

Support for ECHONET-based Smart Home Environments in the universAAL Ecosystem

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Abstract—With the advent of information and communication technology, many Ambient Assisted Living (AAL) solutions are being proposed to increase the quality of life of elderly people and reduce health and social care costs. Among these AAL solutions, universAAL seems to be the most promising platform for easy and economical development of AAL services. However, in its current state, the platform is incompatible with smart home systems which are based on the ECHONET standard. This paper presents the bridging between the universAAL and ECHONET standards through a technical point of view and thereby enables AAL services for ECHONET-based smart home environments.

Index Terms—System Integration, universAAL, ECHONET, Smart Homes

I. INTRODUCTION

The potential impact of Ambient Assisted Living (AAL) solutions is readily understandable. Societal trends indicate that they will be attractive to a large and ever increasing number of elderly population. There have been many efforts based on advanced information and communication technologies (ICT) to provide software infrastructure and middleware for AAL such as: universAAL [1], OpenRemote [2], openHAB [3], etc. All of these platforms utilize ICT to provide the runtime support for the execution of AAL services in a smart home environment, an essential prerequisite for the development of AAL. Among these solutions, universAAL (uAAL) is the most promising and holistic platform which directly benefits the end-user by being an affordable, simple to configure, personalized solution which also further empowers service providers by enabling easier and cheaper development of new AAL services and adaptation of existing ones. uAAL also supports various well known Home and Building Automation standards. Protocols that are popular in Europe, such as KNX, Zigbee and Z-wave (partial), are integrated into the uAAL Middleware (MW). However, the situation is different in Japan, where the ECHONET protocol has become the de jure standard for Homecare Networks. It has been promoted since 1997 by the ECHONET Consortium but unfortunately it is not yet supported by uAAL. The objective of this paper is to design and implement the integration of uAAL and ECHONET standards in order to extend AAL services for ECHONET-based smart home environments.

II. BACKGROUND

A. universAAL (uAAL)

universAAL stands for universal open platform and reference specification for Ambient Assisted Living, and is the result of the European Union funded project to produce an open platform for AAL. uAAL allows the seamless integration of heterogeneous devices within a network environment through two base concepts: i) the usage of three communication buses for topic-based communication among components, namely a Context Bus, a Service Bus and a User Interface Bus; ii) the usage of ontologies for information and services sharing between components. The overview of uAAL platform is depicted in Fig. 1.

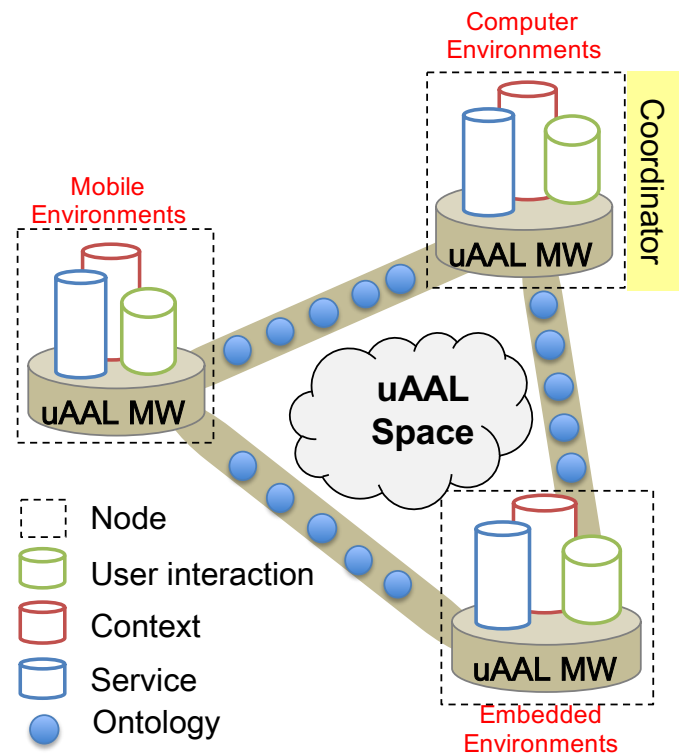


Fig. 1. universAAL Platform Overview

uAAL MW is the core component of uAAL platform which encompasses the communication infrastructure of the

