Argonne NATIONAL LABORATORY

SYCL – Introduction and Best Practices

Thomas Applencourt - apl@anl.gov

Argonne Leadership Computing Facility
Argonne National Laboratory
9700 S. Cass Ave
Argonne, IL 60349

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Introduction

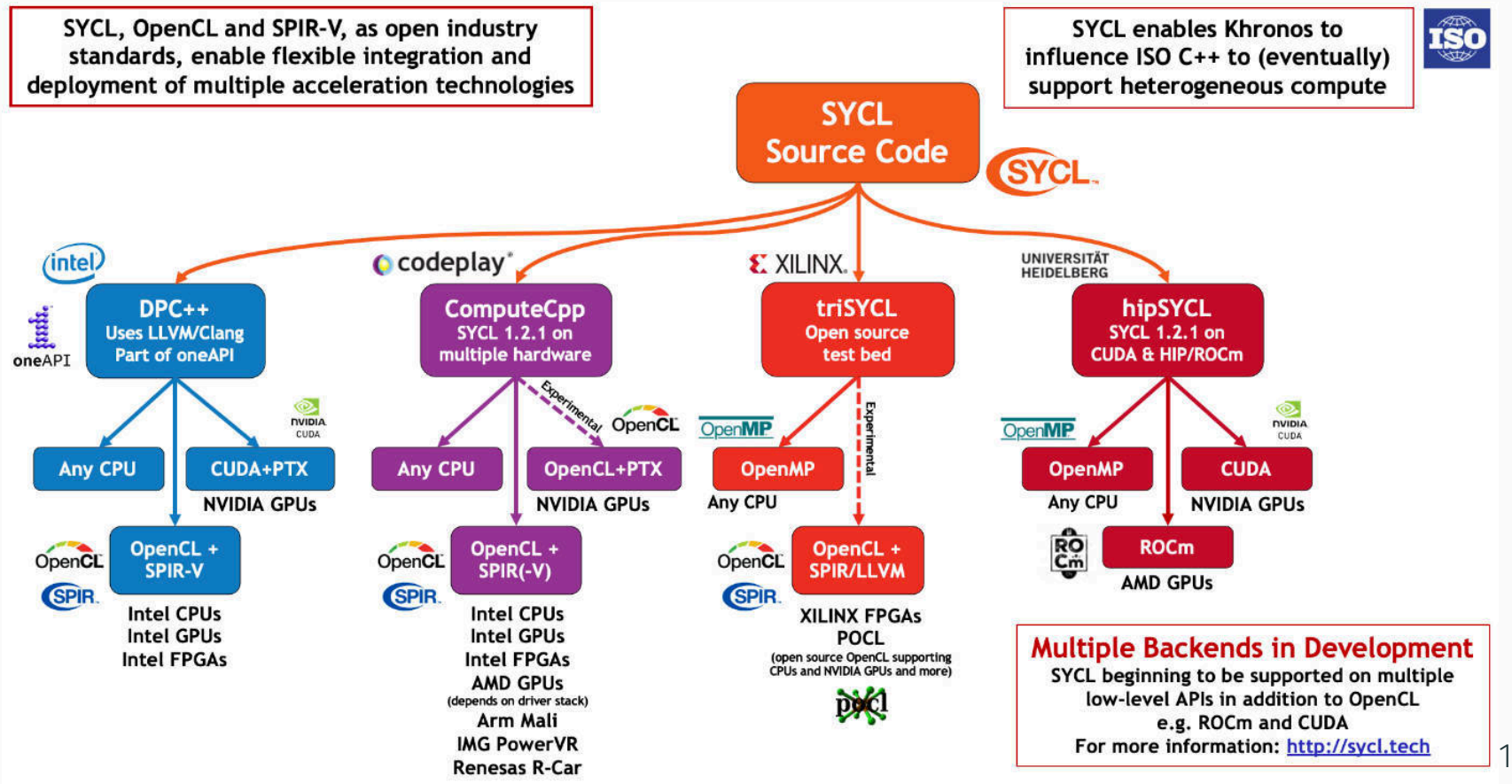
What programming model to use to target GPU?

- OpenMP (pragma based)
- Cuda (proprietary)
- Hip (low level)
- OpenCL (low level)
- Kokkos, raja, OCCA (high level, abstraction layer, academic project)

What is SYCL™?

