Network Model for the Egyptian Oracle

Master's Thesis

In partial fulfillment of Masters Degree

in Digital Media, Northeastern University

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Preamble

By Jeffrey Jacobson, Ph.D., Thesis Advisor

This document describes thesis work by Siddhesh Pandit in partial satisfaction for his Masters in Professional Studies at the Department of Digital Media at Northeastern University, Jeffrey Jacobson, PhD, supervising. Mr. Pandit's assignment is to expand upon the existing open source code for our Egyptian Oracle application, the heart of a public performance. His improvements will allow the pupeteer to control an avatar via wireless LAN or over the internet. This preamble provides the context for his work. For a full report on the project, see **http://publicvr.org/egypt/oracle/whitepaper.pdf** .

The Egyptian Oracle performance is a recreation of an authentic public ceremony, from ancient Egypt's Late Period. As you can see in the image below, we project our Virtual Egyptian Temple on the wall at life-size scale. It is a true three-dimensional virtual space containing the virtual high priest, an avatar controlled by a live human puppeteer, who is hidden offstage. The priest, the live actress (in front of the screen, left), and the audience conduct a three-way interaction. Audience members represent the Egyptian populace and take turns acting out brief roles in the drama. Finally, the sacred boat (left) is another puppet also controlled by the puppeteer; in the drama, it is moved by the will of the temple god. The actress manages the audience who come before the god with questions and problems to be solved. The priest poses questions to the god, and interprets the movements of the boat as divine revelation or judgment. These judgments had the force of law were essential to Egyptian public life.

In the scene above, two audience members represent neighbors engaged in a legal dispute. The sacred boat indicates the will of the god, by pointing to the person on the left, a ruling in her favor. The show conforms to a high level of historical accuracy, suitable for any museum setting. For, historical background, please see http://publicvr.org/egypt/oracle/whitepaper.pdf, p28-32. For a short video demonstrating the interaction, see **http://vimeo.com/24297667**.

Originally, the equipment for the performance included a sound system, digital projector, webcam (for the puppeteer to see the audience), the control device for the puppeteer, and a laptop attached to the projector. Laptop shows a view of the virtual Temple and the digital puppet, as you can see in the image, above. Siddheh's assignment was to enable a second laptop to communicate with the first over a wireless LAN or via the internet. This would allow the puppeteer to be anywhere in the theater or the world. This will allow us to have modified performances for students in remote K-12 classrooms, requiring only a computer, projector, speakers, and microphone on the other end. This would be a prototype for delivery of distance education at a fraction of the cost for traditional Telvision based systems. It is also a first step to creating better avatars for online virtual worlds.

Further requirements for his thesis project are:

- Learn the structure and nature of the performance. Confirm with senior artists and technical people on the project.
- Learn how to write software in Unity (www.unity.com), the game engine we employ for this project.
- Make necessary changes to the Egyptian Oracle software.
- Construct and test modified system.
- Produce this document, which specifies the system and design approach.
- Train the next intern on the use of the system,
- Assist with the setup for at least one performance of Egyptian Oracle.

I am happy to say that Siddhesh has performed all of these tasks, admirably. We will turn this thesis document into a publication in some venue favorable to his career. We will also add this thesis to the documentation for the Egyptian Oracle open source code. (Under the requirements of the grant that funded the project, all software, scripts, and general design for the show is to be released to the public for noncommercial and educational uses.) PublicVR will retain a copyright for the work Mr. Pandit has produced, but he retains unlimited use of it. We will prominently and specifically credit his contribution in the product documentation, our website, and publications regarding The Egyptian Oracle performance. The project was funded by the Digital Startup grant from the National Endowment for the Humanities, number HD5120910.

Last but not least, we would like to thank the previous intern, Ajayan Nambiar, for his considerable help in training Mr. Pandit in Unity and the Egyptian Oracle code, in particular.

For more information, feel free to contact me:

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Abstract

The Egyptian Oracle is a live reenactment of an ancient Egyptan public ceremony developed by PublicVR for National Endownment for the Humanities. The show employs a projected digital backdrop (a virtual temple) and digital avatar/puppet High Priest who interacts with the audience and a live actress. For the purpose of thesis I have expanded the publically available open source code to allow the puppeteer to operate the avatar via an internet or LAN connection. The software platform is Unity3D, and I used Remote Procedure Calls (RPC) for all of the Client-Server communications, not the built-in state synchronization method. For more information on the project and access to the enhanced executable code and open source, please see http://publicvr.org/html/pro_oracle.html.

