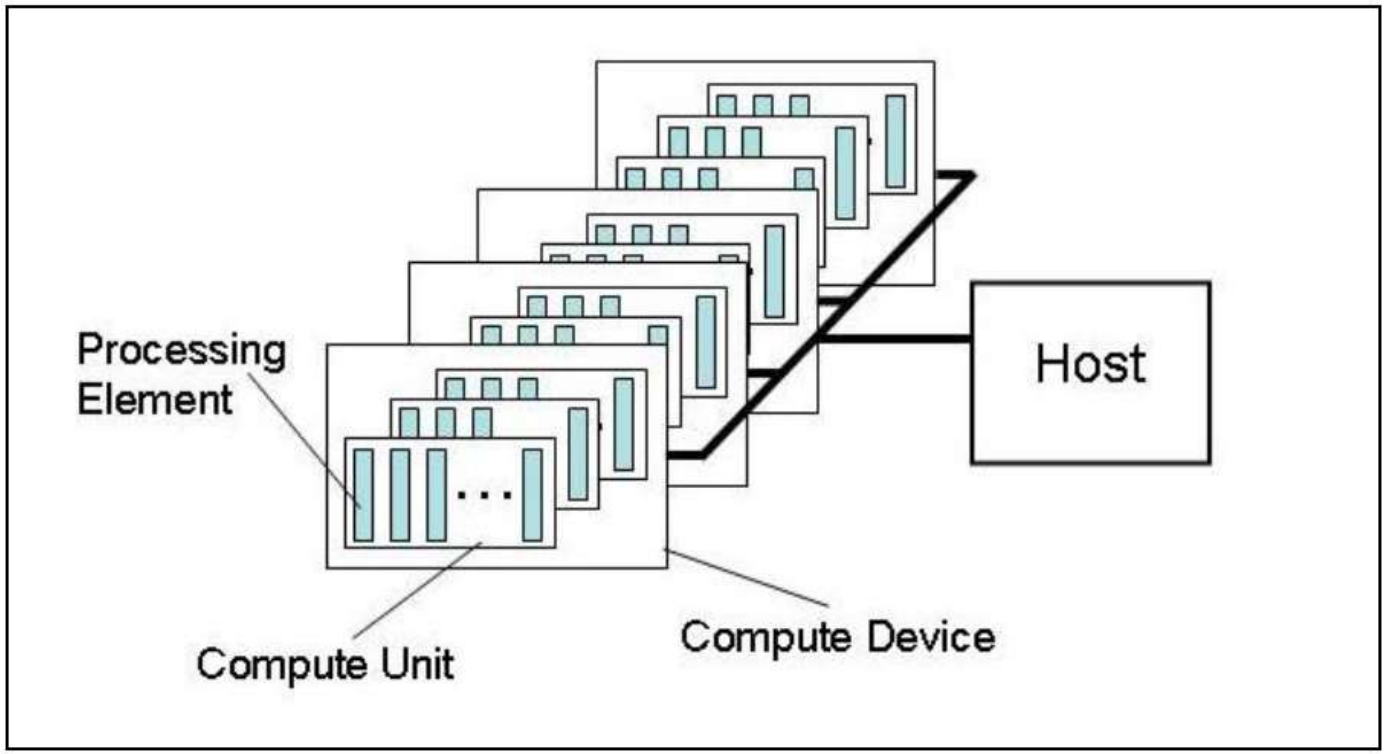
