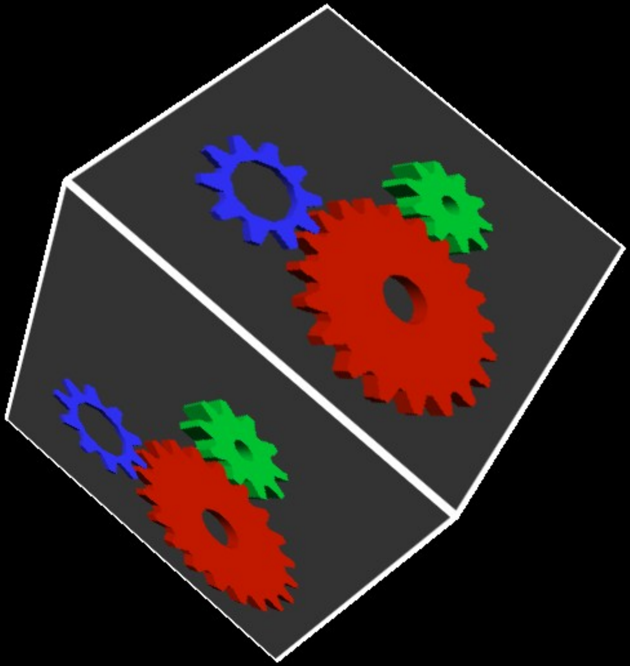
VMGL: VMM-Independent Graphics Acceleration



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Why Virtualize 3D Acceleration?

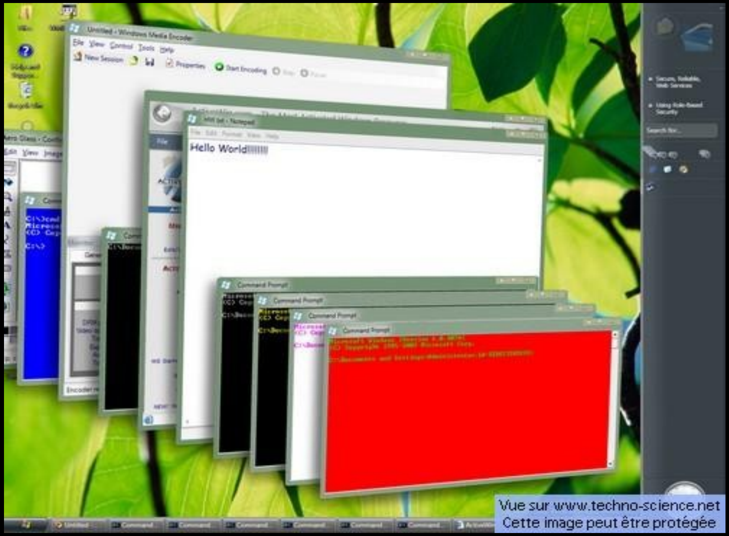
Two simultaneous trends

- VMs out of the server room
- Client apps going 3D

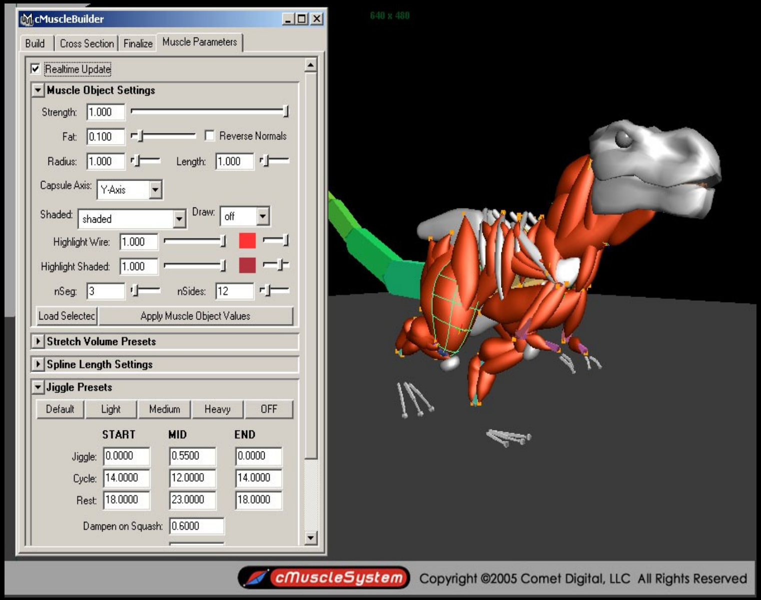
Virtualization of Client Apps

- Soulpads
- The Collective
- Internet Suspend/Resume
- Virtual Appliances
- Moka5

The World Is Going 3D


Hello World!!!!!!
Vue sur www.techno-science.net
Cette image peut être protégée

Ubuntu Dapper 6.06 (TEST)
Support XCB, a modern replacement for the old Xlib: http://xcb.freedesktop.org/



☑ Realtime Update

Muscle Object Settings

Strength: 1.000

Fat: 0.100 □ Reverse Normals

Radius: 1.000 Length: 1.000

Capsule Axis: Y-Axis

Shaded: shaded Draw: off

Highlight Wire: 1.000

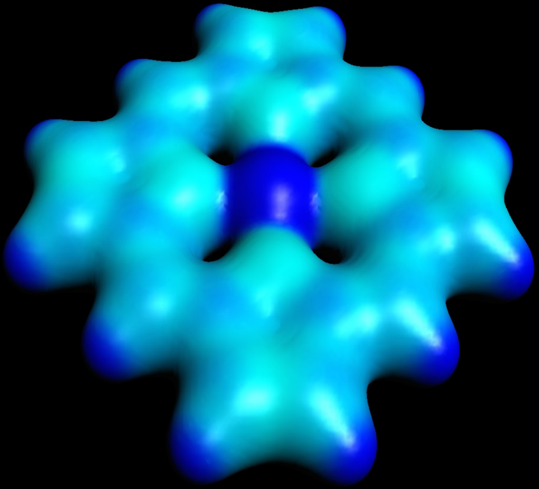
Highlight Shaded: 1.000

nSeg: 3 nSides: 12

Jiggle Presets

	START	MID	END
Jiggle:	0.0000	0.5500	0.0000
Cycle:	14.0000	12.0000	14.0000
Rest:	18.0000	23.0000	18.0000

Dampen on Squash: 0.6000



Why Is 3D Virtualization Hard?