1. Target C++ programmers (template, lambda)
   1.1 No language extension
   1.2 No pragmas
   1.3 No attribute
2. Borrow lot of concept from battle tested OpenCL (platform, device, work-group, range)
3. Single Source (two compilation pass)
4. Implicit data-transfer
5. SYCL is a Specification developed by the Khronos Group (OpenCL, SPIR, Vulkan, OpenGL)

SYCL Implementation



1

[1]Credit: Khronos groups (*https://www.khronos.org/sycl/*)

Goal of this talk

1. Give you a feel of SYCL
2. Go through code examples
3. Teach you enough so that can search for the rest if you interested
4. Question are welcomed! [2]

[2] Please use google-doc or chat. Will be answers during section breaks or by email if we are short on time

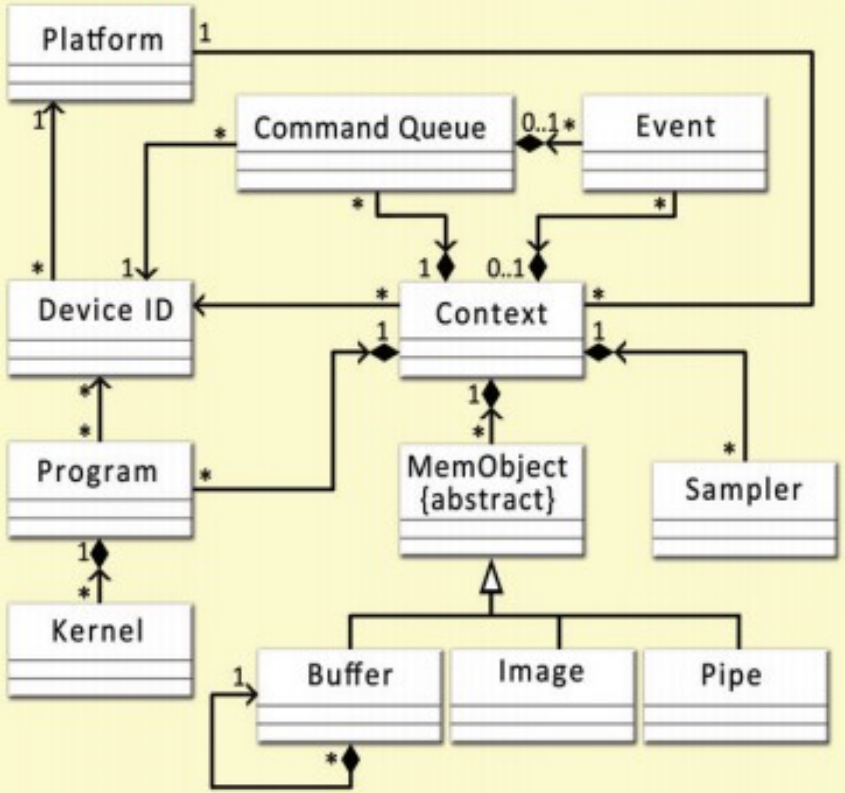
Theory

A picture is worth a thousand words[3]

OpenCL Class Diagram

The figure below describes the OpenCL specification as a class diagram using the Unified Modeling Language[1] (UML) notation. The diagram shows both nodes and edges which are classes and their relationships. As a simplification it shows only classes, and no attributes or operations.

Annotations	
Relationships	
abstract classes	{abstract}
aggregations	♦
inheritance	△
relationship navigability	^
Cardinality	
many	*
one and only one	1
optionally one	0..1
one or more	1..*



[1] Unified Modeling Language (http://www.uml.org/) is a trademark of Object Management Group (OMG).

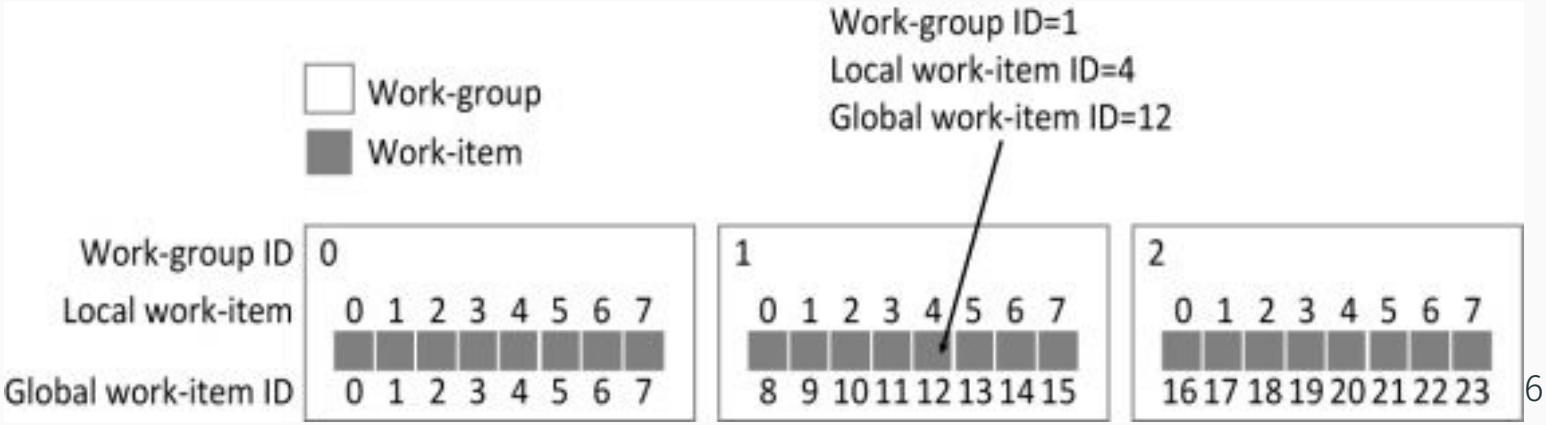
[3] and this is a UML diagram so maybe more!