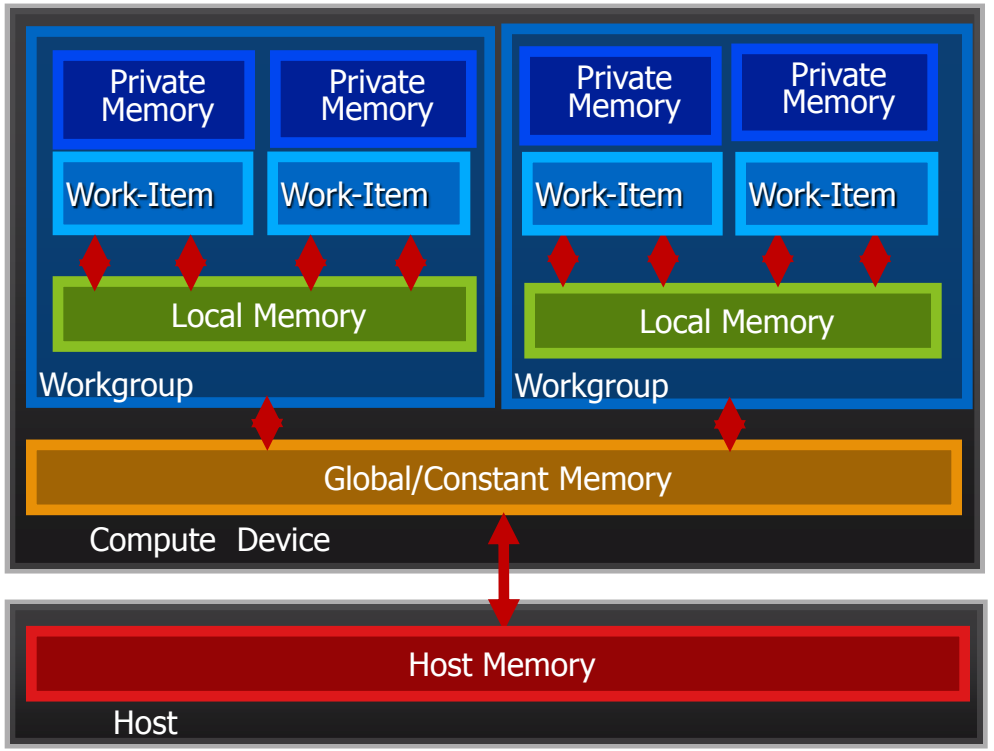
OpenCL Platform Model

