An Introduction to OpenCL

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Overview

- GPU Computing : What is it?
- What is OpenCL?
- Why OpenCL?
- Architecture
- Example Code
- Application

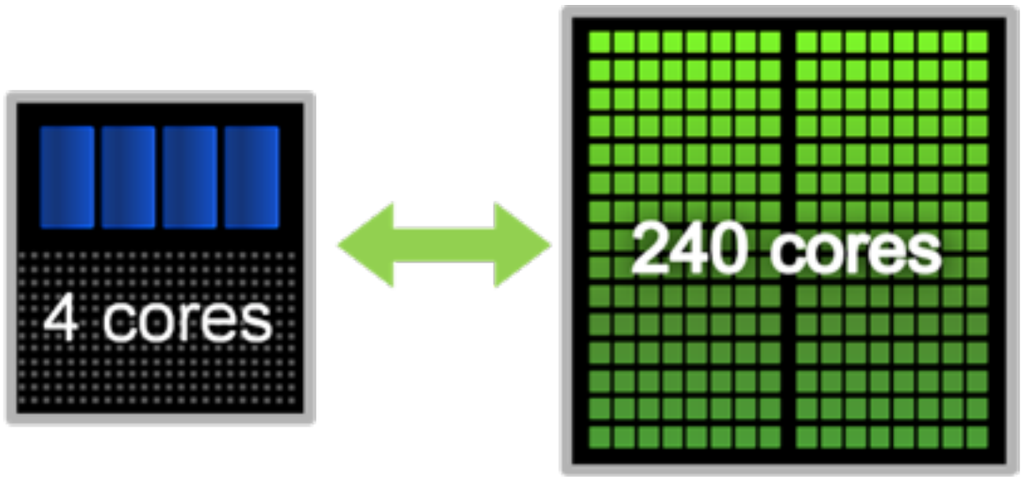
GPU Computing

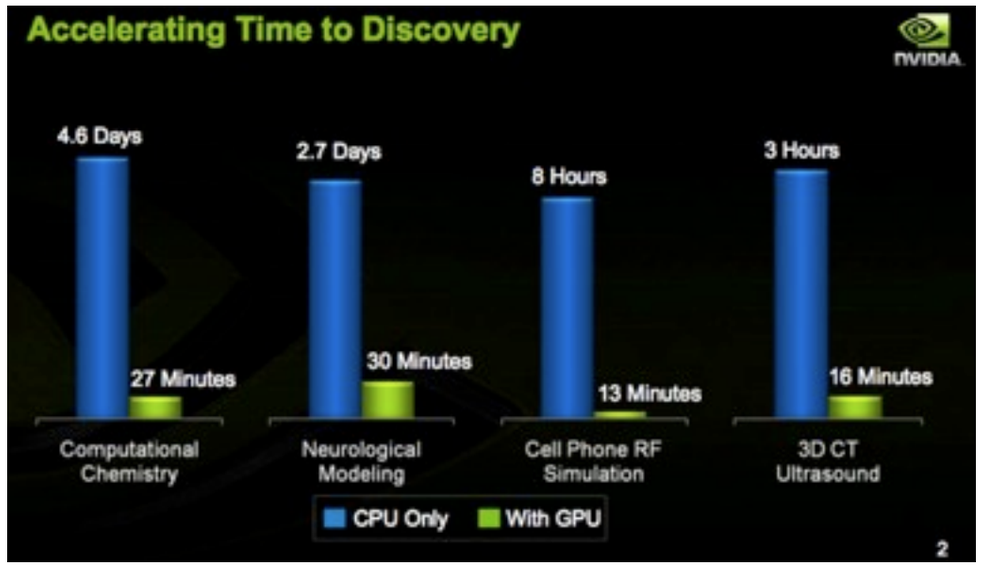
- Using the graphics card with the CPU for general purpose computing

- Take advantage of the inherent parallelism of many computationally intensive operations

- Limited by need to transform problems into the graphics ‘paradigm’