3D vendors compete through HW diversity

- Lack of unifying hardware abstraction
- Closed specs

Open HW abstractions simplify virtualization:

- Network -> Ethernet Frame
- Block Devices -> BIO request
- SCSI drives -> SCSI command packet
- ....

How could we ever write 3D applications?

3D Rendering APIs

De facto unifying sotware abstraction
Developer gets vendor independence

Two main APIs

- OpenGL
- Direct3D

OpenGL

- Cross-platform

VMGL: Virtualizing OpenGL

Provides 3D HW acceleration to applications running inside virtual machines

- GPU independent
- VMM independent
- Guest OS independent

- 87% or better of native HW acceleration
- Two orders of magnitude better than Mesa

VMGL Design

API virtualization

- GPU vendor independence

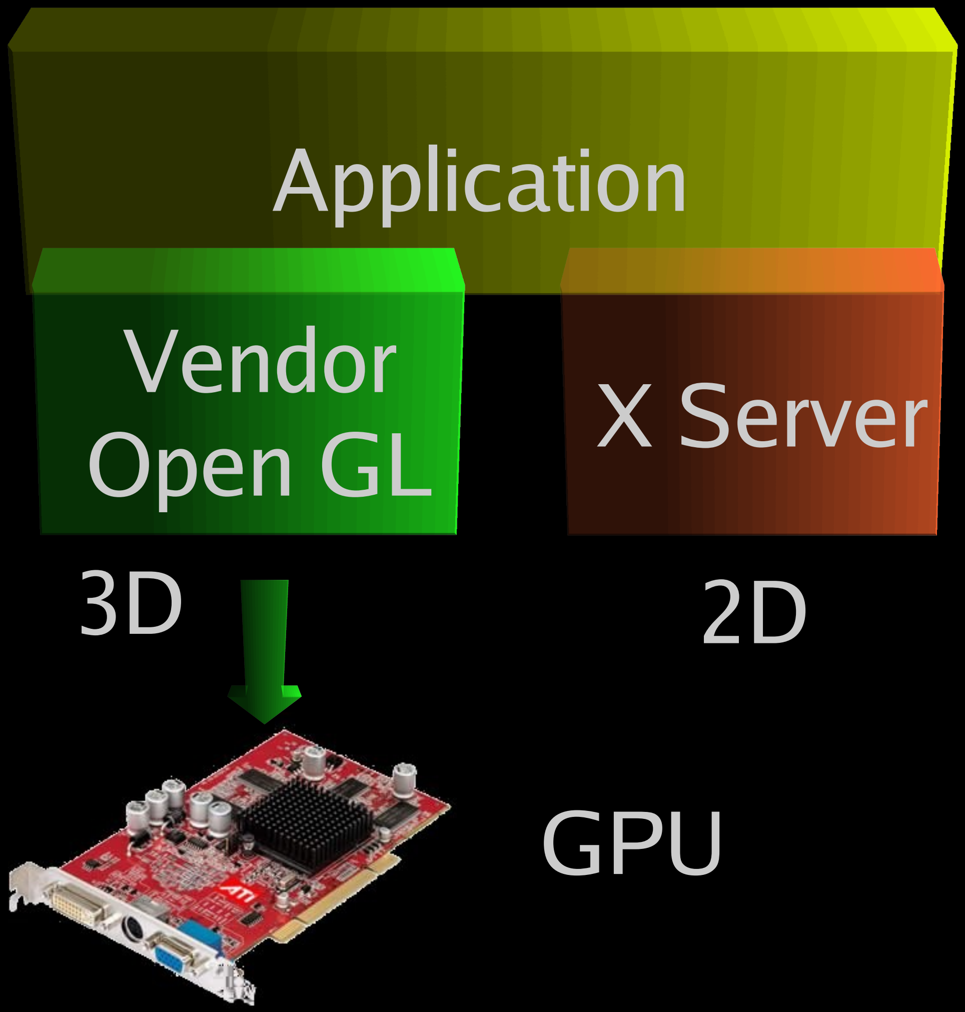
OpenGL: cross-platform API

- Guest OS independence

Network Communication

- VMM independence

OpenGL Apps In X11 Systems



Application

Vendor Open GL

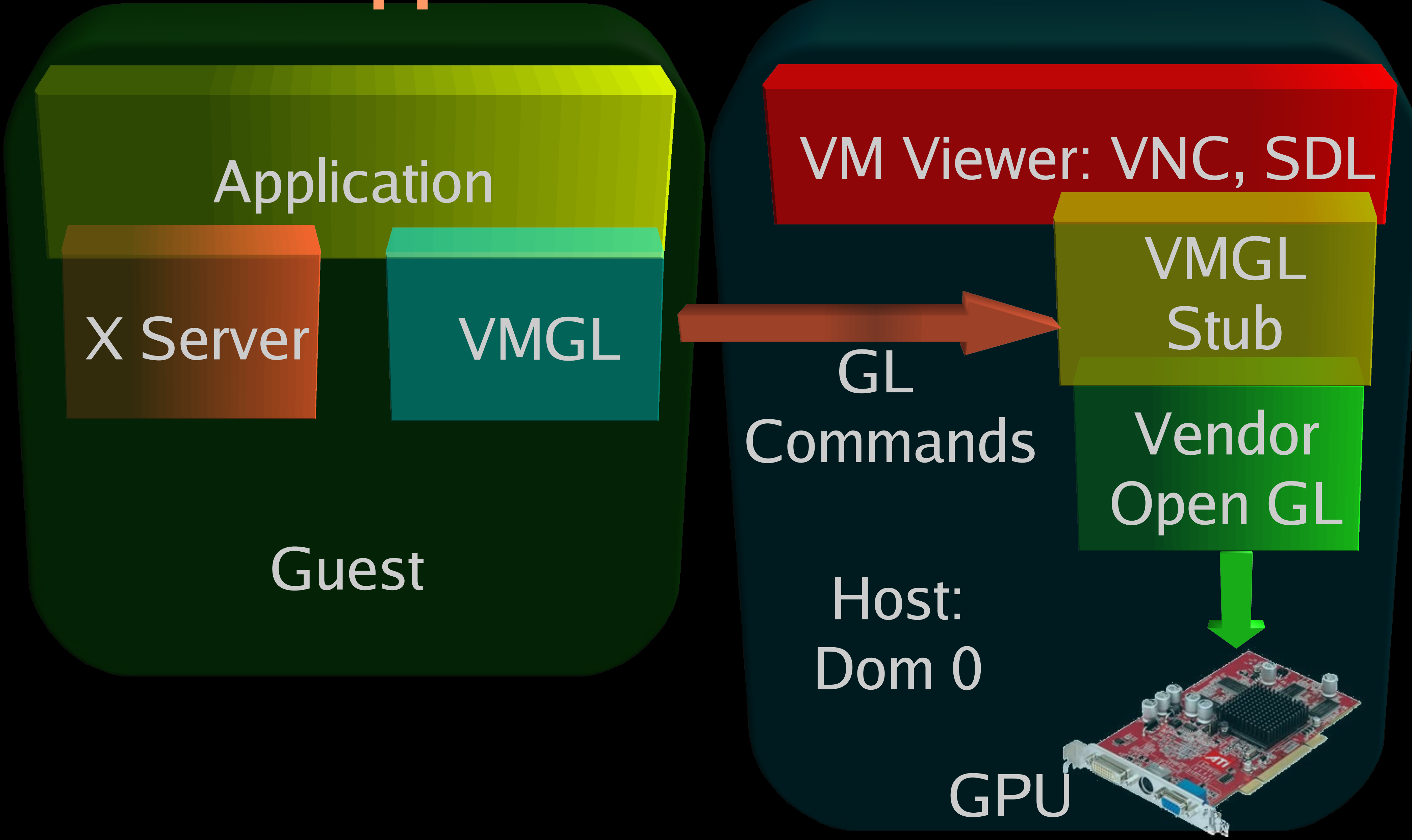
X Server

3D

2D

GPU

VMGL Apps in X11 Guest VMs



Application

X Server

VMGL

Guest

VM Viewer: VNC, SDL

VMGL Stub

GL Commands

Vendor Open GL

Host: Dom 0

GPU

Implementation Aspects

- Efficient GL network transport
- 3D and 2D output composing in VM viewer
- Suspend/Resume implementation
- Dom0 drivers

Efficient GL Transport

Transport over network

- VMM Independence

WireGL / Chromium

Only send updates that “matter”