- **One Host + one or more Compute Devices**
  - Each Compute Device is composed of one or more Compute Units
    - Each Compute Unit is further divided into one or more Processing Elements



OpenCL Memory Model

- **Private Memory**
  - Per work-item
- **Local Memory**
  - Shared within a workgroup
- **Global/Constant Memory**
  - Visible to all workgroups
- **Host Memory**
  - On the CPU

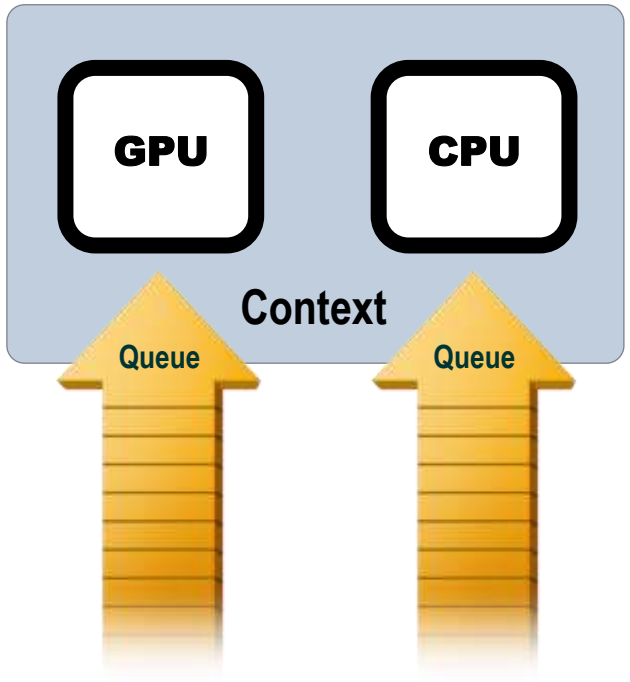


Memory management is Explicit

You must move data from host -> global -> local … *and* back

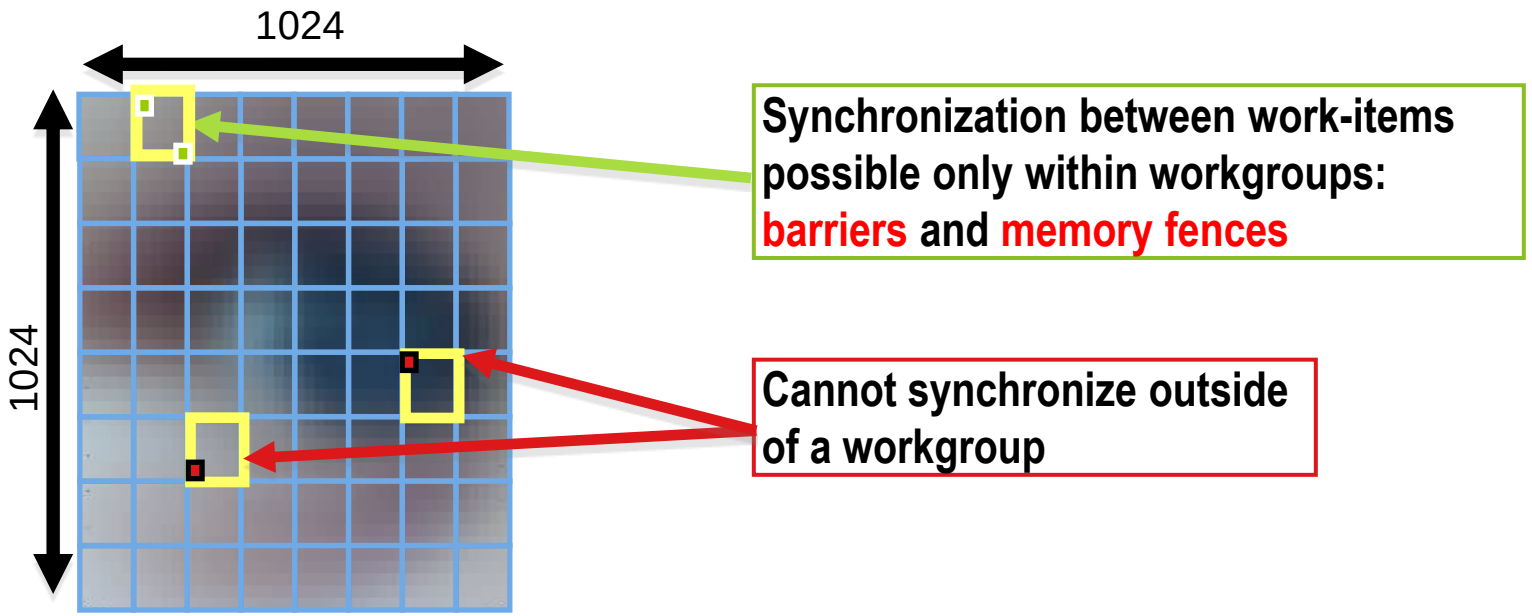
OpenCL Execution Model

- **OpenCL application runs on a host which submits work to the compute devices**
  - **Context**: The environment within which work-items executes … includes devices and their memories and command queues
  - **Program**: Collection of kernels and other functions (Analogous to a dynamic library)
  - **Kernel**: the code for a work item. Basically a C function
  - **Work item**: the basic unit of work on an OpenCL device
- **Applications queue kernel execution**
  - Executed in-order or out-of-order



