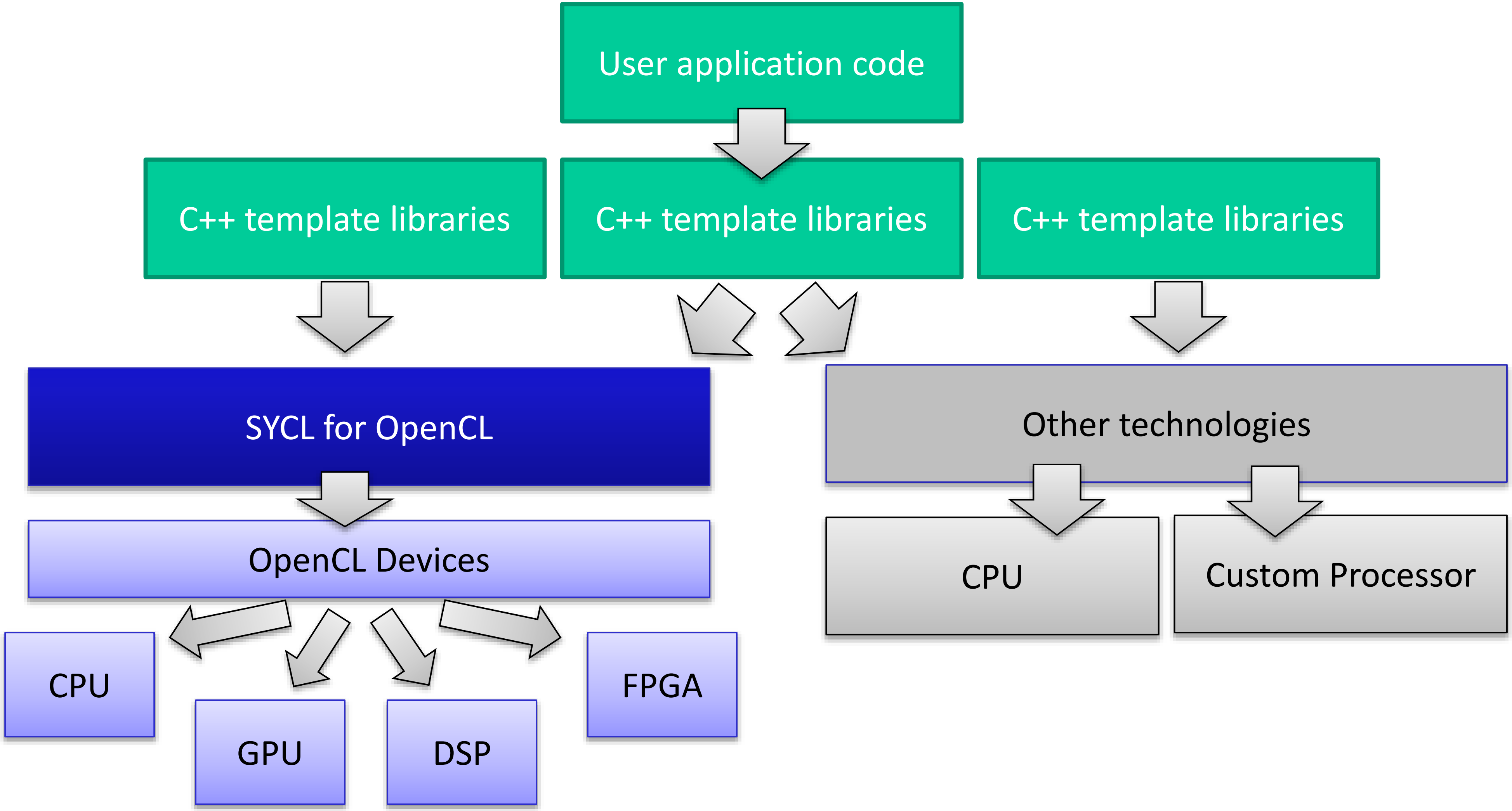
# SYCL for OpenCL

May15

# SYCL for OpenCL - Single-source C++

- **Pronounced ‘sickle’**
  - To go with ‘spear’ (SPIR)
- **Royalty-free, cross-platform C++ programming layer**
  - Builds on concepts portability & efficiency of OpenCL
  - Ease of use and flexibility of C++
- **Single-source C++ development**
  - C++ template functions can contain host & device code
    - e.g. parallel_sort<MyType> (myData);
  - Construct complex reusable algorithm templates using OpenCL for acceleration
- **SYCL 1.2 Final spec released!**
  - At IWOCL in May 2014
- **Multiple implementations**
  - Including open source triSYCL from AMD
  - [https://github.com/amd/triSYCL](https://github.com/amd/triSYCL)

# OpenCL / SYCL Stack



User application code

C++ template libraries

C++ template libraries

C++ template libraries

SYCL for OpenCL

OpenCL Devices

CPU

GPU

DSP

FPGA

Other technologies

