Constructing Home Network Systems and Integrated Services Using Legacy Home Appliances and Web Services

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ABSTRACT

This article presents a framework that adapts the conventional home electric appliances with the infrared remote controls (legacy appliances) to the emerging home network system (HNS). The proposed method extensively uses the concept of service-oriented architecture to improve programmatic interoperability among multi-vendor appliances. We first prepare APIs that assist a PC to send infrared signals to the appliances. We then aggregate the APIs within self-contained service components, so that each of the components achieves a logical feature independent of device/vendor-specific operations. The service components are finally exhibited to the HNS as Web services. As a result, the legacy appliances can be used as distributed components with open interfaces. To demonstrate the effectiveness, we implement an actual HNS and integrated services with multi-vendor legacy appliances.

Keywords: home network system; infrared control; integrated services; legacy migration; service-oriented architecture

INTRODUCTION

The emerging technologies enable general household appliances, such as TVs, DVD players, lights, ventilators, refrigerators, air conditioners, blinds and curtains, to be connected with a local area network at home. A system consisting of such networked appliances is generally called a home network system (HNS, for short), which is intended to provide more convenient and comfortable living for home users. Research and development of the HNS are currently a hot topic in the area of ubiquitous/pervasive
computing. Several HNS products are already on the market, (e.g., Hitachi, 2003; Matsushita, 2005; Toshiba, 2005).

The HNS provides many applications and services. The applications typically take advantage of wide-range control and monitoring of appliances inside and outside the home. Moreover, integrating different appliances via network yields more value-added and powerful services (Kolberg, Magill, & Wilson, 2003), which we call **HNS integrated services**. For instance, integrating a TV, a DVD player, speakers, lights and a curtain would implement a HNS integrated service, say, **DVD theater service**. When a user requests the service, the lights become dark, the curtain is closed, the 5.1ch speakers are selected, the sound volume is adjusted, and the contents are played with the DVD player. Thus, the user can watch movies in a theater-like atmosphere within a single operation.

In general, each networked appliance is equipped with smart embedded devices, including a network interface, a processor and storage, in order to provide and execute the appliance features required for various HNS applications and services. As the embedded devices become more down-sized, cheaper, and more energy-saving, it is expected in the near future that every object will be networked (Geer, 2006).

However, transition to the networked appliances is gradual. Most people are still using **legacy appliances**, which are the conventional non-networked home appliances. Although it is usual to see a network and PCs at home, the networked appliances are not widely spread yet.

There are several reasons why the networked appliances are not spread yet. Firstly, the networked appliances are still quite expensive. Secondly, types of available appliances are limited (audio/visual appliances have been being networked recently, but many others are not yet). Also, due to the lack of **programmatic interoperability** (Smith & Meyers, 2005), the integration of appliances is strictly limited; especially in the multi-vendor environment the integration is quite a challenging problem. Finally, there is a major requirement that the users want to keep using the legacy appliances that they are accustomed to use. Considering these reasons, it is not easy for the general home users to renew immediately all the existing legacy appliances with the networked ones.

To cope with both the emerging HNS and the legacy appliances, this article presents a new framework that adapts the legacy appliances to the HNS. Specifically, for the legacy appliances with the conventional **infrared remote controllers** (denoted by **IrRC**), we propose a way to implement a **smart adapter** on a PC that connects the legacy appliances to the HNS. For this, we exploit the concept of the service-oriented architecture (SOA) (Loke, 2003; Papazoglou & Georgakopoulos, 2003), extensively.

The adaptor is based on a three-layered architecture: **IR device layer**, **service layer**, and **Web service layer**. In the IR device layer, we develop a set of APIs, called **Ir-APIs**, by which the PC can send any infrared signals to appliances. Note that the infrared signals are specific to devices and vendors. Also, executing a feature of an appliance requires the user vendor-specific operations of the IrRC. Thus, it is inconvenient for external HNS applications to use the Ir-APIs directly. Therefore, the service layer then aggregates multiple Ir-API calls within self-contained **services**, so that each of the service achieves a logical feature independent of the vendor (or device)-specific issues. Finally, the services are deployed in the HNS as **Web services** (W3C, 2002) in the Web service layer. Thus, every legacy appliance becomes a distributed component with an open interface, which can be used by various kinds of HNS applications. The users can build their own integrated services and HNS applications with the legacy appliances.

To demonstrate the effectiveness, we have implemented an actual HNS and several integrated services. As a result, it was shown that the proposed framework is well applicable to multi-vendor legacy appliances, and that practical integrated services can be created as relatively small client applications. We also
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