

3D & Multimedia Across Platforms and Devices Using JOGL

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July 27, 2010

Who/What is JogAmp?

- Java Graphics, Audio, Media & Processing High Performance Bindings
 - JOGL → OpenGL
 - JOCL → OpenCL
 - JOAL → OpenAL
 - TODO → OpenMax
- One Stop Community Platform
 - SCM, Bugtracking, Buildserver, Mailinglist/Forum,...
- BSD License
- Commercial Support
- <http://jogamp.org>

Why Java?

- Availability:
 - Java, OpenGL, OpenCL, OpenAL, ..
 - Multiple Vendors
 - OpenJDK / IcedTea
 - Oracle JDK
 - IBM J9, ..
 - PhoneME
 - JamVM
 - CacaoVM
 - Dalvik
 - x86, arm, ppc, sh4, ..
 - GNU/Linux, BSD, MacOSX, MS Windows, QNX

Why Java?

- Managed Code
 - Common API for
 - Windowing
 - GLContext
 - Rendering
 - SwapBuffer
 - OpenGL Pipelining / Debugging / Trace
 - Access to vast number of API / Middleware

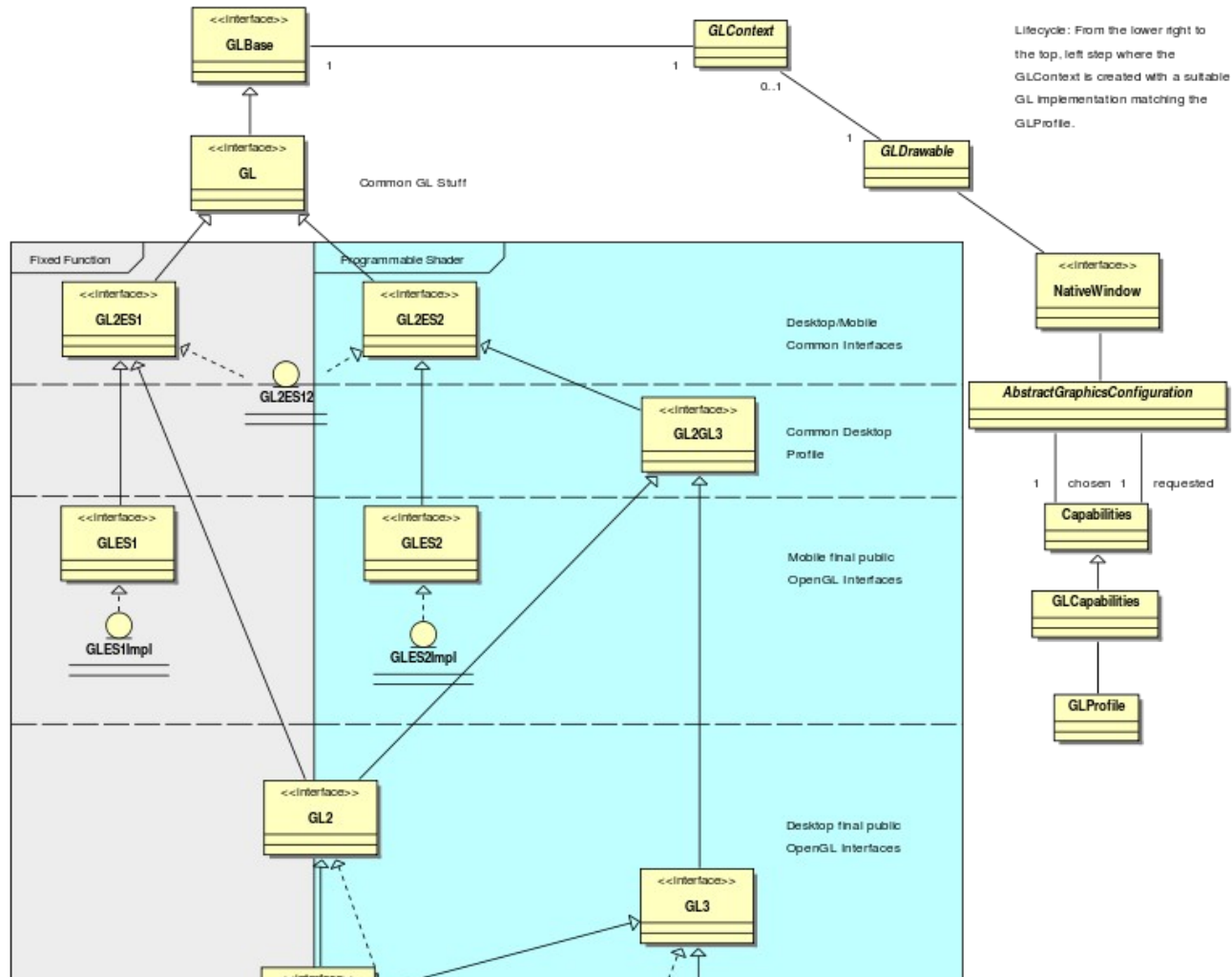
Continuity / Usage

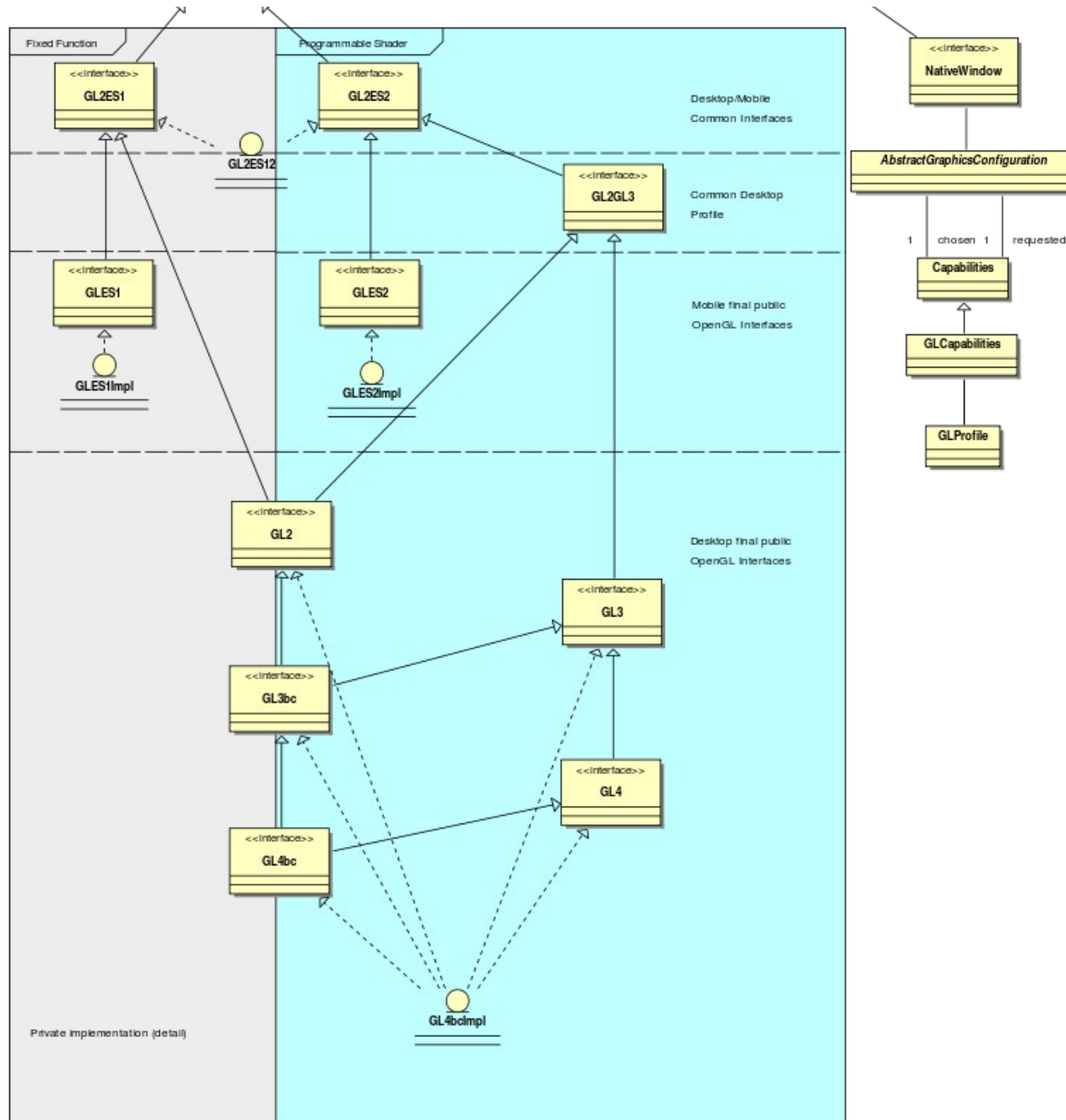
- Usage <http://jogamp.org/jogl/>
 - Ardor3D
 - C3D Studio <http://c3d.com>
 - Elflight Engine
 - Field/Processing
 - Gephi
 - NASA Worldwind
 - ...