CPU

Custom Processor

# Example SYCL Code #1

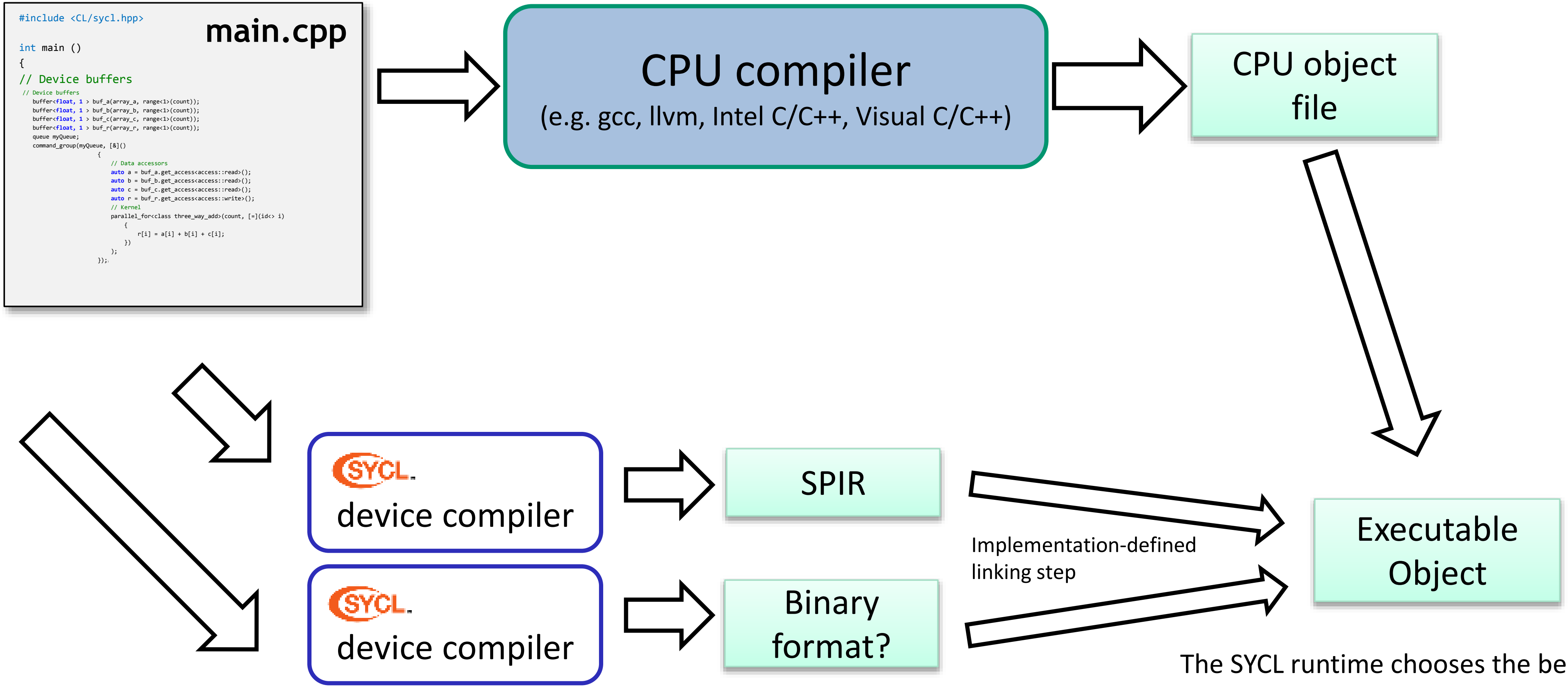
```
#include <CL/sycl.hpp>

int main ()
{
….
    // Device buffers
    buffer<float, 1 > buf_a(array_a, range<1>(count));
    buffer<float, 1 > buf_b(array_b, range<1>(count));
    buffer<float, 1 > buf_c(array_c, range<1>(count));
    buffer<float, 1 > buf_r(array_r, range<1>(count));
    queue myQueue;
    myQueue.submit([&](handler& cgh)
    {
              // Data accessors
              auto a = buf_a.get_access<access::read>(cgh);
              auto b = buf_b.get_access<access::read>(cgh);
              auto c = buf_c.get_access<access::read>(cgh);
              auto r = buf_r.get_access<access::write>(cgh);
              // Kernel
              cgh.parallel_for<class three_way_add>(count, [=](id<> i)
                  {
                      r[i] = a[i] + b[i] + c[i];
                  })
              );
          });
….
}
```