Introduction and Goals

Working with PublicVR, I extended the open source code, orginally developed for their Egyptian Oracle performance (Jacobson, 2011) and extended by Ajayan Nambiar (Nambiar, 2011). The software platform is Unity (http://unity3d.com). For my thesis work, I created a remote control connection for the puppeteer, so he or she can be anywhere on the Internet, controlling the avatar. The software uses a simple client-server model; the computer showing the projections being the server and the computer controlling the puppet being the client. Each time the puppeteer uses the interface on the client to order an animation (or group of movements), they are transmitted to the server so that the same motions are seen on the server side. The puppeteer can now connect the Xbox controller to his/her system connected to the internet and run the show remotely. This work will be a valuable example for artists and performers in digital media, students, game developers, and anyone else interested in mixed physical/virtual reality and digital puppeteering. The Immediate users will be practitioners of educational theater for whom the Egyptian Oracle is a useful show. It illustrates a dimension of Egyptian society that is not well appreciated or understood by the general public: Religious drama and performance were central to their culture, giving the people a direct and practical connection to the divine. Other "users" will be students and engineers who wish to make their own mixed reality applications using our code as a starting point.

Currently, the puppeteer has to be present at the venue, and the contoller hooked on to the main system directly. This creates hurdles, because the organization holding the event has to have a place to hide the

puppeteer or needs to set one up. This becomes very difficult in venues such as PublicVR's portable digital dome. If the puppeteer could control the avatar from a distance, over the Internet, space problems go away.

With this setup, the puppeteer can perform the oracle for remote audiences connected over the internet, like in schools and colleges or at a theater venue. With the right changes in the code this can also be transported to the people who would like to be at the comfort of their homes and enjoy the performance by the use of peer to peer connection. In simpler words, the interested people connect over the internet to the puppeteers computer and see the performance. This is often the model used in imparting distance education.

This remote control interface is an important step towards createing better ways to control control avatars in virtual space for massively multiple online games (e.g. World of Warcraft). This is an important and fast-growing area of the game industry with many opportunities, and the current avatars lack expressiveness. Some applications such as Rock Band by Harmonics studios presents users with a life-size avatar and/or a virtual world they interact with directly, "breaking the fourth wall", an expression from theater.

The code is open source and available at http://publicvr.org/html/pro_oracle.html The main project page points to a wiki that contains the source, exectutable, documentation, forums, etc.

