Smart Phone Based Cognitive Assistant

Sumi HELAL[1], Carlos GIRALDO[1], Youssef KADDOURA[1], Choonhwa LEE[1], Hicham EL ZABADANI[1], and William MANN [2]
[1] Computer and Information Science and Engineering Department
[2] Department of Occupational Therapy
University of Florida, Gainesville, FL-32611, USA
{helal,cgiraldo, yok, chl,hme}@cise.ufl.edu, wmann@hp.ufl.edu

Abstract. The use of pervasive computing technology such as java smart phones and multi-modal sensors in smart homes of the future can potentially enhance elders' independence and quality of life. We present ongoing research projects whose goal is to reduce the demand on elder's attention and effort while performing daily tasks. We present three applications: a Mobile Patient Care-Giving Assistant (mPCA), a General Reminder System (GRS), and an Augmented Awareness System (AAS). The mPCA application is a cognitive assistant designed to improve the independence of live-at-home for Alzheimer Disease (AD) patients. GRS is a reminder application targetted to elders with dementia. AAS is a notification application that boosts the elder awareness about certain events in the surrounding (mail delivery, water leak, etc.) We present these applications and discuss the OSGi-based framework on which these applications are built.

1 Introduction

The cost of home health services for elder persons with disabilities is increasing with the rapidly growing elder population. Quality of life and independence are impacted by disabilities, and our health and caregiver systems will be increasingly stressed as the numbers increase. Hence, there is a significant need today to innovate cost-effective ways to help the elders maintain their independence, and at the same time, reduce caregiver burden. The impressive wireless and portable technologies we have today and the emerging mobile computing paradigm [1] offer a unique and real opportunity for us to create pervasive applications and environments specially designed to support the elderly. Such environments will enable cost-effective self-care and will maintain a higher quality of life and independence for our oldest population.

Alzheimer Disease (AD) is a dementing disorder, characterized by cognitive and behavioral decline. It involves the damage and death of brain cells and breakdown of their connections which impact memory, thought, and language. Other symptoms include difficulty with abstract thinking, disorientation, loss of judgment, and personality changes. People with moderate AD may have great difficulty functioning without supervision. One in ten elders in the US suffers from AD. It is estimated that 1 in 5 elders will have AD by 2050. In 2002, AD will have resulted in health related expenditures of more than $61B [2].

RERC, the center on technology for successful aging at the University of Florida, is exploring the use of pervasive and wireless technology to create tools to help the elder to become more independent.

The mPCA assistant is a smart phone that interacts with a set of sensors in a smart space, in which most of the computation, decisions, and events take place. The mPCA will assist individuals with AD in daily activities by means of reminders, orientation, and context-sensitive teaching, and monitoring. The GRS reminds the elder to perform time sensitive activities such as intake of medications and hydration. The AAS enhances the level of awareness of the habitants of the smart house by notifying them when certain events happen.

The rest of the paper is organized as follows. Section 2 describes our technological solution by means of Smart House, mPCA, GRS, and AAS tools. Section 3 describes the prototype issues, and section 4 presents the conclusions.

2 Our Approach

The world population of people over the age of 65 is growing rapidly at a rate of 800,000 per month [3]. Eventually, many of these people reach a point where they can no longer live independently. Consequently the elderly person needs to be taken to a nursing home. It is well documented that those who live in nursing homes tend to require more hospitalization and doctor visits. Once moved into a facility, it is common for them to become depressed because of their lack of independence. It is everyone's best interest for people to live independently for as long as possible. Technology could play an important role by providing a Smart Environment that aids the elderly in being independent.

Our approach is "Smart House" [4] in which computation is embedded into physical objects (such as walls, floors, doorways, clothes, etc). The Smart House should be able to proactively change its environment to provide services that promote an independent lifestyle for the elderly [5].We have created a Smart Robot called Matilda, which will function as a factitious AD elder. As shown in Figure 1, Matilda's Smart House is equipped with various sensors and devices. This environment includes J2ME smart phones as user devices, ultrasonic location sensor [6], X-10 controlled devices (door, mailbox, curtain, lamp, and radio), and networked devices (microwave, fridge, LCD displays on the wall, and cameras).

We have developed several applications for Matilda's Smart House and we briefly describe a few of them below.

