1-1-2008

A Backup Gateway to Access a Service-oriented Heterogeneous Home Network

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Abstract
Domotics has been favoured by a constant increase of popularity in the last decade. Because of the many home network concepts in this field, it is potentially viable to include several different network technologies in a home automation system; if these technologies are optimally combined then it is presumable to accomplish better results in performance, affordability and stability. For this reason, it is recommended to use each of them for the use of specific services that fit more accurately with their characteristics and capabilities. Nonetheless, besides the diversity of such environments, they all share a common subject: a need for remote control. Actual trends in Domotics are closely oriented to the foremost elements associated with ubiquitous control, which is a significant topic due to the important advantages of having the possibility to manage home services from anywhere at any time. This paper describes a model for a secure, scalable and reliable remote-controlled home automation system; the role of this model is to provide users with a backup gateway to be able to control the services at home (or other buildings) in case of a failure of the main access. The development is focused on a proper handling of the underlying technologies, invisible to the user, to enable the backup gateway agents communicate with both the external agents and the home network agents.

Keywords
home automation system, agent, gateway, middleware, MIDlet, service

Comments
This paper was presented at the Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), 5-9 November 2008, which was held at Glyndwr University, Wrexham, UK. It was published by the University of Plymouth, and the symposium proceedings are available at http://www.cscan.org

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Abstract

Domotics has been favoured by a constant increase of popularity in the last decade. Because of the many home network concepts in this field, it is potentially viable to include several different network technologies in a home automation system; if these technologies are optimally combined then it is presumable to accomplish better results in performance, affordability and stability. For this reason, it is recommended to use each of them for the use of specific services that fit more accurately with their characteristics and capabilities. Nonetheless, besides the diversity of such environments, they all share a common subject: a need for remote control. Actual trends in Domotics are closely oriented to the foremost elements associated with ubiquitous control, which is a significant topic due to the important advantages of having the possibility to manage home services from anywhere at any time. This paper describes a model for a secure, scalable and reliable remote-controlled home automation system; the role of this model is to provide users with a backup gateway to be able to control the services at home (or other buildings) in case of a failure of the main access. The development is focused on a proper handling of the underlying technologies, invisible to the user, to enable the backup gateway agents communicate with both the external agents and the home network agents.

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1. Introduction

Using a heterogeneous architecture increases the flexibility of the system but requires an optimized organization of the resources to achieve a reliable execution of the functionalities that the system is aiming to accomplish. If the system's definition is carried out correctly then the implementation and installation efforts are reduced considerably, nevertheless there is a big constraint when defining such heterogeneous but versatile environments: the appearance of incompatibility issues, mostly generated by the lack of an overall standardization in the Domotic market; a market including many companies and alliances trying to provide the best affordable solutions to fulfil the user needs. However, big steps are being taken towards the process of standardization which indeed will benefit users due to its direct impact in the reduction of prices and the enhancement of the provided QoS in the systems.

Not all the home automation systems (HAS) have to follow the same communications model; it is important to define precisely which relevant communications are going to take place, how, and why; it is also important to

describe accurately which services are provided from the outside to the home and vice versa. Sometimes the lack of a well structured network or a poor definition of the services can make the overall system less useful, secure and it could fail in its scalability. It is necessary a specific structure for the home network; besides if the HAS is oriented to have remote control capabilities, it will be significant to select the most appropriate access networks with the enough QoS to access the services at home. Furthermore to grant access to the home network it is necessary to include a residential gateway (RG) with the following features: it has to be ON always, has to be reliable, remotely manageable, affordable, compatible with standards and capable to connect different home network distribution technologies (HNDT) and transmit information between them. There are many RG solutions to communicate with the home network access technologies (HNAT) since such attractive devices have caught the attention of many researchers, creating different innovative RG approaches, most of them oriented to broadband residential multiservice (Song, 2005).

