UNIFICATION OF DIFFERENT REAL-TIME OPERATING COMMUNICATION SYSTEMS: CORPORATION, SMART HOME AND VEHICLE

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Abstract: *This article presents an unified architecture of the different real-time operating systems: the „corporation" domain, the „smart home" domain and the „vehicle" domain. For designing this architecture, functional requirements are defined in order to allow the real-time communication with the devices networked in the smart home, respectively the real-time communications with the electronic units connected in the car.*

1. INTRODUCTION

In this article I will demonstrate the scientific issues regarding the possibility of real-time communication between systems located in heterogeneous environments can be solved. Adjacent systems that initially appeared without any connection between them were proven by the architecture designed in this paper to be able to establish a real-time communication connection.

This paper brings forward a new perspective on the real-time communication of the distributed heterogeneous systems located in complementary fields: e.g. the "smart home" system, the "corporation" system and the "vehicle" system.

2. FUNCTIONAL REQUIREMENTS

The market requirements in terms of future development of the real-time communication of the distributed heterogeneous systems within the smart home and vehicles are presented below.

2.1. Real-time communication with the devices networked in the smart home/corporation

The real-time communication with the devices networked in the smart home or corporation shall allow:

- controlling the air conditioning systems
- remotely monitoring the smart home via a security camera
- Internet real time downloading one's favorite music to one's mobile device (phone, PDA, etc.) or to any car infotainment system from the server located in a smart home/corporation watching in one's own car or in the office during one's lunch break, the audio-video streaming received from a streaming server located in the smart home/corporation

2.2. Real-time communications with the electronic units connected in the car

The following functional requirements enable the real-time connection to the electronic devices from the vehicle in order to diagnose, maintain and monitor them. Such applications shall include:

- real-time diagnosis, maintenance and remote monitoring of a damaged vehicle
- real-time surveillance of the vehicle route in the event of a stolen vehicle
- communication with various traffic monitoring institutions so that the driver can receive real time information on potential traffic hazards and so that, in the event of a vehicle component failure or accidental break press by the other drivers, this information can be made available also automatically and in real time to the traffic monitoring institution so that the other traffic participants can break in due time when approaching a cross street, thus avoiding a potential collision

3. PROPOSED ARCHITECTURE

3.1. Definition of the proposed distributed heterogeneous systems

The distributed heterogeneous systems which communicate in real time are defined as those systems whose accuracy depends not only on the logical result of the processing, but also on the time when it becomes available for use.

Based on the requirement analysis of the preceding chapters and the current state of technology, the following systems were defined to communicate in real time:

- the "vehicle" system - contains all the vehicle electronic devices connected to a infotainment and telematics services central unit which can communicate with both the local and the remote vehicle user via the Internet;
- the "corporation" system – is represented by both our daily work setting and the diagnosis, maintenance and monitoring center for the in-vehicle electronically controlled units and smart home appliances;
- the "smart home" system - includes all interconnected appliances and multimedia devices in the smart home with which both the local user and the remote user can engage in real-time communication.

In this paper, this type of systems are proposed to communicate in such a way, that in the event of a user being placed in any of the given system mentioned below, he/she would be able to control any electronic device located in any of the other adjacent systems.

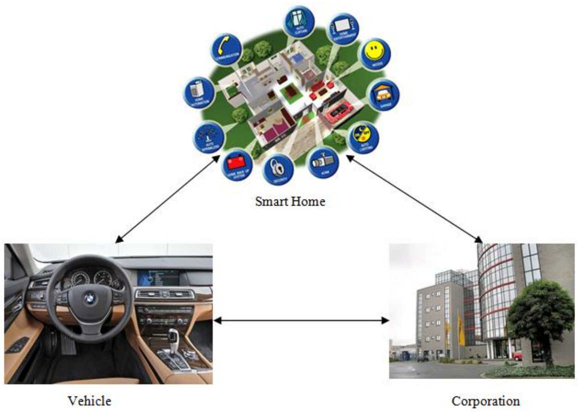

Fig. 1 Presentation of the distributed heterogeneous systems proposed in this paper

The following technological components are therefore needed:

- broadband access networks to provide Internet uninterrupted high-speed connection
- residential gateways that interconnect the broadband access network to the local network in the smart home or car
- a local network that connects various appliances in the smart home
- access technologies that facilitate the communication among/with the smart home devices
- a local network that connects the electronic devices in the vehicle
- access technologies that facilitate the communication between/with the electronic devices in the car

The figure below shows the components that are intended to operate in real time from the three areas specified above. The automotive field is designed as the head unit to which the user has direct access. It is represented in the figure only by the infotainment and the telematics systems. As noted above, all electronic devices in the vehicle communicate with the head unit in real time. The "corporate" domain comprises a residential gateway, servers, PCs, mobile computers, PDAs, smart phones, etc. The "smart home" system includes a residential gateway, PCs, laptops, printers, audio / video, cameras, air conditioning appliances, etc.

3.2. Real-time communication protocols for wide areas

There are several reasons for the SIP 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

Because 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.

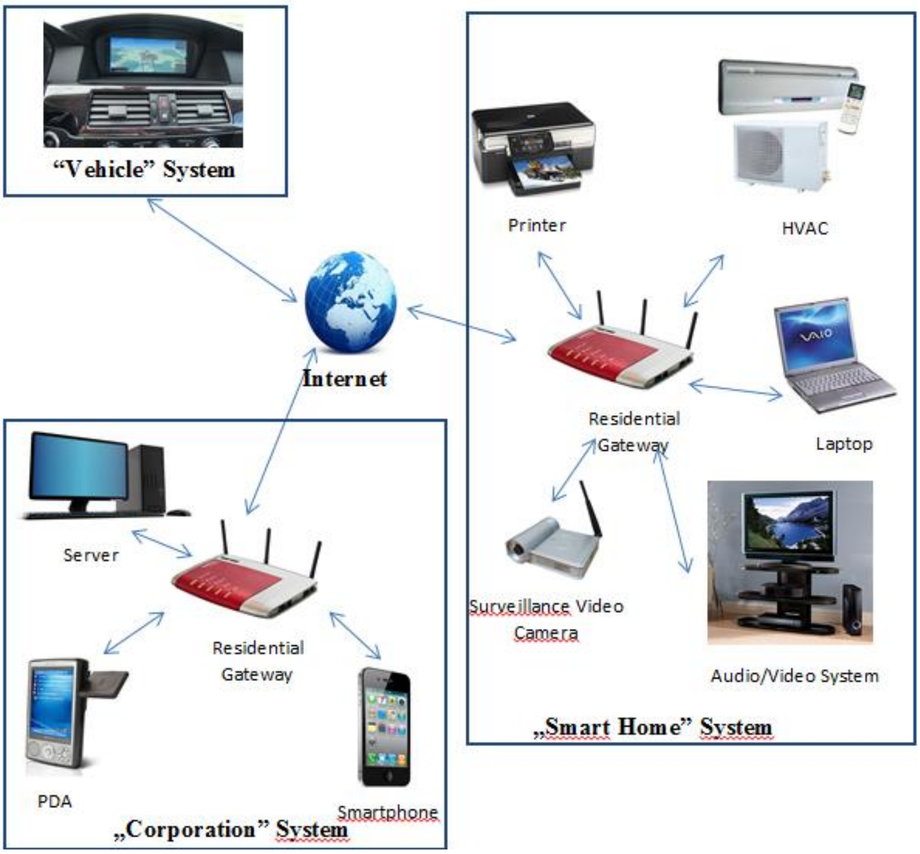

Fig. 2 Physical placement of different systems components which are intended to communicate in real time

