Croquet based Virtual Museum Implementation with Grid Computing Connection

Riri Fitri Sari, Patrick Pabeda
Electrical Engineering Department
Faculty of Engineering, University of Indonesia
Kampus Baru UI Depok 16424, Indonesia
riri@eng.ui.ac.id, ppabeda@ui.edu

Abstract

A 3D computation technology in the form of Virtual Reality enables user to access ancient artifacts and facilitates the feel of presence. Virtual Reality consumes a lot of computing resources. Grid computing can be used to manage the distributed computation resources to perform computational processes.

Croquet application is used in this work to provide a virtual museum which will store an ancient Java manuscript. Croquet is a virtual machine which can be programmed for a collaborative 3 dimension application. The collaboration in virtual world can be conducted for multi users. In this work, we have created a virtual museum using a 3 dimension processing application support using 3D Studio Max. The Croquet application has been connected to a grid computing based on Globus and JOGL based manuscript system through Virtual Network Computing.

A user acceptance test was conducted and the result indicated that the users where satisfied with the application performance, although Croquet is still rarely used despite its usefulness for Virtual Reality. The connection between the VR world and Globus based Grid Computing System for a 3D manuscript has successfully been implemented, despite of the slow processing in the system.

Keywords: Croquet, Grid Computing, Virtual Museum, Virtual Reality

1. Introduction

Presently, many ancient artifacts are spread out around the world, especially in Indonesia. A special care is required because the artifacts are very sensitive due to aging. Those who want to touch or feel some aging artifact are frequently prevented to get access to it, e.g. due to the museum’s glass box preservation approach to avoid deterioration. On the hand, computer technology development has been advancing and offer solutions to the problem. 3D computing technology has been used in many aspects of human life, such as films, games, and other entertainment media including education programs. 3D computing becomes a solution for maintaining the ancient artifacts, due to its capability to make the artifacts to be accessed freely and lively. The original artifacts are converted to a digital format using photography technology. The digitized artifacts are rendered using 3D application. The rendered artifacts are placed in a program with an interface which provides interaction capability.

Grid computing technology offers the possibility of bringing ancient artifacts to a real condition through the digital version. This technology has been developed to enable distributed computing. High computing resources are available today, despite of its underutilization in some cases. Grid technology supports integration of many resources (computer, network, data, instrumentation, etc).

In this work we develop a virtual museum which shows 2 different cultures, ancient Java and English. The second is to implement Grid infrastructure to support 3D rendered computing process. The third is to make virtual museum as a collaboration place for users.

The application is a virtual museum based on Croquet application and a Grid computing infrastructure. This virtual museum consists of 2 rooms filled with ancient culture of a nation in each room. One room will have a digital book which can be open by the users. The digital book is connected to a Grid application which supports the interaction with many users. Our application is restricted for a local network, and provides an entry tool to collaborate using Globus.
and Java-based VR which has been developed in other work [1].

The application in this work is evaluated for the performance and conformability for the users on using the application. A qualitative data will be used to show the level of user satisfaction and comments.

2. Virtual museum and grid computing

2.1. Virtual Museum

The sensitiveness of old manuscript is the main issue to be tackled in this paper through virtual museum. Virtual museum is a museum in virtual world which enable users to access them easily from any place. With this concept, information from the ancient manuscript in the museum can be preserved and accessed widely through a virtual reality.

Virtual reality (VR) is a technology which allows a user to interact with a computer-simulated environment, be it a real or imagined one. Most current virtual reality environment are primarily in the form of visual experiences, displayed either on a computer screen or through special stereoscopic displays, but some simulations include additional sensory information, such as sound through speakers or headphones. Some advanced VR tools such as, haptic systems which include tactile information, generally known as force feedback is used widely in medical and gaming applications [2].