The project portrays a useful perspective of a ubiquitous system which permits the integration of different physical layers and protocols in an interoperability schema with the rest of the elements and access networks. It considers the importance of the implementation of backup plans to support the whole lifetime of the communication cycles between agents especially if the control has to go through a secure gateway in situations that may have an elevated risk. An approach of service oriented architecture (SOA) is used as a basis to demonstrate the importance of having an underlying middleware design. Jini (http://www.jini.org/wiki/Main_Page) is the chosen SOA technology thanks to its capability to work in different platforms and the fact that is a mature open source technology.

2. Description of the system

It is important to observe meticulously the current state-of-the-art of all involved technologies before embarking upon the creation of a HAS, the options in the market are many and only a careful analysis will identify which ones are more suitable for the targeted requirements. There are many different elements that play an important role in the architecture of a HAS. Certainly the most relevant ones are: HNDT, HNAT, Gateways, other devices and software. In this project the different elements are conceptualized into agents for a better division of their roles to facilitate their definition. The agent concept has already been refined as it is shown several recent publications explaining the creation of sophisticated Multi agent systems (MAS) (Mas, 2005). Agents are usually capable of bidirectional interaction, either in the form of message passing or through producing changes in the MAS common environment. The proposed remote-controlled HAS generally classifies the different elements into three agent-type groups: *home-network agents*, *gateway agents* and *remote agents*. The first group includes all the operational nodes within the home network independently of the network technologies, the second group represents the elements which manage any inbound/outbound communications with the outside world and finally the third group, the *remote agents*, represent all agents dealing with users outside the home-network perimeter and which communicate with the gateway agents. Such classification helps to divide easily the specialized roles and characteristics of the different agents in the system. In this model, the main HAS elements are identified as follows:

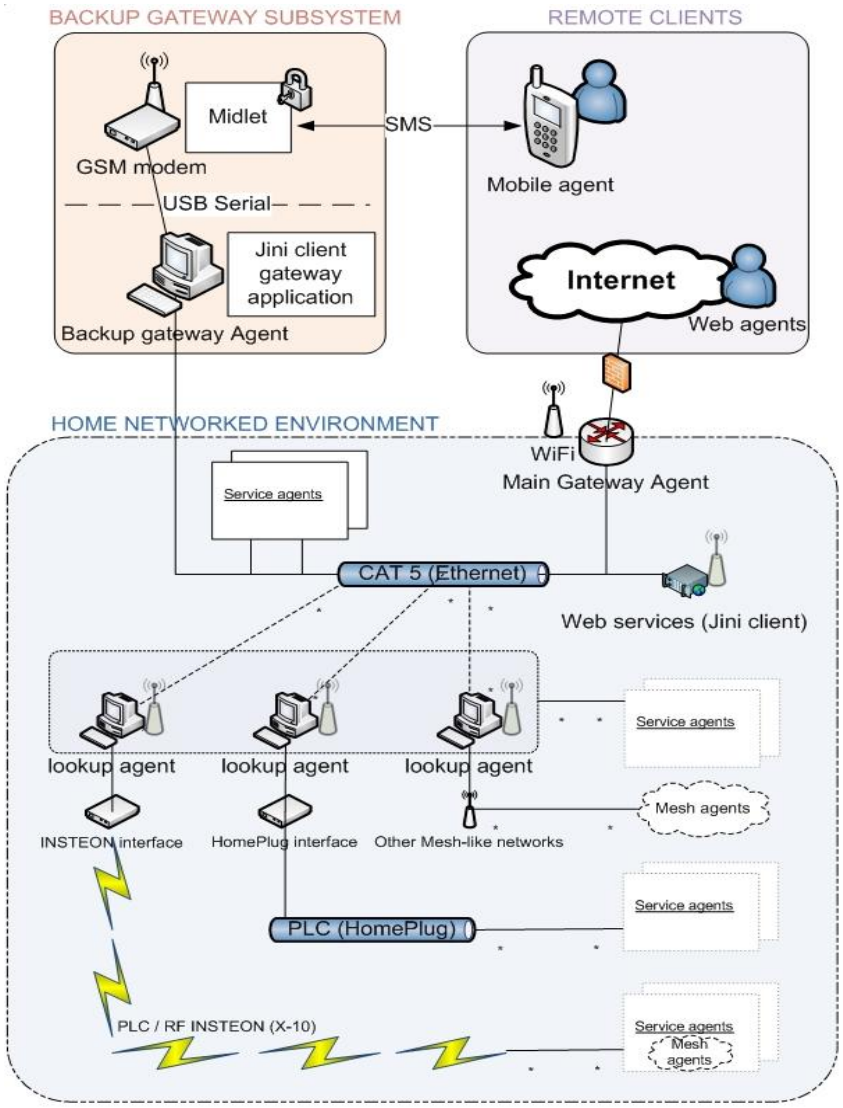

Figure 1: System's architecture

2.1 Home network access and distribution technologies

On one hand, the main access to the home network makes use of an ADSL connection through a standard residential gateway, the usage of the same gateway for home control and the other Internet services reduce costs and ease the installation efforts. The "back door" or secondary access makes use of the GSM network by means of short messages (SMS), principally. The complementation of these technologies fulfils successfully the requirements of the system providing high

flexibility, good access opportunity and enough scalability to adapt to the incoming 4G mobile technologies.

On the other hand, the HNDT used in the system vary considerably since their deployment depends on the compatibility of the suitable devices carrying out the tasks defined on the services. In this model the system relies on a Gigabit Ethernet "backbone" combined with a wireless 802.11g network to communicate the Gateways with the main services and the lookup services in the networks. Using both protocols gives more flexibility to the system and prepares it for further control extensions oriented to handheld devices more in accordance with a ubiquitous control initiative. In this model, Lookup services will be located in machines including other interfaces such as PLC, Bluetooth or mesh-like lightweight protocols to be able to register and control services provided by devices which cannot connect directly to the "backbone". The resulting home network does not depend on expensive gateways or equipment and will have an organized structure able to fit different standards of the market in order to choose the preferable solutions of each customer. It seems that in the future there will be solutions to converge network protocols at home, in fact there are some recent studies (Yoon et al., 2005) already trying to enhance the coexistence of dissimilar networks.

2.2 The relevance of an underlying middleware in a HAS

Building the software's architecture involves organization and modularity identification, particularly while defining the agents, because this involves many software components such as services, events, behaviour, states, properties and data (Mine 2001). Java and concretely Jini technology adjusts well to multi-agent systems because is mainly based on SOA and distributed systems with software elements scattered in the network communicating and sharing; a good example is the JADE framework developed by Bellifemine et al. (2005) which is compliant with the FIPA (http://www.fipa.org/).

The resulting multi-agent schema is suitable for all project sizes, although this approach is not fully compliant with recent standardised agent frameworks (e.g. FIPA) it still includes some of the advantages related to the latest multi-agent system paradigms. Ideally in the future, if devices are able to publish standardized services for these systems the resulting applications will be far more powerful and scalable than the existing ones. The following diagram summarizes the relationship between agents in this model:

As the term indicates, middleware is the software that is virtually situated between the different blocks or modules of the system acting as the 'glue' that ties them together. The main role of middleware is to allow interoperability between the different software components usually running in different machines across a network, solution which optimally fits large and complex distributed applications. Middleware is often an important constituent in a HAS; It is common for a HAS to include different platforms and logic blocks that need to be interrelated to accomplish all the purposes of the system, but in occasions, they may not be compatible to each other or simply they cannot perform some tasks alone correctly and need extra resources. Consequently there must be a robust middleware in-

between to carry out these tasks. Building middleware is a complex task, fortunately there are middleware platforms specially oriented to middleware development and refinement; they vary in size and characteristics although they all share the same common objective which is to provide software developers with tools to implement the software solution they necessitate to build a HAS or other systems.

