SYCL Academy

MANAGING DATA

LEARNING OBJECTIVES

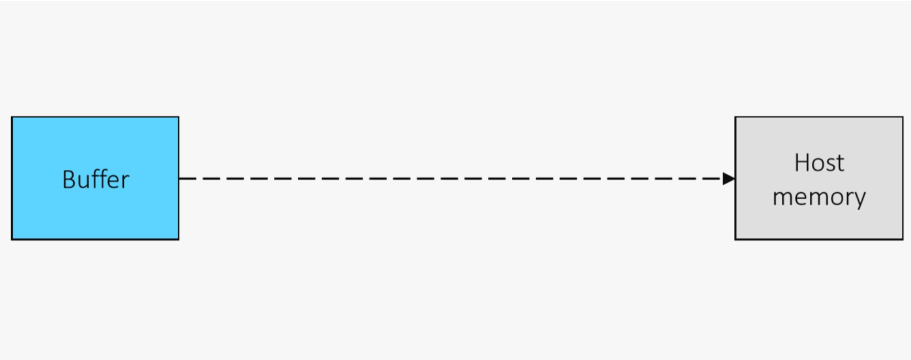
- Learn about the buffer/accessor model for managing data
- Learn how to use buffers and accessors
- Learn how to access data in a kernel function
- Learn how a buffer synchronizes data

SYCL BUFFERS & ACCESSORS

- SYCL separates the storage and access of data
  - A SYCL buffer manages data across the host and any number of devices
  - A SYCL accessor requests access to data on the host or on a device for a specific SYCL kernel function
- Accessors are also used to access data within a SYCL kernel function
  - This means they are declared in the host code but captured by and then accessed within a SYCL kernel function

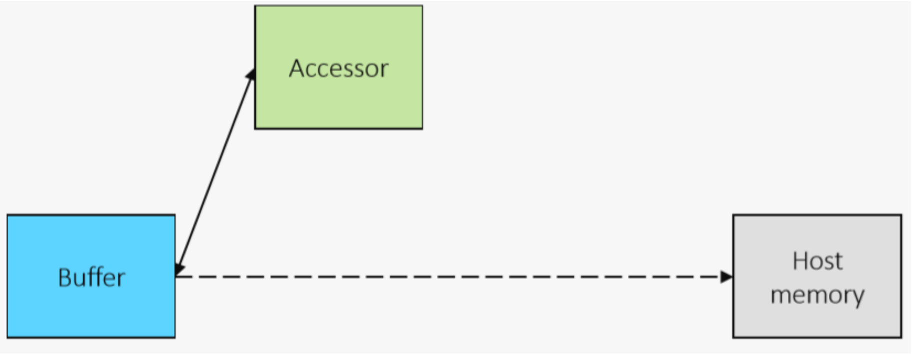
SYCL BUFFERS & ACCESSORS

- A SYCL buffer can be constructed with a pointer to host memory
- For the lifetime of the buffer this memory is owned by the SYCL runtime
- When a buffer object is constructed it will not allocate or copy to device memory at first
- This will only happen once the SYCL runtime knows the data needs to be accessed and where it needs to be accessed



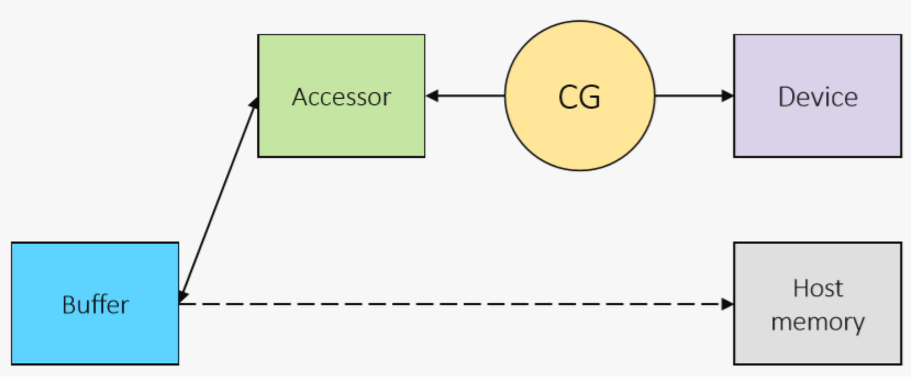
SYCL BUFFERS & ACCESSORS

- Constructing an accessor specifies a request to access the data managed by the buffer
- There are a range of different types of accessor which provide different ways to access data