Functional Diagram
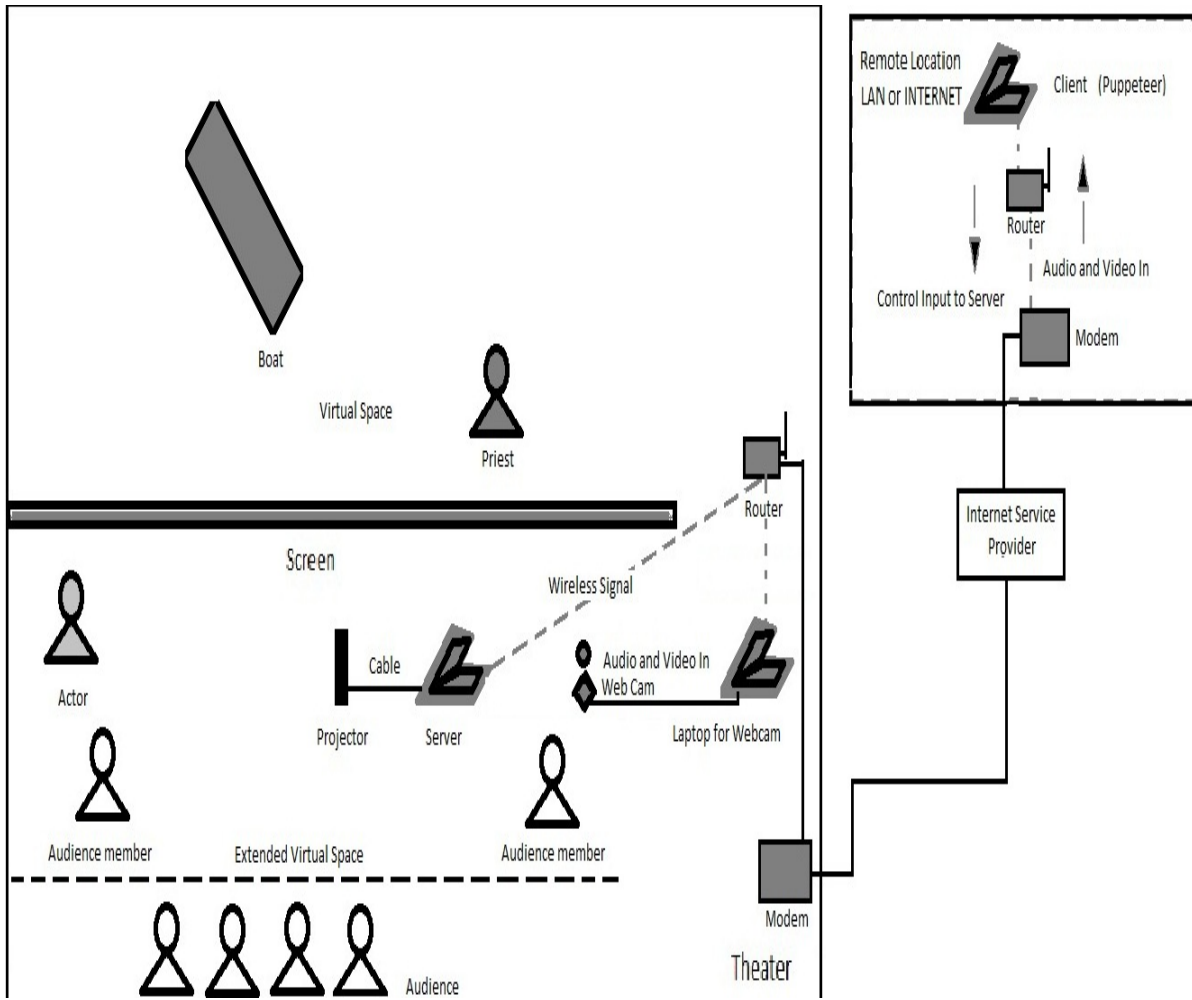
The virtual and physical spaces create a single social/performance space for the audience. This diagram shows the arrangement which takes full advantage of the remote control code; the puppeteer can be anywhere.

Design Approach

The puppeteer is responsible for controlling the characters, the sacred boat and the priest, via the Xbox controller attached to the main system. The Xbox controller triggers special animations, movements of the priest and the sacred boat presented on screen. In the current performance, the puppeteer has to be present at the venue, and the contoller hooked on to the main system directly. This creates hurdles, because the organization holding the event has to have a place to hide the puppeteer or needs to set one up. This becomes very difficult in venues such as PublicVR's portable digital dome. If the puppeteer could control the avatar from a distance, over the Internet, space problems go away. The organization could even save on transportation costs.

To program the remote control interface, I had to delve deep into the prewritten code learn how to transmit control commands over the network, learn how to pipe information (sound and video) back to the puppeteer, and understand human factors design of the puppeteer's control and monitoring equipment. I also had to thouroughly research the unity forums, documentation, and tutorials. I made my changes incrementally, starting with the open source code for the Egyptian Oracle. Ajayan Nambiar had worked on the the code most recently (Nambiar, 2011) and he has provided invaluable help during this process. Dr. Jacobson provided guidance in the design and purpose of the code and in this document.

For software testing, a single computer was used in the primary stages, running two instances of the application where in one would be the server and other would be the client. After getting the expected results, testing was done over the LAN and the last stage was testing for the internet. After each test result, changes in the code were done as needed. Approach similar to black box testing was used.

Software Strategy

My strategy was to have the server produce a view of the virtual world and feed that to a projector for the audience to see. The client communicates with the server over the LAN or the internet, telling it to (1) perform movements in the priest/avatar (2) move the sacred boat (3) move the viewpoint from one part of the temple to another. To see what this looks like, refer to the video posted on the project web page at http://publicvr.org/html/pro_oracle.html. The remote control allows the puppeteer to be hidden

from view, anywhere in the theater (communication via LAN) or far away anywhere on the internet.