2.1 Mobile Patient Care Giver Assistant (mPCA)

This is an attention-capturing application to help patients with moderate AD. This is activated when a particular task needs to be done by the elder at a given time. It first, attempts to capture the elder's attention. Once attention is captured, the system delivers the task to be done by the elder (e.g. the elder needs to drink water to be hydrated). The task is delivered in a form of a video clip played in one of the four flat panel monitors as seen in Figure 1. With the help of the smart environment, the system determines the right monitor to be activated (the one the elder is facing).

The attention-capturing process in mPCA attempts alternative mechanisms in an increasing order of intervention and interactivity. The initial phase simply calls the

elder's name (message played in the phone) requesting the elder to respond in a certain way (e.g. say "yes"). If attention is not secured, richer audio is attempted by playing special songs and sounds and then repeat the name calling and confirmation request. If this fails, the system actuates the vibrator on the smart phone and outputs the name calling using pre-recorded sounds of relatives and significant others. The protocol, if necessary, progresses to using visual cues by playing a video clip on the video monitor most facing the elder. The ultrasonic location is used to determine the orientation of the patient, and to subsequently select an ideal monitor to play the video clip. If the task can not be delivered because the elder does not respond or the elder asks for help (e.g. by saying “help”), the system makes use of tracking cameras to take a recent picture of the elder. This picture is sent to the phone of the care giver or any family member.

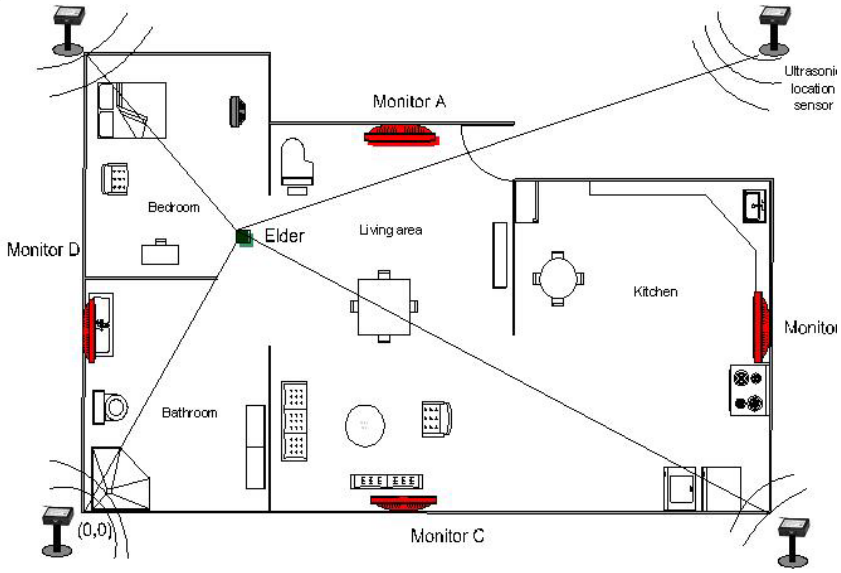

Figure 1. Matilda smart house

2.2 General Reminder System (GRS)

The GRS reminds the elder to perform critical tasks such as medication intake and doctor appointments. It makes sure the elder takes medicine doses according to the schedule to ensure the medicine works effectively and the illness is properly treated. This application will play an audio message on the elder's smart phone whenever a medicine is due. Then the patient should use the mobile scanner attached to the phone to check if it is the right medication or not. The smart phone will send the data read by the scanner to the server, which will check how much medicine is available to order a refill whenever the quantity goes below a certain level.

2.3 Augmented Awareness System (AAS)

The goal of this system is to enhance the level of awareness of the occupants by notifying them when certain events happen (mail delivery, someone at the door, water leak, etc), and also reduce the level of efforts by automating tasks (e.g. controlling appliances, lighting and doors). We have chosen voice interface to reduce the level of attention of the elder to control the environment.

Appliances, lights, door latches, mail box sensors, leak sensors, and window sensors are attached to X-10 components that are being registered into our OSGi framework as events. Whenever mail is delivered, an event is sent in the framework. The framework delivers a voice message to the smart phone of the elder.

3 Prototype issues

We have adopted the Open Service Gateway Initiative (OSGi) [7], as a pervasive space infrastructure technology that provides a managed, extensible framework to integrate various devices in Matilda Smart House. OSGi's main goal is to provide a common infrastructure for developers and equipment vendors to develop, deploy, and manage services in an organized and coordinated fashion.

