Design of Embedded System for Grid Handtop Computing (ESGHC)

Lim Kek Yong[1], Wong Poh Lee[1], Mohd Azam Osman[1], Chan Huah Yong[1]
[1]*Universiti Sains Malaysia, School of Computer Sciences, 11800 USM Penang, Malaysia*
forester_lky@hotmail.com, wongpohlee@hotmail.com, azam@cs.usm.my, hychan@cs.usm.my

Abstract

This paper discusses the design of the Embedded System for Grid Handtop Computing (ESGHC), the implementation and the methods used in ESGHC. ESGHC applies the grid computing technology which is built under a grid environment for handtop devices. By having ESGHC, sharing of handtop devices in terms of computational power and storage are virtually possible. Besides, grid services can be accessed everywhere at any time through handtop devices. This research aims at applying the mobile grid technology to the medical line.

1. INTRODUCTION

Personal Digital Assistants (PDAs), smartphones, laptops and handtops are increasingly common. Individuals often own a collection of these mobile devices. However, interface design of mobile devices is more restrictive than the interface design of desktop computers due to the limitation of computational power, smaller screen size and low screen resolution [1]. In order to overcome these disadvantages, ESGHC has provided a dynamic UI (User Interface) which is fully capable of running on a handtop device. The term *dynamic* as in dynamic display in this paper refers to the ability to adjust screen resolution (i.e. width, height) while the application is running. The UI of ESGHC is fully navigable with the ability to input values using the touch screen technology. In addition, the UI of ESGHC enables the use of a finger instead of a stylus for most common tasks.

Handtop devices are often resource limited: low computational power, finite battery life and constrained storage space. These restrictions increase the application's execution time and hinder operability [2,3]. As a result, ESGHC provides a group of *collaborative* computing resources which are shared among dynamic collection of individuals and organizations to support applications with high computational power and storage requirements. ESGHC integrates mobile grid technology during execution. The term *grid* denotes the integration and coordination of resources and users that live inside different control domains [4].

The rest of the paper is organized as follows: The next section describes about the use of mobile devices in a grid environment. Section 3 presents the use of gridsphere in ESGHC. In section 4, grid portlets are discussed. Section 5 discusses the approach and methodology of ESGHC which consist of three different modules that are the Web Portal module, the Dynamic Display module and the Medical Application module. Section 6 explains the system architecture and the platform structure of ESGHC. In section 7, sample user interfaces of the application are presented which includes the user registration page, the profile manager, the medical application (health portlet), list of symptoms, messaging portlet and medical report. Section 8 concludes the paper.

2. MOBILE GRID COMPUTING

Mobility issues can be attended with the technology of Mobile Grid. Mobile Grid is a platform that enables both fixed and mobile users to have access to Grid resources which utilizes the technology transparently and efficiently. It also makes Grid services available and accessible anytime and anywhere from mobile devices [5]. Several researches have been carried out on mobile grid and highlighted both advantages and limitations in extending the grid to the mobile world [6].

Generally, wireless mobile devices are characterized by several limitations and constraints. The computational power is limited in most of these devices (maybe with the exception of notebook computers), the built-in memory is low and the storage capacity is limited compared to desktop computers despite the use of external memory cards by some

978-1-4244-2315-6/08/$25.00 ©2008 IEEE.

devices. Besides, the battery life is short and the display facilities are restricted in size and quality [7].

Network connectivity are normally unstable (intermittent connectivity and poor bandwidth) due to mobility issue. This issue can be overcomed by making mobile devices a platform that would benefit from the Mobile Grid [7]. The advantages of Mobile Grid computing comprise mobile-to-mobile and mobile-to-desktop collaboration in order to share resources, and to improve user experiences. A grid-based mobile environment would allow mobile devices to become more efficient by off-loading resource-demanding work to a more powerful devices or computers [8].

A. Technical Specifications of Handtop Device

ESGHC is designed using a handtop (Ruvo Avox). This handtop is used for the development and the execution of ESGHC. The technical specifications of the handtop are as follows:

- VIA® ULVC-M 1.2GHz processor
- 6.5 inch Wide WVGA(800x480) TFT LCD
- 30GB Hard Disk Drive
- 768MB DDR2 Memory
- Touch Screen Function with Stylus Pen

3. THE USE OF GRIDSPHERE IN ESGHC

ESGHC web portal is developed based on the Gridsphere 2.0[9] and it can be customized according to the developer's preferences. Gridsphere is fully Java™ Specification Request 168 Portlet Specification (JSR 168) compliant. In other words, any portlets that are designed using JSR 168 can be deployed to other JSR 168 compliant portals. Gridsphere is a framework which contains a feature called Role Based Access Control (RBAC), separating users into guests, users, administrators and super users. Thus, different users can view the portal in their respective preference settings. For instance, user A has a blue theme background while user B has a green theme background. Besides, job maintenances become easier and simple. Gridsphere supports up to 13 languages which are French, English, German, Czech, Chinese, Polish, Hungarian, Italian and etc. Users can select their desired language anytime without altering codes [10].

