XLcloud – 3D Rendering in the Cloud

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Summary

- Some words about the project
- Remote rendering principle and optimizations
- Remote Rendering middleware
- Demos
Origin of the project

Winner of 1st Call for Projects “Cloud Computing” by the FSN in 2011

- Project length: 36 months
- Official Start: 01/01/2012
- Coordinator: Bull
- Open Source (Apache V2)
- http://gitorious.ow2.org/xlcloud
- http://xlcloud.org/
- http://gitorious.ow2.org/xlcloud

Consortium

- ATEME: H264/MPEG-4/AVC low latency compression algorithms
- Bull: cloud infrastructure, distributed systems architecture and HPC cluster
- CEA List: interactive simulation of natural phenomenons, virtual reality
- EISTI: marketplace, OpenERP integration
- Inria Reso: energy efficiency
- TSP (Artemis Lab): remote rendering, video compression, multimodality
- Silkan: massively distributed (HPC) software architecture for interactive simulation
- OW2: communication, dissemination
XLcloud objective

Establish the demonstration of a High Performance Cloud Computing (HPCC) platform designed to run effectively a representative set of compute intensive workloads including interactive games and 3D graphics applications
Capabilities of the XLcloud platform

- The platform exposes an on-demand Platform-as-a-Service service endpoint (and GUI) which developers can use to manage software stacks of nearly any scale and complexity without sacrificing control.

- The platform's main design paradigm is to make it easy to manage the complete application lifecycle, including resource provisioning, configuration management, application deployment, software updates, monitoring, and access control.

- The software stack artefacts produced by XLcloud are primarily targeted toward delivering two kinds of virtual clusters, but could easily be extended to produce other types of virtual platforms:
  - An HPC Virtual Cluster based on SLURM
  - A Remote Rendering Virtual Cluster based on Ogre3D
Remote Rendering
How remote rendering works?
How remote rendering works?

Local Input
- AI
- Data

Remote Input
- Network parameters
- User interaction

Scene Graph
- Scene analyzer
- Scene description

Application Engine
- Rendering engine

Scene (description)
- 2D/3D graphics

Network
- Client
- Server

Terminal parameters
- Interactivity

Player
- Network ready packets
- RTP/UDP Packetizer
- Streamer
- Compressed stream
- Depth map
- Motion vectors
- Segmentation map
- 2D/3D graphics
- Graphics Encoder
- Network (ready packets)
- Packets
- Compressed stream
- Video Encoder
- Network
- Rendered graphics
- Rendered graphics
- Rendered graphics
- Rendered graphics
How remote rendering works?

xlcloud added value

Server

Network ready packets

Streamer

RTP/UDP Packetizer

Compressed stream

Video Encoder

Depth MAP
Depth Quality control

Transmoder

Pre-Processing

Graphics Encoder

2D/3D graphics

Motion vectors

Segmentation map

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Buffers extraction optimizations

Rendering engine

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xlcloud added value

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How remote rendering works?

xlcloud
Powering Computation in the Cloud
Examples of applications in Remote Rendering
The problem that the Cloud can solve for Remote Rendering

Network Bitrate (kb/s)

Video bitrate

Time (s)

Frozen image

Frozen image

Frozen image

Frozen image
The problem that the Cloud can solve for Remote Rendering

Reduce the video bitrate to keep it under the network bitrate
The objective is simple, the results when applying traditional rate control are just ... horrible
Problem Statement

- Find new representation spaces of video sequences that allows to reduce the debit beyond the theoretical limit of the pixel space while preserving the user experience
Proposed Approach

- Statistically detect regions of interest (ROI)
- Create importance maps
- Concentrate the coding error in “less important” areas
- Correlate importance maps with the characteristics of the image, measured in real time
- Perform a segmentation of the image in relation to these characteristics
- Build a hybrid space
- Compress the hybrid space
- Transmit, decode and display the rendered hybrid space
What is the “important” info?

Player’s attention is game specific and it depends on the graphical content, action, interaction
What is the “important” info? “Ask” the user …

5 players, 2 games (Doom3 and 0AD), 1 eye-tracker and many playing hours

To get this …
What is the “important” info? “Ask” the user ...
Intra-player analysis

Strong correlation if $r_p > 0.5$
Inter-player analysis

Doom3, $r_p > 0.85$ (between $\bar{x}_{Doom3}$ and all the tests)

0 A.D., $r_p > 0.69$ (between $\bar{x}_{0AD}$ and all the tests)
Region of Attention Model

$$f(x, y) = Ae^{-\left(\frac{(x-x_0)^2}{2\sigma_x^2} + \frac{(y-y_0)^2}{2\sigma_y^2}\right)}$$

Modulate the quality of the video encoding based on RoA
Additional control: adaptive video coding based on depth map

- Control of region quality based on distance from viewpoint
- Inverse exponential function to correct non-linear depth values
- Variable range support
Displacing the errors in the video frame is fine, however it has theoretical limits imposed by the “Pixel” space.

