Blink: 3D Display Multiplexing for Virtualized Applications

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January 20, 2006

Introduction
- Motivation

History: The Tahoma Project
- Sprites and Tiles
- Lessons Learned

Blink
- GL in, GL out
- Communication Protocol
- JIT Compiler for OpenGL
- Stored Procedures
- Safety Checks

Evaluation
- Compiler
- Graphics Throughput

Demo

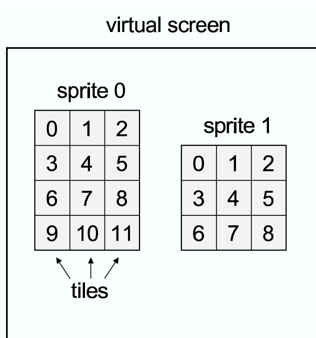
Why VM's need Graphic Acceleration

Virtual Machines are not only for data centers:

- VMWare now ships a free Firefox VM
- The Stanford Collective "Virtual Appliance" Application Bundles
- The CMU Internet Suspend Resume project
- Some distro installers need graphics
- We should be able to do better than VNC

Project Background

- Blink started as part of the “Tahoma” Browser OS
- First developed at the University of Washington, early 2005
- For *Tiled* 2D graphics
- Idea: Treat 4kB pages as 32x32 tiles, track updates with MMU
- Backend draws tile-grids (*Sprites*) to the screen with OpenGL



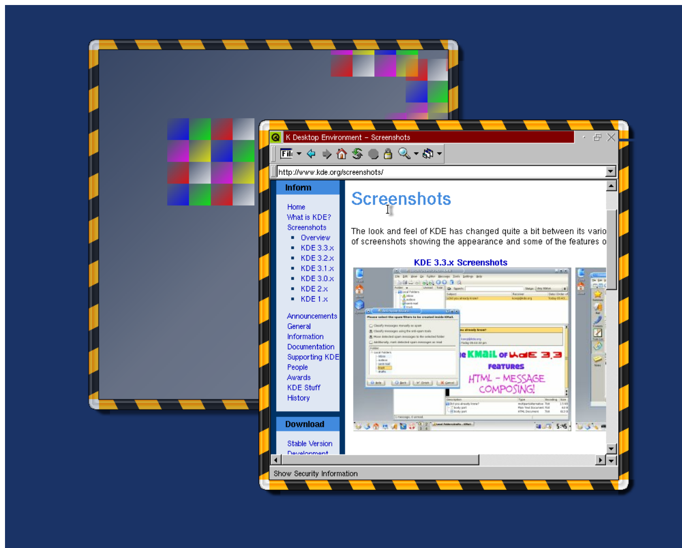
(a)

```
struct {
   int  tile_MFN;  // tile frame #
} tile;

struct {
   int   x, y;               // sprite posn.
   int   width, height  // # tiles
   tile  tile_array[ ];
} sprite;

struct {
   int       num_sprites;
   sprite  sprite_array[ ];
} virt_screen;
```

(b)


K Desktop Environment - Screenshots
http://www.kde.org/screenshots/
Inform
Home
What is KDE?
Screenshots
Overview
KDE 3.3.x
KDE 3.2.x
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Screenshots
The look and feel of KDE has changed quite a bit between its vario
of screenshots showing the appearance and some of the features o
KDE 3.3.x Screenshots
Show Security Information

Lessons Learned

- Modern GPU's are extremely fast
- Tiles make update tracking easy, thus reduces bus traffic
- But most software expects a linear framebuffer
- And porting QT embedded to tiles was quite painful

A Natural Thought

So...

- If we are going to *output* OpenGL anyway...
- Why not just take OpenGL as input as well?
- Read serialized from Client
  - Interpret it
  - Check that it's safe
  - Execute it
- (Then we can always do the tiling in the client if we want)

Serialize OpenGL in Client

Turn:

```
glBegin(n);
```

into:

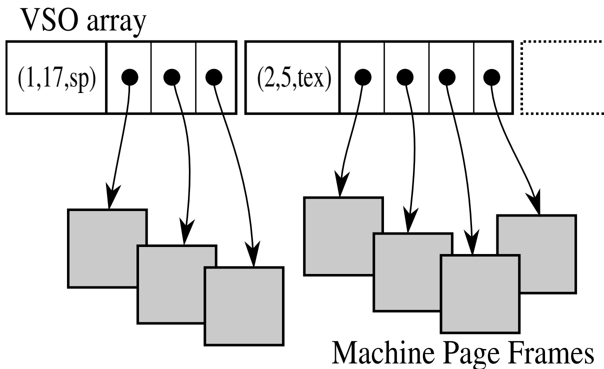
```
op->code=GL_Begin;
op->args[0]=n;
```