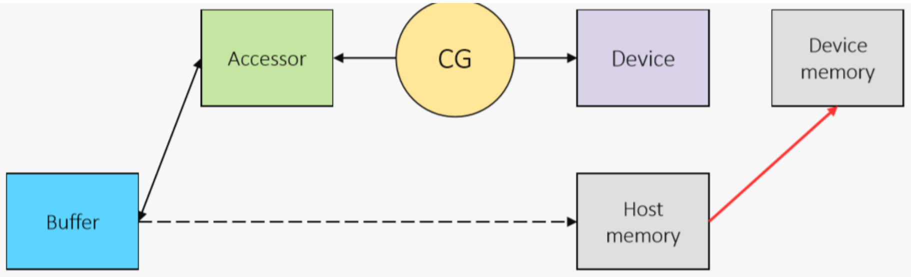
SYCL BUFFERS & ACCESSORS

- When an accessor is constructed it is associated with a command group via the handler object
- This connects the buffer that is being accessed, the way in which it's being accessed and the device that the command group is being submitted to



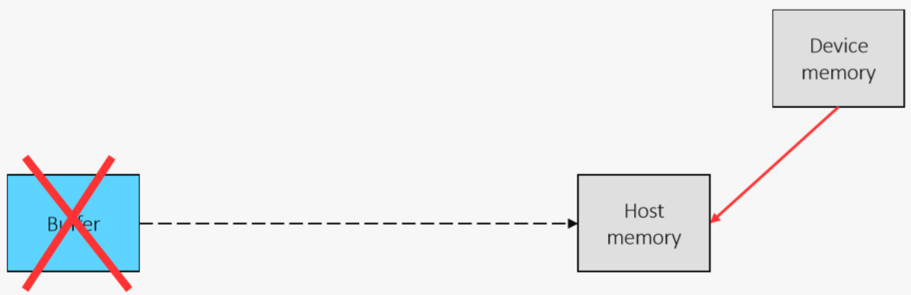
SYCL BUFFERS & ACCESSORS

- Once the SYCL scheduler selects the command group to be executed it must first satisfy its data dependencies
- This means allocating and copying data to the device the data is being accessed on if necessary
- If the most recent copy of the data is already on the device then the runtime will not copy again



SYCL BUFFERS & ACCESSORS

- Data will remain in device memory after kernels finish executing until another command group requests access in a different device or on the host
- When the buffer object is destroyed it will wait for any outstanding work that is accessing the data to complete and then copy back to the original host memory