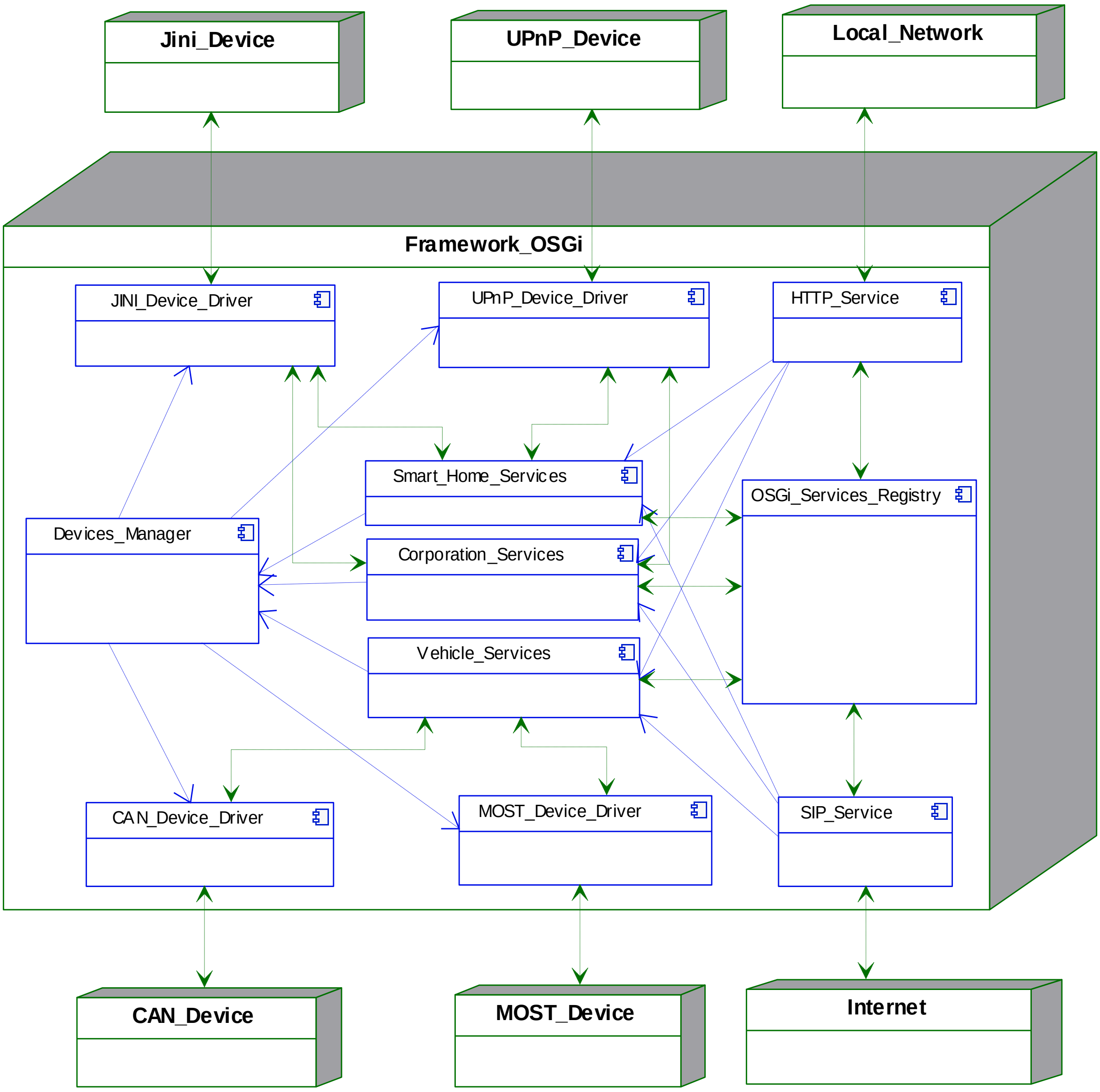

Fig. 32 Unification of the real time operating communication systems: corporation, smart home and vehicle

Therefore, in this paper, the HTTP will be used in order to configure remotely the interconnected devices, while the SIP extended protocols will be used in real-time communication with the presented interconnected devices. MOST and CAN standards will be utilized for the in-vehicles communication. A 3G connection will be used for accessing the connected devices through Internet and a WLAN connection will be used for communication to the gateway residential server in the smart home or respectively when the vehicle gains access to the router's coverage area. The GPS will be used to determine the vehicle's position and a RDS and TMC connection will be utilized for receiving traffic information. As far as the real-time communication in the smart home is concerned, the most appropriate fashion of communicating is the wireless networking mode, therefore such standards as IEEE 802.11, Bluetooth and IEEE 802.15 as well as other transport protocols and wireless hardware solutions will be used.