Continuity / Maturity

- Maturity
 - Version 1
 - JSR-231
 - Version 2
 - OpenGL Profiles (ES 1+2, GL 2 + 3 + 4)
 - Windowing Toolkit Abstraction
 - Continuity Build/Test Server <http://jogamp.org/chuck/>
- Community Contributions
 - FreeBSD Port
 - JOAL Fixes
 - JOCL Project
 - Bugzilla Entries and Test Cases
 - Code Reviews

OpenGL Profiles





Flexible GL Profile Coding

```
import javax.media.opengl.*;           // Common JOGL
import com.jogamp.newt.*;             // Common NEWT

public void run() {
    GLProfile glp = GLProfile.getDefault(); // Get the platforms default GL profile
    GLCapabilities caps = new GLCapabilities(glp);
    GLDrawable drawable = GLWindow.create(caps);
    ...
    GL gl = drawable.getGL();
    int programs[] = new int[1];

    if( gl.isExtensionAvailable("GL_VERSION_2_0") ) {
        // able to use OpenGL 2.0 functionality
        programs[0] = gl.getGL2().glCreateProgram();
        ...
    }
    if( gl.isExtensionAvailable("GL_ARB_vertex_program") ||
        gl.isFunctionAvailable("glGenProgramsARB") ) {
        gl.getGL2().glGenProgramsARB(1, programs, 0);
    }
    ..
}
```

Flexible GL Profile Coding

```
...
GL gl = drawable.getGL();
...

// The following can be queried on a GL instance or the GLProfile itself
If ( gl.isGL4bc() )      {
    // OpenGL 4 Backward Compatible Profile Engine
    GL4bc gl4bc = gl.getGL4bc();
    ...
} else if ( gl.isGL4() )  {
    // OpenGL 4 Core Profile Engine
} else if ( gl.isGL3bc() ) {
    // OpenGL 3 Backward Compatible Profile Engine
} else if ( gl.isGL3() )  {
    // OpenGL 3 Core Profile Engine
} else if ( gl.isGL2() )  {
    // OpenGL 2 Profile Engine
} else if ( gl.isGLES1() ) {
    // OpenGL ES 1 Profile Engine
} else if ( gl.isGLES2() ) {
    // OpenGL ES 2 Profile Engine
} else {
    Throw new RuntimeException("No Engine Available For Unknown GL Profile: "+glp);
}
}
```

Windowing Toolkits

JOGL

Xyz

NativeWindow Interface

SWT

AWT

NEWT

X11
(Unix)

GDI
(Windows)

Coco
(MacOSX)

Framebuffer
(Mobile)

JOGL Example: AWT

```
96     GLCapabilities config = new GLCapabilities(GLProfile.get(GLProfile.GL2)); //1
97     config.setSampleBuffers(true); //2
98     config.setNumSamples(4); // 4x anti aliasing (just as example) //2
99
100    GLCanvas canvas = new GLCanvas(config); // something to render to //3
101    canvas.addGLEventListener(this); //4
102
103
104    JFrame frame = new JFrame("JOGL-JOCL Interoperability Example");
105    frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
106    frame.add(canvas); //5
107    frame.setSize(width, height);
108    frame.setVisible(true);
109
110    // start rendering thread
111    Animator animator = new Animator(canvas); //6
112    animator.start(); //6
```

1. Chose GL Profile
2. Config GL Capabilities
3. Create GLDrawable (AWT)
4. Hook GLEventListener to GLDrawable
5. Add GLDrawable to Window
6. Animator Thread