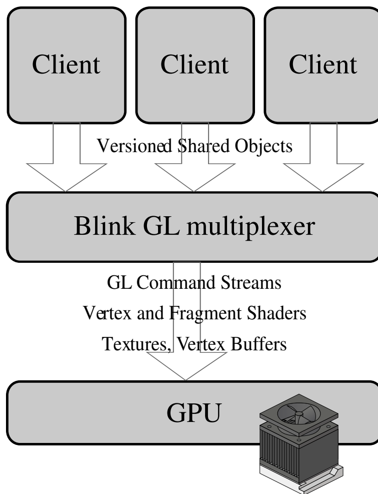
And Interpret it in the Server

```
switch(op->code)
{
    case GL_Begin:
        glBegin(op->args.integers[0]);
        break;
        ...
}
```

(turns in to a rather large switch() statement)

Versioned Shared Objects




Client
Client
Client
Versioned Shared Objects
Blink GL multiplexer
GL Command Streams
Vertex and Fragment Shaders
Textures, Vertex Buffers
GPU

A Couple of Improvements

- Turn the Interpreter into a JIT Compiler
- Add virtual registers, arithmetic, conditionals
- Call client code as *Stored Procedure* callbacks
- Results: Native speed asynchronous execution

List of Callbacks

Callback Name	Executed
`init()`	At first display
`update()`	On client VM request
`reshape()`	On window move or resize
`redraw()`	For each display
`input()`	On user input

Static Verification

Safety:

- We need to check certain properties during compilation...
- Not all callbacks are allowed to draw to screen
- Client should not exceed its *scissor* rectangle, or disable scissor

Performance:

- Advance knowledge of client actions can also be used for optimizing display
- E.g. if client does not enable Z-buffer, there is no need to clear it first
- If client does not use transparency, we do not have to draw windows behind it

Evaluation

Test Machine:

- 2GHz single-threaded Intel Pentium4 CPU
- 1024MB SDRAM
- 2+ years old
- ATI Radeon 9600SE 4xAGP graphics card with 128MB DDR RAM ($70).

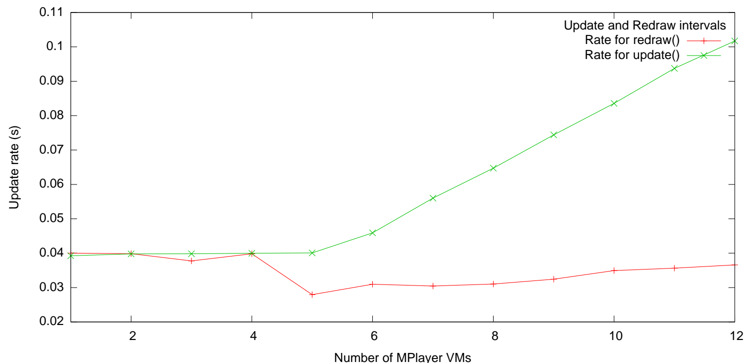
JIT Performance

Type of input	#Instr.	Compile	Execute
OpenGL-mix	8,034	102 (41) cpi	41 cpi
Arith-mix	8,192	99 (55) cpi	50 cpi

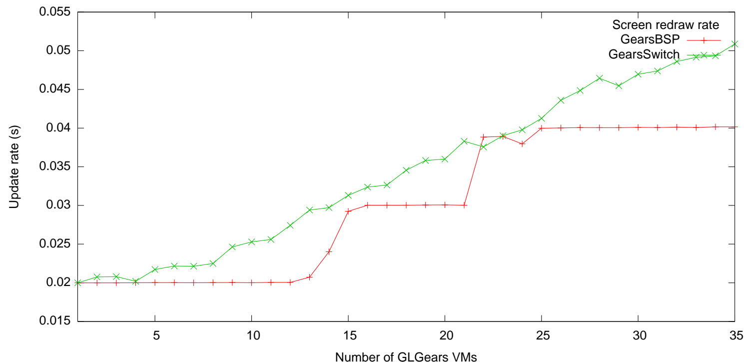
Quality of JIT'ed Code

Scenario	Execute
OpenGL-mix Native	552 cpi
OpenGL-mix Blink	554 cpi
OpenGL-mix Blink + JIT	656 cpi

MPlayer VM's



Gears VM's



Demo