2.2 Grid Computing

Grid computing is an emerging computing model which provides the ability to perform higher throughput computing by taking advantage of many networked computers to model a virtual computer architecture that is able to distribute process execution across a parallel infrastructure. Grid uses the resources of many separate computers connected by a network to solve large-scale computation problems. Grids provide the ability to perform computations on large data sets, by breaking them down into many smaller ones [3].

Grid computing manages resources which consist of many distributed and geographically separated computers to solve a large computing problem in a large scale. Grid computing focuses on the ability to support computation across administrative domain sets it a part from traditional computer clusters or traditional distributed computing [4].

This approach implies the use of secure authorization techniques to allow remote users to control computing resources. Grid computing reflects a conceptual framework rather than a physical resource.

The Grid approach is used to provide a computational task with administratively-distant resources. The focus of Grid technology is associated with the issues and requirements of flexible computational provisioning beyond the local (home) administrative domain.

A Grid environment is created to address resource needs. The use of those resources (e.g. CPU cycles, disk storage, data, software programs, peripherals) is usually characterized by its availability outside of the context of the local administrative domain [3].

3. Supporting technology

3.1 OpenGL

Open Graphics Library (OpenGLX) is a standard specification which define a cross-language cross-platform API for writing applications that produces 3D and 2D computer graphics. The interface consists of over 250 different function calls which can be used to draw complex three-dimensional scenes from simple primitives. OpenGL is widely used in CAD, virtual reality, scientific visualization, information visualization, flight simulation and video game development [5].

At its most basic level, OpenGL is a specification, which means that it is simply a document that describes a set of functions and the precise behaviors that they must perform. From this specification, hardware vendors create implementations - libraries of functions created to match the functions stated in the OpenGL specification by making use of hardware acceleration where possible [5].

OpenGL serves two main purposes are [5]:

- To hide the complexities of interfacing with different 3D accelerators, by presenting the programmer with a single, uniform API.
- To hide the differing capabilities of hardware platforms, by requiring that all implementations support the full OpenGL feature set (using software emulation if necessary).

3.2 Croquet

Croquet is an open source project to build and provide a collaborative application for multi users. The capability provided by Croquet includes a network architecture supporting communication, resources distribution, and computing resources to synchronized users [6].

Croquet enables cooperation at all levels. An application written using Croquet SDK is automatically supports collaboration between people. Users can view each other in real time. The result of
ones work is immediately available to other users. Application objects in Croquet share a common protocol which allows them to cooperate. For example, every Croquet object can be attached to another Croquet object so that it moves in a fixed relationship to the other object.

3.3 Squeak

Croquet runs within Squeak, a highly capable cross-platform open-source implementation of Smalltalk. The Smalltalk language provides a very powerful, flexible, yet easy-to-lean language for writing Croquet applications and machinery. Croquet applications are built by defining application objects with specific behavior, and Smalltalk has traditionally been the language used for discussing programs [6].

The Squeak implementation of Smalltalk provides a single environment in which applications are developed and used. There is no separate "run-time" environment. Instead, all programming tools are available at all times even while the application is running. Changes can be made dynamically, without needing to restart the application and recreating the application state [6].

3.4 Virtual Network Computing

Virtual Network Computing (VNC) is a desktop sharing system which uses the Remote Frame Buffer (RFB) protocol to remotely control another computer. It transmits the keyboard presses and mouse clicks from one computer to another relaying the screen updates back in the other direction, over a network [7].

VNC is platform-independent. VNC viewer on any operating system can connect to a VNC server on any operating system. There are clients and servers for almost all operating systems and for Java. Multiple clients may connect to a VNC server at the same time. This technology's popular uses include: remote technical support, and accessing files on one's work computer from one's home computer [7].

Conceptually a VNC client can be assumed as a sort of abstracted video card. This "video card" happens to be over a network and is accessible only via the RFB protocol.

VNC has two parts, a client and a server. The server is the program on the machine that shares its screen, and the client (or viewer) is the program that watches and interacts with the server [7].