- glTextureXY only when texture visible

Combine, reorder and buffer commands

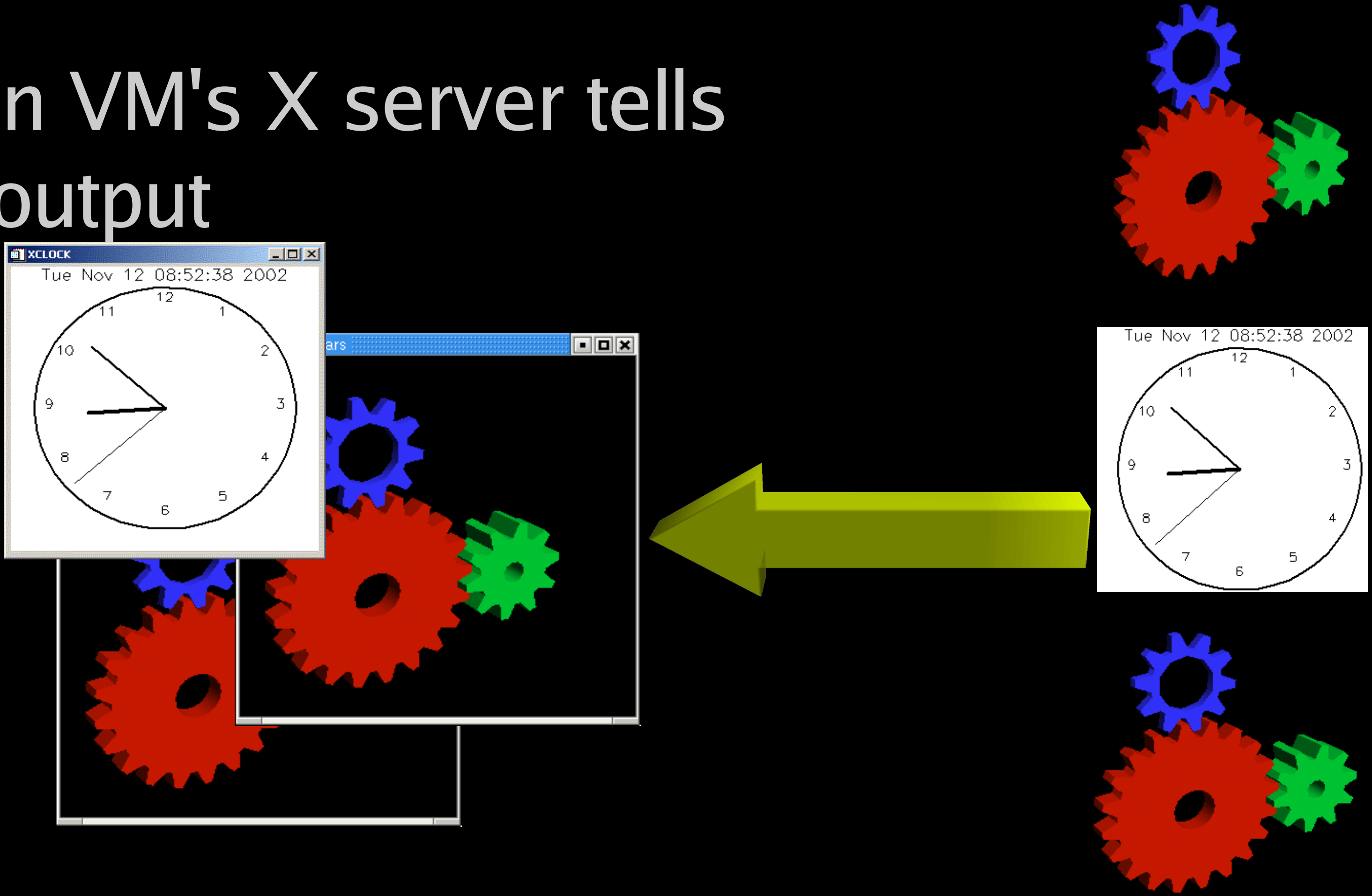
- glRotate + glTranslate ->
  Single matrix transformation

Window Manager Extension

Compose 3D and 2D output on VM viewer

Extension in VM's X server tells viewer 3D output

- Position
- Size
- Clipping



Suspend / Resume

Think each GL app as a GL device

- Runtime: keep track of OpenGL state
- Suspend: “freeze”G L device (trivial)
- Resume: flush state to new GL stub

OpenGL state is GPU independent

- Suspend/resume across different GPUs

OpenGL state is bounded

- Upper bound: GPU mem size

VMGL Suspend / Resume State

Windows

- Visual bits
- Binding to window manager extension

GL Contexts

- Context data: fog, transformations...
- Textures: pixmap, clamp mode
- Display Lists: verbatim unrolling

Domain 0 GPU Drivers

ATI & Nvidia:

- GPU Mem mapping in user-space GL lib