# Example SYCL Code #2

```
#include <CL/sycl.hpp>

int main ()
{
….
 // Device buffers
    buffer<float, 1 > buf_a(array_a, range<1>(count));
    buffer<float, 1 > buf_b(array_b, range<1>(count));
    buffer<float, 1 > buf_c(array_c, range<1>(count));
    buffer<float, 1 > buf_r(array_r, range<1>(count));
    queue myQueue;
    myQueue.submit([&](handler& cgh)
    {
              // Data accessors
              auto a = buf_a.get_access<access::read>(cgh);
              auto b = buf_b.get_access<access::read>(cgh);
              auto c = buf_c.get_access<access::read>(cgh);
              auto r = buf_r.get_access<access::write>(cgh);
              // Kernel
              cgh.parallel_for<class three_way_add>(count, [=](id<> i)
                  {
                      r[i] = a[i] + b[i] + c[i];
                  })
              );
          });….
}
```

**Some language restrictions within kernels**

# Build Process Overview



**main.cpp**

```
#include <CL/sycl.hpp>

int main ()
{
// Device buffers
 // Device buffers
    buffer<float, 1 > buf_a(array_a, range<1>(count));
    buffer<float, 1 > buf_b(array_b, range<1>(count));
    buffer<float, 1 > buf_c(array_c, range<1>(count));
    buffer<float, 1 > buf_r(array_r, range<1>(count));
    queue myQueue;
    command_group(myQueue, [&]()
                    {
                        // Data accessors
                        auto a = buf_a.get_access<access::read>();
                        auto b = buf_b.get_access<access::read>();
                        auto c = buf_c.get_access<access::read>();
                        auto r = buf_r.get_access<access::write>();
                        // Kernel
                        parallel_for<class three_way_add>(count, [=](id<> i)
                            {
                                r[i] = a[i] + b[i] + c[i];
                            })
                        );
                    });
```