ESGHC targets four different types of users which include the guest, normal users, the administrator and the super user. Each type of users has their limitations in terms of usage and functions. Table 1 lists the functions for each type of users.

Table 1. Functions for Different Types of Users

Type of Users	Functions
Super user	Creating groups, users and system layouts
Administrator	Add users from a group and delete users from a group
Normal User	Able to request services from the centralized server.
Guest	A user that has not logged into the portal

4. GRID PORTLETS

Portlets are defined as visual components that can be assimilated into web portals. Portlets provide *mini-applications* that can either display informational content or provide access to other services. The gridsphere portal allows users to customize their workspace by adding and removing portlets as needed as shown in Figure 1 [11].

Figure 1. Group Member Configuration Menu

Grid portlets has been used to interact in a grid environment. By having grid portlets, users can submit their job to the centralized server. The Grid Portlet Services API contains a collection of Java interfaces and base classes which are supported by Globus Toolkit 2 (GT2), GT3, GT4 and other service-oriented technologies to provide support for persisting information about resources and tasks performed by users on the Grid [12]. The core and basic portlet services provided by ESGHC are described in Table 2 below.

Table 2. Descriptions of the Portlet Services Offered in ESGHC

Portlet services	Description
Login	Allows a user account to be retrieved from a username and password.
Profile manager	Provides users the ability to configure group memberships, selecting time zone, updating password and selecting desired language (supports up to 13 different languages)
Layout Manager	Provides theme configuration for users to select their preferred theme (e.g. default or monochrome) and to create a new tab to add in portlets based on user's preferences.
Credential manager	Allows adding and removal of user credentials and the configurations of a credential retrieval service
Resource browser	Provides a hardware list, a service list and a job queue list of the system.
Job submission	Uploads the job and the broker will automatically find an appropriate node to handle the job.
Job monitoring	Specifies any given job to be monitored and information to be achieved.
File transfer	Managing and scheduling file transfers
Notification	Defining and delivering specific events to the users/administrators
Health	Provides a three dimensional human body for the patients to select a symptom and to submit to the doctor and pharmacist for solution. Patients have the ability to position the view (front/back) and to zoom (in/out) of a specific part when selecting the symptom.
Doctor	List the jobs which are requested by patients with record date, user ID and status. Doctor can answer the query by clicking on the user ID.
Pharmacy	List the queries which are requested by the doctors with the patient's symptom and provides an edit pad for replying the queries.

5. APPROACH AND METHODOLOGY

The system has three major components which are the Web Portal module, the Dynamic Display Module and the Medical Application module. The definitions of the components are described in Table 3.

Table 3. Major Components of ESGHC

Components	Description
Web Portal	Provides online services for use through ESGHC web page.
Dynamic Display	Provides users to view a portal which has a dynamic display.
Medical Application	Provides users to share, publish data to the server and to retrieve data from different resources.

Gridsphere 2.0 is used to develop the ESGHC web portal with a dynamic display. In order to integrate Gridsphere framework with ESGHC, Apache Tomcat 5.5.25 is used as the ESGHC servlet container. This is because Apache Tomcat 5.5.25 is capable of reducing garbage collection which improves performance and scalability [13].

JavaServer Page (JSP) and JSR 168 is used to develop the grid portal [14]. JSP [15] runs on a server which operates as an independent platform. This technology uses the XML-like tag, named JSP action, to store the content of the portal and invoke the built-in functionality. This technology also enables the system to build up a portal which has a dynamic display. Furthermore, JSP allows Java codes and pre-defined functions to be embedded in the portal.

Flash technology is used to create a 3-dimensional model of a human body. This increases interactivity of the medical application. Therefore, flash player is integrated into the application which enables SWF (Shock Wave Files) to be executed. ActionScript, which is an embedded scripting language in flash technology, is used to enable the animation of the human body to be zoomed in or to be zoomed out [16].

When an application is developed, a major portion of the application involves the creation and maintenance of the persistence layer to store and retrieve objects from the database. Whenever any changes are made to the underlying database schema, it can be expensive to distribute the changes to the rest of the application [17]. As a result, we use the hibernate technology to interact with the database in order to overcome the problem. Hibernate is driven by XML configuration files to configure data connectivity and map classes to database tables in which it needs to interact. Hibernate is a powerful object-relational persistence framework for Java applications. It supports a collection of persisting objects and object relations which provides a rich data query language to retrieve objects from the database. This technology significantly reduces the development time [17].