BUFFER CLASS

```
template <typename dataT, int dimensions>
sycl::buffer;
```

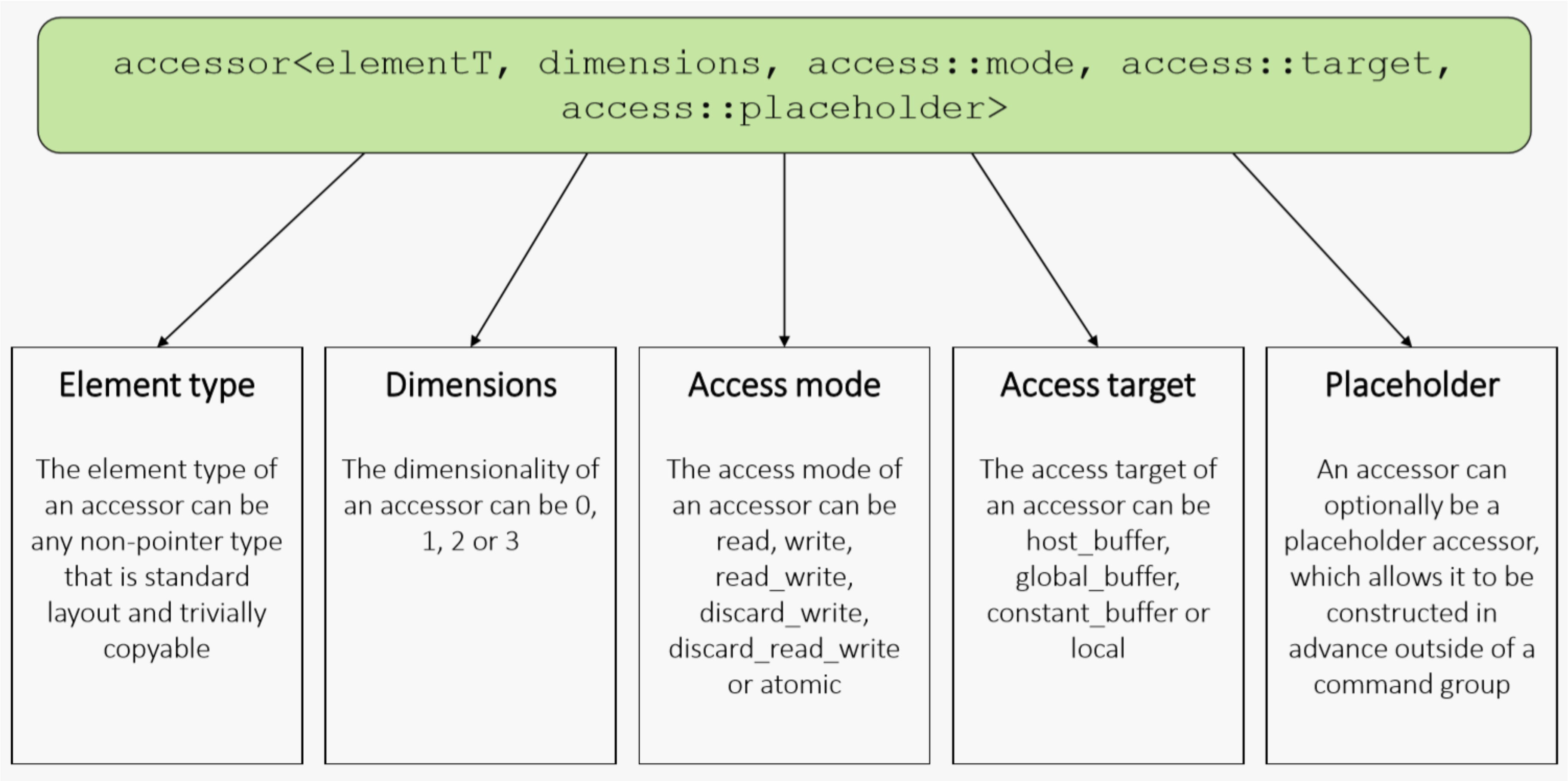
- A `buffer` manages data across the host application and kernel functions executing on device(s).
- It has a typename which specifies the type of the elements of data it manages.
- It has a dimensionality which specifies the dimensionality that the elements of data are represented in.

CONSTRUCTING A BUFFER

```
int var = 42;
auto buf = sycl::buffer{&var, sycl::range{1}};
```

- A `buffer` can be constructed from a pointer to data for it to manage and a `range` which describes the number of elements of data.
- Using CTAD the type and the dimensionality can be inferred.

ACCESSOR CLASS



```
accessor<elementT, dimensions, access::mode, access::target,
access::placeholder>
```

Element type

The element type of an accessor can be any non-pointer type that is standard layout and trivially copyable

Dimensions

The dimensionality of an accessor can be 0, 1, 2 or 3

Access mode

The access mode of an accessor can be read, write, read_write, discard_write, discard_read_write or atomic

Access target

The access target of an accessor can be host_buffer, global_buffer, constant_buffer or local

Placeholder

An accessor can optionally be a placeholder accessor, which allows it to be constructed in advance outside of a command group

ACCESSOR CLASS

- There are many different ways to use the `accessor` class.
  - Accessing data on a device.
  - Accessing data immediately in the host application.
  - Allocating local memory.
- For now we are going to focus on accessing data on a device.