An N-dimension domain of work-items

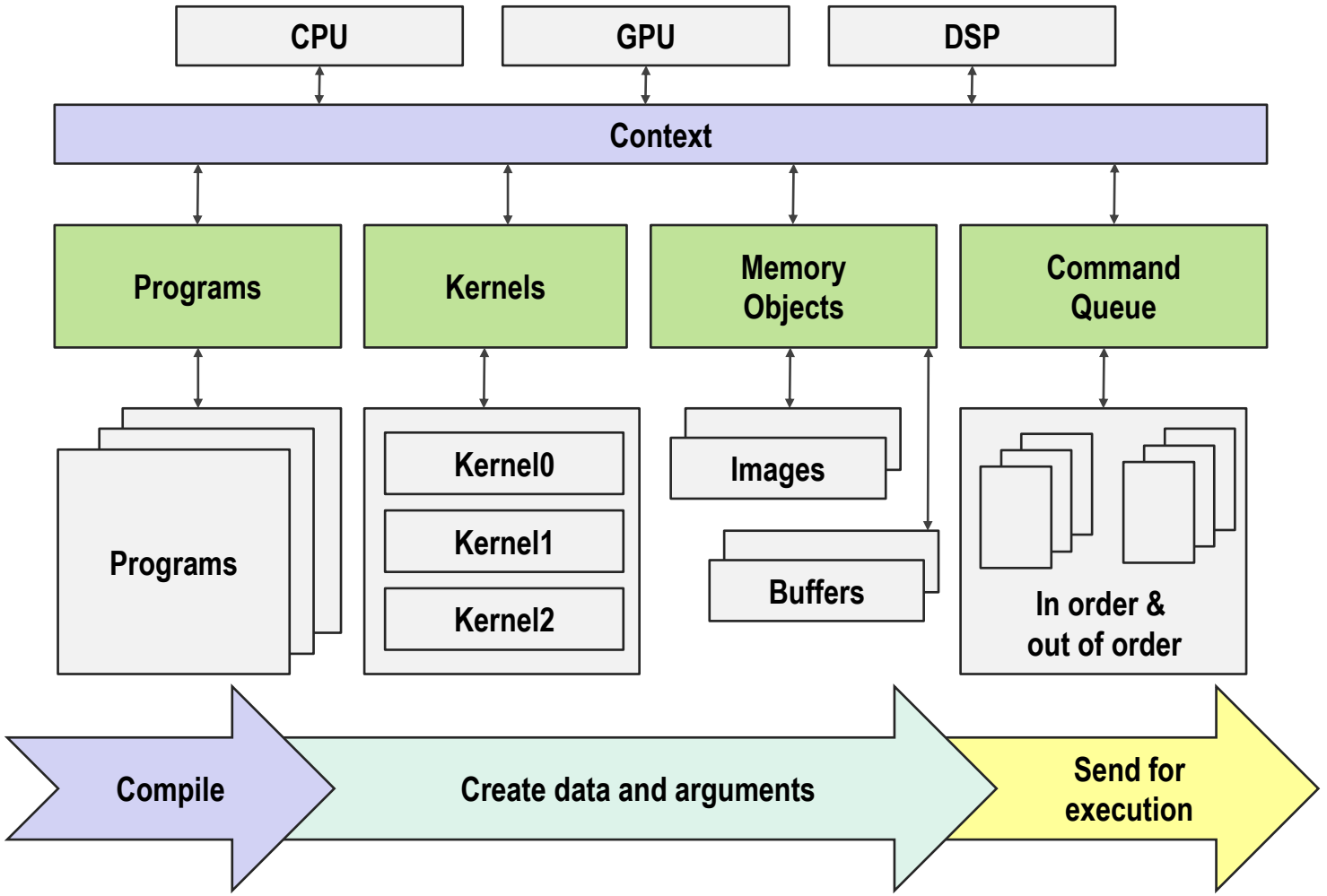
- **Kernels executed across a global domain of *work-items***
- **Work-items grouped into local *workgroups***
- **Define the "best" N-dimensioned index space for your algorithm**
  - Global Dimensions: 1024 x 1024 (whole problem space)
  - Local Dimensions: 128 x 128 (work group … executes together)