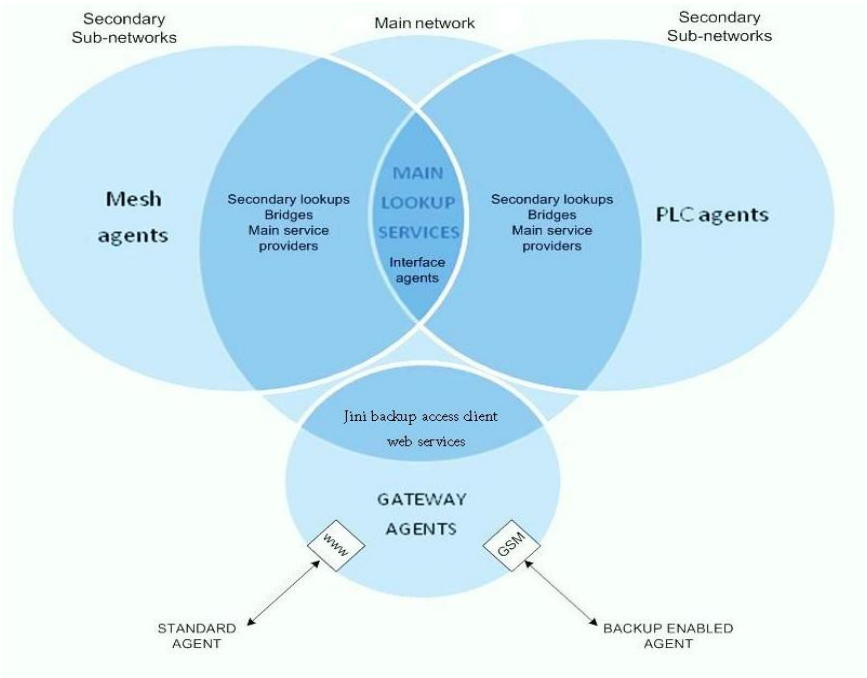

Figure 2: Agent relationships

Developing middleware for gateways can play an important role in remote-controlled HAS's since they can provide the right mechanisms to offer ways of using local services in a remote device and can apply extra security to the external control attempts. There is plenty of related work regarding this topic; two examples are the gateway middleware solution created by Raatikainen (2001) and the study about the use of middleware in remote control proposed by Shafiq et al. (2005). Other related work examples about middleware are the ones carried out by Staff (1999) and Lerner et al. (2000).

2.3 Backup Gateway bundle application

At the outset the use of wireless technologies didn't seem as the logical choice because the use of mobile phones and wireless long-range network technologies are always target of discussion in Domotics; the reasons for these disapprovals point out that mobile devices have reduced features (not easy to implement accessible interfaces), wireless networks usually have slower rates and that electromagnetic

waves can be harmful. However, the inspiration of this design was mainly imbued by the popularity of the GSM network which counts with a high presence among users and with excellent coverage; it is also foreseen that there will be a constant improvement of handheld device capabilities as it is nowadays (incoming of 4G). Ideally, in the future users will be able to interact with the electronic environment (distributed systems, home network, PAN, Internet, etc) through a personal handheld device.

In order to be able to access the home network from the GSM network the MTX65 terminal is a convenient interface, especially because the embedded JVM is able to handle AT commands in a much easier way than writing the commands in the absence of high-level translation. The interaction between the user and the terminal is very simple; the bilateral communication is reduced to the minimum, by means of a standard message format representing principally service IDs and notifications. Eventually the remote-controlled HAS will send alerts to the user´s mobile phone informing about unusual state changes within the building, the Jini client end of the bundle will detect the anomaly and it will provide the MIDlet (http://en.wikipedia.org/wiki/MIDlet) with the information to prepare and send a SMS with optional ringtones if necessary. Afterwards the user is able to activate some service functionalities by sending the proper IDs to the bundle which will consequently execute the services in the network through the lookup services. The communication between the modem and the machine containing the Jini client is through the USB serial port, the MIDlet deals with the user´s side while the Jini client deals with the home network. Due to the reduced capabilities of the modem it is important to prioritize the use of resources (processing, memory, etc) in the machine´s side when possible.