CONSTRUCTING AN ACCESSOR

```
auto acc = sycl::accessor{bufA, cgh};
```

- There are many ways to construct an `accessor`.
- The `accessor` class supports CTAD so it's not nessesary to specify all of the template arguments.
- The most common way to construct an `accessor` is from a `buffer` and a `handler` associated with the command group function you are within.
  - The element type and dimensionality are infered from the `buffer`.
  - The `access::target` is defaulted to `access::target::global_buffer`.
  - The `access::mode` is defaulted to `access::mode::read_write`.

SPECIFYING THE ACCESS MODE

```
auto readAcc = sycl::accessor{bufA, cgh, sycl::read_only};
auto writeAcc = sycl::accessor{bufB, cgh, sycl::write_only};
```

- When constructing an `accessor` you will likely also want to specify the `access::mode`
- You can do this by passing one of the CTAD tags:
    - `read_only` will result in `access::mode::read`.
    - `write_only` will result in `access::mode::write`.

SPECIFYING NO INITIALIZATION

```
auto acc = sycl::accessor{buf, cgh, sycl::no_init};
```

- When constructing an `accessor` you may also want to discard the original data of a `buffer`.
- You can do this by passing the `no_init` property.

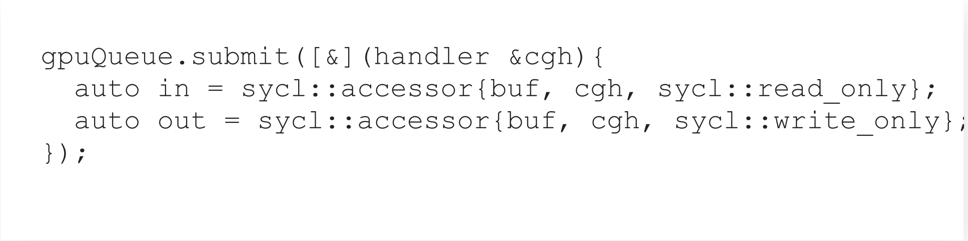
ACCESS MODES

- A **read** `accessor` instructs the SYCL runtime that the SYCL kernel function will read the data – cannot be written to within a SYCL kernel function.
- A **write** `accessor` instructs the SYCL runtime that the SYCL kernel function will modify the data – creating a dependency for future command groups.
- A **no_init** `accessor` instructs the SYCL runtime that the SYCL kernel function does not need the initial values of the data – removing the dependency on previous command groups.

ACCESSOR RESOLUTION

- If a command group has more than one `accessor` to the same `buffer` with conflicting `access::mode` they are resolved into one:
    - read & write => read_write.
- If a command group has more than one `accessor` to the same `buffer` all must have the `no_init` property for it to apply.
- Within the SYCL kernel function there are still multiple `accessors`, but they alias to the same memory address.

ACCESSOR RESOLUTION



```
gpuQueue.submit([&](handler &cgh){
  auto in = sycl::accessor{buf, cgh, sycl::read_only};
  auto out = sycl::accessor{buf, cgh, sycl::write_only};
});
```

- Here `in` and `out` both point to `buf` but one is `access::mode::read` and one is `access::mode::write`.
- So the SYCL runtime will treat them both as `access::mode::read_write`.
- Both will point to a single allocation of global memory on the device(s).
- The runtime will resolve the data dependency into `access::mode::read_write`.

OPERATOR[]

```
gpuQueue.submit([&](handler &cgh){
  auto inA = sycl::accessor{bufA, cgh, sycl::read_only};
  auto inB = sycl::accessor{bufB, cgh, sycl::read_only};
  auto out = sycl::accessor{bufO, cgh, sycl::write_only};
  cgh.single_task<add>([=]{
    out[0] = inA[0] + inB[0];
  });
});
```

- As well as specifying data dependencies an `accessor` can also be used to access the data from within a kernel function.
- You can do this by calling `operator[]` on the `accessor`.
    - This operator can take an `id` or a `size_t`.

QUESTIONS

EXERCISE

Code_Exercises/Exercise_3_Scalar_Add/source

Implement a SYCL application that adds two variables and returns the result.