

“Composition of Services for Notification in Smart Homes”

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Abstract

Giving notifications in a timely manner is an essential service that Smart Home should provide. Communication of resident's data to their doctor, health care provider or family member via email, phone call, or text message is indispensable. In order to reduce the cost, improve extendibility and reduce the developer's burden and learning curve, we propose a service-oriented notification system. This system has different simple services which provide essential communication needs, and by composing these services with applications more sophisticated needs can also be satisfied. A detailed description and the architecture are elaborated below.

Keywords: Notification Service, Ubiquitous computing, Service Oriented Architecture, OSGi.

1. Introduction

The challenges of holding mobility make it difficult to live alone independently for elderly adults. Smart home environments provide assistance to elderly ones and persons with special needs in performing their activities of daily living. Smart Home aims at providing a more independent life to those people who require only a little assistance, so that they can stay at home instead of moving to some nursing facility. The emerging wireless technology and pervasive computing model help us to create prevalent environments to support the aged people.

The objective is to design a cost effective, easy to use notification service influenced by contextual factors [1], which means the notification system decides the best time and form for presenting messages, depending on the state of its users and their environment along with estimating the value of the message content. This notification system uses a service-oriented architecture. The architecture will create independent services for different notification needs and will compose these services among

themselves, with other services and applications to create more advanced notifications.

The rest of the paper is organized as follows: Section 2 presents related work. Section 3 gives more details on our approach. Section 4 highlights the architecture. Section 5 contains the conclusion and future work.

2. Related Work

Considerable research is going on medical alert system [2] and medical monitoring for independent living [3]. The emergency response systems like [2] and Home alert system like [3, 4] guarantee a reliable solution for our daily life but the initial investment and the recurrence cost to choose these services may be expensive for middle-class people. These solutions are also fixed for a particular set of devices and configuration of the system. Future Smart Home environments will contain a wide variety of devices and services from different manufacturers and developers. Also these devices and services are expected to be added and removed in a dynamic way. In this context, Service Oriented Architecture is the solution which will help us to achieve the vendor independence platform and architecture. Service Oriented Architecture separates process into distinct services which can be distributed over a network. The processes can be combined and reused as per application requirement. Our application meets these requirements minimizing any deployment or recurrence cost.

3. Our Approach

Smart Home is an application of pervasive computing that integrates devices and services into everyday living environment to benefit their inhabitants. A complete smart home architecture will have the following components: device network with different smart home appliances, vendor independent service-hosting platform and a service centre for

managing networks and service deploy functions [11]. Open Service Gateway Initiative (OSGI) tries to meet these requirements by providing a managed, extensible framework to connect various devices in a local network. The general smart home design is shown in Figure 1 [12].

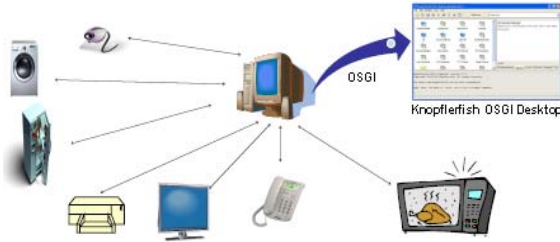


Figure 1: General Smart home design

In a Smart Home environment there is a continuous need for communication with external entities in different ways. Sending data, email, text message, or making automated phone calls are a constant necessity. Usually it is up to the programmer to learn how to use and program these functionalities in order to incorporate them in the applications. This is tightly-coupled to the particular programming language and platform the developer use. Therefore the developer has to learn all the details and get the required libraries in order to provide these notifications in different applications and configure them with the particular details of each user.

Our idea is to provide these different means of communication a message as services within the Smart Home. This way an application can consume a service instead of implementing it. These services will be personalized for the person who lives in the Smart Home. Data such as the email, phone number and address need not to be entered or queried in each application. This will allow the developer to focus on other aspects of development and not on notifications details. We understand that this will be very beneficial in terms of cost, development time and learning curve.

Notifications are used very frequently by a lot of applications and modules. These programs will definitely reduce the time and cost of development. Also learning the particular details to provide certain notification can be time consuming. Moreover, if new technology arrives it will be hard to integrate with existing application and a re-implementation might be the only way to put them together. The developer will have to learn again the details of the technology and it definitely will increase the cost and time of

development. By providing these ways of notification as services, they can be easily used and updated without affecting the applications using it, as they will follow a service-oriented approach. Also these services can be easily composed to create more sophisticated services by combining them with other services and applications within the Smart Home.

4. Architecture

In this section we will present a detailed architecture of our approach. We also describe a set of demos we have developed in our Smart Home Lab that make use of this approach and the benefits we have received of using notifications as services. Figure 2 shows this basic design architecture of the smart home notification system developed by our research group [5].