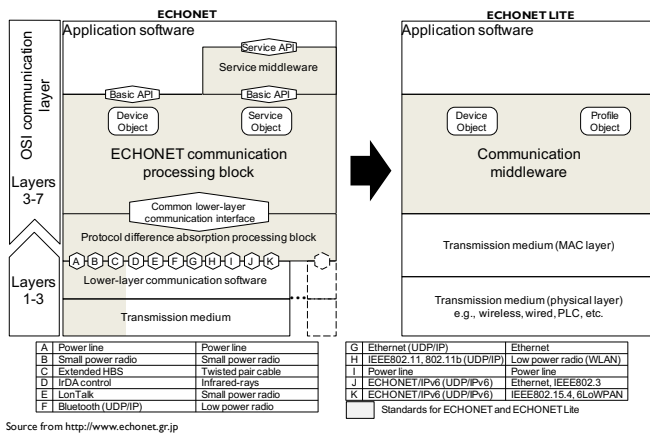


Fig. 2. ECHONET and ECHONET Lite Standard Overview



Fig. 3. iHouse: Smart Home Environment

platform. All devices that run this MW are nodes which can share knowledge and functionalities with other nodes in the form of ontology. The heart of this MW is formed by three buses and all the communication takes place via one of three following buses:

- Context Bus (CB) is an event-based communication channel to allow nodes to publish context events to the CB, regardless of the existence of recipients or not. Recipients are context subscribers which register their interest to the CB to be able to receive specific kind of events.
- Service Bus (SB) is a call-based communication channel which allows nodes to request services from other nodes. Service providers are called service callees. They announce themselves by registering a service profile which describes their capabilities to the SB. The counterpart to service callees are service callers which send a service request through the SB to ask for a specific request.
- User Interface Bus (UI Bus) is used for delivering messages related to user interactions.

B. ECHONET (Lite)

ECHONET [5], which has become a de jure home network standard certified by ICE and ISO, stands for Energy Conservation and Homecare Network. However, the ECHONET protocol did not attain widespread adoption due to two major factors. Firstly, the specification requires more complicated system configuration for multiple controllers and multiple devices. Another factor was the overall complexity of the protocol, leading to only a few compliant implementations. Therefore, in 2011 it was redesigned as the substantially simplified ECHONET Lite protocol. An overview of these two protocols is shown in Fig. 2.

C. Smart Home Environment

The environment used as the testing environment for the purposes of this paper is the iHouse, an ECHONET-based smart home environment located in Ishikawa, Japan (Fig. 3). The iHouse was the outcome of a research project funded by

the Japanese Ministry of Internal Affairs and Communications. It is a state of the art experimental environment, representative of future smart homes, which utilizes more than 300 ECHONET and ECHONET Lite sensors and actuators.

III. BRIDGING BETWEEN UNIVERSAAL AND ECHONET

Due to the fact that most devices in smart home environments are resource constrained IoT devices with limited processing capabilities, the uAAL platform should be integrated with the home gateways (HGW) of the smart homes. In order to perform bridging between uAAL and ECHONET, the HGW must at least support the followings:

- ECHONET Interface is responsible for interacting, managing and controlling ECHONET-based devices.
- uAAL Adaptation is responsible for translating the ECHONET-based frames into ontologies usable by the uAAL MW as well as translating commands received from uAAL MW into ECHONET-based frames suitable for ECHONET-based devices.
- uAAL MW is responsible for establishing communication channels with other nodes in uAAL space.

The architecture of HGW is depicted in Fig. 4 (Since the ECHONET does not provide facilities for UIs, the UI Bus is ignored in this architecture).

A. ECHONET Interface

ECHONET interface translates ECHONET frames into ECHONET objects and vice versa. The details of the frame translation are illustrated in Fig. 5 and Fig. 6.