3.3. Choosing a residential gateway server type

The OSGi terminal system supports configuration, diagnostics, update / upgrade and display functions. The features of an OSGi system are:

- OSGi-based gateway remote management
- display and service functions
- turning the provided services on and off
- remote troubleshooting and technical problem solving for the users

In this paper, OSGi shall be used as the framework for residential gateways therefore the real time communication and discovery protocols used by the connected devices must be adapted to OSGi calling methods. As defined by DEG (Device Expert Group), DAS (Device Access Service) provides an exact solution for this. DAS also allows for the dynamic discovery of the real time interconnected devices while they are running which allows for greater flexibility. In this fashion, UPnP or Jini services may be imported into the OSGi framework altogether behaving as a single valid OSGi service entity which makes this entity fully accessible by other OSGi services. Similarly, services registered within the OSGi framework may be exported so that they could be detected through native discovery techniques. For example, a Jini service point can be detected by an UPnP control point with the help of an OSGi framework. The OSGi device accessing service is currently used in the architecture that brings improvement to the currently available real-time communication of the distributed heterogeneous systems, a service that enables the discovery, the recording and the real-time communication of different heterogeneous devices.

3.4. Unified system architecture

The following figure presents the real time communicating interconnected electronic devices located in three complementary systems: corporation, smart home and vehicle. They are presented as follows:

- **The Jini and UpnP devices** – which are part of the "smart home"/"corporation" systems
- **The CAN and MOST devices** – which are part of the "vehicle" system
- **The OSGi framework** – which unifies real-time services offered by the systems described above and which includes:
    - **the OSGi Service Registry**
    - **the “smart home”/”corporation” services** – the application that controls the communication with the devices connected in the smart home/corporation
    - **The “vehicle” service** – the application service that controls the communication with devices connected in the vehicle
    - **The HTTP service** – this represents the HTTP servlet from the Java Embedded Server which delivers the remote OSGi services to the online diagnostic, maintenance and monitoring center thanks to the center’s Web browser
    - **The 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
    - **The Device Manager** – it provides access to the networked device drivers
    - **The base driver for the Jini, UPnP, CAN, MOST devices** – this driver is meant to use its own language protocol in order to communicate with the interconnected devices

4. CONCLUSION

The architecture designed in this paper allowed the online real-time remote control of the electronic devices interconnected within one of the systems mentioned above from any another adjacent one. Therefore it was defined the systems which were going to communicate in real time by presenting the physical components that were going to interact, the technologies and the protocols used as well as the design of the real-time communication architecture. This type of communication was established among the following systems: the system called the "smart home" - which included all the electronic devices interconnected within the smart home system, the system called "vehicle" – which incorporated all the interconnected electronic devices in the vehicle and which could be also perceived as a mobile system and the system called "corporation" – which could be considered an online center for diagnostics, maintenance and monitoring.

From an economic perspective, the applications based on the presented architecture for the automotive systems, could lead to lower repair costs of one's private vehicle as for instance in the case of a driver who is traveling abroad and who is unable to reach a repair center in the immediate proximity of a potential malfunction occurrence. Also by using such applications that remotely monitor the vehicle, the number of road accidents caused by potential damage to the safety systems such as the steering and the brake systems can decrease significantly. Therefore, in this paper, I was capable of contributing to the implementation of the real-time communication of the distributed heterogeneous systems by introducing a real-time communication architecture designed to function for interconnected electronic devices belonging to three major complementary systems, which initially seemed incompatible: the “smart home" system, the "corporate” system and the "automotive" system.

The contributions of this paper to the development of the previously presented real-time communication of the distributed heterogeneous systems are intended to be used not only in the area of the traffic safety – as described above – but also for making electronic transactions from one's vehicle dashboard, for collecting highway access fees for instance, etc. In this fashion, the driver is given the opportunity to make electronic transactions from one's vehicle board, similar to those made on the Internet. Secure wireless connections can be established between the infotainment system located on the vehicle's board and an access point located in gas stations or in the street. These access points will be ready for the driver to use while waiting on a green traffic light. Access points can also be placed in any immobile suitable area. Also, taking into account a broader perspective, the communication can be established both with other moving vehicles and with the immobile access points located on the roadside.

In conclusion, let us imagine a scenario where the user can comfortably perform transactional operations from the board of his car, can surf the Internet, can control electronic devices interconnected in his smart home/office or remotely monitor any activity inside his house while away.

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