In our Smart Home Lab we use phidgets, telos motes, Insteon, X10 and various other types of intelligent sensors [6, 7]. As shown in Figure 2, Home Network can be subdivided into different components such as Home Control, Security, Health and Entertainment. These applications have been developed as OSGi bundles which have been deployed as OSGi services [8, 9]. These application services are running in an OSGi framework. This allows OSGi services to provide other applications and services

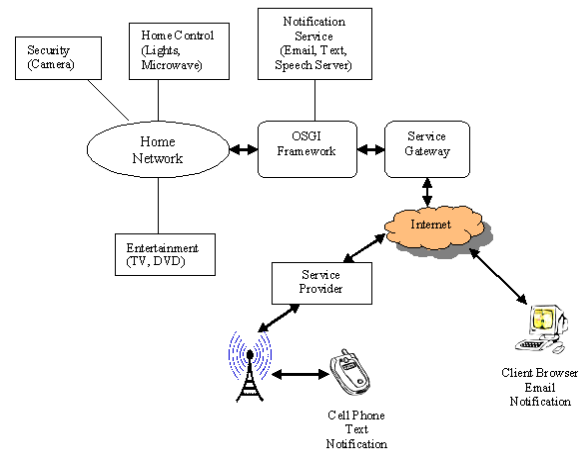


Figure 2: Basic Design Architecture

with the required notification functionalities. Our Notification bundle is also a service deployed in the OSGi framework. This bundle is being used by all the other applications shown in Figure 2 such as Home Control, Security, Health and Entertainment. We will

briefly describe a few of the demos developed using this approach below:

- **Microwave demo** – In this demo a microwave oven is controlled using the computer and an RFID reader. RFID tags are used to identify the food or meal. When a tag is read, the food data and cooking information is queried. The microwave uses this information to automatically set the appropriate time and temperature for the food preparation. The notification services are used to say loud what food is being cooked. The notification system also notify when the food is ready. It also displays an appropriate message. The reminder message can be played by the computer using notification speech server and displayed on the TV.
- **Medicine demo** – This demo helps in the management of the medicines in the Smart Home environment [10]. This demo integrates the doctor, the pharmacy and the smart home to ensure safety and check for conflicts. Prescriptions are checked for conflicts with other prescriptions, with over-the-counter medicines and conflicts with food. This demo also reminds the elder people with special needs, of critical tasks such as medication intake and doctor appointments. These reminders use the speech notification service. Also notifications can be sent to the health care provider in the case that the person misses a dosage of a medicine. When a conflict arises also a notification can be set to the doctor or health care provider and also to the resident. These notifications can be customized and messages can be sent to end user's mobile phone or to email account depending on the preferences. Also if the person is not within the home network and cannot hear the speech notification, a message alerting of this situation can be sent also. This shows how many different uses can be given to this notification services. The developer does not need to create them but just use them.
- **Smart Fridge Demo** – This demo helps in tracking food items in the Smart Home. Food is identified by RFID tags. A particular food item has some data indicating the resident's preferences of items and threshold weights. The preference order will indicate if the resident wants the food to be automatically reordered and the threshold weight will indicate when it is a good time to reorder. The reordering can be done by sending a notification to the grocery store when the weight goes below the threshold for a particular food item. This demo can also inform end users using the notification service when important food items such as milk and eggs goes below the threshold value to the shop nearby. The notification service is also used in conjunction with the medicine demo to detect conflicts between food and medicines. When a conflict arises a message can be sent to the appropriate parties and the resident notified. All these services can be used by the developer but there is no need to re-develop them.
- **Macro demo** - Powerful technology does not always have user-friendly nature. As a consequence, usability of technology reduces. As an example, clumsy look of Knopflerfish OSGI Desktop may make users reluctant of using OSGI applications. Secondly Centralized complex applications may not become useful for elderly ones and people with special needs. The goal of the Macro demo is to Control or schedule any Smart Home applications on the fly and improve the quality of life of elderly people by using distributed architecture with wireless technologies and the Internet. In this demo we have developed a platform independent graphical user interface called Application Management System by which an end user can check or schedule device applications connected in home network. Notification Service may be used as a component of this demo. The example given below will clearly demonstrate the usefulness of Notification Service in Macro Demo. Suppose an old person is at home alone and is unfit to walk. The son is at the office during daytime. It may be possible that the person accidentally falls from the sofa or bed and his son wants immediate notification when an accident like this happens so that he can help his father. Therefore, he has scheduled an event using the macro demo that whenever the pressure sensor attached to his father's wrist triggers, a text notification will be sent to his mobile phone. Our notification text message service easily fits into this scenario without modifying a single line of code and perform the operation expeditiously.

The above examples clearly demonstrate the potential benefits of having notification technologies in Smart Home environment to support independent living. The service-oriented approach allow to reduce the deployment and development cost as the developer needs to learn only what the services do and how to use and does not have to develop the services every time. This also shows how the same service can be used several times by different applications. So a repetitive task now does not have to be repeatedly developed; only repeatedly used.

5. Conclusion and Future Work

A service-oriented approach significantly simplifies the task of satisfying simple communication need as well as more complex ones. This paper presents the advantage of such approach and also demonstrates how smart home applications can benefit from it. Reducing the cost and time of development is essential for smart homes to become ubiquitous. Having these basic functionalities available as services will greatly reduce the learning curve of the developer as well as the customization that each smart home requires. As our prototyped implementation shows these simple and combined services markedly simplify the development of applications and satisfy the different needs for communication via various means.

A major challenge in future notification system will be to predict immanent importunity of messages. Additional user studies are needed to capture this and to create prediction models. Although our proposed notification service has an audio based service, there are several new trends in Smart Home that can be integrated to our notification service such as video based multimedia service. By using our notification service through ubiquitous computing the dream of future smart home will come true.

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