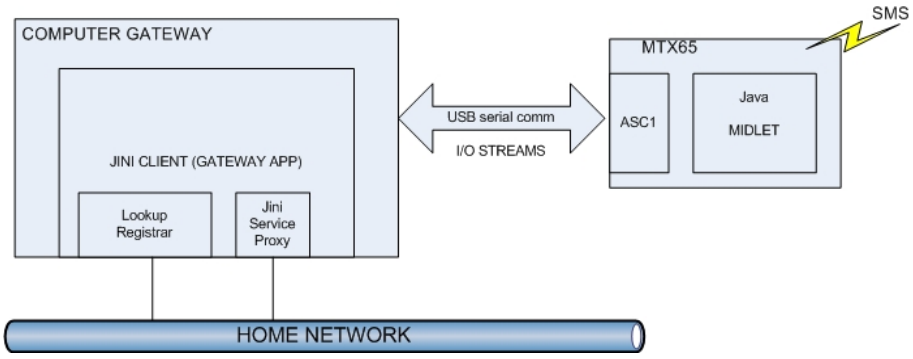

Figure 3: Backup gateway subsystem

Having a closer look, the next diagram shows the two use cases were the bundle application is in use. The first case occurs when the system detects a situation (fire, flood, door left open, robbery, etc) that requires dispatching an alert to the user instantly; these notifications should use a mechanism independent from the one used to update the notifications in the web gateway to assure that at least one of them informs the user. Yet both of them will depend on receiving properly the context awareness information from the home network. The second use case occurs when an external user decides to use one of the remote-able services through the backup

system, in this case the user activates the desired service by sending their IDs (plus parameters if needed), after a proper authentication the Jini client application checks if the services are available and right afterwards makes use of their functionalities.