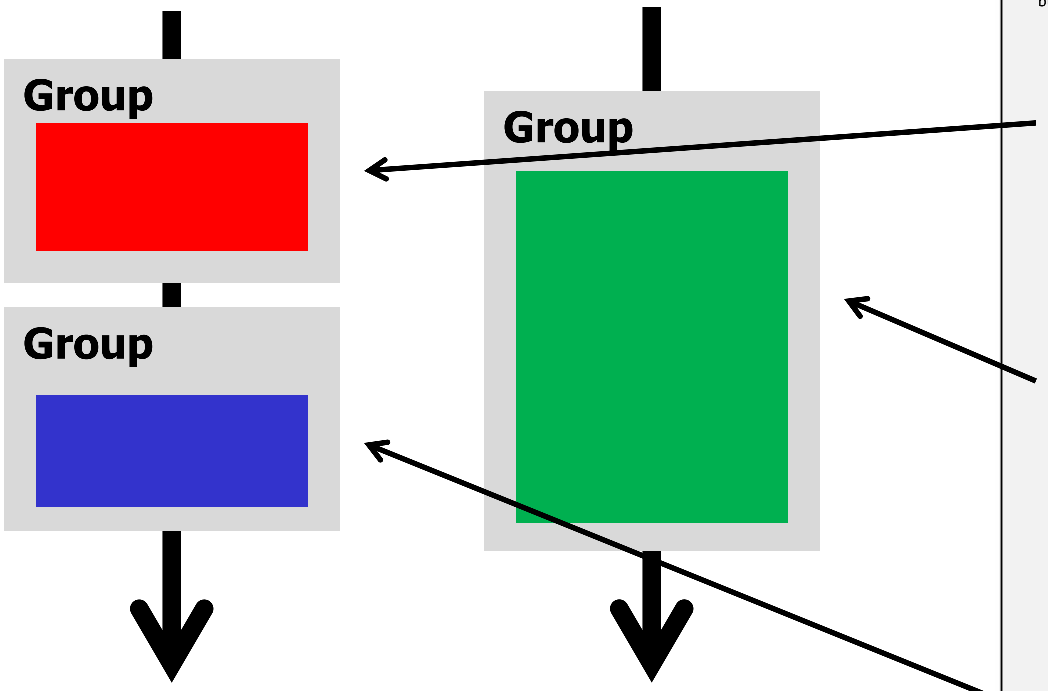
Multi-device compilers are not required, but is a possibility

The SYCL runtime chooses the best binary for the device at runtime

# Major talking points

- **SYCL uses standard C++ with no language extensions**
- **Tasks, such as memory object creations, mapping, copies and kernel execution, are scheduled automatically**
  - Using SYCL allows for dependencies to be tracked automatically
  - Specifying data access rules reduces overheads, allows for efficient scheduling
- **Hierarchical Parallelism**

