oneAPI Technical Advisory Board Meeting: sycl::accessor simplification

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SYCL 1.2.1: Hello World

accessor An accessor is a class which allows a SYCL kernel function to access data managed by a buffer or image class. Accessors are used to express the dependencies among the different command groups.

```
// Create a queue to enqueue work to
queue myQueue;

// Wrap our data variable in a buffer
buffer<int, 1> resultBuf { data, range<1> { 1024 } };

// Create a command_group to issue commands to the queue
myQueue.submit([&](handler& cgh) {
  // request access to the buffer
  auto writeResult = resultBuf.get_access<access::mode::discard_write>(cgh);

  // Enqueue a parallel_for task
  cgh.parallel_for<class simple_test>(range<1> { 1024 }, [=](id<1> idx) {
    writeResult[idx] = idx[0];
  });
});
```

Buffer handles storage and data ownership

Accessor handles access to the data

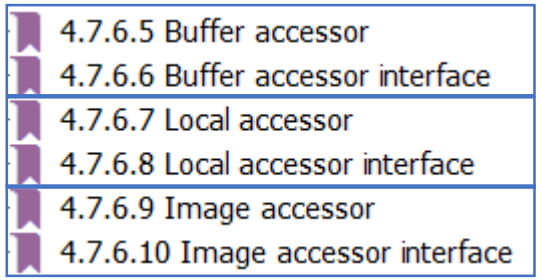
access

The problems – Verbosity and Consistency

1. **sycl::accessor** has 5 template arguments and only 2 of them have default values
   - One is forced to type at least 3 template arguments

```
// We define the subset of the accessor we require for the kernel
accessor<int, 1, access::mode::read_write, access::target::global_buffer>
    ptr(syclBuffer, cgh, singleRange, offset);
```

   - **sycl::buffer/sycl::image** have **get_access()** member functions with 1-2 template arguments, but they do not cover all accessor use cases (placeholder, local, dimension=0, etc.)



2. **sycl::accessor** behavior and API depends on the template arguments
   - There are 3 different sections of the standard, which describe **sycl::accessor** type, depending on **access::target** template argument
   - A set of available constructors depends on 3 out of 5 template arguments
   - Whether accessor constructor is a **blocking** operation or **non-blocking**, depends on **access::target** template argument

```
/* Available only when: ((isPlaceholder == access::placeholder::false_t &&
accessTarget == access::target::host_buffer) || (isPlaceholder ==
access::placeholder::true_t && (accessTarget == access::target::global_buffer
|| accessTarget == access::target::constant_buffer))) && dimensions > 0 */
template <typename AllocatorT>
accessor(buffer<dataT, dimensions, AllocatorT> &bufferRef);
```

The challenges - Extensibility

New use cases appear

1. **Host tasks (SYCL 2020 Provisional)**
   - One may now build a DAG for running tasks on the Host, thus host accessors shall support non-blocking construction as well.
   - Existing access targets are insufficient to decide, whether accessor constructor should be a **blocking** or **non-blocking** operation.

2. **Atomicity (Intel extension)**
   - No reasonable default values for **memory_order** and **memory_scope** for all possible platforms
     - There is a need to set up defaults on the level of accessor:
       - 2 more template arguments
       - only if **access::mode** == **atomic**
   - Note: **access::mode::atomic** is deprecated in SYCL 2020 provisional

SYCL 2020 Provisional

- **sycl::host_accessor** is defined as a distinct type for access memory on host

- **sycl::accessor** and **sycl::host_accessor** now accept tag arguments in constructor.
  2 helper tag types are introduced with a set of predefined inline variables:

  - inline constexpr mode_tag_t<…> **read_only**{};
  - inline constexpr mode_tag_t<…> **read_write**{};
  - inline constexpr mode_tag_t<…> **write_only**{};
  - inline constexpr mode_target_tag_t<…> **read_constant**{};

- A set of deduction rules are requested on implementation level
  to deduce all accessor template arguments with optional use of tag types

- All accessor constructors accept **property_list**:

  - **discard_write** and **discard_read_write** modes were deprecated
  - replaced with **noinit**{} runtime property

New API comparison – device accessor

	SYCL 1.2.1	SYCL 2020 Provisional

via constructor	`sycl::accessor<int,1, sycl::access::mode::write > A1(buf,cgh);`
	`sycl::accessor<int,1, sycl::access::mode::read_write > A2(buf,cgh);`
	`sycl::accessor<int,1,`
	`sycl::access::mode::discard_read_write> A3(buf,cgh);`
	`sycl::accessor<int,1,`
	`sycl::access::mode::write,`
	`sycl::access::target::global_buffer,`
	`sycl::access::placeholder::true_t > A4(buf);`
	`sycl::accessor<int,1,`
	`sycl::access::mode::read,`
	`sycl::access::target::constant_buffer > A5(buf,cgh);`
		`sycl::accessor A1(buf, cgh, sycl::write_only);`
		`sycl::accessor A2(buf, cgh);`
		`sycl::accessor A3(buf, cgh, sycl::noinit);`
		`sycl::accessor A4(buf, sycl::write_only);`
		`sycl::accessor A5(buf, cgh, sycl::read_constant);`