Programming Kernels: OpenCL C

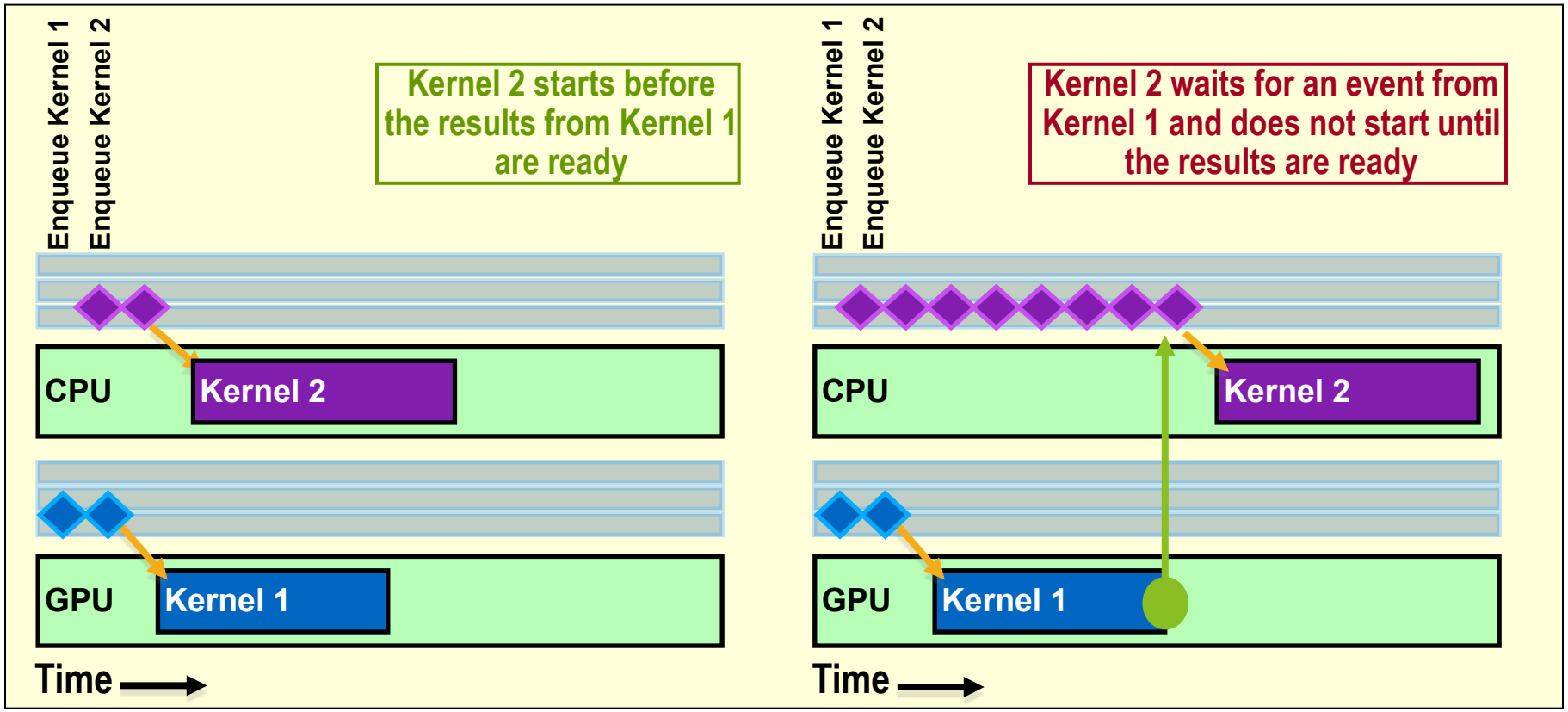
- **Derived from ISO C99**
  - But without some C99 features such as standard C99 headers, function pointers, recursion, variable length arrays, and bit fields
- **Language Features Added**
  - Work-items and workgroups
  - Vector types
  - Synchronization
  - Address space qualifiers
- **Also includes a large set of built-in functions**
  - Image manipulation
  - Work-item manipulation,
  - Math functions, etc.

Creating an OpenCL Program



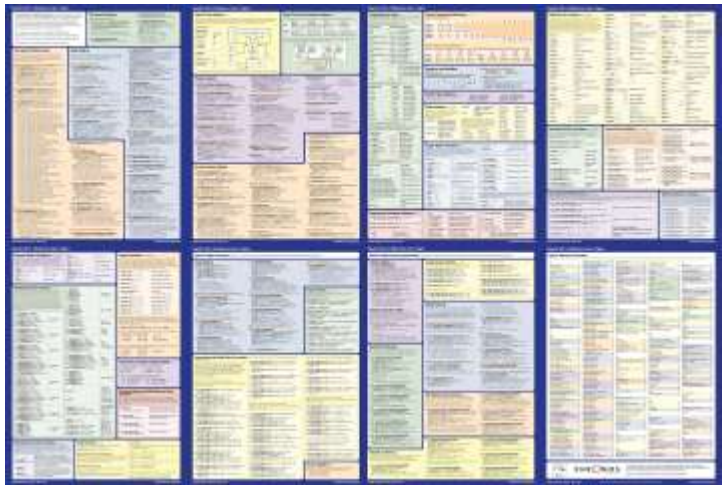
Synchronization: Queues & Events

- Events can be used to synchronize kernel executions between queues
- Example: 2 queues with 2 devices



