ARCHITECTURE OF THE INTERNET REAL TIME COMMUNICATION WITH THE SMART HOME DEVICES SYSTEM

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Abstract: *This article presents an architecture of the Internet real-time communication with the UPnP and Jini devices connected within smart home system. In order to communicate remotely via Internet with smart home devices, an OSGi-based architecture was proposed, whereby the MOST protocol was used for the internal client-server communication protocol.*

1. INTRODUCTION

The architecture presented in the current paper should make possible that devices which are relying on different technologies to discover and to interact each other. This must be done in a transparent mode to the user. It should also be possible to interact with those devices using a preferred mode of action, both for the user and for the device involved in the communications. This multi-modality should also be transparent to the user. Another requirement of the proposed work in this paper is that the Internet user can also communicate remotely with the electronically devices connected to a residential gateway, as the user would be present within the local domain where the device is located.

2. REAL-TIME COMMUNICATION PROTOCOLS FOR WIDE AREAS

There are several reasons for the SIP[1] protocol as well as some of its extensions can be particularly convenient for communicating with connected devices and that is due especially to the fact that the SIP protocol meets all requirements for accessing the electronic devices via the Internet:

- support for addressing and abstract naming of the interconnected devices
- security regarding both privacy and authentication
- support for different communication mechanisms for networked devices
- load capacity allowed based on the MIME types
- interaction with various networking technologies currently utilized in buildings: X.10, CAN, CPL, etc. via a gateway
- support in offering mobility to the interconnected devices
- reutilization of already functioning SIP infrastructure for a new range of services

Due to the fact that the users are familiar with the Web protocol, the HTTP protocol is used also as a complementary protocol for the extended SIP protocol. Although HTTP does not support a notification mechanism, it can still be used to check the status of connected devices by sending HTTP GET requirements and by sending simple commands to devices connected to HTTP PUT. These applications can be downloaded and processed by servlets or CGI scripts (Common Gateway Interface) implemented in residential gateways which are then directed to the connected devices. Therefore, in this paper, the HTTP and the SIP extended protocols will be used for the remote communication with the presented interconnected devices.

3. COMMUNICATION AND DESCOVERY PROTOCOLS FOR DEVICES THAT COMMUNICATE IN REAL TIME WITHIN THE SMART HOME

UPnP (Universal Plug and Play) [2] and Jini (Java Intelligent Network Infrastructure) [3], can be mentioned among some of the topologies for real time operating systems currently used in the smart home. It appears that out of all the available discovery protocols and available services, UPnP is the proper protocol for the mutual discovery of networked devices. UPnP is based on an industry standard and thanks to the use of XML files the networked devices are able to describe all the capabilities they provide.

In contrast to the UPnP protocol, the Jini protocol has a simple API description and requires devices to have JVM installed on them. So by comparison to UPnP, Jini is not designed directly for the interconnected devices. However, both protocols UPnP and Jini complement each other and they can be used according to which purpose each of them serves best.

4. OSGI AS FRAMEWORK USED AS RESIDENTIAL GATEWAY

OSGi[5] appeared on the market in 1999 to define specifications for the providing of services to enable local network interconnection devices within vehicles, home or other environments. OSGi specification attempts to standardize how to provide secure and reliable service to their remote management, reuse of services and interconnection of different network standards. The OSGi specifications define a platform that provides a framework for implementing the various services. The framework includes a Java framework for extended service life-cycle management, persistent data storage, version management and a service registry. The life-cycle management provided by the framework allows developers to divide the running applications in small parts, providing mutual services, called bundle. These software components implemented in Java can be loaded, installed and activated in a framework. When activated, the bundle can register services in the registry service to provide services to other bundles in the framework. When a service is no longer needed anymore, it can be removed from the framework without to enable other bundles. The bundle can be installed and updated by the framework in a dynamic and accessible way. The new bundle can be installed for added features and the bundle existing can be modified and updated without having to reboot the whole system. The services registration is used to find and use other services in a secure and controlled manner. The service gateway operator has complete control over the platform and it can decide which services are allowed to be used.