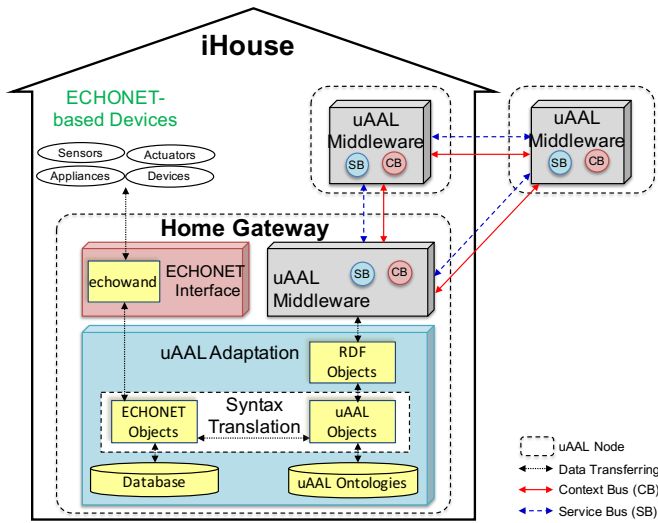


Fig. 4. Architecture Overview of the Home Gateway

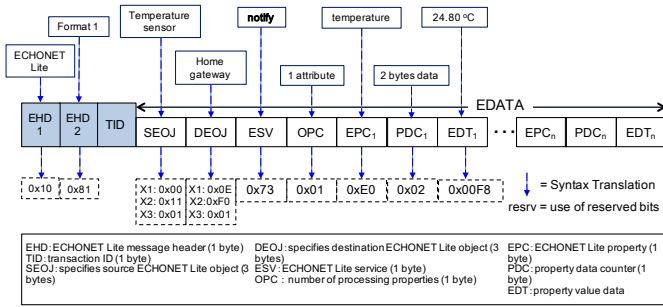


Fig. 5. Temperature Sensor Sends data to Home Gateway Frame

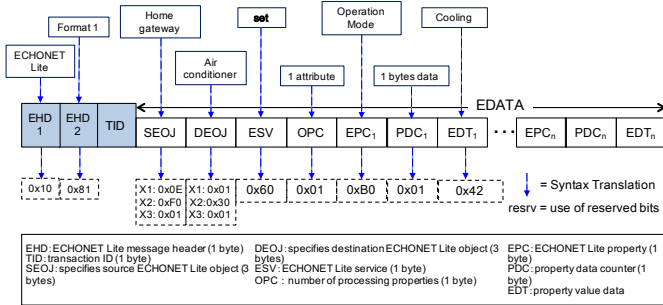


Fig. 6. Home Gateway Sets Operation Mode of Air-conditioner Frame

B. uAAL Adaptation

Because information sharing between uAAL nodes is in the form of ontology, the main mission of uAAL adaptation is to map the ECHONET objects into uAAL ontology. However, the uAAL ontologies can not support all attributes of the ECHONET standard. There is an alternative ontology model called SAREF [7] introduced by oneM2M working group that can cover all attributes of ECHONET but it is not compatible with uAAL ontologies. To this end, an ontology model based on oneM2M ECHONET ontology as shown in Fig. 7 which is compatible to uAAL ontologies was defined and implemented.

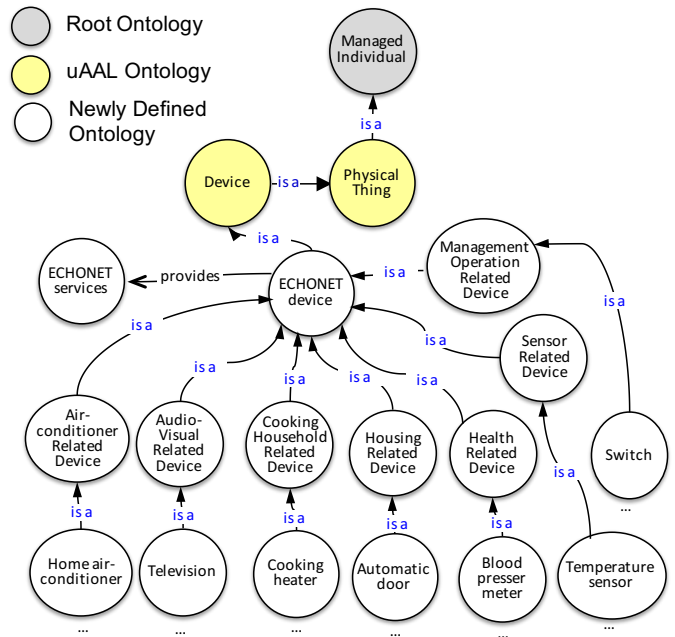


Fig. 7. uAAL-Compatible Ontology Model Extended from SAREF

uAAL adaptation takes ECHONET objects passing from ECHONET interface as input and translates them into uAAL resources (ontologies, objects) directly usable by uAAL MW and vice versa.

C. uAAL Middleware

uAAL MW is responsible for exchanging information between uAAL nodes by utilizing two buses: CB and SB as shown in Fig. 8 and Fig. 9.

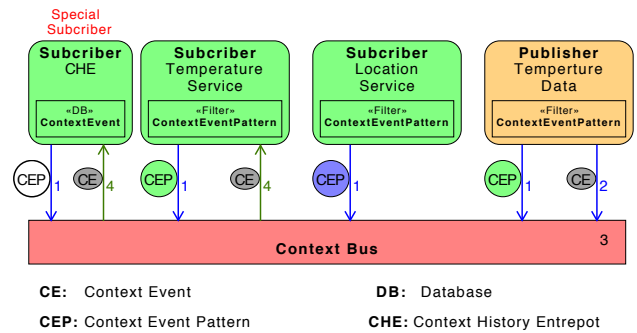


Fig. 8. The Overview of the Context Bus

The CB is used by Publishers (senders) to notify possible subscribers about events of interest. It is suitable for notifying data-change events or reporting notification data from the ECHONET-based network to the nodes in uAAL space. In order to use the CB, first all context publishers and subscribers

must register using the Context Event Pattern to register their events of interest. Whenever an event is published, the CB does the match-making and forwards the event to the interested subscribers. There is one special subscriber called Context History Entrepot (CHE), that will receive all the events published to the CB for storing and deriving new contextual information in uAAL space.