- Additional improvement: represent the image by using two spaces
  - Regions containing edges – represented as color pixels
  - Edge free regions – represented as polynomial coefficients
Hybrid Space – Visual Results

Original Image

Hybrid Space

Pixel Information

Polynomial Information

Reconstructed Image
Remote Rendering Middleware
Remote Rendering – 3 Layers structure

- Cluster: Lobby Component
- Node: Lobby Agent Component
- Application
Remote Rendering – 3 Layers Structure

Sequence Diagram for Remote Rendering Session Submission
Remote Rendering – 3 Layers Structure

- Session Initialization
- X Server launch
- RR Middleware components launch
- Application launch
Remote Rendering Middleware - Components

- Remote Rendering Library
- Graphics Engine Video Output (GEVO)
- Interaction Module (NetInput)
- Open Source Graphics Engine (OGRE)
- Ogre-GEVO Plugin
- Video Encoder
- Local Dependencies
- Streaming Server
- Lobby Agent
RR Middleware – Application Integration

Ogre Application

Ogre – GEVO Plugin

GEVO - RRStream

Video Encoder

Streaming Server

Remote Rendering Library

Interactivity (NetInput)

RR Dependencies

RR Middleware
Demo
Games

4 sessions, 1280x 720
Nvidia K340 grid
Intel Xeon 2 cores
4 sessions, 1280x 720
Nvidia K340 grid
Intel Xeon 2 cores
CPU
Games

4 sessions, 1280x 720
Nvidia K340 grid
Intel Xeon 2 cores
CPU
Games

4 sessions, 1280x 720
Nvidia K340 grid
Intel Xeon 2 cores
GPU
4 sessions, 1280x 720
Nvidia K340 grid
Intel Xeon 2 cores
GPU
4 sessions, 1280x 720
Nvidia K340 grid
Intel Xeon 2 cores
Network

Games
Games

4 sessions, 1280x 720
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Concluding Remarks

- A demonstration of a High Performance Cloud Computing platform

- More computation is available, better compression is possible
  - Modulate the compression quality with respect to user attention and application behavior
  - Generate in real time complementary representation spaces for images
XLCLOUD: the interventional radiology use case

Philippe Gravez, Virtual Reality Project Manager, CEA LIST, FR
XLCloud: the interventional radiology use case

Interactive simulation / Virtual Reality for training / Cloud

Introduction

CEA List & technological research

I. CEA List & XLCloud

Interactive simulation
Motivations for XLCloud
2 use cases

II. Interventional radiology

What is it?
Esprimed
VR training tool

III. Implementation

Architecture of XDE applications
Remote deployment

Conclusion
Contribute to business competitiveness through innovation and technology transfer.
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Interactive dynamic simulation
Interactive simulation lab: addressed topics

1. Interactive multi-physics simulation
   - Multibody multi-contact nonsmooth dynamics
   - Soft parts
   - Fluids
   - Interactive Dosimetry
   - «Advanced» interactions: haptics, tracking, HMD, ...

2. Digital human
   - Accurate manipulation in VR
   - Mixed Reality
   - Dynamic simulation, Interactions
   - Dynamic multi-objective control

Physics

OW2con'14
Interactive simulation lab: some applications

1. Interactive multi-physics simulation
   - Virtual prototyping, scenario validation
   - Training (VR / MR)

2. Digital Human
   - Assistance for assembling, maintenance or recycling
   - Ergonomic assessment, cobot design...

- xde Physics

OW2con'14
Motivations for XLCloud / Use cases

**XLCloud**
- HPC
- Interactive video streaming

**Access to HPC capabilities**
- CFD & dosimetry simulation

**High interactivity**
- Virtual Reality requirement

**Ease of deployment**

**Collaborative working / scalability**
- Several persons, remotely located, interacting with the same virtual mock-up from heterogeneous computer interfaces

⇒ **2 XLCloud use cases**
- Interactive smoke simulation (with Silkan) (HPC++)
- Interventional radiology (with Esprimed) (Interactivity++)
Interactive simulation / Virtual Reality for training / Cloud

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Interventional radiology is a medical sub-specialty of radiology which utilizes minimally-invasive image-guided procedures to diagnose and treat diseases in nearly every organ system (Wikipedia)

- This means that surgeon and medical staff are always exposed to X-rays
- This is becoming a world wide issue raised by safety authorities
The Esprimed interventional radiology training tool
XLCloud: the interventional radiology use case

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XDE architecture

Python binding

- orocos
  - Native solver
- orocos
  - Device driver
- orocos
  - Viewer (ogre)
According to the considered application and the local resources, select the components to be virtualized.

Network of Orocos agents

- Native solver
- Device driver
- Viewer (ogre)
- Remote rendering
Development of a training tool for interventional radiology

A business supported use case

Main motivation: ease of deployment in hospital facilities

Open a path toward scalability and collaborative work