

# Ubiquitous Home Computing and Networking

Feng Zhang, Yong-Deak Kim

## ABSTRACT

*This paper proposes an OSGi Gateway based framework for ubiquitous computing home networks, presents an example of a service discovery procedure based on this architecture, and identifies some key challenges for the implementation of ubiquitous computing home networks.*

## INTRODUCTION

While 4G networks are driven towards ubiquitous wireless communications with high data rates and stringent quality of service provisioning, home networks are integrating the previously separate devices and incorporating ubiquitous computing. Over the last decade, various electronic equipments have been deployed in ordinary homes. Meanwhile, more and more houses will have multiple PCs and can access to various outside telecommunication and data networks. Consumers are acquiring, viewing and managing an increasing amount of contents on these devices. As such, they want to easily and conveniently enjoy this content across different devices and locations in the home environment, regardless of the source. Ubiquitous computing home networks are expected to integrate current existing and the state-of-the-art wired and wireless technologies. In this paper, we propose an OSGi-based open architecture at home with the consideration of 4G wireless networks and describe an example of a service discovery process. At the end of this paper, we identify some key challenges during the development of ubiquitous home networks for 4G systems.

## UBIQUITOUS HOME NETWORKS AND SERVICES

Figure 1 imagines future ubiquitous home networks and typical services which can be provided within an intelligent house. Future intelligent house will provide various types of services such as context-aware services with mobility support, appliance maintenance services, health-care services, and so on.

There are also many suitable technologies can be used in ubiquitous computing home networks. For system platform, Open Service Gateway Initiative (OSGi) and LonWorks are attracting for their general-purpose, secure support for deploying extensible and downloadable applications. For service discovery, Jini, Universal Plug-and-Play (UPnP), Service Location Protocol (SLP), and Service Discovery Protocol (SDP) can be used. IEEE 1394, Home Phone Line Networking Alliance (HomePNA), Home Cable Network Alliance (HomeCNA) are potential technologies for network connectivity, whereas Home Audio Video Interoperability (HAVi) is one of the candidates for interoperable technologies. RFID sensing technology has also attracted considerable attention and has been envisioned to be widely used in the near future.

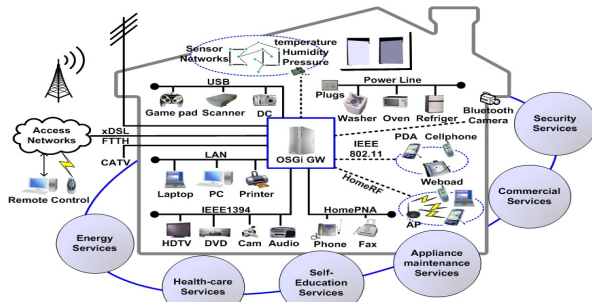


Fig. 1. Ubiquitous home networks and services

Among those technologies, OSGi is emphasized because it is a co-operate effort in creating an interoperable environment for ubiquitous services at home. OSGi specifications are hardware-independent. The use of OSGi can bridge and unify multiple networking technologies, and enable richer devices interaction and service delivery. The main reason to select the OSGi is that it has the advantages of modularity and the ability of evolution, particularly with the continuing development of 4G wireless systems. OSGi also enables the seamless delivery of services, remote administration and management, enables the exchange of data between service gateways and network operators.

**OSGI-BASED UBIQUITOUS HOME FRAMEWORK**

The overall network architecture is shown in Figure 2. The proposed architecture is based on OSGi service platform. It explores the service gateway to provide a uniform interface for various services over heterogeneous systems.