In this paper the center of a smart home is represented by a residential gateway which establishes the connection of the electronic devices to the Internet. As illustrated in the figure below, by using Ethernet or IEEE 802.11 networking, a residential gateway provides central connection coordination for various heterogeneous communication technologies such as Jini and UPnP.

5. “MOST” AS CLIENT-SERVER COMMUNICATION PROTOCOL

MOST is a function oriented high-speed multimedia technology to network a variety of devices (namely the MOST nodes). MOST defines mechanisms for sending streaming data and packet-based data, and provides a complete application framework to control interaction between devices in a clearly structured way [6].

The MOST specification[6] defines not only the lower layers of a MOST network, which provide the basics for the transmission of data and for the network management, but also the protocols and mechanisms for implementing applications on top of those [7].

In the MOST specification, a MOST device contains multiple components that are the interface of an application and are called function blocks (FBlock). According to the MOST specification, an MOST FBlock, whose functions are used and controlled by an application, is referred to as a Slave.

In the Figure 1 it is shown how the application, which uses the FBlock and is

referred to as its Controller, is setting/reading the properties of the FBlock, is receiving the notification of changes sent by the FBlock, or is calling the methods implemented by the controlled FBlock [8].

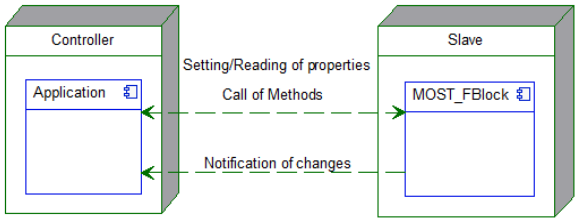

Fig 1. Interacting with an FBlock (Slave)

6. PROPOSED ARCHITECTURE

As presented in the figure 2, by activating of the HTTP (HyperText Transfer Protocol) or SIP (Session Initiation Protocol) in the OSGi framework of a residential gateway, a remote user can use a combination of username and password to access and perform operations on packages and services offered by the OSGi from anywhere via the Internet.

This allows users to remotely access information from the OSGi framework and to send control messages to services supported by the residential gateway OSGi, by using a standard Web browser.

In the figure 2 presents the software components necessary to access the interconnected UPnP and Jini devices via the Internet through the OSGi framework by using HTTP and SIP services:

- **HTTP service** – this represents the HTTP servlet in the Java Embedded Server which remotely delivers OSGi online services to the monitoring, diagnostic and maintenance center thanks to the user's web browser;
- **SIP service –** this server accepts SIP messages from users logged onto the Internet and converts SIP message from the DMP (Device Messaging Protocol) content into the currently available OSGi converting methods. This software component also sends back the OSGi generated messages to the SIP operating device which can be located either inside of a domain or on the Internet;
- **OSGi Service Registry** - such as the name implies it is the OSGi services' register;
- **Generic User Interface Manager** - provides generic user interface description;
- **User Devices Register** - used to authenticate the users;
- **Jini and UPnP Driver** - this is the real-time communication interface with the Jini device, respectively UPnP device connected to the residential gateway;
- **MOST/Jini and MOST/UPnP Gateways** – their role is to convert the MOST messages into the corresponding Jini/UPnP messages and vice versa by converting messages coming from the corresponding MOST devices into Jini/UPnP messages. This translation is done according to a predefined Jini-MOST table, respectively UPnP-MOST table;
- **MOST FBlock for Jini/UPnP device** - this component is the MOST functional block associated to the Jini/UPnP device;
- **MOST Dispatcher** – its role is to route the messages between the MOST functional blocks and their associated shadows;
- **MOST Shadows of the Jini/UPnP ECU** – this is the MOST FBlock shadow designed to the associated Jini/UPnP device;
- **Jini and UpnP devices** – which are part of the "smart home"/"corporation" systems;
- **Device Manager –** it provides access to the networked device drivers.

7. SUMMARY

I proposed in this paper the architecture of the Internet real-time communication with the smart home electronic devices system.

The UPnP and Jini were used in the presented smart home architecture.

The HTTP and the SIP extended protocols were used for the remote communication with the presented interconnected devices.