JOGL Example: GLEventListener

```
96     GLCapabilities config = new GLCapabilities(GLProfile.get(GLProfile.GL2));
97     config.setSampleBuffers(true);
98     config.setNumSamples(4); // 4x anti aliasing (just as example)
99
100     GLCanvas canvas = new GLCanvas(config); // something to render to
101     canvas.addGLEventListener(this);
...

114     public void init(GLAutoDrawable drawable) {
...
134         // enable GL error checking using the composeable pipeline
135         GL gl = drawable.getGL();
136         gl = gl.getContext().setGL(
137             GLPipelineFactory.create("javax.media.opengl.Debug", GL2.class, gl, null) );
138
139         gl.setSwapInterval(1);
...
14x     }

198     public void display(GLAutoDrawable drawable) {
199
200         GL2 gl = drawable.getGL().getGL2();
201         gl.glClear(...);
...

```

AWT Agnostic Coding

```
import javax.media.opengl.*;           // Common JOGL
import com.jogamp.newt.Window;         // Common NEWT
import com.jogamp.newt.event.*;       // Generic NEWT Event Handling
import com.jogamp.newt.event.awt.*;   // NEWT → AWT Adapter
import java.awt.Component;            // Identify if GLDrawable is AWT (GLCanvas)

class GearsMouseAdapter extends MouseAdapter {
    public void mousePressed(MouseEvent e) {
        ..
    }
}

public void init(GLAutoDrawable drawable) {
    ..
    MouseListener gearsMouse = new GearsMouseAdapter();

    if (drawable instanceof Component) {
        Component comp = (Component) drawable;
        new AWTMouseAdapter(gearsMouse).addTo(comp);
    } else if (drawable instanceof Window) {
        Window window = (Window) drawable;
        window.addMouseListener(gearsMouse);
    }
    ..
}
```

NEWT Requirements (*done*)

- Seamless integration into the platform's
 - Creation/Destruction of top level and child windows
 - Multithreaded Access to Window Surface
 - Re - Parenting
 - Decorated- and Undecorated - Windows
 - Passive Fullscreen Mode, no change of display mode
 - Event handling, at least per creation thread

NEWT Requirements (*todo*)

- Transparency (*API prepared*)
- Active Fullscreen Mode
(*change display mode, API prepared*)
- Drag & Drop (*Pending*)

UI Requirements *(todo)*

- Should be abstracted from the windowing toolkit
- Should support multithreading
- Seamless integration into
 - A native window (HUD)
 - A custom Scenegraph (2D plane within 3D)

UI Requirements *(todo)*

- Generic UI Rendering
 - Rendering shall be performed using native rendering TKs (JOGL, ..)
 - Render primitives on an offscreen 2D plane to be
 - integrated into a custom 3D scenegraph
 - rendered as a HUD.
- Generic User Input
 - Input events should be delegated from the custom scenegraph to the UI input module.

JOCL Introduction

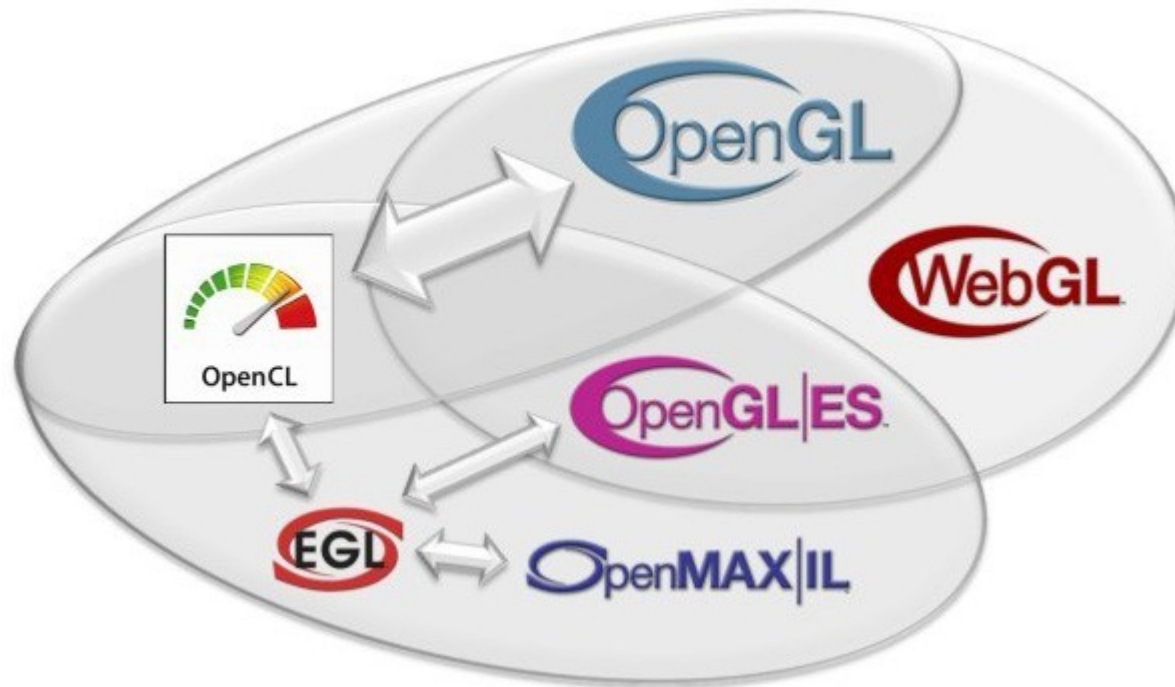
JOCL is an OpenCL language binding for the Java platform.