The VNC protocol allows the client and server to negotiate which encoding will be used. The simplest encoding, which is supported by all clients and servers, is the raw encoding where pixel data is sent in left-to-right scan line order. After initial setup, it only transfers rectangles that change. Because of that, this encoding works very well if only a small portion of the screen changes from one frame to the next (like a mouse pointer moving across a desktop, or text being written at the cursor), but bandwidth demands get very high if a lot of pixels change [7].

4. E–Museum implementation

4.1 Museum Frame Development

The museum frame was developed using technical AutoCAD. AutoCAD is a Computer Aided Design program to support a 2D & 3D modeling process. Prior to develop the frame, a museum concept was created. The museum will have 2 rooms with a corridor which connects both rooms. The first room consists of Indonesian paintings, and the other room is filled with English culture. A desk with artifacts on it exists in each room. Figure 1 shows the museum.

The museum model from AutoCAD is transferred to 3DMAX a 3D animation application program.

![Figure 1. Museum drawing from AutoCAD](image)

Simulated virtual museum application requires a file with ASE file extension. Meanwhile, AutoCAD produces a file with DWG extension. Figure 2 shows 3DMAX program, in which DWG file is imported, and then is exported to ASE file. That file will be used for simulation in Virtual museum.

Previously, a museum sketch/drawing has been developed. The drawing is entered to the simulation program which is called Croquet. A new project is created and named Museum. In this project, 2 virtual worlds have been created. The first is a world for hoster as the server, and the other is as the navigator which is a world for user to navigate.

Upon creating HosterWorldMuseum class, 2 methods were developed, initialize and turn. Initialize is a method used for making the island showed in Hoster and will be accessed by all users through navigator. HosterMasterMuseum is a subclass of BFDParticipant. This will be used for creating an execution of virtual world and hoster. This includes a
process to develop an entry port for navigator world to collaborate internally. The class consists of 2 methods, registerPortal and setup. RegisterPortal is used to create a shadow to be connected to another portal in the navigator. This method requires information of portal name that will be created and the designated island. There is a function to develop a portal and ensure the availability of another virtual world in the network. If there is another virtual world exists, and then it will be directly added a connection to a portal belongs to the hoster.

Figure 2. 3DStudio Max application appearance

4.2 Integration of Museum Drawing into Croquet

Upon creating the hoster side as the service provider, then we create a user side to be able to enter hoster virtual world. The Program is called Navigator.

NavigatorMasterMuseum, also has 2 methods, registerPortal and setup. registerPortal has the same code with HostMasterMuseum because the usage is only to create a portal connecting to another virtual world.

The setup method uses CroquetHarnessWithMenu function to help user n interacting with system. A system name is determined and is stored in variable myName, where in the name includes computer network name. To develop a virtual world navigator, an island object is created to make NavigatorWorld. A portal is developed to open connection with another virtual world.

4.3 Connection to Grid Infrastructure

The purpose of this research is to combine a virtual reality with Grid infrastructure. This will use a common remote desktop connection using VNC. A program in Grid is run in a computer in which Croquet will make a connection with VNC server at the computer with Grid application is in service. The application in Grid is represented by a virtual book contending ancient Java manuscript. The connection is shown in Figure 3.

Figure 3. Croquet and Grid Computing connection

Croquet provides an additional class for accommodating RFB protocol. The additional feature in Croquet consists of RFB server and client. In Museum project, a new morphic project was created and called VNC to illustrate the usage to connect with VNC server which runs in another computer. A workspace was opened and an instruction of RFBClient open was written to open a page for connection to VNC server. A connection from the page to VNC server is conducted by assigning an IP server address to the client. On connection, an interacting phase is started by showing server screen at client. Client can push keyboard button and click the mouse to send to server.

4.4 Test Platform

Two platforms were used. The first is based on Microsoft Windows and the second is Linux. Linux uses 2 common distributions, Ubuntu 6.06 and Fedora Core (4 and 5). Library of OpenAl has been installed in all platforms, where Windows uses OpenALwEAX.exe and Libopenal.so.1 for Linux. This test platform is illustrated in Figure 4.