This architecture consists of four main layers. The lowest physical layer consists of not only various wired networks, such as IEEE 1394 and PLC, but also different wireless access networks such as RFID, WLAN/WPAN, emerging UWB and WSNs to achieve ubiquitous connectivity. All the intelligent devices connect to IPv4/IPv6 backbone through the OSGi service gateway. Compared to former network & control platform, we not only include QoS, mobility management and security

blocks but also emphasize the autonomous control function which considers the wireless ad hoc and sensor networks deployed in a home environment. OSGi framework is based on the top of network & control Platform to provide an execution environment for service applications. Usage of OSGi import and export models provides a unique solution for incorporating different industry standards. Firstly, the applications need to be registered in the framework of OSGi. For example, if a printer uses the Jini technology, then the Jini Driver needs to register in the OSGi framework first. Similarly, if the printer uses another technology, like UPnP, the same registration process, called importing, needs to be taken. Subsequently, the administration application obtains the services and converts them into the appropriate formats, such as MPEG4, XML or WML, which can be delivered to wireless devices. Conversely, if the services come from the radio access interface, the ad hoc device, regarded as the User Agent in the SLP, sends a multicast request to the Service Agent in the OSGi. This request includes service types and string based queries. Then the administration application converts them into the OSGi services which can be registered in the OSGi framework. This completes the exporting process. Users can add the new application ID into the system if there is no discovery failure. By using both exporting and importing processes, services can be easily discovered by driver bundles between current wired home applications and the future wireless ad hoc or sensor devices.

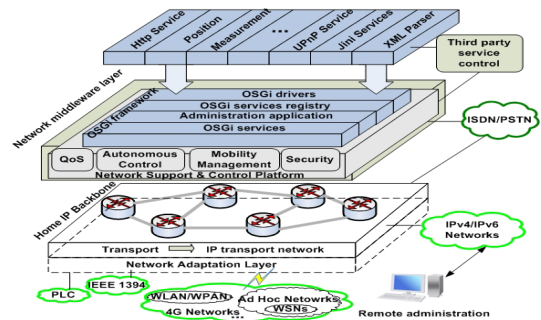


Fig. 2. Ubiquitous home network architecture based on OSGi.

## KEY ISSUES

The future ubiquitous and pervasive computing home environment will comprise a wide variety of devices and services from different manufacturers and users will be able to access the ubiquitous appliances anywhere and anytime through home networks. Table 1 provides an overview of the major challenges in future home networks. In addition, two key challenges are identified as follows:

**Interoperability:** Products from different vendors often do not interoperate well because of industry proprietary rights or different standards. Design guideline and common baseline must be approved through industry widely consensus to pursue transparently cooperation among various electronic devices. To facilitate this interoperability, we need to build blocks such as transparent connectivity between devices and unify framework for device discovery, configuration and control.

**Autonomous Control:** As the advances in wireless communications and electronics, ubiquitous home environment will integrate wireless sensor networks. Wireless sensor networks have fundamentally different architecture than normal wired data networks. Wireless sensor networks, which are highly constrained in resources and have fundamentally different architectures than normal wired data networks, have multi-hop characteristics to be deployed in the ubiquitous environment.

## CONCLUSION

In this paper, we propose an OSGi-based architecture for home networks and present a service discovery procedure for interoperability. We also identify some key challenges of developing ubiquitous home networks.

Future work will focus on those challenges and implement our OSGi-based architecture and functionalities into ubiquitous home server.

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TABLE 1 AN OVERVIEW OF THE MAJOR CHALLENGES IN UBIQUITOUS HOME NETWORKS

<b>Requirements</b>	<b>Key Challenges</b>	<b>Proposed Solutions</b>
Interoperability	Design guideline and common baseline are needed to pursue transparently cooperation among various electronic devices.	Interoperable building blocks for devices and software infrastructure.
Autonomous Control and Resource Management	Networks such as sensor networks should be self-organized and devices should be automatically self-configured and collaborated.	Robust, adaptive, distributed, scalable, and open control algorithms should be developed to meet such special needs. Cross-layer design and advance physical layer techniques can be enforced.
Privacy and Security	Location information is sensitive and remote access to home networks can expose the infrastructure to risk.	Explicitly registration or employ cross-domain AAA or design privacy extensions [1].
QoS Support	QoS mechanisms are essential for home networks in the presence of various tasks and applications' needs. It is also important to achieve reliability and survivability, especially when coupled with the ad hoc accretion of network nodes.	Manufacturers must agree on how to address QoS in a home environment. Fault-tolerant architecture and failure recovery protocols are required.