OpenCL allows to run high performance tasks within a heterogeneous system.

OpenCL performs well on data parallelism, hence it differs from the thread and task based models.

Implementations are provided in form of graphics drivers, compilers or within the operation system.

Context sharing



Hello World with JOCL

Sum array A and B (per element) and write the result into array C. (“VectorAdd”)

Procedure:

- OpenCL Context creation (Platform and device selection)
- OpenCL Program compilation and upload
- A and B initialization with random numbers
- A and B data upload
- Execute the OpenCL Kernel of the program
- Download C when result is available

Hello JOCL

A+B=C

```
24 public static void main(String[] args) throws IOException {
25
26     int elementCount = 11444777;
27     int localWorkSize = 256;
28     int globalWorkSize = roundUp(localWorkSize, elementCount);
29
30     // set up
31     CLContext context = CLContext.create();
32
33     CLProgram program = context.createProgram(HelloJOCL.class.getResourceAsStream("VectorAdd.cl")).build();
34
35     CLBuffer<FloatBuffer> clBufferA = context.createFloatBuffer(globalWorkSize, READ_ONLY);
36     CLBuffer<FloatBuffer> clBufferB = context.createFloatBuffer(globalWorkSize, READ_ONLY);
37     CLBuffer<FloatBuffer> clBufferC = context.createFloatBuffer(globalWorkSize, WRITE_ONLY);
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```

Context creation for default Platform + all Devices

Compile + link OpenCL Program for all devices of the context.

Hello JOCL

A+B=C

```
24 public static void main(String[] args) throws IOException {
25
26     int elementCount = 11444777;           // Length of arrays to process (random number)
27     int localWorkSize = 256;              // Local work size dimensions
28     int globalWorkSize = roundUp(localWorkSize, elementCount); // rounded up to the nearest
29                                           // multiple of the localWorkSize
30
31     // set up
32     CLContext context = CLContext.create();
33
34     CLProgram program = context.createProgram>HelloJOCL.class.getResourceAsStream("VectorAdd.cl").build();
35
36     CLBuffer<FloatBuffer> clBufferA = context.createFloatBuffer(globalWorkSize, READ_ONLY);
37     CLBuffer<FloatBuffer> clBufferB = context.createFloatBuffer(globalWorkSize, READ_ONLY);
38     CLBuffer<FloatBuffer> clBufferC = context.createFloatBuffer(globalWorkSize, WRITE_ONLY);
```

Create Java FloatBuffer
+ OpenCL Buffer

Buffer length

Access mode;
allowing misc. optimizations

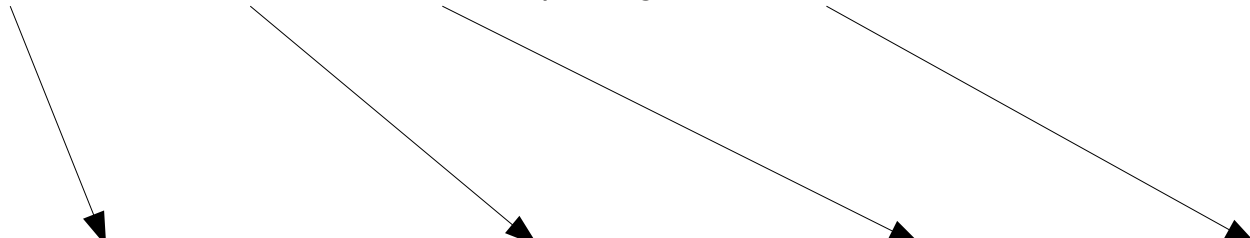
Hello JOCL

A+B=C