Memory management: SYCL innovation

1. Buffers encapsulate your data
2. Accessors describe how you access those data
3. Buffer destruction will cause synchronization

Implicit Loop

- A Kernel is invoked once for each work item [4]
- local work size Work items are grouped into a work group [5]
- The total number of all work items is specified by the global work size



[6]

[4] similar to *`MPI_rank`*
[5] similar to *`pragma omp simdlen/safelen`*
[6] Credit The OpenCL Programming Book by Fixstars

Implicit Loop

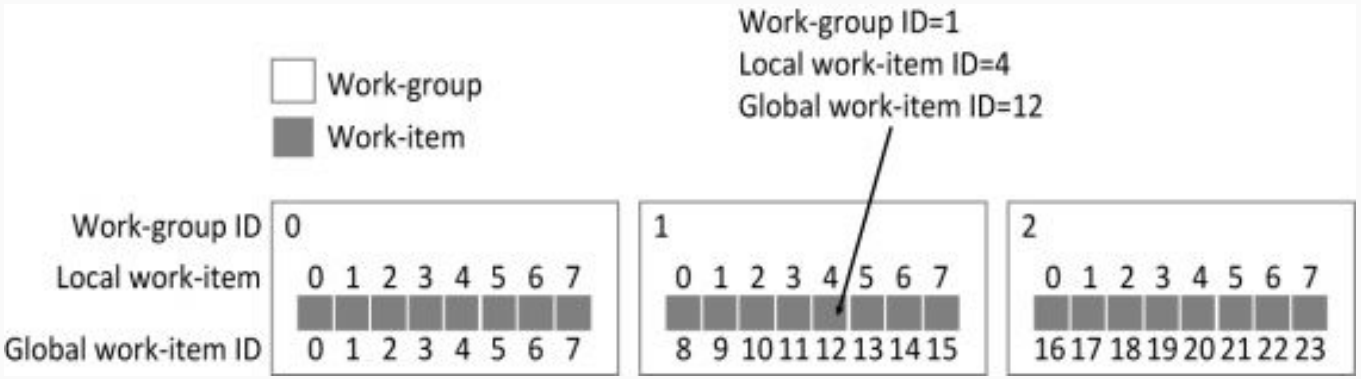
```
global_work_size = 24 ; local_work_size = 8
```

SYCL / Opencl / CUDA:

```
parallel_for<global_work_size,local_work_size>(mykernel);
```

Explicit loop[7]

```
# wG = work_group ; wC = work_item
for (wG_id=0; wG_id++; wG_id < (global_work_size / local_work_size)
    for (local_wI_id=0; local_wI_id++; local_wI_id < local_work_size)
        global_wI_id = local_wI_id + wG_id*local_wG_size
```



[7] Using chunking / tilling / vectorization technique

Live-demo

Bookkeeping

1. Using Argonne Cluster for convenience
2. Using Intel SYCL (DPC++) compiler
3. Running on Intel Integrated Graphic Iris Gen9
4. Example available at *https://github.com/alcf-perfengr/sycltrain*

Conclusion

Conclusion

1. SYCL is C++
2. Lost of Vendors / Hardware supported (Intel, nvidia, AMD / CPU, GPU, FPGA)
3. Implicit data-movement by default (Buffer / Accessors concepts)

Lot of goods resources online

Spec

1. *https://www.khronos.org/registry/SYCL/specs/sycl-1.2.1.pdf*
2. *https://www.khronos.org/files/sycl/sycl-121-reference-card.pdf*

Examples

1. *https://github.com/codeplaysoftware/computecpp-sdk/tree/master/samples*
2. *https://github.com/alcf-perfengr/sycltrain*

Documentations

1. *https://sycl.tech/*
2. Mastering DPC++ for Programming of Heterogeneous Systems using C++ and SYCL (ISBN 978-1-4842-5574-2)

Q&A

Thanks you! Do you have any questions?