- Limited to certain operations



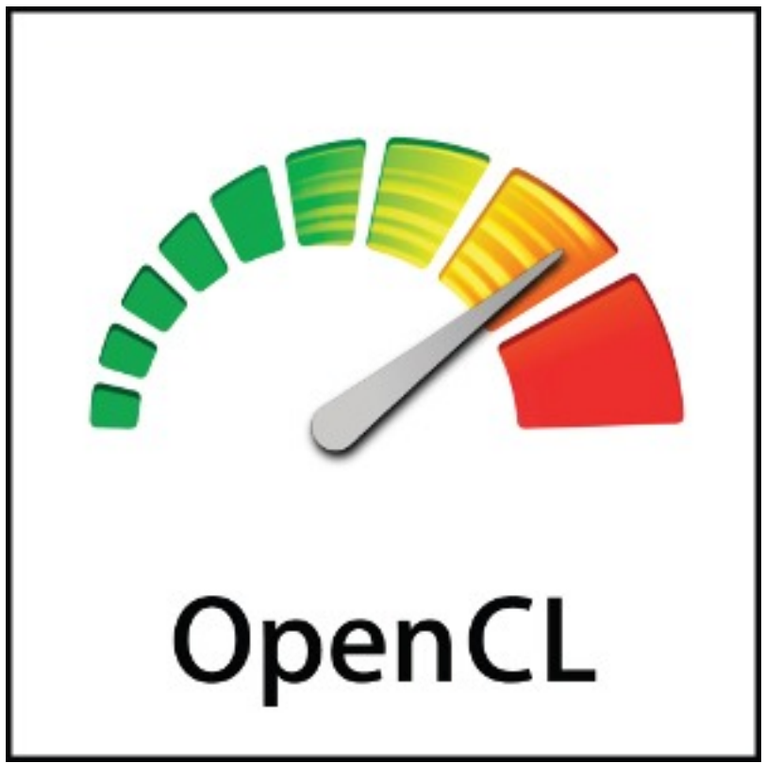


What is OpenCL?

- Framework based on open standards for parallel and distributed computing

- Based on ANSI C

- Must be supported by hardware
  - e.g. Builds on top of NVIDIA's CUDA architecture



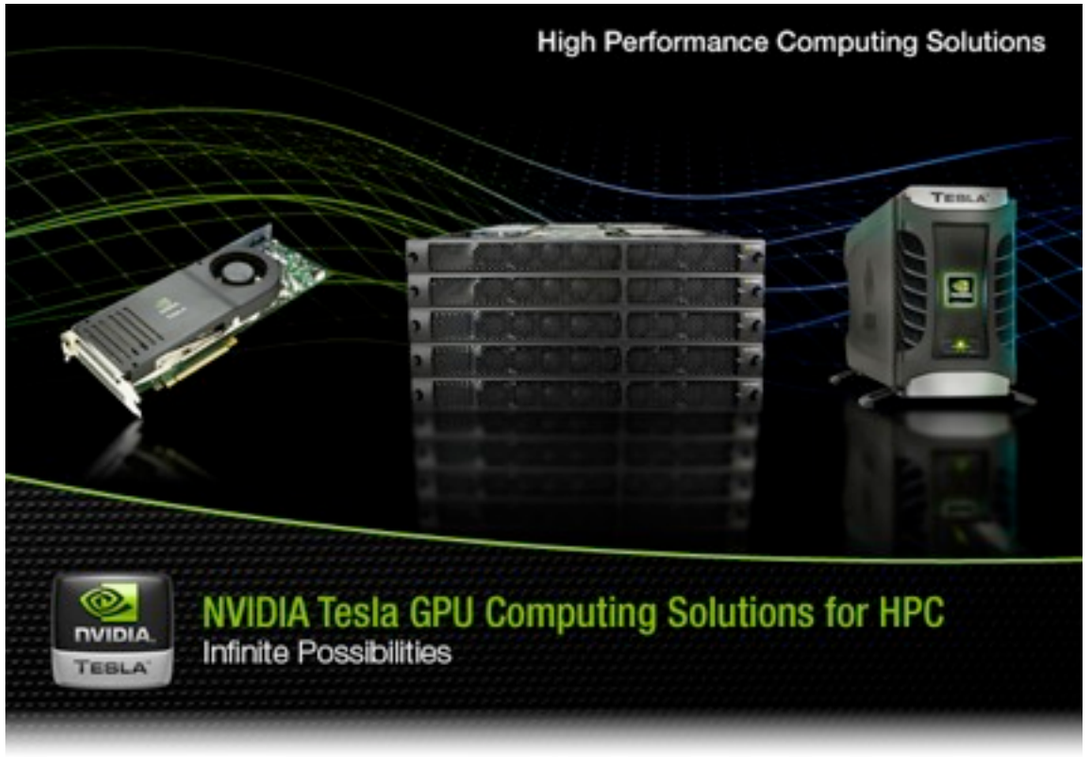
Why OpenCL?

- Allows you to write one piece of code that can then run over multiple machines/ architectures/operating systems