6. SYSTEM ARCHITECTURE OF ESGHC

A prototype system of the medical application has been developed for the handtop grid application. This application has achieved the objectives of grid services which enables sharing of resources. Besides, this application enables the client to publish data or knowledge to the server and to retrieve data from different resources (i.e. database or mobile).

An online medical center has been established to apply the medical application discussed above. Figure 2 shows the overview system architecture of ESGHC.

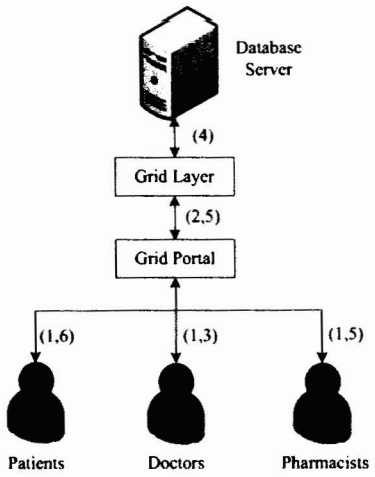

Figure 2. System Architecture

The labeled numbers in Figure 2 are described as follows:

1. Patients, doctors or pharmacist logs into the system using their handtop or laptop. A patient logs into the grid and enters the information of the symptom. The information is published.
2. Once the grid service (server) gets the query, the server will automatically search for any available doctors who are connected to the grid service. If available, the query is sent to the doctor.
3. The doctor will enter the possible information about the illness and send it back to server.
4. The server will search for the information of the sickness from the database. The possible sickness is then sent to the grid.
5. When the above steps are achieved, the server will search for any pharmacists who are connected to the grid. The pharmacist will send the information of the medicine that the patient needs to the server.
6. Finally, the patient (sender) will retrieve the information with regards to the possible information about the illness and the prescription.

A.ESGHC Platform Structure

ESGHC consists of 4 services layers, which are the application interface, the grid service architecture layer, the core services layer and the resource layer as shown in Figure 3. The description of the platform is shown in Table 4.

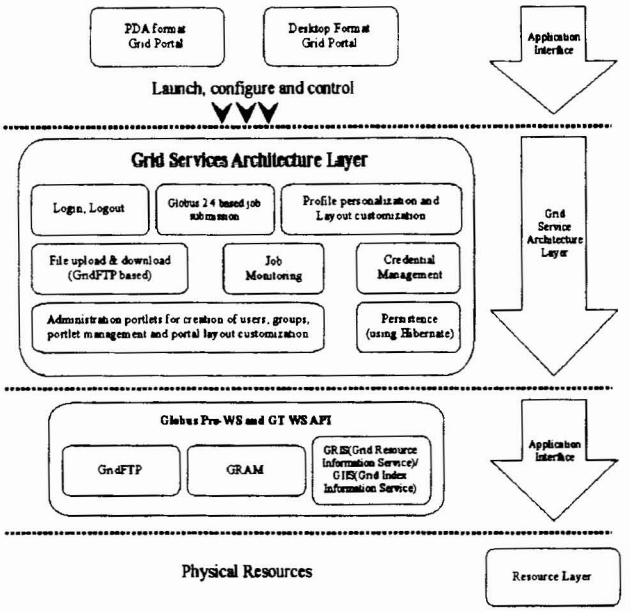

Figure 3. ESGHC Platform Structure

Table 4. Description of ESGHC Platform Structure

Service Layers	Description
Application Interface	• Dynamic display (Handtop/Desktop view) • User friendly Interface
Grid Service Architecture Layer	• Grid portlets used to interact in a grid environment. • Communication (protocols) & security.
Core Services Layer	• Globus Resource Allocation Manager(GRAM) - Remote allocation, reservation, monitoring, control of compute resources. • Grid File Transfer Protocol(GridFTP) - High-performance data access & transport • Monitoring and Discovery System(MDS) - provides information about the available resources on the Grid and the status. • Grid Security Infrastructure(GSI) - For secret and secure communication between software in a grid computing environment
Resource Layer	• All available computing resources

7. SAMPLE USER INTERFACE

This section discusses several user interfaces of the ESGHC. These user interfaces are based on the prototype of the developed application.

A.User Registration Page

User's Registration Page is a page for users to register as a role of a normal user. A notification mail is sent to the user's e-mail address and the user will receive a unique password which is needed to activate the account through the ESGHC webpage. Figure 4 shows the user interface of the user registration page.

