories such as SDRAM or registers, which needs to be initialized by device driver running on external CPU. The behavioral algorithm of front-end part is shown in Fig. 5.

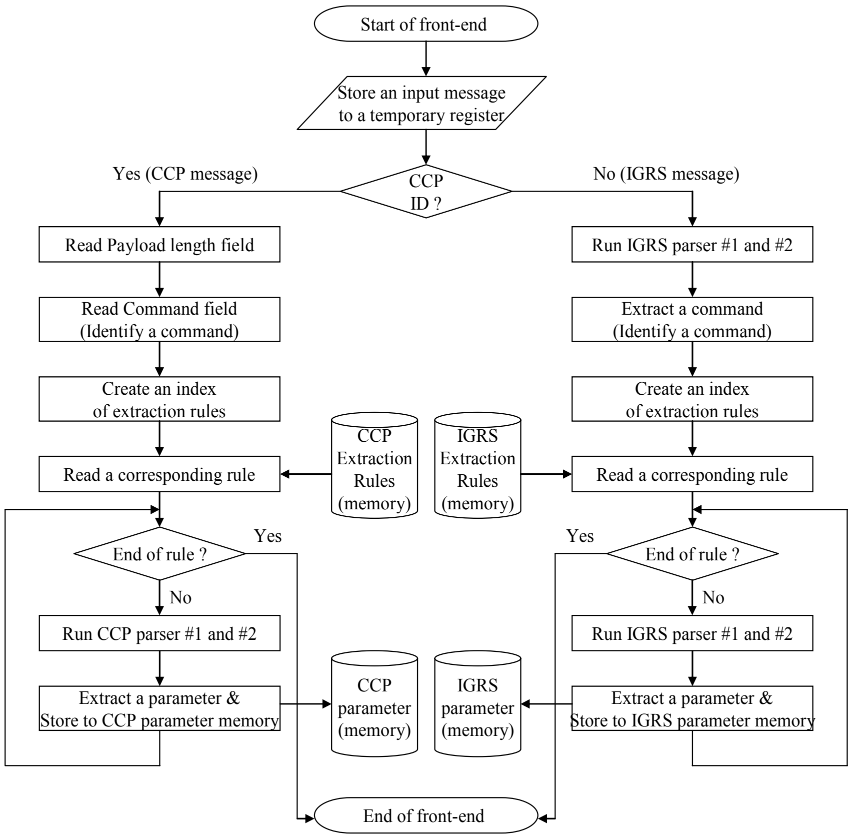

Fig. 5. Behavioral algorithm of front-end part of FPGA

With the similar concept, back-end part of FPGA converts incoming messages by combining extracted parameters and invariable context composing a newly converted message according to combination rules which are also stored initially by device driver. This variable rule-based design offers hardwired logic flexibility and compatibility regardless of revision of middleware specifications.

5 Conclusion

In this paper, S/W conversion module and FPGA-based H/W conversion module are experimentally designed. And basic mutual registration functions are verified by using commercial version of GUI application programs of CCP and IGRS. Especially, the basic architecture for hardwired logic interoperable with two home network middlewares, CCP and IGRS, is proposed. Hereafter, it is needed to develop more common interoperable functions such as resource discovery, resource sharing and so on, and also to design configurable general-purpose chip architecture providing interoperability among various home network middlewares in order for commercialization of low-cost home network devices.

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