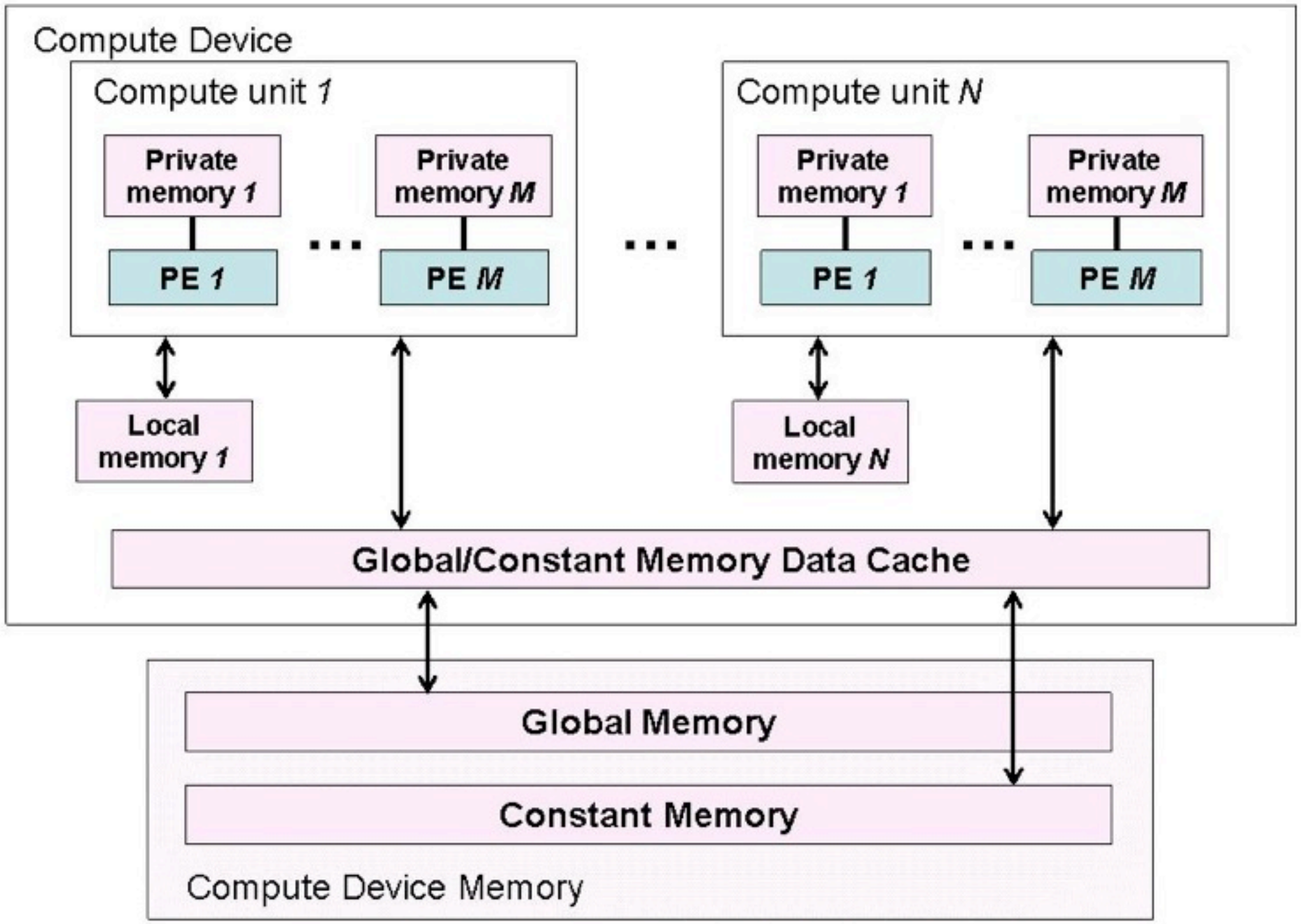
- BUT probably not optimal for all (or any) of the compute engines

- Allows for a broader range of CPU and GPU devices

- Can use **multiple** processing units.....



OpenCL Architecture



Basic Program Structure

- **Host program**
  - Create memory objects associated to contexts
  - Compile and create kernel program objects
  - Issue commands to command-queue
  - Synchronization of commands
  - Clean up OpenCL resources

Platform Layer

  - Query compute devices
  - Create contexts

Runtime

- **Compute Kernel (runs on device)**
  - C code with some restrictions and extensions

OpenCL Language

Example Code : Vector Addition

- Add two vectors together:

c[i] = a[i] + b[i]

- Equivalent c loop:

```
int iNumElements = 11444777;

for (int i = 0; i < iNumElements; i++) {
        c[ i ] = a[ i ] + b[ i ];
}
```

Example Code : Vector Addition

- **Set Up**
  - Set work sizes for kernel execution
  - Allocate and init host data buffers
  - Create context for GPU device
  - Query compute devices
  - Create command queue
  - Create buffers on the GPU device
  - Create and build a program
  - Create kernel
  - Set kernel arguments
- **Core sequence**
  - Copy (write) data from host to GPU
  - Launch kernel in command-queue
  - Copy (read) data from GPU to host... block
- **Clean up**

Kernel Code

- **Source code for the computation kernel, stored in text file (read from file and compiled at run time, e.g. during app. init)**

```
// OpenCL Kernel Function for element by element vector addition
// ****************************************************************************
__kernel void VectorAdd ( __global float* a, __global float* b, __global float* c,
                          __global int iNumElements)
{
    // get index into global data array
    int iGID = get_global_id(0);

    // bound check (equivalent to the limit on a 'for' loop for standard/serial C code
    if (iGID >= iNumElements)
    {
        return;
    }

    // add the vector elements
    c[iGID] = a[iGID] + b[iGID];
}
```

Demo of OpenCL Computation

....Realllllllly fast.....

OpenCL and OpenGL

- Can set up your 'context' so that OpenGL and OpenCL share buffers
- This points to a situation where OpenCL calculates your data (very quickly) and OpenGL plots it.
- The future for massive, complex visualisations...

Demo of OpenCL/OpenGL interoperability

Two open standards in one....

Summary

- OpenCL a new standard for Parallel computing
- Allows rapid computation (up to 100x speed increase) of certain problems
- Can also be used to improve visualisation times since shared buffers with OpenGL