Simulation Modelling Practice and Theory 26 (2012) 1–15

Contents lists available at SciVerse ScienceDirect

Simulation Modelling Practice and Theory

journal homepage: www.elsevier.com/locate/simpat

Network traffic analysis and evaluation of a multi-user virtual environment

Juan L. Font, Daniel Cascado, José L. Sevillano *, Fernando Díaz del Río, Gabriel Jiménez

Department of Computer Technology and Architecture, University of Seville, Seville, Spain

ARTICLE INFO

Article history:
Received 30 December 2011
Received in revised form 12 March 2012
Accepted 13 March 2012
Available online 10 April 2012

Keywords:
Virtual world
Open Wonderland
Network traffic
Micro scale model

ABSTRACT

Virtual world applications allow users to interact within a simulated world. Network responsiveness and reliability contribute to the user experience, thus being able to model and reproduce certain network scenarios is a key issue to assure proper user experience and for being able to provide an estimation of the required network resources. The present study aims to model the client network traffic for the virtual world application Open Wonderland as the basis to tools for evaluating its network requirements. A micro scale modelling was performed, studying the outgoing network traffic from a black box approach that omits the details of traffic generation of the subcomponents and focuses on their overall combined traffic. The model obtained provides high goodness of fit for audio and object synchronisation traffic, reflected in a Pearson correlation coefficient close to its maximum value and low deviation figures measured by Root Mean Square Deviation.

1. Introduction

Nowadays, the virtual world concept has become familiar to wider audiences thanks to applications such as Second Life or World of Warcraft. Although their focus ranges from gaming to social interaction, they all base the user's experience on a virtual world environment, a distributed simulation shared by several users.

Given the acceptance of virtual world paradigm and following the recent proliferation of the so-called "persuasive systems" focused on motivating healthy lifestyle habits [1], our research group has developed a persuasive system called "Virtual Valley", relying on the virtual world concept [2,3]. Virtual Valley is based on Open Wonderland, a Java open source software for creating collaborative 3D virtual worlds (also known as Collaborative, Networked or Distributed Virtual Environments).

Open Wonderland was originally conceived as a tool for collaborative working by Sun employees [4], and as such it has some characteristics that make it very interesting for our application: focuses on social interaction and communications; open platform that allows new developments; can be installed and used by organizations within their own infrastructure, without the cost of renting a virtual space on a third party server and also allowing control of private medical data; etc. [5].

The latest version of this client–server architecture is Project Wonderland 0.5, shown in Fig. 1 [6]. Open Wonderland is subdivided in several independent subprojects listed below [7]:

- Wonderland: comprises both the core of OWL client and server as well as a set of modules that provide key functionalities such as security, shared applications, avatars and so on. It also contains the web administration server. Specifically, the shared application feature allows sharing applications among different users. Some of these applications are already integrated in Wonderland, like the multi-user PDF Viewer and the SVG White board. But users can also share additional external applications installed in the server (like Firefox or OpenOffice) using the Shared Applications Server-SAS.

* Corresponding author. Tel.: +34 954556142.
E-mail address: sevi@atc.us.es (J.L. Sevillano).

1569-190X/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.simpat.2012.03.003

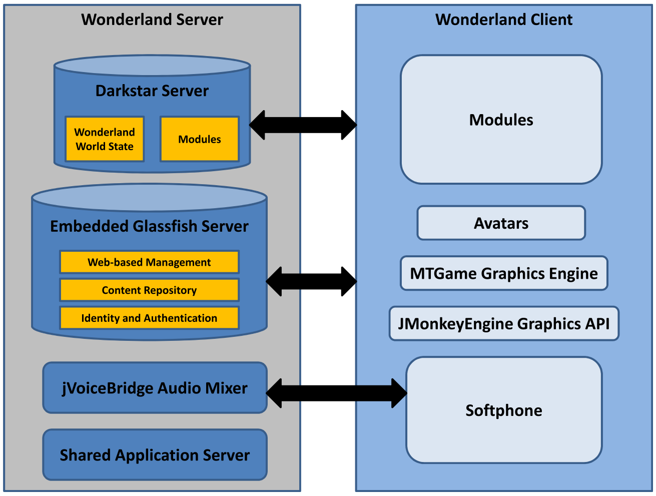

Fig. 1. Wonderland client–server architecture.

- Wonderland Modules: repository for Wonderland extension modules which expand its functionalities. Some of these modules are shipped by default within the OWL binary releases. There are also experimental modules provides by OWL developers and the community.
- MTGame Graphics Engine: high-performance graphics engine that extends jMonkeyEngine. MTGame adds multi-threading capabilities for improved graphics performance.
- jVoiceBridge: pure-java audio mixing platform providing real-time immersive audio (via VoIP) with time distance attenuation and a selectable range of qualities as well as a companion software phone, called *softphone*' that allows phone calls between users within the virtual world. It supports mixing high-fidelity, stereo audio at up to CD quality. Open Wonderland also depends on several several open source projects:
- Darkstar: Java platform started by Sun Microsystems for scalable communications and persistence in games. OWL includes a Darkstar service that manages all client and world state. Nowadays the project development is officially halted but a community fork has been create, called RedDwark Server [8].
- Glassfish: highly scalable, open source pure-Java application server that provides several functionalities for the Java EE platform such as RMI, XML and web server. OWL is based on an embedded instance of the Glassfish server. Wonderland web applications include web-based management of the server and worlds, a content repository for hosting all world data, and an integrated single-sign on system used to maintain identity across Wonderland services.
- jMonkeyEngine: 3D game engine written entirely in Java. JME provides core graphics APIs, including graphics primitive and shader support. The Wonderland graphics system is based on these core APIs, with some extensions from MTGame to support multithreading.

In Wonderland, like in any other virtual world, the user is represented by a 3D object known as an avatar. There can be many other objects in the virtual world, which can be 3D objects like pieces of furniture, buildings, etc.; or 2D objects like screens with applications (web browsers, word processors, and so on). The usual way to model the spatial relationships between objects is using a scene graph. Each object is a node (or *Cell* in Wonderland terminology) in this graph. The *Cells* (representing any volume of space of the virtual world) are organised in a graph with a tree hierarchy [9]. An example of such a tree is shown in Fig. 2.

As it will be discussed in Section 3, the network traffic derived from Wonderland is mainly due to three sources. First, object synchronisation which allows all users to have a coherent view of the virtual world (including moving objects like avatars). Second, messages intended to support communications among users, including voice traffic (the main source of traffic) but also text messages (chat). And, finally, traffic due to the execution of applications shared among different users. The latter is very difficult to model, as it depends on the particular application. Therefore, this study will focus on the first two sources: object synchronisation and voice traffic.

The aim is twofold: on the one hand, several gaming sessions will be performed, increasing the number of concurrent players between them, and the network traffic will be captured and analysed to obtain a preliminary model of the client network traffic. On the other hand, this model will be the basis for future simulation aimed to test its accuracy and determine some OWL network related parameters such as scalability and needed network resources.

The motivation for a detailed study of the OWL client traffic is to define a micro scale model as a first step to create tools for the evaluation of OWL network requirements. Part of the OWL traffic depends on user activity, a random process that implies variable bandwidth. Simpler network models based on parameters such as long run bandwidth lack the necessary