```
35     CLBuffer<FloatBuffer> clBufferA = context.createFloatBuffer(globalWorkSize, READ_ONLY);
36     CLBuffer<FloatBuffer> clBufferB = context.createFloatBuffer(globalWorkSize, READ_ONLY);
37     CLBuffer<FloatBuffer> clBufferC = context.createFloatBuffer(globalWorkSize, WRITE_ONLY);
...
46     // get a reference to the kernel function with the name 'VectorAdd'
47     CLKernel kernel = program.createCLKernel("VectorAdd");

48     // and map the buffers to its input parameters.
49     kernel.putArgs(clBufferA, clBufferB, clBufferC).putArg(elementCount);

1 // VectorAdd.cl
2 // OpenCL Kernel Function
3 kernel void VectorAdd(global const float* a, global const float* b, global float* c, int elements) {
...
15 }
16
```

The diagram consists of four arrows pointing from the arguments of the `putArgs` call in the host code to the corresponding parameters in the kernel function signature. The first arrow points from `clBufferA` to `global const float* a`. The second arrow points from `clBufferB` to `global const float* b`. The third arrow points from `clBufferC` to `global float* c`. The fourth arrow points from `elementCount` to `int elements`.

Hint:

`putArg(arg)` increments internal index, `rewind()` resets it to 0.
`setArg(index, arg)` uses the explicit index.

Hello JOCL

A+B=C

```
51 // create command queue on fastest device.
52 CLCommandQueue queue = context.getMaxFlopsDevice().createCommandQueue();
53
54 // asynchronous write of data to GPU device, blocking read later to get the computed results back.
55 queue.putWriteBuffer(clBufferA, false)
56     .putWriteBuffer(clBufferB, false)
57     .put1DRangeKernel(kernel, 0, globalWorkSize, localWorkSize)
58     .putReadBuffer(clBufferC, true);
59
60 // cleanup all resources associated with this context.
61 context.release();
```

Command Queue of fastest device.

“blocking read”

```
1
2 // OpenCL Kernel Function for element by element vector addition
3 kernel void VectorAdd(global const float* a, global const float* b, global float* c, int numElements) {
4
5     // get index into global data array (0 means first dimension)
6     int iGID = get_global_id(0);
7
8     // bound check (equivalent to the limit on a 'for' loop for standard/serial C code)
9     if (iGID >= numElements) {
10         return;
11     }
12
13     // add the vector elements
14     c[iGID] = a[iGID] + b[iGID];
15 }
16
```

work item index

... result available in buffer C

Deployment

- Preinstalled Bundles
 - Applications
 - Mobile / Embedded Devices
- Online / Cached
 - Applet
 - Classical
 - JNLP
 - Webstart (JNLP)

Items in Progress

- JOAL test/demos
- NEWT MacOSX test/finish
- JOCL Stabilization/MacOSX
- Applets
- Mobile Platform
 - OpenJDK, Oracle's ARM Hotspot, ..
 - Snapdragon (ATI), Omap (PowerVR), ..
 - Linux and WinCE
- OpenGL 4.1

Roadmap

- OpenMAX (A/V)
 - HW Implementation (mobile)
 - SW Implementations (desktop)
 - LIMOA - LIM OpenMAX Implementation
 - Bellagio
- Text Rendering
 - Loop/Blinn, BSpline, GLSL, ..
- Generic UI

Q&A

- How to use GLSL?
- Is Cg supported?
- Why is neither Swing nor AWT recommended?
- How to write AWT agnostic code?
- Is there any IDE supported?

Thank You



- Dominik aka DemoscenePassivist
- Kenneth Russell
- Michael Bien
- Rami Santana
- Rayan Jreije
- .. and all the many contributors and sponsors