Figure 4. Test Platform
5. Implementation and result analysis

5.1 Application Testing

Upon completion of 3D collaboration programming using Croquet application, many valuable lessons learned are collected. 3D programming with object oriented programming make programming easier, due to the available basic classes, especially in base rendering with standard shape. Croquet was developed using Squeak programming tool which provides an interface for Smalltalk programming language.

Croquet as a virtual machine can be run easily in multi several platforms i.e. Windows, Linux, and Mac OS. Croquet runs in a platform individually and separately from the master platform. Although it is in a separate platform, Croquet can fully use the master platform resources from the storage up to the processor and network. Croquet has a little weakness is in the required library where all platforms do not provide the standard one in their operation, such as OpenAL. OpenAL was developed by Creative Lab to exchange sound track system between several platforms.

The 3D graphics from Croquet is shown in Figure 5. There are no significant handicaps to create drawings in every test platforms. In every platform the 3D has the same appearance due to the utilization of OpenGL library. OpenGL is dominant in rendering process and in drawing of modest shape such as lines and dots.

In 3D collaboration programming, Croquet provides many alternative instructions in manipulating 3D drawings. For example, enlarging and turned drawing can easily be done.

In order to make a unique condition in the museum for certain culture situation, a specific wayang (Javanese Puppet) character is shown in the museum to represent the ancient Java culture, Figure 6 and Figure 7 show a drawing of "Ban Infant Orphan Election" to represent English culture as shown in the Museum of London [8].

The communication between users in virtual world is supported by Chat function which can be directly implemented in the developed program. This function is shown in Figure 8. However the avatar replication and the computer name are restricted by the security system such as firewall, due to the restriction on the communication function.
Although Croquet provides a lot of support, several handicap existed because lack of documentations provided by the Croquet developer, especially in bridging 2 programs which are created separately with different basic communication method, such as in Grid implementation. In Figure 9, we use a VNC communication to bridge two different platforms between Grid implementation and Croquet.

The Java based virtual book which will be arranged in this museum has been produced in a separate project and the Globus Grid mechanism utilization are beyond the scope of this paper.

![Figure 9](image1.png)

**Figure 9. Snapshot on VNC connection to a machine which runs a Java application**

On completing the experiment in communicating using VNC/RFB, it was found that during the connection of portal in VNC, as shown in Figure 10, virtual machine in Croquet sometimes becomes unstable and easily stops. This is possibly due to the limited computing resources or incompleteness in Croquet. Another discrepancy is the permitted resolution of 800 x 600 pixels with color depth of maximum of 24 bit. RFB client used for this museum application is the development version and makes the buffer memory only capable of supporting the above resolution and color depth.

![Figure 10](image2.png)

**Figure 10. Portal location with VNC connection for showing a virtual book**

Croquet consumes a lot of processor resources. The operation sometimes cannot perform the tasks because Croquet uses most of the processor resources.

### 5.2 Test on User

In order to get feedback from users on the performance and satisfaction in using the Croquet, a questioner with the scale of 1 to 5 (worst to best) was distributed to 10 users. A calculation of the average value of the responses and standard deviation with 95% confident were conducted.