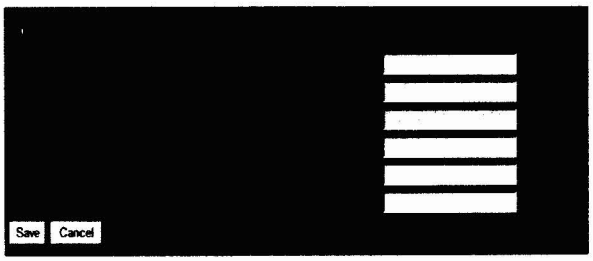

Figure 4. User's Registration Page

B.Profile Manager Page

Figure 5 shows the profile manager page of the the ESGHC website. This page contains the selection choices of up to 13 different languages which include French, English, German, Czech, Chinese, Polish, Hungarian, Malay, Italian and etc. Users can select their desired language anytime and configure group membership (e.g. Health portlets) at this page. Besides, users can select the time zone and location as well as to update the password.

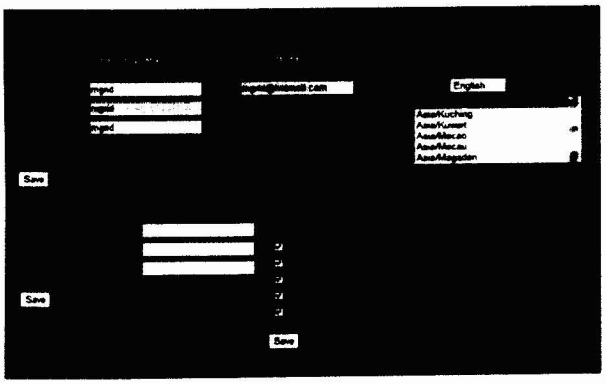

Figure 5. Profile Manager Page

C.Health Portlets and List of Symptoms

Figure 6 shows the sample portlets where users can view the position (front/back) of a 3-dimensional model of a human body. Flash technology is used to develop this section. By clicking on a particular part of the model, users can zoom into a specific portion of body.

Figure 7 shows a list of symptoms which is displayed for user's selection once the above steps are performed. The selected symptom will then be submitted for further process.

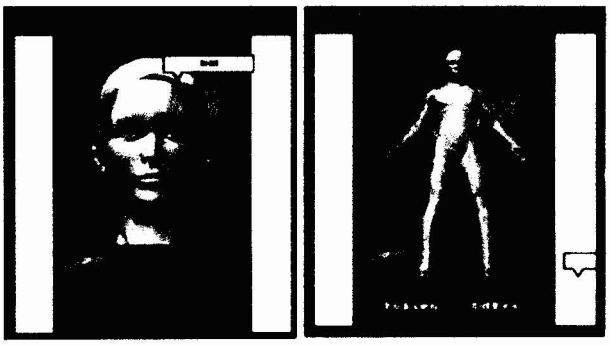

Figure 6. Medical Application (Health portlet)

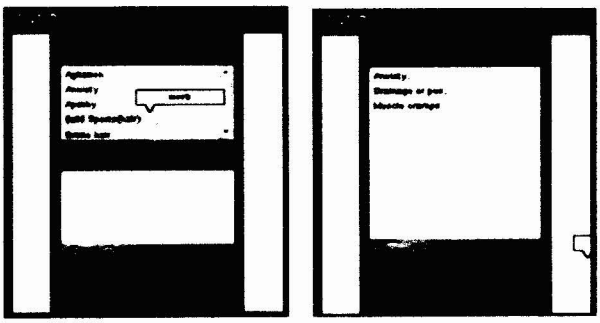

Figure 7. List of Symptoms

D.SMS Portlet

After a user (patient) submits the selected symptom, the doctor will receive a message. The doctor will select the user's identity to answer the query on an edit pad as shown in Figure 8. After the answer is submitted, the message is sent to the pharmacist. The pharmacist will then suggest the medicine that the patient needs to take according to the doctor's prescriptions.

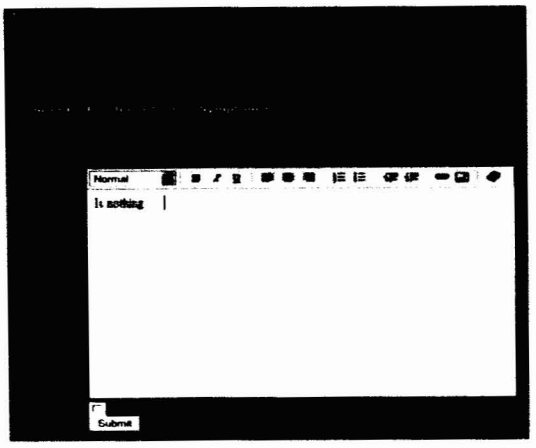

Figure 8. Messaging Portlet

E.Medical Report

After all the information is gathered from the doctor and the pharmacist, a message will be sent back to the particular user. The user can check the medical report via e-mail as shown in Figure 9.