Figure 2 shows our applications as bundles on the OSGi framework. The framework is the heart of the smart space where services (e.g. application components) can be registered, looked up, and be executed. A bundle is a collection of zero or more services. Whenever a bundle wants to provide a service, it registers with the framework to allow other bundles to get reference to it. The Event Broker Bundle, an addition made in our lab to the framework, is a module that coordinates service interactions via application events. The bundles must register (subscribe) their interest to particular services with the Event Broker Bundle. For the subscription, the bundle provides the event name and a listener function. Whenever an event occurs, the source bundle (the one that provides the service), signals the event broker of it. Then the Event Broker Bundle invokes the listener functions of all bundles that subscribe to that event.

We have developed three bundles; the GRS Bundle, the Attention Capture bundle, and Multimedia Messaging Bundle. As seen in Figure 2, the GRS Bundle schedules all the tasks to be performed by a person in the Smart House. Whenever a task is to be done by that person, the GRS Bundle signals to the Event Broker. Then the Attention Capture Bundle, already subscribed to receive events from the GRS Bundle, is notified by the Event Broker Bundle by executing its own handling function. Once this bundle captures the elder's attention, then it signals to the Multimedia bundle, which will be in charge of delivering the Multimedia message.

In the design of the Attention Capture Bundle, tasks are being divided according to the level of importance, as follows:

> **A**: Critical Events. The system needs to capture the elder's attention in a small period of time. Examples of such events are the detection of a water leak, someone at the door, medicine, food burning on the stove, and so on.

B: Non-Critical Events. The system needs to capture the elder's attention within a given time. Examples of such events are the elder needs to drink water; the food in the microwave is ready etc.
C: Informative Events. The system tries to capture the elder's attention, but if it is not successful, then it does not try again. Based on these levels, the attention capture bundle can decide whether to insist on capturing the attention right away, giving some time or just giving up on it.

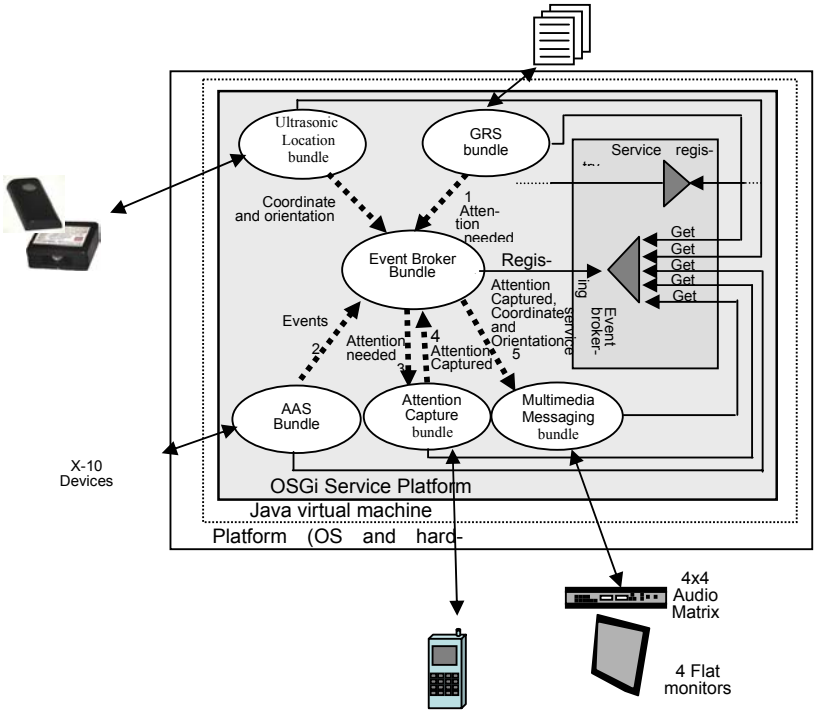

Figure 2. Applications as bundles on the OSGi framework.

To be more effective on capturing the attention of a person, we have taken into consideration physical and cognitive impediments. If a person has cognitive problems, attention needs to be addressed in a different way as if the person is blind or deaf. Table 1 shows some guidelines that we have followed:

Impediment	Effective ways of capturing attention
Mental (Alzheimer's Disease)	Voice messages coming from family members, particular music, smell, vibration
Blindness	No visual cues, rich audio, smell
Deaf	No audio, video sign language or video w/ captions.

Table 1. Guideliness to effectively capture the elder's attention.

Program 1 shows the pseudo-code for the GRS Bundle in which the level of urgency is added to a task. In program 2, the Attention Capture Bundle extracts the level of importance of the task, as well as the impediment of the person to decide the better way to capture the attention of that person.