Oblivious to Xen additional indirection

- Virtual -> Physical (VM) -> Machine
- Even for domain 0

Fix open source portion of driver

Use Xen-paravirt mem mapping functions

VMGL Evaluation

VMGL: OpenGL Virtualization

- API v1.5
- Shaders through extensions

Frames per second
CPU, bandwidth consumption
Resume latency, state size

Workloads

- Games & entertainment fuel 3D industry

Workloads

Quake 3

```
thewhiteguy played with fire
wjc was killed by Plinny's Garand
Mr T connected
[3dc]Leonidas WAS KILLED BY TEAMMATE DocNartman
DocNartman was killed by Niners's Thompson
```

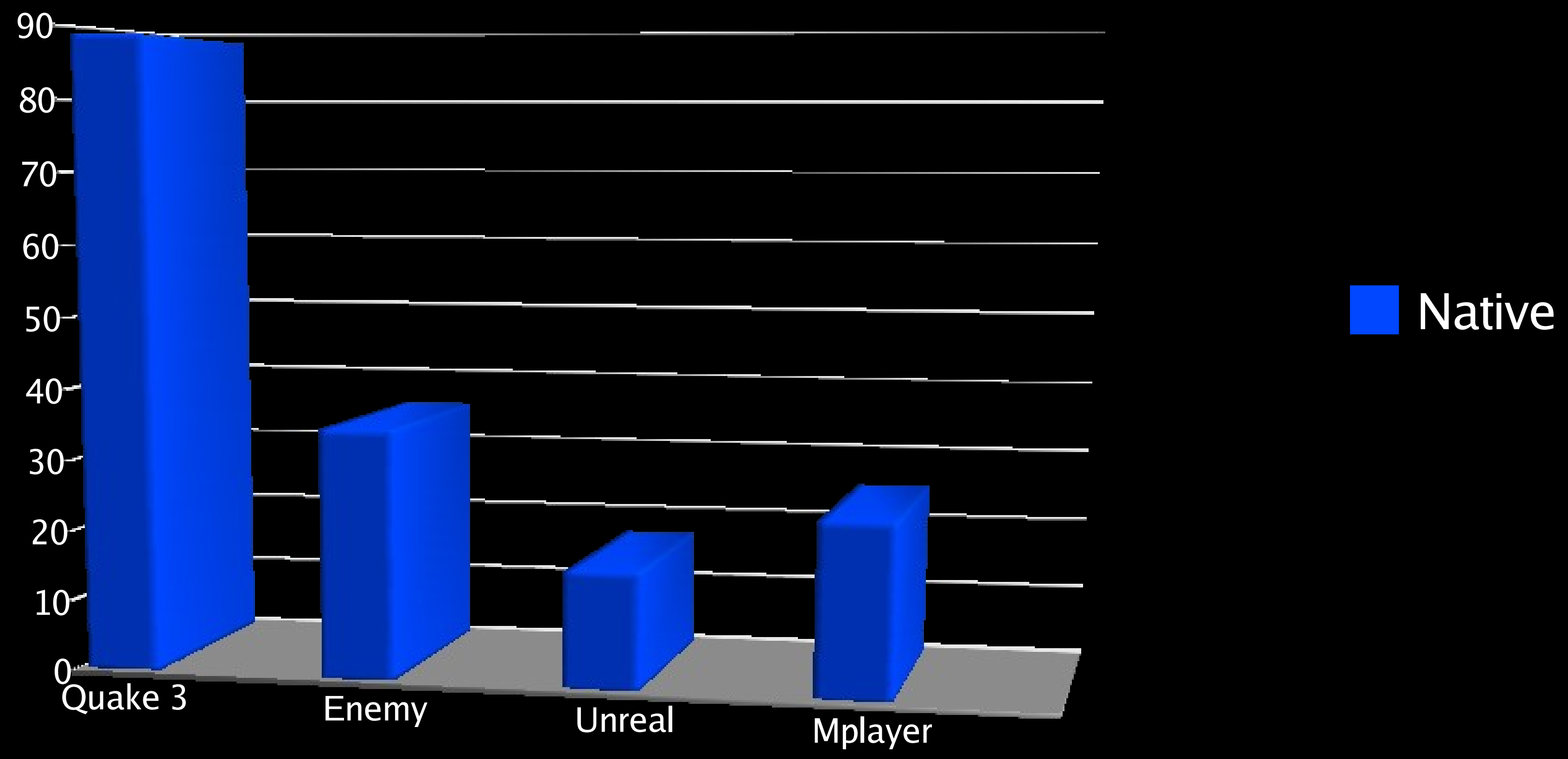
```
DEMO CONTROLS
TAB         scores
F1-F5       avidemo record
F11-F12     screenshot

KP_DOWN     slow down (--)
KP_LEFT     slow down (-)
KP_UP       speed up (++)
KP_RIGHT    speed up (+)
SPACE       normal speed

ENTER       External view
LFT/RGHT    Change angle
UP/DOWN     Move in/out

BACKSPACE help on/off
```