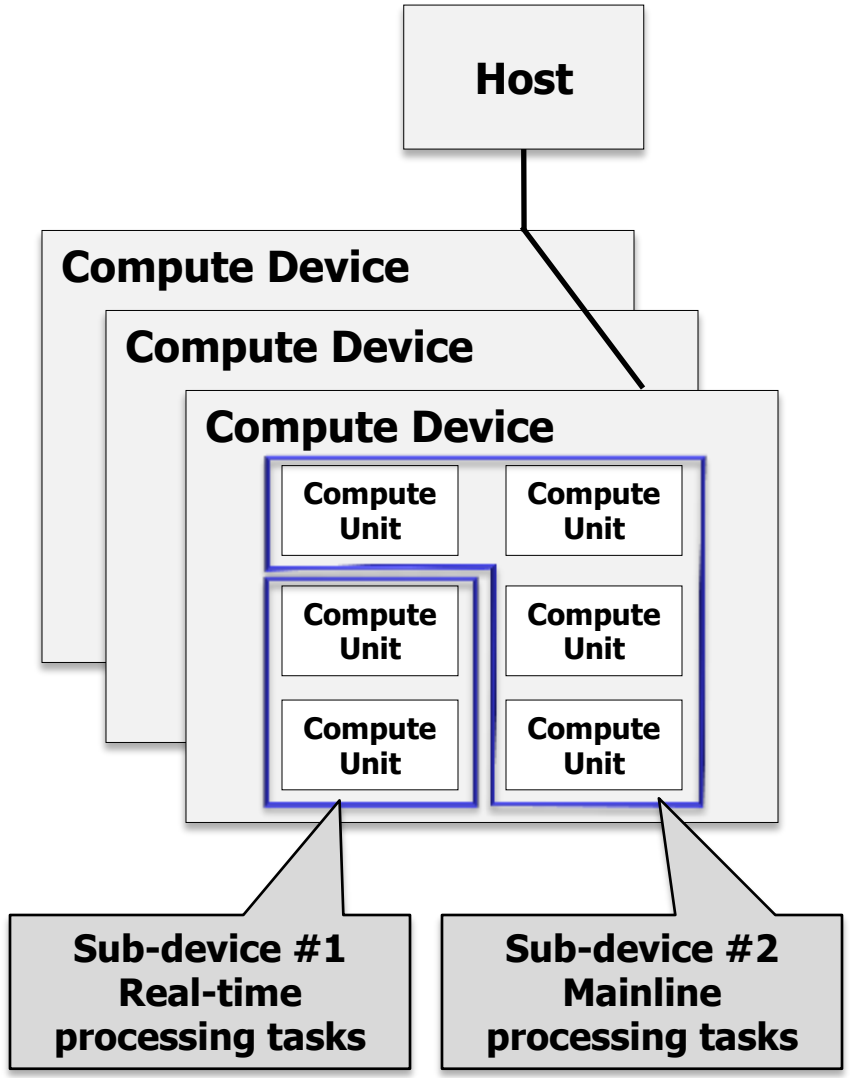
OpenCL 1.2 Announced in December

- **Significant updates - Khronos being responsive to developer requests**
  - Updated OpenCL 1.2 conformance tests available
  - Multiple implementations underway
- **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