Program 1:

```
PersonSchedule Matilda = new PersonSchedule(String persontype);
Matilda.AddTask( Time1, task1, levelB);
Matilda.AddTask( Time1, task5, levelC);
      :
/*Signaling the Event whenever an activity needs to be per-
formed. Then,the bundle scheduler signals to the Event Broker
that an event has occurred */
      :
GenericEvent eventObject= new GenericEvent(prop);
eBroker.signalEvent(SCHEDULER_EVENT, eventObject);
      :
```

Program 2:

```
public void start(BundleContext bContext)
throws BundleException
{
      :
// subscribing for the Scheduling event
eBroker.subscribe(SCHEDULER_EVENT,this);
      :
//Method being called by the Event Broker when
// a task need to be done in the Scheduler
}
public void handleEvent(GenericEvent e)
{
Properties props=e.properties;
String PersonType= props.get("UserModel");
  String Level= Props.get("level");
  if(PersonType=="AD")
  {//execute the Alzheimer's disease attention capture
   //routine
   ADFSA(Level);
  }
  else if(PersonType=="Blindlness")
  {// execute the blindless attention capture routine
  BlindFSA(Level);
  }
  else if(PersonType=="Deafness")
  {// execute the deaf attention capture routine
  DeafFSA(Level);
  }}
```

A state transition diagram for capturing the attention of AD can be found in [8]. Figure 3 shows a state transition diagram for cuing a blind person. The level of importance determines if the system should wait for some time or call a care giver. Once

this bundle captures the elder's attention, it sends a signal to the Multimedia Messaging Bundle, which is responsible of delivering a multimedia message to the elder using the services provided by the Ultrasonic Location Bundle.

Certain events depend on the dynamicity of the environment that can not be scheduled, such as mail coming, detection of water leak etc. Those events are captured by the AAS Bundle, which is in charge of signaling the Event Broker to be delivered to the Attention Capture Bundle

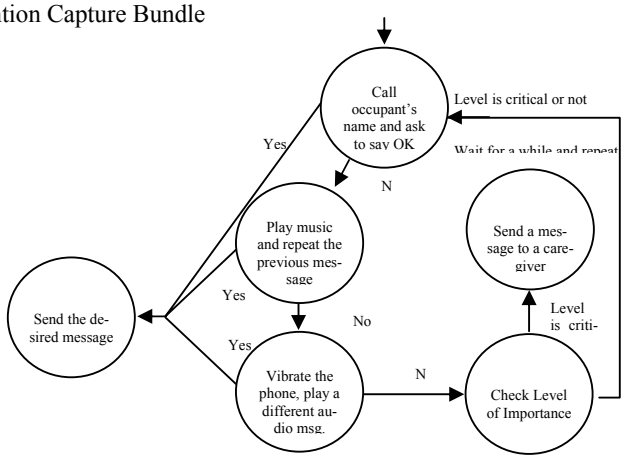

Fig. 3. Transition diagram for cuing a blind person.

References

[1] The i85s Product Specification Sheet: The Motorola iDEN, Java-enabled, Mobile-IP, Smart Phone (http://www.motorola.com/LMPS/iDEN/products/i85s/i85shtml)

[2] Koppel R. Alzheimer Disease: The cost to U.S. Businesses in 2002. Alzhiemer's Association (2002)

[3] Oxford University: Injuries of Aging Person's Report. http://www.jr2.ox.ac.uk/bandolier/band25/b25-2.html (1998)

[4] Sumi Helal, Choonhwa Lee, Carlos Giraldo, Youssef Kaddoura, Hicham Zabadani, Rick Davenport, and William Mann: Assistive Environments for Successful Aging.

[5] B. Winkler: An Implementation of an Ultrasonic Indoor Tracking System Supporting the OSGi Architecture of the ICTA Lab, Master's thesis, University of Florida (2002)

[6] Hexamite: Local Positioning System, http://www.hexamite.com

[7] Open Services Gateway initiative: Specification Overview Version 1.0 January (2000) http://www.trialog.com/Pdf/OsgiOverview.pdf

[8] Sumi Helal, Bryon Winkler, Choonhwa Lee, Youssef Kaddourah, Lisa Ran, Carlos Giraldo and William Mann: Enabling Location-Aware Pervasive Computing Applications for the Elderly, Proceedings of the First IEEE Pervasive Computing Conference in Forth Worth Texas (2003)