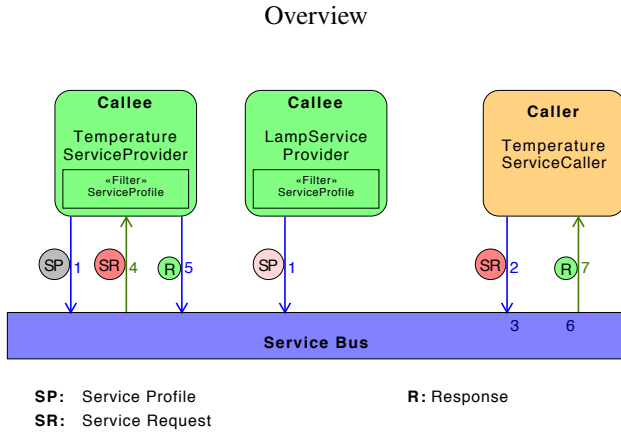


Fig. 9. The Overview of the Service Bus

On the other hand, the SB works similar to a broker who collects all callee and caller information then decides the best matches for them. The SB allows nodes in uAAL space to request some services from ECHONET-based network and vice versa. In order to use the SB, callees (service providers) must register their Service Profiles. These profiles describe their capabilities. Whenever a caller (service consumer) sends a Service Request, the CB does the match-making and passes the request to the matched callees. The callees perform the requested service and send a Service Response to the SB. Then, the SB aggregates responses from callees and sends the response back to the caller.

IV. EXPERIMENT AND RESULT

To evaluate the proposed solution, a prototype system has been implemented. The software and hardware details of the prototype system are shown in Fig. 10.

Two Intel NUC 6i3SYK with Ubuntu 16.04 LTS 64-bit OS are used as two uAAL nodes, one operating as the HGW of iHouse and the second node located outside of the iHouse premises. More specifically, the uAAL HGW node is responsible for performing bridging operations between the ECHONET-based environment of the iHouse and the second uAAL node. These two nodes are connected via the Internet using uSpace Gateway, a feature of the uAAL platform. The deployment environment of uAAL platform used on the two nodes is karaf 3.0.4 with Java SE-1.8.

The main goal of the experiment was to verify the correct operation of the prototype uAAL HGW node as well as the smooth bridging between the ECHONET-based network and

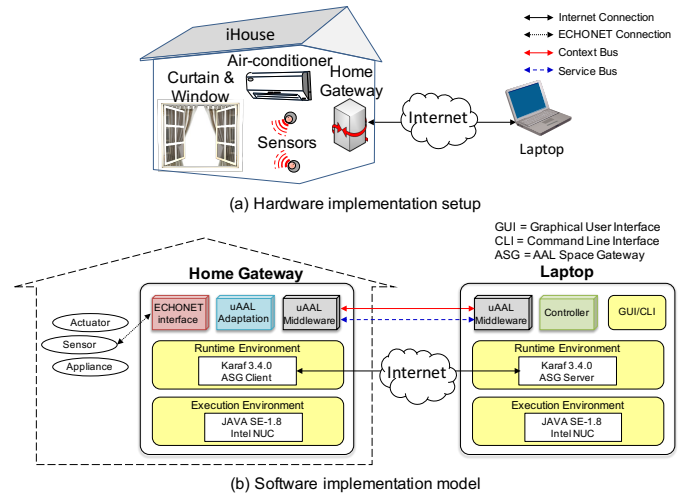


Fig. 10. Implementation Model

the second experimental uAAL node via the CB and SB. We were able to verify the correct operation of the proposed solution. The HGW was able to publish temperature data from temperature sensors inside iHouse via the CB to the second node. The correct operation of the SB was verified through an experiment which would set the operation mode of a specific air-conditioner to Cooling mode through the HGW after receiving the request from the second uAAL node. Further testing was conducted with three uAAL nodes.

V. CONCLUSION AND FUTURE WORK

This paper presents a solution to extend AAL platform to the ECHONET-based smart home environment using uAAL. As future work, various uAAL services will be adapted for use with the proposed solution and confirm their correct operation.

ACKNOWLEDGEMENT

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