**Table 1. Calculation result of questioner responses**

<table>
<thead>
<tr>
<th>Question number</th>
<th>Question Description</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OpenGL knowledge</td>
<td>1.600</td>
<td>0.316</td>
<td>2.033</td>
<td>1.167</td>
</tr>
<tr>
<td>2</td>
<td>Squeak knowledge</td>
<td>1.100</td>
<td>0.316</td>
<td>1.296</td>
<td>0.904</td>
</tr>
<tr>
<td>3</td>
<td>Croquet knowledge</td>
<td>1.100</td>
<td>0.316</td>
<td>1.296</td>
<td>0.904</td>
</tr>
<tr>
<td>4</td>
<td>Easily</td>
<td>1.100</td>
<td>0.316</td>
<td>3.357</td>
<td>2.043</td>
</tr>
<tr>
<td>5</td>
<td>Museum ambiance in VR</td>
<td>3.300</td>
<td>0.483</td>
<td>3.599</td>
<td>3.001</td>
</tr>
<tr>
<td>6</td>
<td>Avatar chat</td>
<td>3.500</td>
<td>0.527</td>
<td>3.827</td>
<td>3.173</td>
</tr>
<tr>
<td>7</td>
<td>Opinion an turning Makara UI</td>
<td>4.000</td>
<td>1.247</td>
<td>4.773</td>
<td>3.227</td>
</tr>
<tr>
<td>8</td>
<td>Three avatar in one world</td>
<td>3.700</td>
<td>0.483</td>
<td>3.999</td>
<td>3.401</td>
</tr>
<tr>
<td>9</td>
<td>Javanese puppet picture</td>
<td>3.400</td>
<td>0.843</td>
<td>3.923</td>
<td>2.877</td>
</tr>
<tr>
<td>10</td>
<td>Opinion in Virtual Machine compare with another VM</td>
<td>3.400</td>
<td>0.843</td>
<td>3.923</td>
<td>2.877</td>
</tr>
<tr>
<td>11</td>
<td>Benefit as source of Information</td>
<td>3.900</td>
<td>0.568</td>
<td>4.252</td>
<td>3.548</td>
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<tr>
<td>12</td>
<td>Opinion on used 3D technology and Virtual Machine</td>
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<td>0.632</td>
<td>4.592</td>
<td>3.808</td>
</tr>
<tr>
<td>13</td>
<td>Agreement for future development using Croquet</td>
<td>4.500</td>
<td>0.527</td>
<td>4.827</td>
<td>4.173</td>
</tr>
</tbody>
</table>

Survey result indicates that programming language, such as Croquet, Squeak and OpenGL are not widely familiar to the user recognized because 3D programming has not been used significantly in Indonesia. Presently, most of the computer games use OpenGL as the base. OpenGL is not as popular as DirectX which was developed by Microsoft when is compatible with system, such as appearance, sound and user input, whereas OpenGL only provides graphic library. Common people are more familiar with virtual machine using VMWare operating system and Microsoft Virtual PC 2004. Figure 11 shows the user responses for programming language.

![Figure 11](image3.png)
Figure 11. User Response on programming language for VR

Users are satisfied with the developed application, especially on the turning of object such as Makara (University of Indonesia’s Coat of Arms). Croquet can be used for information resources. This is illustrated at Figure 12 in the point related to moving object.

Figure 12. User Response on Croquet program

Users feel satisfied with 3D application and Virtual Museum. Figure 13 shows an illustration of the user’s opinion on Croquet, source of information, 3D dan Virtual machine, and possibility for further development.

Figure 13. User Response on Croquet and further work on VR

6. Further Work

Croquet can be developed further, especially on the usage as virtual machine. Croquet’s integration to Grid environment can support process execution in Croquet which consumes large processor resource. A new communication type may be developed to have a more real condition and be able to communicate and collaborate beyond the local network. In our work Virtual reality input devices have not been used. The use of a glove as an input device can be implemented in the future work.

7. Conclusion

Upon completing the modeling, programming and analyzing the results of developed application, we concludes that Croquet can be a supporting application in achieving a collaboration application with 3D appearance. Croquet can be run in most platforms, such as Windows, and Linux. Croquet uses some native libraries to create virtual world. Some of them are OpenGL, OpenAL, and RFP protocol. Library version is very important especially for Linux platform. At the moment, Croquet still has some minor problem and requires huge computing resources to run the 3D application smoothly.

Grid computing supports in developing virtual book is very helpful in virtual museum development because grid computing make the process faster than when we use single computer. Developed virtual museum can be used as a good tool to introduce ancient literature and culture. The virtual museum application developed in this work can be extended to create a more complex virtual museum.

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9. References


