A proposal for a hardware architecture for ubiquitous computing in smart home environments.

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Abstract. One of the major exponents for ubiquitous computing may be found in smart home environments, where a great deal of different devices must interact, process received information and actuate. Devices like sensors, effectors, microcontrollers, PDAs, personal computers, laptops, multimedia centers, mobile phones, etc. must operate together in order to suit user preferences. This paper proposes a hardware architecture for ubiquitous computing in smart home environments where the devices may autonomously act and collaborate with other devices. Proposed architecture supports previous work about agent-based service personalization software architecture.

1 Introduction

In this paper we discuss our approximation to ubiquitous computing in smart home environments. We show our progress in this subject and propose a hardware architecture for ubiquitous computing in smart home environments. Proposed architecture supports previous work about agent-based software architecture for service personalization [1][2][3].

The rest of this paper is as follows, Section 2 recalls the most relevant concepts our research is based on. Section 3 discusses our proposed architecture. The last section sheds light on our future work.

2 Smart home environments

In this section we show the state of the art in smart homes environments. We discuss smart home devices, smart home networks, distributed object architectures, software agents and microcontrollers.

When designing a smart home we can find the followings elements: Control and telemetry devices, to perform light control; power consumption and security and alarm services; video and audio devices, **t**o distribute multimedia contents across home rooms; telephony and data devices**,** to supply inbound and outbound communications; and communication and integration elements, to provide proper mechanisms for communicating home devices.

The most extended technologies in smart home networks are wired technologies as: X10 [4] Lonworks/Lontalk [5], EIB [6], Home Plug&Play [7] and IEEE 1394/ FireWire [8]. On the other hand, wireless technologies, like Bluetooth [9] and Wifi [26], are used in most data communication processes. Zigbee [10] may be seen as a new approach to include wireless communications into smart homes.

From the software engineering point of view, most software architectures for distributed objects separate interface and implementation CORBA [11] or SOAP / Web Services [14][15]. Others are operating system oriented as DCOM [12] or language oriented as JINI [13].

These ideas have been extended to software architectures for distributed objects in smart home environments. In such way Open Systems Gateway Initiative (OSGI) [16] is based on JINI. Universal Plug and Play (UPnP) [17] uses a TCP/IP stack and Web technology to interconnect electrical devices, wireless devices, computers, etc. by using XML documents. Home Audio / Video Interoperability (HAVi) [18] was designed for communicate audio and video systems using Firewire. Aladdin [19] was designed to manage modified X10 devices using DCOM. Heterogeneous Inhouse Networking Environment (HINE) [20] is aimed to residential gateways. Finally, Service and Networks for Domotic Applications (SENDA) [21][22] is based on CORBA architecture as a middleware for communications.

Jennings and Wooldrige [23] defined agents by summarizing their characteristics as autonomy, social ability, reactivity and proactivity. We have used software agents in previous works [1][2][3] for service personalization into smart homes, and we are extending this approach to *smart environments*.

Finally, a microcontroller is an integrated circuit in which CPU, memory system, and input output system are packaged together. It's a whole computer in a single chip. [24]. There are a lot of different microcontrollers for different purposes. From simply 8 bits microcontrollers to J2ME native microcontrollers, prices and capabilities differ a lot. Our solution mixes software agents, microcontrollers and wireless communications to propose the final architecture.

3 Proposed architecture

We propose a three-layer architecture where the lower one handles sensor and effectors. This layer can communicate with the other two ones by using Zigbee protocol. Currently, an 8 bit ATMEL microcontroller with a Zigbee RF module may carry out this task. This level is composed by end devices (Zigbee network terminology).

The second layer is a set of nodes based on embedded Linux system with RF communication capability. This layer is the middleware between both upper and lower layers. Each system hosts a JADE LEAP platform [25] where software agents may live and communicate via Zigbee with the lower layer and via Bluetooh with the upper one. Zigbee nodes of this level act as Zigbee routers for a Zigbee network. Moreover, by using Bluetooth, this layer is part of a Bluetooth piconet. Different embedded systems belonging to this layer act as piconet slaves. Each one of the systems can communicate with the other ones by using Bluetooth or Zigbee.

Finally, the upper layer is a Media Center running OSGi[16] and JADE[25]. The OSGi supports the functionality of a residential gateway at low cost. This layer is able of RF communication via Bluetooth with the second layer. This layer is the master of the above described piconet. The upper layer is also the coordinator of the Zigbee network. This level also uses Wifi to communicate with multimedia devices, PCs, etc.

An application example of the proposed architecture is shown in Figure 1 (only two nodes of the second layer has been drawn for the sake of clarity).