Enemy Territory

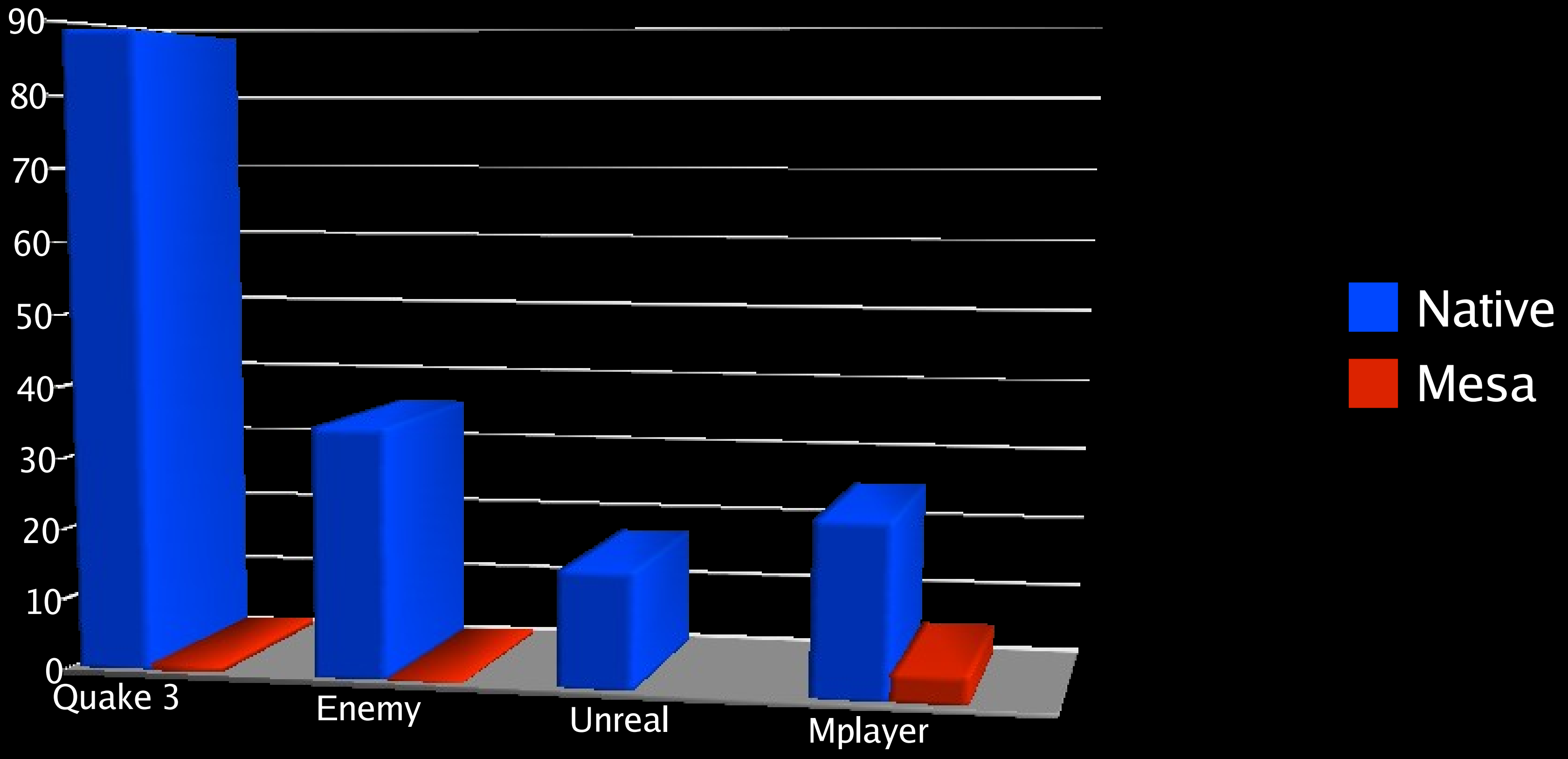
Unreal 2004

Mplayer

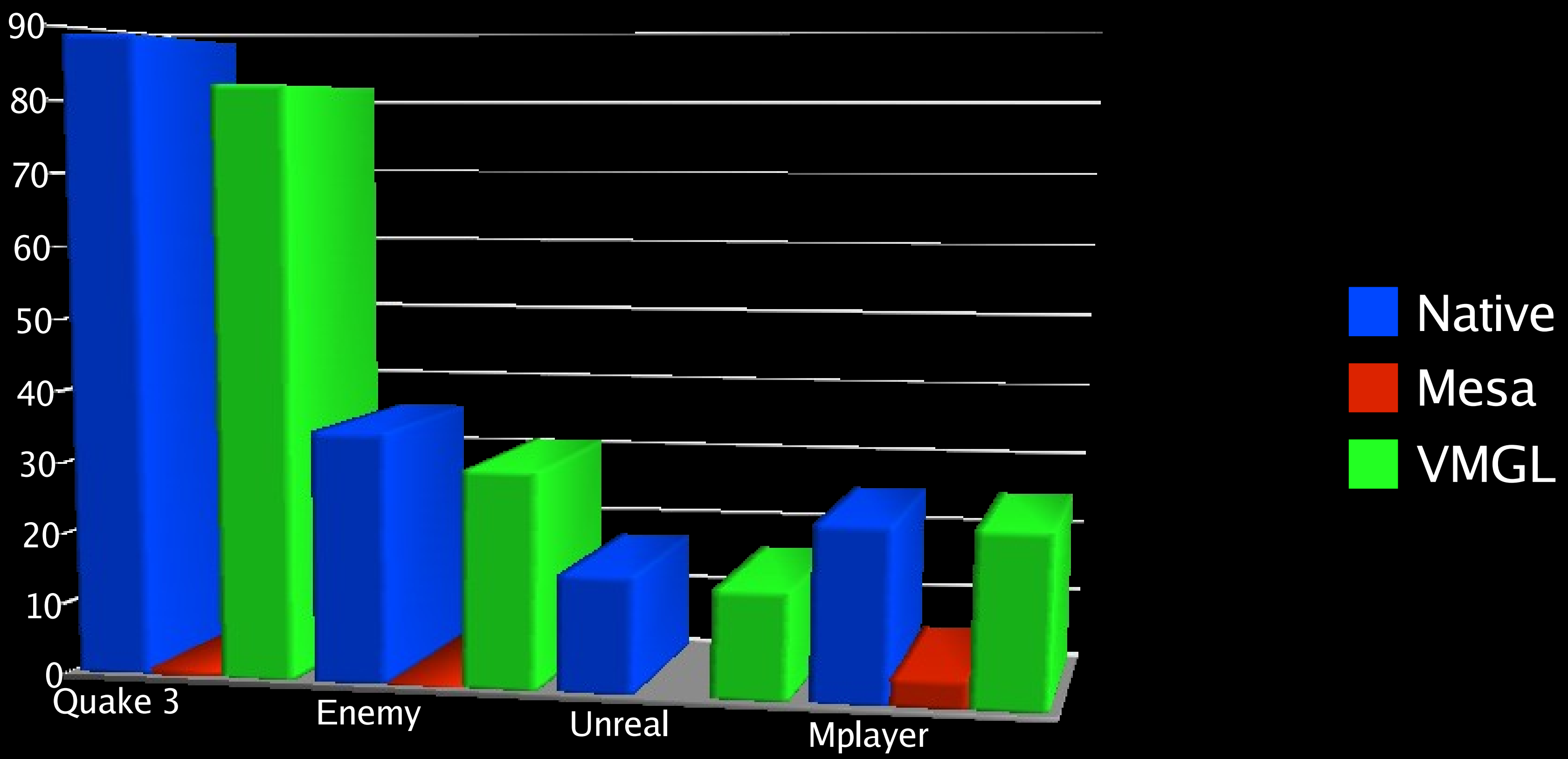
Performance (FPS)



Performance (FPS)