In order to communicate remotely with electronic devices connected via a residential gateway in the smart homes, an OSGi-based architecture was proposed, whereby the MOST protocol was used for the internal client-server communication protocol.

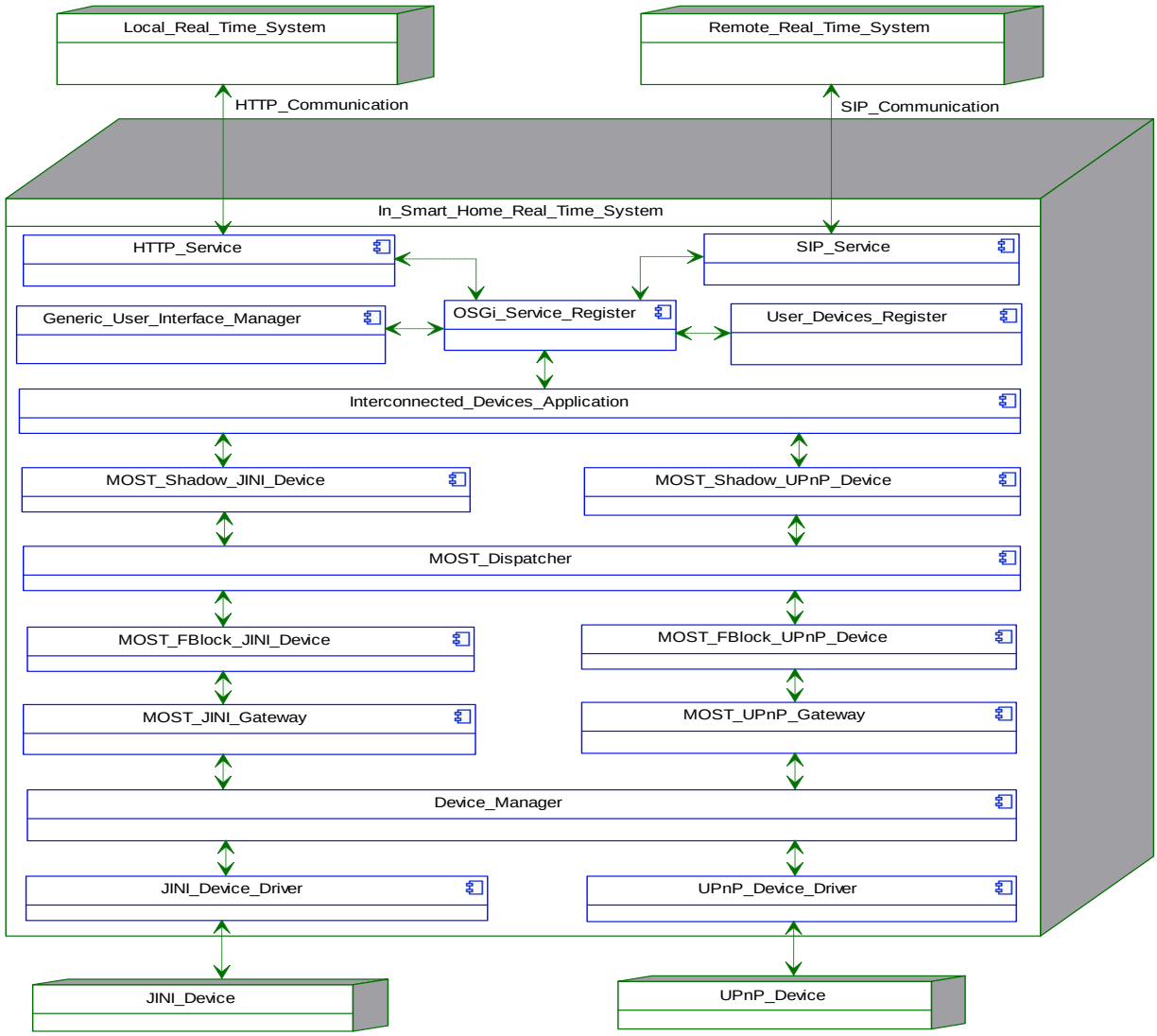

Fig. 2 Internet real-time communication with the UPnP and Jini smart home/corporation interconnected devices

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