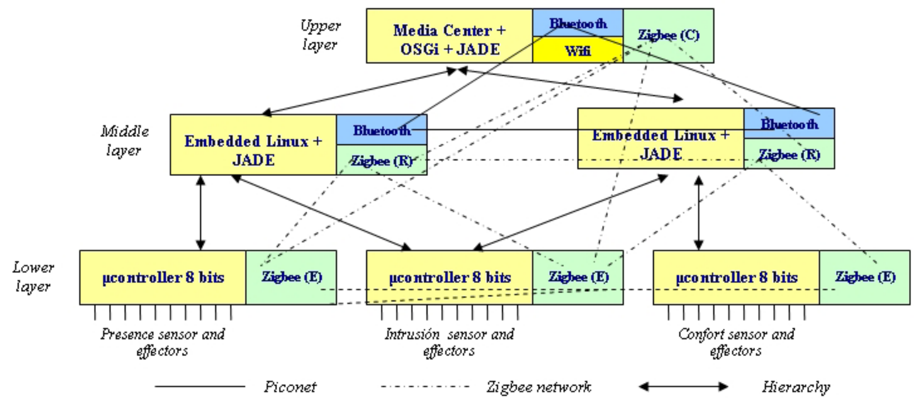

Fig. 1. Application example for smart home environments

This architecture is being used to implement our context hierarchy proposal, described in [3], where sensors feed data to context aggregators that are used by service and device agents to perform their tasks into the smart environment.

4. Future work

We are currently developing the lower layer of the proposed architecture, in which one of the Zigbee nodes must act as the network coordinator to form and test the Zigbee network. The main drawback of Zigbee nodes is that routers and coordinators need always be powered and never put to sleep. To solve this problem, we are considering to design as coordinator the upper layer and as routers all the nodes belonging to the second layer.

We are also considering to extend the first and second layer of the piconet to one scatternet if necessary if the number of the nodes belonging to the second layer increase.

References

1. Velasco, J. R.; Marsá-Maestre, I. Navarro, A.; Lopez, M.A,; Vicente, A.J.; De La Hoz, E.; Paricio, A.; Machuca, M. “Location-aware services and interfaces in smart homes using multiagent systems”. Proc. 2005 Int. Conferecence on Pervasive Systems and Computing. PSC’05. (Las Vegas, Nevada, USA June 27-30 2005) ISBN 1-932415-52-1. pp 104-110.
2. Marsá-Maestre, I.; Machuca, M.; Navarro, A.; Velasco, J. R. “A practical aproach to user location awarenesss in smart homes using bluetooth”. Proceedings of 1st Iberomaerican Congress on Ubiquitous Computing CICU’2005, (Alcalá de Henares, España, 2005) ISSN 1613-0073.
3. Marsá-Maestre, I. “SETH: a Hierachical, Agent-Based Architecture for Smart Spaces” Technical Report 2006. <www.it.aut.uah.es/ist/papers/TR2006-101.pdf>
4. X-10 Comunications Protocol and Power Line Interfaces PSC04 & PSC05. <http://www.x10pro.com/pro/pdf/technote.pdf>
5. Control Network Protocol Specification. ANSI/EIA-709. 1-a-99- 1999.
6. EIBA Handbook Series. European Installation Bus Association. Abril 1999.
7. Evans G. “CEBus desmystified: The ANSI/EIA 600 User’s Guide”. Mc Grwa-Hill Professional Publishing. Marzo. 2001.
8. P1394b Draft Standard for a high performance serial bus. Noviembre 2001. <http://grouper.ieee.org/groups/1394/1/Documents/>
9 Sriskanthan N.; Tam, F.; Karande, A. “Bluetooth based home automation system”. Microprocessors and Mycrosystems 26. 2002. pp 281-289
10. Poole, I. “What exactly is Zigbee?. Communications Engineer. Volume 2. Issue 4. August-September 2004. pp 44-45
11. CORBA ® BASICS. <http://www.omg.org/gettingstarted/corbafaq.htm#TotallyNew>
12. Webopedia. DCOM. <http://www.webopedia.com/TERM/D/DCOM.html>
13. Sun Microsystems. “Jini architecture specification” Diciembre 2002. <http://java.sun.com/products/jini/>
14. SOAP. Versión 1.2. “Messaging Framework”. Junio 2003. http://www.w3.org/TR/soap12-part1/
15. Web Services Architecture. Febrero 2004. <http://www.w3.org/TR/ws-arch/>
16. Open Systems Gateway Initiative. “The OSGi Service Platform - Dynamic services for networked devices“. Versión 4. Octubre 2005. <http://www.osgi.org/>
17. Universal Plug and Play. Dicembre 2003. <http://www.upnp.org/resources/default.asp>
18. AVi. “The HAVi specification” <http://www.havi.org/HAVi_1.1.pdf>
19. YI-MING, WANG; RUSSEL, WILF; ARORA, ANISH. “Towards Dependable Home Networking: An Experience Report” IEEE Internacional Conference on Dependable Systems and Networks. Junio 2000. P:43-48
20. HINE. Herogeneus Inhouse Networking Enviroment <http://www.eurescom.de/~pub-deliverables/P900-series/P915/D4/p915d4.pdf>
21. Moya Fernández, F. “Infraestructura de comunicaciones para la creación modelado y gestión de servicios y redes para el hogar”. Directores: Juan C. López López, M. Luisa López Vallejo. Universidad Politécnica de Madrid, Departamento de Ingeniería Electrónica, 2003.
22. SENDA papers. <http://arco.inf-cr.uclm.es/senda-papers.html.en>
23. Jennings, N.; Wooldridge, M.. “Software Agents”. IEEE Review, January 1996, pp 17-20
24. Wikipedia. La enciclopedia libre. <http://en.wikipedia.org/wiki/Microcontroller>
25. JADE. Java Agent DEvelopment Platform. http://jade.tilab.com/
26. Wikipedia. La enciclopedia libre. http://en.wikipedia.org/wiki/WiFi