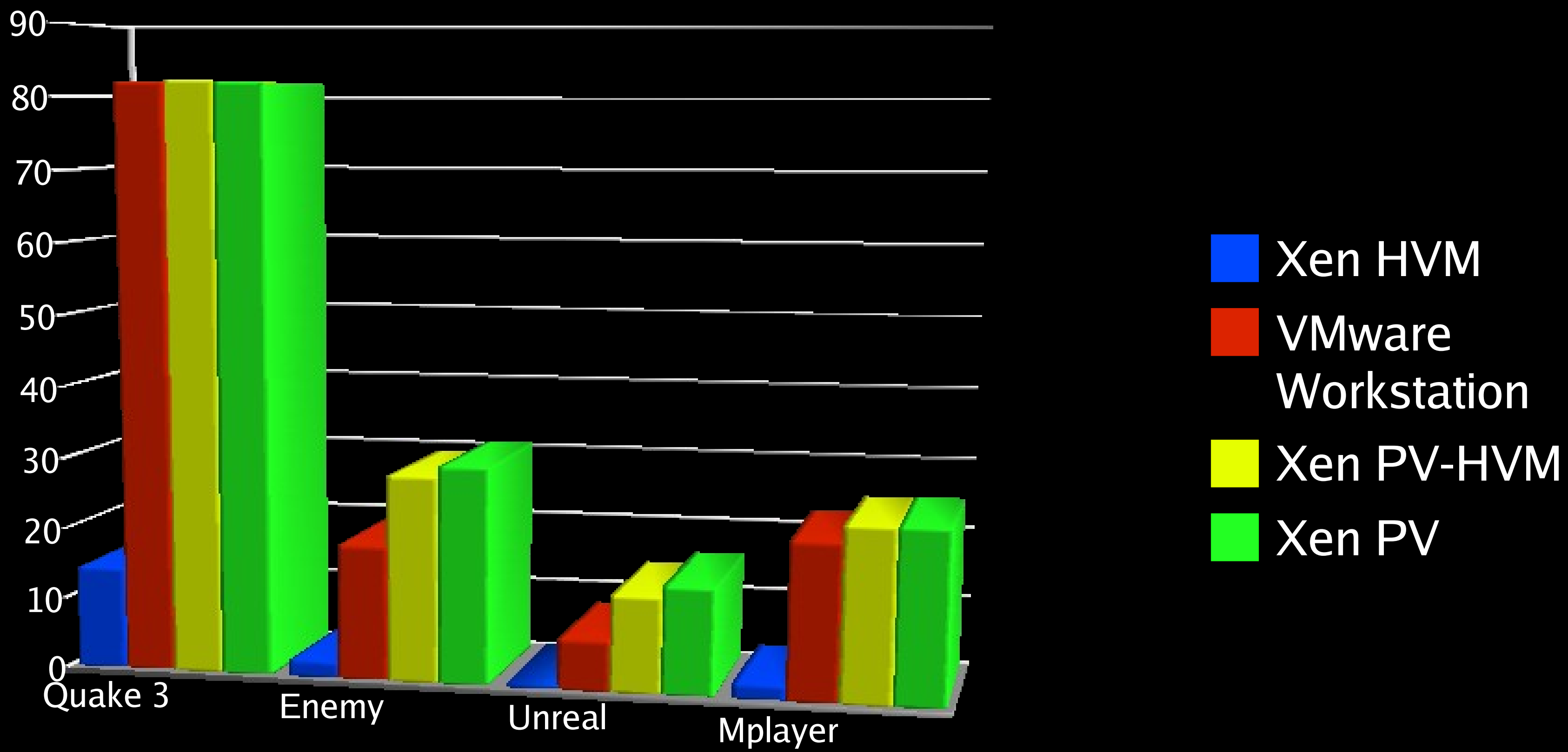


Performance (FPS)



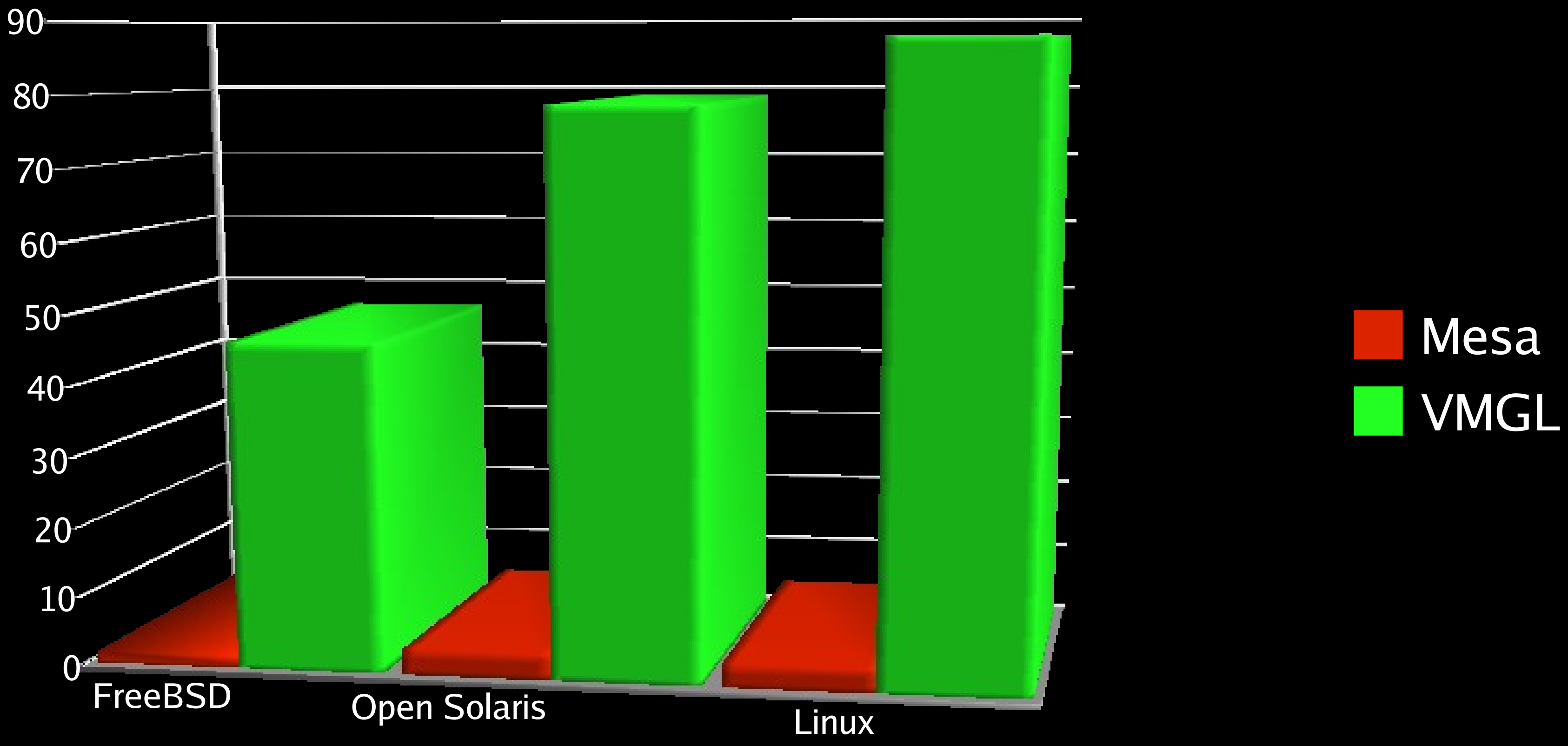
- 87% or better of native performance

VMM Portability (FPS)