One way to accomplish client-server communication is to use the state synchronization in Unity3d through its network view component. This can be conducted two ways, (1) *reliable delta compressed* and the other is (2) *unreliable*. In the *reliable delta compressed* method the client and server send data back and forth whenever there is a change in state. In the unreliable method there is a continuos transfer of data even if there is no change of location of the objects in concern, which causes overheads in data transmission. Testing both methods of state synchronization with Egyptian Oracle revealed poor performance and were limited to translating objects in a map space. They were not adequate for implementing the animations in Priest avatar. Hence, I turned off state synchronization in the network component in Unity3D, and used Remote Procedure Calls (RPC) instead.

Remote Procedure Calls implemented in Unity is associated with the network view component. In Egyptian Oracle, the client is responsible for triggering the events. The puppeteer triggers the events by the use of his keyboard and the xbox controller. The functions that listen to the input signals transmitted by the controller and the keyboard are invoked on every instance of the application connected in a client server model in order to trigger of the animations and scene transitions respectively. This is necessary to have the coordination between the animations running on the instances of applications connected over the network. This invoking of function calls is done through remote procedure calls. Which means that the same copy of the function call and definition on the clients is invoked when the function call is invoked on the server and vice-versa. The server makes sure each client gets the function call through the RPC format.

In the current module, the first need is to have a system that lets the puppeteer be off stage, which means we are not projecting from puppeteer's machine, because he can be anywhere on the internet, thus the machine projecting needs to be the server. Thus, an architecuture which has a passive server coordinating the connection of the client over the LAN or Internet, giving full control to the client has been put in place. The camera movements, scene changes and animations on the avatars are done through remote procedure calls by adding the network view component to the existing objects in concern. All the scripts in use had to be restructered to accommodate the RPC structure and the network view.

In summary, the puppeteer triggers events on the client by the use of his keyboard and an xbox

controller, then the client implements the event in its own copy of the virtual world, and transmits that same event to the server using a Remote Procedure Call (RPC). The server then implements that action in its own copy of the scene. In this way, the client and server see that same thing, but only simple command data needs to be exchanged over the network. The basic approach can accommodate multiple clients, which is one of our goals for the future. Multiplayer online games have used this basic architecture for a long time.

Scope

The project focused on improving the Egyptian Oracle performance, only, by the addition of the remote control interface. It will include the addition of some movements and gestures for the puppet as we understand its full potential.

Usage

Hardware:

1. Onkyo HT-S6300 Theater System

- 1200 Watt system (130 Watt * 7 Channels plus 290 Watt powered sub-woofer)

2. Mackie ProFX8 Mixer

- Professional 8 channel mixer

- 4 low-noise mic pre-amps with LED metering

- 32-bit Sound FX processor with reverb, chorus and delay

- Precision 7-band graphic EQ for tuning mains

- USB I/O for recording and music playback via Mac or PC

3. Audio 2000 Dual Channel Wireless Microphone Headset

- UHF Band 670MHz – 695MHz

- Two control knobs (One for each channel)

- Two independent XLR balanced output and one 1/4 inch unbalanced audio output

- Two Lapel & Two Headband Headset Microphone

4. PylePro PDWM2600 Dual UHF Wireless Microphone System

- Operating range of up to 150 feet

- 1/4 inch mixed unbalanced output

- Frequency range: UHF 600 – 700 MHz

- Two wireless microphones

5. Laptop

 - Microsoft Windows 7

- Intel or AMD 2 GHz processor

- 128 MB dedicated graphics card

- 80 MB Hard Disk

6. Xbox controller   -

USB 2.0 connector

7. Projector

   Standard LCD or DLP projector

Software:

1. Unity game engine v3.5.2 to deploy final compilation

2. Logic Pro 8 used for sound composition.

3. 3ds Max 2011 for modeling and rendering

   Please refer to the documentation for Egyptian Oracle Project Software for details, which is pending completion.

