Khronos - Connecting Software to Silicon

- Khronos defines open, royalty-free standards to access graphics, media, compute and input hardware
- Khronos APIs are low-level – just above raw silicon – to create the “foundation” functionality needed on every platform
- Safe forum for industry cooperation
  ‘By the industry for the industry’
  - Open to any company to join
  - IP framework to protect members and industry

APIs enable software developers to turn silicon functionality into rich end user experiences
Board of Promoters

Over 100 members – any company worldwide is welcome to join

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Processor Parallelism

CPUs
Multiple cores driving performance increases

Emerging Intersection

Multi-processor programming – e.g. OpenMP

Heterogeneous Computing

GPUs
Increasingly general purpose data-parallel computing

Graphics APIs and Shading Languages

OpenCL is a programming framework for heterogeneous compute resources
The BIG Idea behind OpenCL

- **OpenCL execution model ...**
  - Define N-dimensional computation domain
  - Execute a kernel at each point in computation domain

- **C Derivative to write kernels – based on ISO C99**
  - APIs to discover devices in a system and distribute work to them

- **Targeting many types of device**
  - GPUs, CPUs, DSPs, embedded systems, mobile phones.. Even FPGAs

### Traditional loops

```c
void trad_mul(int n,
             const float *a,
             const float *b,
             float *c)
{
    int i;
    for (i=0; i<n; i++)
        c[i] = a[i] * b[i];
}
```

### Data Parallel OpenCL

```c
kernel void
dp_mul(global const float *a,
       global const float *b,
       global float *c)
{
    int id = get_global_id(0);
    c[id] = a[id] * b[id];
} // execute over "n" work-items
```
OpenCL Working Group

• Diverse industry participation — many industry experts
  - Processor vendors, system OEMs, middleware vendors, application developers

• Apple made initial proposal and is very active in the working group
  - Serving as specification editor
OpenCL 1.2

- Specification and full conformance tests now available
- Backward compatible upgrade to OpenCL 1.1
- OpenCL 1.2 will run any OpenCL 1.0 and OpenCL 1.1 programs
- OpenCL 1.2 platform can contain 1.0, 1.1 and 1.2 devices
- Maintains embedded profile for mobile and embedded devices
OpenCL Milestones

- **Multiple conformant implementations shipping**
  - For CPUs and GPUs on multiple OS

- **18 month cadence between OpenCL 1.0, OpenCL 1.1 and OpenCL 1.2**
  - Backwards compatibility protect software investment
New Features in OpenCL 1.2

• Partitioning Devices
  - Applications can partition a device into sub-devices
  - Enables computation to be assigned to specific compute units
  - Reserve a part of the device for use for high priority/latency-sensitive tasks or effectively use shared hardware resources such as a cache

• Separate compilation and linking of objects
  - Provides the capabilities and flexibility of traditional compilers
  - Create a library of OpenCL programs that other programs can link with

• Enhanced Image Support
  - Added support for 1D images, 1D & 2D image arrays
  - OpenGL sharing extension now enables an OpenCL image to be created from an OpenGL 1D texture, 1D and 2D texture arrays
New Features in OpenCL 1.2 (continued)

- **Custom devices and built-in kernels**
  - Drive specialized custom devices from OpenCL – even if not programmable
  - Embedded platforms often contain hardware that cannot support OpenCL C
  - Built-in kernels represent hardware capabilities such as video encode/decode
  - Can enqueue built-in kernels to custom devices alongside OpenCL kernels

- **DX9 Media Surface Sharing**
  - Efficient sharing between OpenCL and DirectX 9 or DXVA media surfaces

- **DX11 surface sharing**
  - Efficient sharing between OpenCL and DirectX 11 surfaces
Installable Client Driver

- ICD released into open source!
- Analogous to OpenGL ICDs in use for many years
  - Used to handle multiple OpenGL implementations installed on a system
- Optional extension
  - Platform vendor will choose whether to use ICD mechanisms
- Khronos OpenCL installable client driver loader
  - Exposes multiple separate vendor installable client drivers (Vendor ICDs)
- Application can access all vendor implementations
  - The ICD Loader acts as a de-multiplexor

ICD Loader enables application to use any of the installed implementations

Vendor #1
OpenCL

Vendor #2
OpenCL

Vendor #3
OpenCL

ICD Loader ensures multiple implementations are installed cleanly
WebCL – Parallel Computing for the Web

• Khronos launching new WebCL initiative
  - First announced in March 2011
  - API definition already underway

• JavaScript binding to OpenCL
  - Security is top priority

• Many use cases
  - Physics engines to complement WebGL
  - Image and video editing in browser

• Stay close to the OpenCL standard
  - Maximum flexibility
  - Foundation for higher-level middleware
Visual Computing Ecosystem

High performance compute and graphics interop – buffer and events

Compute and mobile APIs interoperate through EGL

JavaScript bindings to OpenCL
Parallel computation in HTML5
WebCL Open Process and Resources

- Khronos open process to engage Web community
  - Public specification drafts, mailing lists, forums
  - [http://www.khronos.org/webcl/](http://www.khronos.org/webcl/)
  - webcl_public@khronos.org

- Khronos welcomes new members to define and drive WebCL
  - info@khronos.org

- Nokia open sourced prototype for Firefox in May 2011 (LGPL)
  - [http://webcl.nokiaresearch.com](http://webcl.nokiaresearch.com)

- Samsung open sourced prototype for WebKit in July 2011 (BSD)

- Deformation Demo:
  - Calculates and renders transparent and reflective deformed spheres on top of photo background
  - Performance comparison on Mac
    - JS: ~1 FPS
    - WebCL: 87-116 FPS
  - [http://www.youtube.com/user/SamsungSISA#p/a/u/1/9Ttx1A-Nuc](http://www.youtube.com/user/SamsungSISA#p/a/u/1/9Ttx1A-Nuc)
OpenCL Desktop Implementations

- http://developer.amd.com/zones/OpenCLZone/
OpenCL Books – Available Now!

• **OpenCL Programming Guide**
  - The “Red Book” of OpenCL

• **The OpenCL Programming Book**
  - By Fixstars

• **Japanese OpenCL 1.1 spec**
Khronos OpenCL Resources

- **OpenCL is 100% free for developers**
  - Download drivers from your silicon vendor

- **OpenCL Registry**
  - www.khronos.org/registry/cl/

- **OpenCL 1.2 Reference Card**
  - PDF version

- **Online Man pages**
  - http://www.khronos.org/registry/cl/sdk/1.2/docs/man/xhtml/

- **OpenCL Developer Forums**
  - Give us your feedback!
  - www.khronos.org/message_boards/
Looking Forward

**OpenCL-HLM**
Exploring high-level programming model, unifying host and device execution environments through language syntax for increased usability and broader optimization opportunities.

**Long-term Core Roadmap**
Exploring enhanced memory and execution model flexibility to catalyze and expose emerging hardware capabilities.

**OpenCL-SPIR**
Exploring low-level Intermediate Representation for code obfuscation/security and to provide target back-end for alternative high-level languages.