- VMM and VM type independent

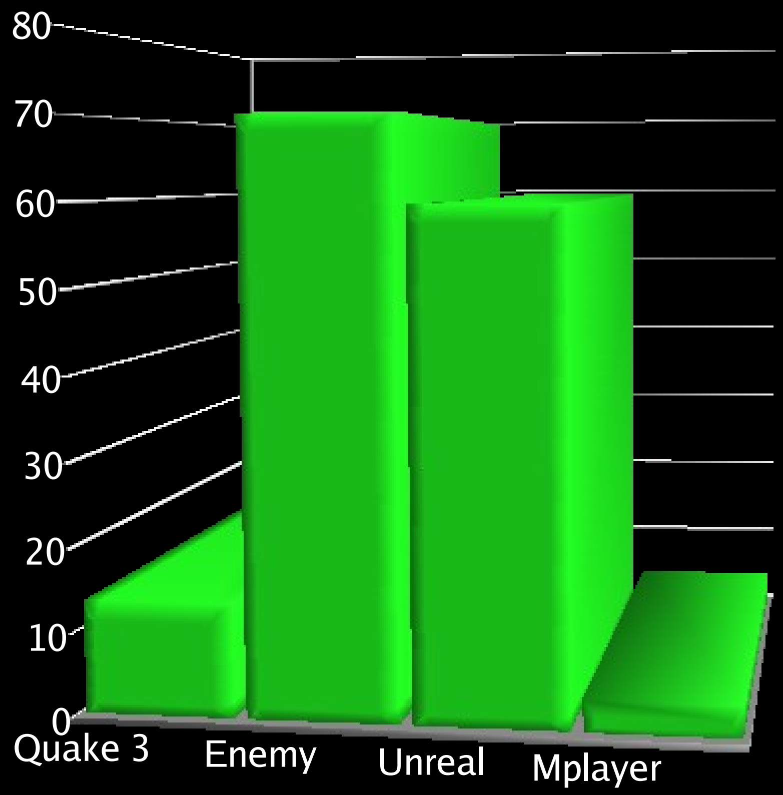
Guest OS Portability (FPS)



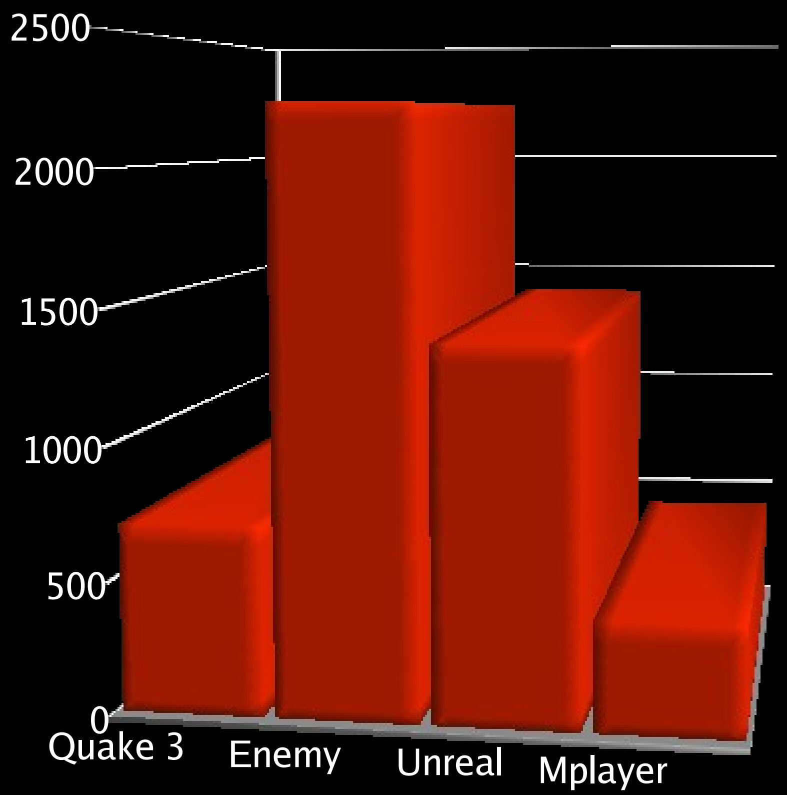
- Easily ported to other X11-based OSs

Suspend Resume Performance

State Size(MBs)



Resume Time (ms)



- State size bounded
- Also across GPUs from different vendors

Wrapping Up

VMGL: OpenGL virtualization -> 1K downloads

Enable intersection of two growing trends

- Virtualization
- 3D Graphics

GPU/vendor independence
VMM independence
Guest OS independence

To appear @ VEE 2007

- More eval & details there

TODO

Xen-specific improvements

- Shared memory transport (XenSocket?)

Windows

- Code porting
- Window Manager hooks
- Direct3D support via translation layers

THANKS

Demo

Q&A

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