via buffer	`auto A1 = buf.get_access<sycl::access::mode::write >(cgh);`
	`auto A2 = buf.get_access<sycl::access::mode::read_write >(cgh);`
	`auto A3 = buf.get_access<sycl::access::mode::discard_read_write>(cgh);`
	`//auto A4 = not supported`
	`auto A5 = buf.get_access<sycl::access::mode::read,`
	`sycl::access::target::constant_buffer> (cgh);`
		`auto A1 = buf.get_access(cgh, sycl::write_only);`
		`auto A2 = buf.get_access(cgh);`
		`auto A3 = buf.get_access(cgh, sycl::noinit);`
		`auto A4 = buf.get_access(sycl::write_only);`
		`auto A5 = buf.get_access(cgh, sycl::read_constant);`

New API comparison – host accessor

	SYCL 1.2.1	SYCL 2020 Provisional

via constructor	`sycl::accessor<int,1,`
	`  sycl::access::mode::write,`
	`  sycl::access::target::host_buffer> A1(buf);`
		`sycl::host_accessor A1(buf, sycl::write_only);`

	`sycl::accessor<int,1,`
	`  sycl::access::mode::read_write,`
	`  sycl::access::target::host_buffer> A2(buf);`
		`sycl::host_accessor A2(buf);`

	`//sycl::accessor<not supported> A3(buf);`	`sycl::host_accessor A3(buf, cgh, sycl::write_only);`
	`//sycl::accessor<not supported> A4(buf);`	`sycl::host_accessor A4(buf, cgh);`
via buffer	`auto A1 = buf.get_access<sycl::access::mode::write     >();`	`auto A1 = buf.get_host_access(sycl::write_only);`
	`auto A2 = buf.get_access<sycl::access::mode::read_write>();`	`auto A2 = buf.get_host_access();`
	`//auto A3 = not supported`	`auto A3 = buf.get_host_access(cgh, sycl::write_only);`
	`//auto A4 = not supported`	`auto A4 = buf.get_host_access(cgh);`

Hesitation

A ***placeholder*** accessor is not bound to a command group at construction time.

It is expected to be bound later.

Within SYCL 2020 provisional logic:

- accessor (buffer) -> **non-blocking**, **placeholder**
- accessor (buffer, handler) -> non-blocking, not-placeholder
- host_accessor (buffer) -> **blocking**, **not-placeholder**
- host_accessor (buffer, handler) -> non-blocking, not-placeholder

Absence of the handler is interpreted differently by deduction guides.

This difference is nonintuitive.

Placeholder host accessors are not supported.

Possible solution: split host_accessor in two types:

- host_accessor (buffer) -> **always blocking**
- host_task_accessor (buffer, handler) -> **always non-blocking**

Is such granularity good enough?

Further work

Create a dedicated atomic accessor (extension):

```
template <typename DataT, int Dimensions,
    memory_order DefaultOrder, memory_scope DefaultScope,
    access::target AccessTarget = access::target::global_buffer,
    access::placeholder IsPlaceholder = access::placeholder::false_t>
class atomic_accessor;
```

Create more dedicated types/aliases (the list is not finalized):

- local_accessor (alias)
- local_atomic_accessor (alias)
- host_task_accessor
- image_accessor
- host_image_accessor

Is such granularity good enough?

Resolve zero-dimensional use case:

- sycl::buffer<int, **1**> buf(range<1>(1));
- sycl::accessor<int, **0**, sycl::access::mode::write> acc(buf);
  - Zero-dimensional accessor are not deducible

Is it an important use case?

Other changes in accessor

- Removed size_t overload for operator[]
  - operator[](id<Dimensions> Index)
  - ~~operator[](size_t Index)~~
    - This allowed passing item<Dimensions> directly to operator[] (when Dimensions == 1)
    - This disallowed passing Types, with user defined conversion to size_t

Is a disallowed use case important one?

- Accessor allows const qualified type as a dataT
  - This is equivalent to **access::mode::read**

```
template <typename dataT,
          int dimensions = 1,
          access_mode accessmode =
            (std::is_const_v<dataT> ? access_mode::read
                                    : access_mode::read_write),
          target accessTarget = target::global_buffer,
          access::placeholder isPlaceholder = access::placeholder::false_t // Deprecated
>
```

- More defaults for template arguments
- isPlaceholder template argument is deprecated – replaced with runtime value evaluated from constructor arguments
- Accessors now meet the C++ requirements of ContiguousContainer and ReversibleContainer
- Read only accessor return const reference from operator[]
  - const DataT& operator[](id<Dimensions> Index)
  - ~~DataT operator[](id<Dimensions> Index)~~

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