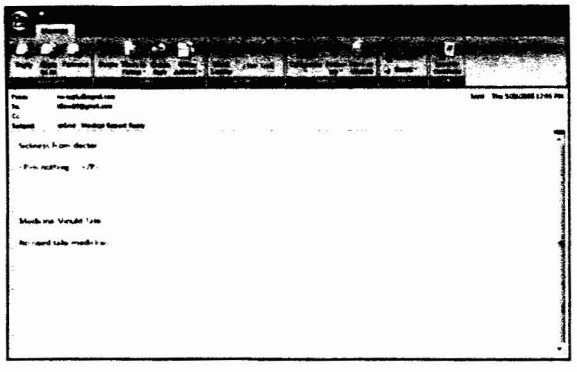

Figure 9. Medical Report

8. CONCLUSIONS

ESGHC has provided a dynamic UI for handtop and the ability for handtop devices to share computational power and storage virtually in a grid environment. This environment creates a virtual supercomputer which is cost effective and portable compared to real supercomputers.

Besides, ESGHC improves the patient's care by ensuring fast and on demand access anywhere at any time (e.g. home, office, medical centers or across the country). Patient's records can be accessible easily which enables doctors and pharmacists to carry out their job in an effective and productive manner.

REFERENCES

[1] Jun Gong, Peter Tarasewich, " Guidelines for Handheld Mobile Device Interface Design" College of Computer and Information Science, Northeastern University.

[2] David E. Millard, Arouna Woukeu, Feng(Barry) Tap, Hugh C. Davis, "Experiences with Writing Grid Clients for Mobile devices", *Proceedings of 1st International ELeGI Conference,* Vico Equense-Napoli (Italy), 2005

[3] Marty Humphrey, "Mobile OGSI.NET: Grid Computing on Mobile Devices", *Proceedings of the 5th IEEE/ACM International Workshop* on Grid Computing (associated with Supercomputing 2005), Department of Computer Science, University of Virginia Charlottesville, Pittsburgh, PA. November 8, 2004.

[4] Ian Foster, "What is the Grid? A Three Point Checklist", Argonne National Laboratory & University of Chicago, July 2002

[5] Stan Kurkovsky, Bhagyavati, Arris Ray, Mei Yang.'Modeling a Grid-Based Problem Solving Environment for Mobile Devices', *the International Conference on Information Technology:* Coding andComputing (ITCC'04), Las Vegas, Nevada, April 05 - 07, 2004.

[6] Bhagyavati and S. Kurkovsky. "Wireless Grid Enables Ubiquitous Computing", *The 16th International Conference on Parallel and Distributed Computing Systems(PDCS-2003)*, Reno, NV, Aug. 2003

[7] David E. Millard, Arouna Woukeu, Feng (Barry) Tao, Hugh C. Davis. "Experiences with Writing Grid Clients for Mobile devices" School of Electronics and Computer Science, University of Southampton, UK.

[8] Ian T. Foster, 'The Anatomy of the Grid: Enabling Scalable Virtual Organizations', Proceedings of the *7th International Euro-Par Conference* Manchester on Parallel Processing, p.1-4, August 28-31, 2001

[9] Wikipedia, "Web portal", Available at: http://en.wikipedia.org/wiki/Web_portal

[10] The GridSphere Portal, Available at: http://www.gridsphere.org/gridsphere/gridsphere

[11] GridSphere Portlet Reference Guide, Available at: http://www.gridsphere.org/gridsphere/docs-GS-2.2.X/ReferenceGuide/ReferenceGuide.html

[12] The Globus Toolkit 4: Key Components, Available at: http://gdp.globus.org/gt4tutorial/multiplehtml/ch01s04.html

[13] Apache Tomcat – product feature, Available at: http://en.wikipedia.org/wiki/Apache_Tomcat#Tomcat_5.5.x

[14] Portlet standard JSR168, Available at: http://www.jcp.org/en/jsr/detail?id=168.

[15] Java Servlet 2.3 and Java Server Pages 1.2 Specifications, Available at: http://java.sun.com/products/servlets

[16] ActionScript, Available at: http://en.wikipedia.org/wiki/ActionScript

[17] Hibernate – how does hibernate work? Available at: http://www.javajazzup.com/issue6/page27.shtml