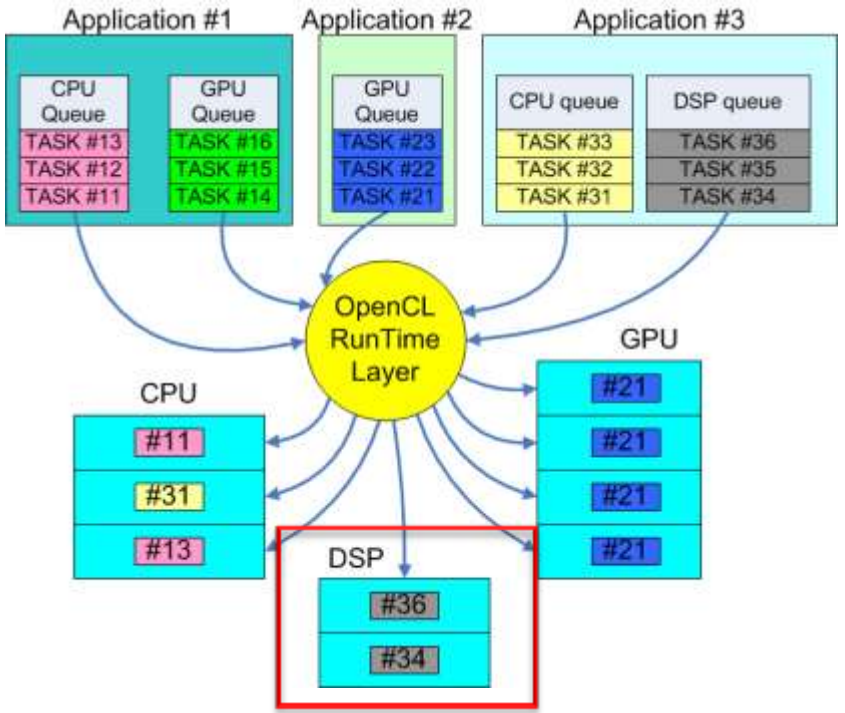
Partitioning Devices

- **Devices can be partitioned into sub-devices**
  - More control over how computation is assigned to compute units
- **Sub-devices may be used just like a normal device**
  - Create contexts, building programs, further partitioning and creating command-queues
- **Three ways to partition a device**
  - Split into equal-size groups
  - Provide list of group sizes
  - Group devices sharing a part of a cache hierarchy



Custom Devices and Built-in Kernels

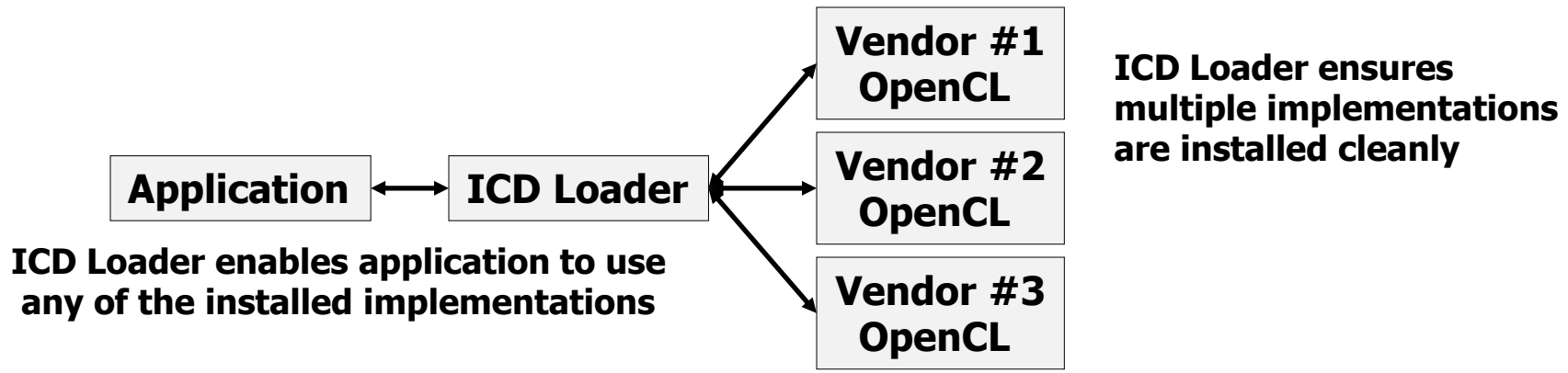
- **Embedded platforms often contain specialized hardware and firmware**
  - That cannot support OpenCL C
- **Built-in kernels can represent these hardware and firmware capabilities**
  - Such as video encode/decode
- **Hardware can be integrated and controlled from the OpenCL framework**
  - Can enqueue built-in kernels to custom devices alongside OpenCL kernels
- **FPGAs are one example of device that can expose built-in kernels**
  - Latest FPGAs can support full OpenCL C as well
- **OpenCL becomes a powerful coordinating framework for diverse resources**
  - Programmable and non-programmable devices controlled by one run-time



Built-in kernels enable control of specialized processors and hardware from OpenCL run-time

Installable Client Driver

- **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



Other Major New Features in OpenCL 1.2

- **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 to
- **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
- **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
- **And many other updates and additions..**