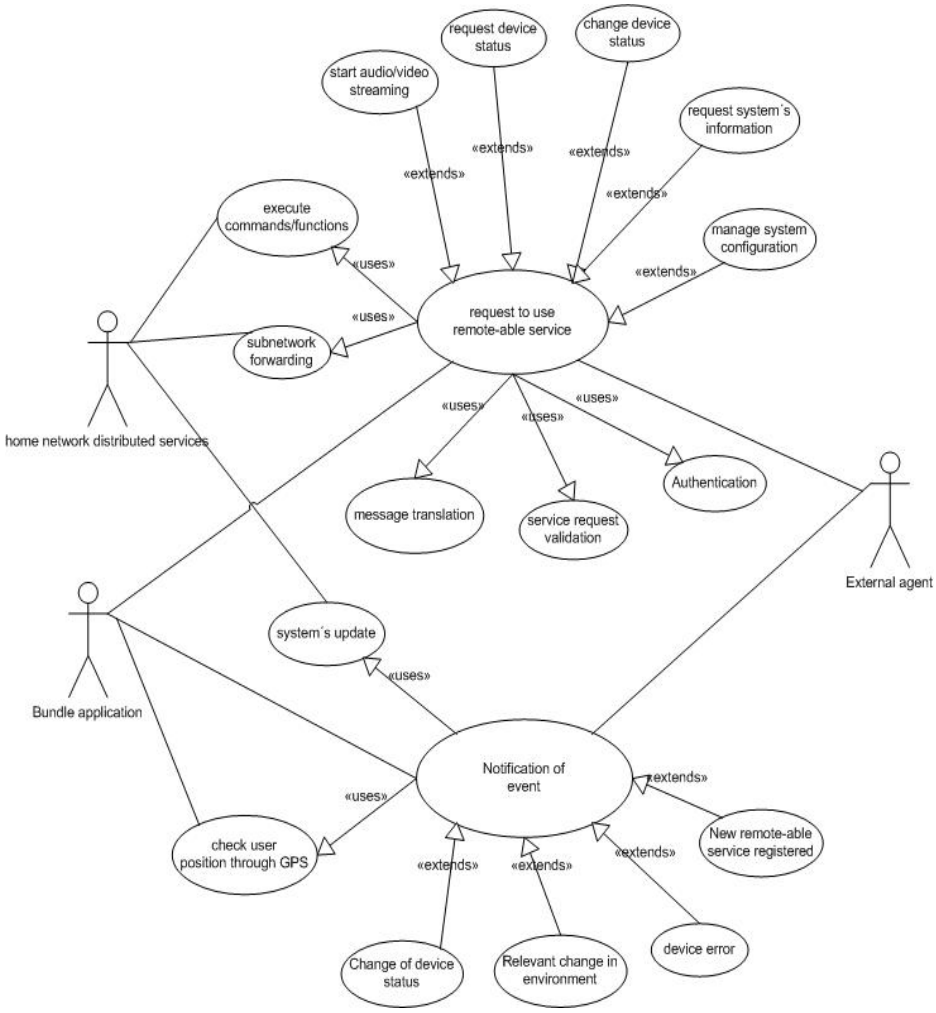

Figure 4: Backup gateway uses

2.4 Activating a remote service

First of all the system must have services already registered before any attempt of a remote control is done. Every service that is deployed in the system has to find the lookup services and ake their functions public to give clients the possibility to use them. The services oriented to remote control have to follow a remote-able template that is used by the gateway client to find them and approve them. When the system has registered the services successfully then the user is able to request their use by

sending the proper Ids in a SMS. The following sequence chart describes the mechanism of requesting a service remotely:

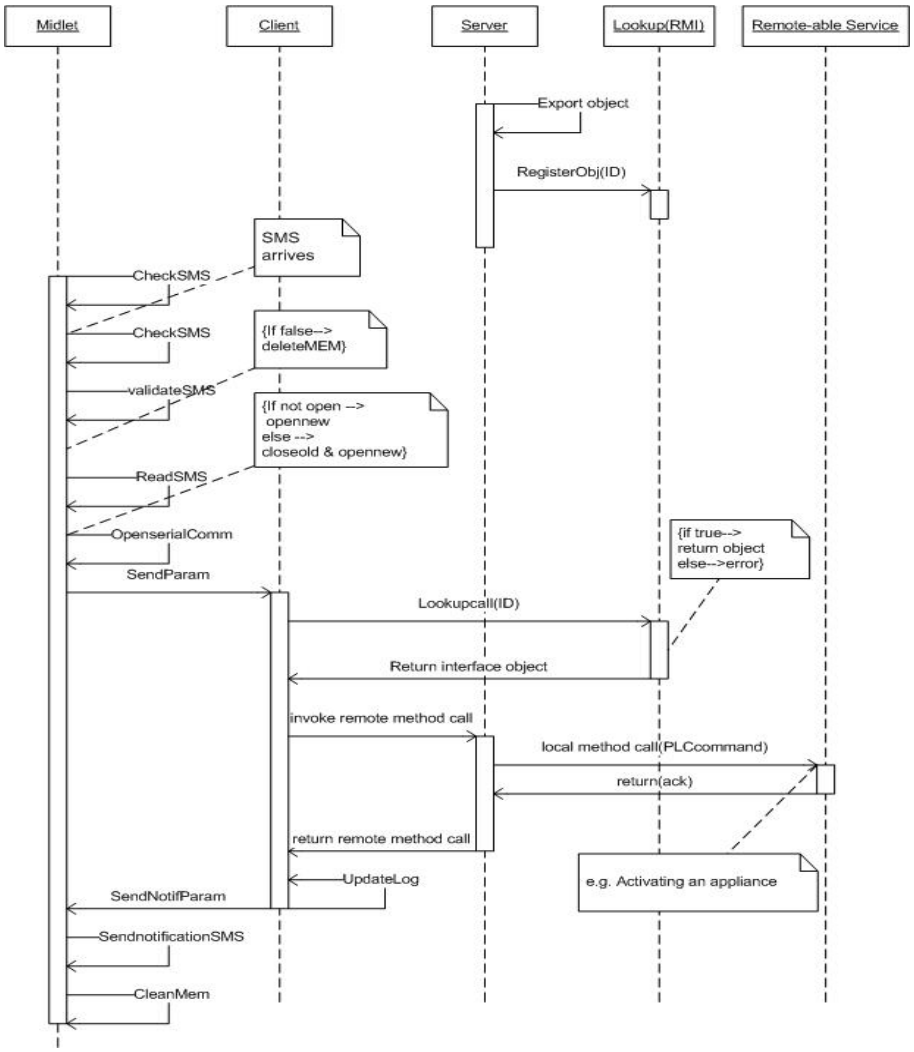

Figure 5: Request a remote-able service

3. Conclusion and future improvements

As the project is still in the testing phase it is premature to precisely summarize the positive and negative aspects of the implicated techniques and technologies of the model. Nevertheless communications between agents have been satisfactory so far and the practice has resulted as a constructive experience for further improvements and developments. The use of the GSM network as a secondary access proved to be optimal if the user is looking for a quick access no matter where he/she is located. In addition, thanks to the SIM card, AT commands and the embedded java the backup

gateway provides strong security to assure user´s authenticity. Since the terminal can open TCP/IP connections it can also connect to the primary gateway and send some parameters in the case of failures or access services directly through a URL. Moreover the system´s modularity, achieved mainly with the agents and the SOA, provides high flexibility and scalability which will fit well the implementation of systems for bigger buildings; however there must be important agreements among g the vendors to provide an standardised set of services in devices/applications that can be made public to any system.

The system does not consider a priori accessibility and the development of interfaces although a useful extension could be a HMI interpreter in the external device which can understand the messages and translate them into easy interfaces to achieve a design for most users. Since the terminal does not have the capabilities, it was not possible to use MMS, however this technology is widely used nowadays ad it will be easy to implement for systems with these characteristics.

4. References

Bellifemine, F., Caire, G., Poggi, A., and Rimassa, G. (2008). JADE: A software framework for developing multi-agent applications. Lessons learned. Inf. Softw. Technol. 50, 1-2. Jan. 2008. 10-21.

Lerner M., Vanecek G., Vidovic N. and Vrsalovic D. (2000) “Middleware Networks: Concept, Design, and Deployment of Internet Infrastructure”, Kluwer Academic Publishers, 2000.

Mas, A. (2005). Software Agents and Multi-Agent Systems. Prentice-Hall.Miles, Ian (1988) The Shaping of Technologies to Come (review of Elliott [1988]), Project Appraisal, Vol. 3, No. 4, pp. 231-33.

Mine, Y., Hiraishi, H., & Mizoguchi, F. (2001). Collaboration of networked home electronics using multi-agent technology. IFSA World Congress and 20th NAFIPS International Conference, Joint 9th, 5, pp. 2648-2652.

Raatikainen, K., Middleware for future mobile networks, Procedings of Int. Conf. of 3GWireless’2001. May 2001. ISSN No. 152902592. pp 722-727.

Shafiq, M. O., Ali, A., Ahmad, H. F. and Suguri, H., (2005) "A middleware based approach for integration of Software Agents and Web Services", in 14th IEEE International Workshops on Enabling Technologies: Infrastructures for Collaborative Enterprises (WETICE-2005), June 13-15, 2005, Linkoping University, Sweden.

Song, S.W.; Zheng, J.D.; Gardner, W.B. Rapid System Prototyping, 2005. (RSP 2005). The 16th IEEE International Workshop on Volume , Issue , 8-10 June 2005 Page(s): 267 – 269

Staff A. “Making Sense of Middleware”. Application Development trends, Volume 6, number 6, May 1999.

Yoon D.K., Lee,K.R., Myoung K.J.,, Kwon,W.H., (2005) “Design and Implementation of Wireless Home Network System Using Home Network Control Protocol”, Proceedings of the International Conference on Control, Automation and Systems (ICCAS).pp.1558-1562, Jun. 2005.