User interface instructions

After starting the oracle application, you will see a window which is seen as below,

1. Server Side

If you plan to start a server on the **Internet**, you need to enter a unique name for differentiating between the list of already running servers. You can add a unique name by clicking in the text field marked as "**Game Name**".

for LAN, click on the button marked as "**LAN**", a screen shown as below appears,

Click on "Start Server" button to start the server. Note down the *ip*. Next image is the same screen which is seen after the server is started be it on the LAN or Internet

Clicking on the "Exit" button shuts down the LAN or the Internet server.

2. Client Side

After starting up the application, the first screen seen is as below, in order to see the list of running servers on the Internet, click on the **"Refresh"** button. To get connected over LAN click on **"LAN"** button.

After clicking on the refresh button you will see new button(s) appear as seen in the screen below. Each new button will have a name of the server. Clicking on corresponding button connects you to the related server running over the internet.

In case of LAN, make sure you click on the LAN button on the first screen and then type in the related *ip* provided by the server in the text field by erasing out the default. Click on connect to get connected to the server.

The connection established is seen as below, this screen is same over the Internet and LAN.

Delivered

- Additions to the Egyptian Oracle open source code which allows the puppeteer to control the priest avatar over a TCPIP connction.
- Documentation of the modifications to the open source, the hardware design, and discussion of the principles behind the design. Also include advice to potential developers on how to apply this technique to other digital puppetry applications.
- The master's thesis document itself.
- A conference or journal article based on the thesis to be submitted to a venue.

Conclusion and Future Work

With the right changes in the code, Egyptian Oracle can be transmitted to people who would like to be at the comfort of their homes and enjoy the performance by the use of peer to peer connection. In simpler words, the interested people connect over the internet to the puppeteers computer and see the performance in the near future.

In the future, we would like to investigate ways for the video and audio feeds from the audience are taken back to the puppeteer in an application that runs parallel with the oracle and occupies very less bandwidth while doing so. The current solution is to use Skype or some similar software, but that has limitations.

On July 13th, we will have complete demonstration of the Egyptian Oracle show, but we will use this remote control code to place the puppeteer in the back of the theater, behind the audience. This will give him a superior view of the action and provide an opportunity to demonstrate remote-control.

References

Jacobson, A. (2011) Egyptian Ceremony in the Virtual Temple; Avatars for Virtual Heritage; Whitepaper and Final Performance Report to the National Endowment for the Humanities. Digital Startup Grant #HD5120910, 2010-2011 academic year. http://publicvr.org/publications/EgyptianOracleFinalReport.pdf

Nambiar, A. (2011) Sound Spatialization For the Egyptian Oracle, Masters Thesis for a Degree in Professional Studies, *Department of Digital Media, Northeastern University*. http://publicvr.org/publications/NambiarA2011.pdf

Nambiar, A., Jacobson, J., Hawkins, J. (2012) Spatialized Audio for Mixed Reality Theater; The Egyptian Oracle, *International Conference of Auditory Displays*, Atlanta, GA, USA, June, 2012 http://publicvr.org/publications/Nambiar2012.pdf

Unity3d (2012) http://unity3d.com

The Egyptian Oracle

7:00pm, July 13th,
Raytheon Amphitheater
Egan Engineering/Science Building,
120 Forsyth St. Northeastern University, Boston, MA

PublicVR will recreate an important religious event, the Oracle, from ancient Egypt's late period. Projecting our Virtual Egyptian Temple onto a wall opens the real space into the virtual, creating a shared continuum for audience and actors. The star is a virtual High Priest, controlled by a human puppeteer interacting with a live actor and the audience, who role-play the Egyptian populace. The high priest queries the spirit of the temple god, which is embodied in a ceremonial boat, carried by eight assistants. Fortunes will be told, judgments made, and blessings given. We will film the event, ask audience members what they learned, and have a general discussion afterward, all totaling 80 minutes. The information we gather will help us improve the show and inform our educational research. This was made possible by the National Endowment for the Humanities (grant HD5120910), PublicVR, and Northeastern University. Our actors are from the Puppet Showplace Theater in Brookline. No charge.

For directions and parking see: http://www.northeastern.edu/egan/directions.html

For questions, call: 617-435-0517 or write to jeff@publicvr.org

Project website: http://publicvr.org/html/pro_oracle.html