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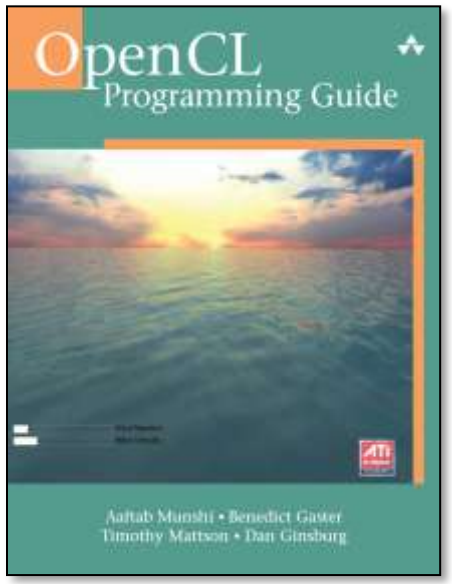
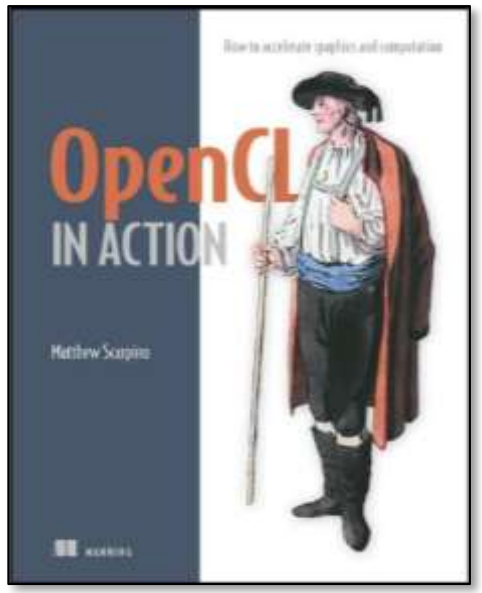
OpenCL Desktop Implementations

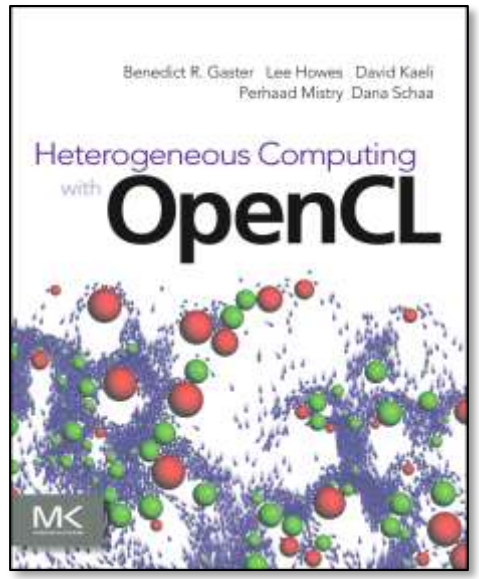
- http://developer.amd.com/zones/OpenCLZone/
- http://software.intel.com/en-us/articles/opencl-sdk/
- http://developer.nvidia.com/opencl

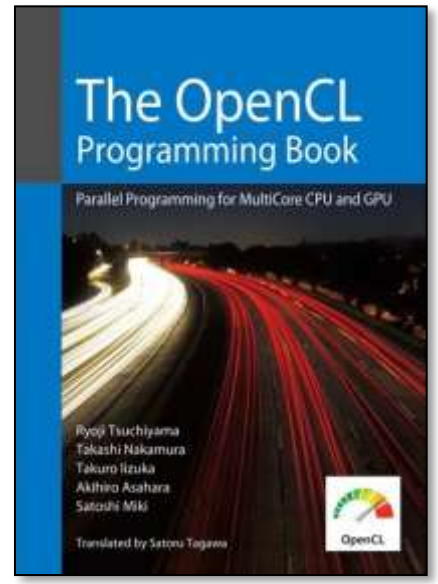
OpenCL Books – Available Now!

- **OpenCL Programming Guide - The "Red Book" of OpenCL**
  - http://www.amazon.com/OpenCL-Programming-Guide-Aaftab-Munshi/dp/0321749642
- **OpenCL in Action**
  - http://www.amazon.com/OpenCL-Action-Accelerate-Graphics-Computations/dp/1617290173/
- **Heterogeneous Computing with OpenCL**
  - http://www.amazon.com/Heterogeneous-Computing-with-OpenCL-ebook/dp/B005JRHYUS
- **The OpenCL Programming Book**
  - http://www.fixstars.com/en/opencl/book/









Spec Translations

- **Japanese OpenCL 1.1 spec translation available today**
  - http://www.cutt.co.jp/book/978-4-87783-256-8.html
  - Valued partnership between Khronos and CUTT in Japan
- **Working on OpenCL 1.2 specification translations**
  - Japanese, Korean and Chinese

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
  - http://www.khronos.org/files/opencl-1-2-quick-reference-card.pdf
- **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/