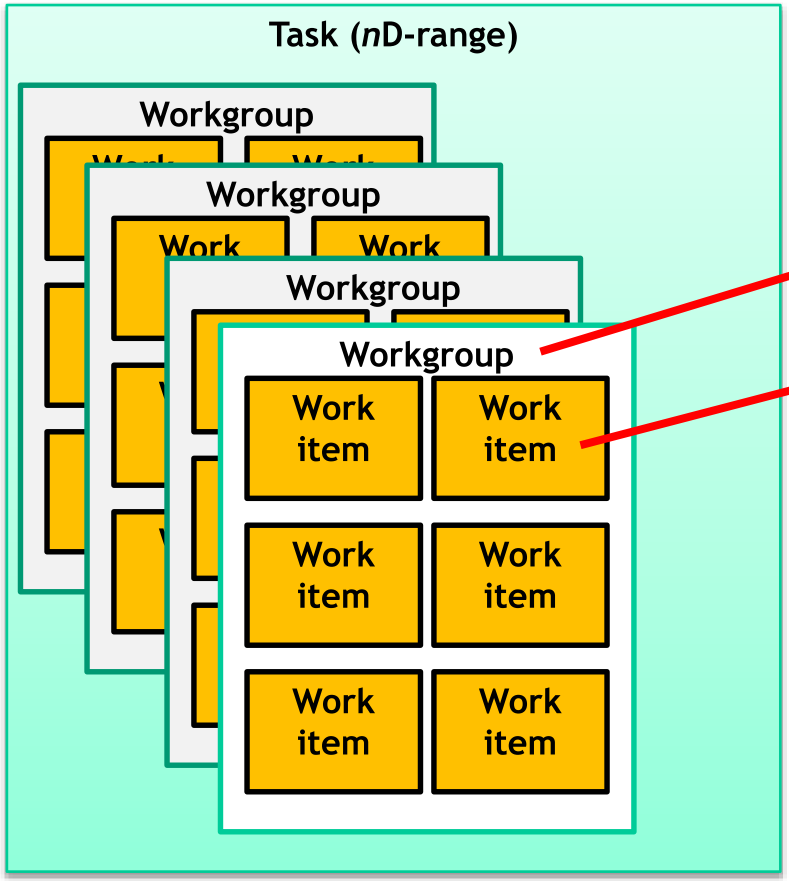
# Task Graph Deduction



Efficient Scheduling

```
const int n_items = 32;
range<1> r(n_items);

int array_a[n_items] = { 0 };
int array_b[n_items] = { 0 };

buffer<int, 1> buf_a(array_a, range<1>(r));
buffer<int, 1> buf_b(array_b, range<1>(r));

queue q;
command_group(q, [&]()
{
 auto acc_a = buf_a.get_access<read_write>();
     algorithm_a s(acc_a);
     parallel_for(n_items, s);
});

command_group(q, [&]()
{
 auto acc_b = buf_b.get_access<read_write>();
     algorithm_b s(acc_b);
     parallel_for(n_items, s);
});


command_group(q, [&]()
{
 auto acc_a = buf_a.get_access<read_write>();
     algorithm_c s(acc_a);
     parallel_for(n_items, s);
});
```

# Hierarchical Data Parallelism



```
buffer<int> my_buffer(data, 10);

auto in_access = my_buffer.access<cl::sycl::access:read_only>();
auto out_access = my_buffer.access<cl::sycl::access:write_only>();

command_group(my_queue, [&]()
{
   parallel_for_workgroup(nd_range(range(size), range(groupsize)),
      lambda<class hierarchical>([=](group_id group)
   {
      parallel_for_workitem(group, [=](tile_id tile)
      {
         out_access[tile] = in_access[tile] * 2;
      });
   }));
});
```

Advantages:

1. Easy to understand the concept of work-groups
2. Performance-portable between CPU and GPU
3. No need to think about barriers (automatically deduced)
4. Easier to compose components & algorithms

# What Does This Mean for Developers?

- **Enables a standard C++11 codebase targeting multiple OpenCL devices**
  - As it's C++, a host CPU device implementation can be provided in headers
- **SYCL is cross-toolchain as well as cross-platform**
  - No language extensions, standard C++ compilers can build SYCL source code
- **Device compilers enable SYCL running on OpenCL devices**
  - Can have multiple device compilers linking into final executable
  - Doesn't affect original source build
- **You could implement SYCL simply using C++ threads**
  - All the synchronization, parallelism wins remain - but running on CPU
  - No external dependencies

# What Does This Mean for Developers?

- **Enables developers to move quickly into writing SYCL code**
  - Provides methods for dealing with targets that do not have OpenCL(yet!)
  - Has other development benefits…
- **A fallback CPU implementation is debuggable!**
  - Using normal C++ debuggers
  - Profiling tools also work on CPU device
- **Huge bonus for productivity and adoption**
  - Cost of entry to use SYCL very low

# OpenCL Features within SYCL

- **Can access OpenCL objects from SYCL objects**
- **Can construct SYCL objects from OpenCL object**
- **Interop with OpenGL remains in SYCL**
  - Uses the same structures/types
- **Developers still have the ability to optimize at a low level should they need to**

# In Summary

- **SYCL: a royalty-free, cross platform C++ programming layer**
  - Very low cost to entry
- **An OpenCL ecosystem based on standard C++**
  - Single source development without language extensions
  - C++ developers can easily utilize OpenCL in code
- **Final SYCL 1.2 available online**
  - https://www.khronos.org/opencl/sycl
  - Together with conformance tests!
- **Please use the SYCL forum thread for feedback!**
  - http://www.khronos.org/**opencl/sycl**