



# The **OpenCL** C++ Wrapper API

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Khronos OpenCL Working Group

*Authors:* Benedict R. Gaster and Lee Howes

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# 1. Introduction

This specification describes the OpenCL C++ wrapper API (Version 1.2). It should be used in conjunction with the *OpenCL Specification*, Version 1.2. The C++ wrapper is built on top of the OpenCL C API and is not a replacement for it. An implementation of the C++ Wrapper API calls the underlying C API, which is assumed to be a compliant implementation of the *OpenCL Specification* platform and runtime API at version 1.2 or below. The C++ API corresponds closely to the underlying C API and introduces no additional execution overhead. C++ header macros adapt to the underlying C API version against which the header is compiled.

The wrapper interface is defined within a single C++ header file **cl.hpp**. All its definitions are contained within namespace **cl**. There is no additional requirement to include **cl.h**; to use either the C++ wrapper or the original C API, simply include **cl.hpp**.

The API is divided into a number of classes with corresponding OpenCL C types. For example, class **cl::Memory** maps to OpenCL type **cl\_mem**. When possible, C++ inheritance provides an extra level of type correctness and abstraction. For example, class **cl::Buffer** derives from base class **cl::Memory** but represents the 1D memory subclass of all possible OpenCL memory objects.

The following sections describe each class in detail. The index section at the end of this document lists each class, constructor, and method defined by the C++ wrapper API.

## 2. C++ Platform layer

### 2.1 Platforms

Class **cl::Platform** provides functionality for working with OpenCL platforms. The following static method lists the available platforms<sup>1</sup>:

```
static cl_int cl::Platform::get(VECTOR_CLASS<Platform> * platforms)
```

*platforms* is a vector of OpenCL platforms found.

**cl::Platform::get** returns **CL\_SUCCESS** on success. Otherwise, it returns the following error:

- **CL\_INVALID\_VALUE** if *platforms* is **NULL**.

The method

```
cl_int cl::Platform::getInfo(cl_platform_info name,  
                             STRING_CLASS * param)
```

---

<sup>1</sup> Section 5 describes C++ classes **VECTOR\_CLASS** and **STRING\_CLASS**.

gets specific information about the OpenCL platform. Table 4.1 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_platform\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_platform_info</b>	<b>C++ return Type</b>
CL_PLATFORM_EXTENSIONS	STRING_CLASS
CL_PLATFORM_NAME	STRING_CLASS
CL_PLATFORM_PROFILE	STRING_CLASS
CL_PLATFORM_VENDOR	STRING_CLASS
CL_PLATFORM_VERSION	STRING_CLASS

Table 1: Differences in `cl::Platform::getInfo` return type vs. *OpenCL Specification* table 4.1

*name* is an enumeration constant that identifies the platform information being queried. It can be one of the values specified in table 4.1.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 4.1 is returned. If *param* is NULL, it is ignored.

**cl::Platform::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_platform_info, name>::param_type
cl::Platform::getInfo (void)
```

gets specific information about the OpenCL platform. Table 4.1 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_platform\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the platform information being queried. It can be one of the values specified in table 4.1.

**cl::Platform::getInfo** returns the appropriate value for a given *name* as specified in table 4.1.

The method

```
cl_int cl::Platform::getDevices(cl_device_type type,
                               VECTOR_CLASS<Device> * devices)
```

gets the list of devices available on a platform.

*type* is a bitfield that identifies OpenCL device type. The *type* can be used to query specific OpenCL devices or all available OpenCL devices. Table 4.2 of the *OpenCL Specification* Version 1.2 specifies the valid values for *type*.

*devices* returns a vector of OpenCL devices found. *devices* must not be NULL.

**cl::Platform::getDevices** returns CL\_SUCCESS if the method is executed successfully. Otherwise, it returns one of the following errors:

- CL\_INVALID\_DEVICE\_TYPE if *type* is not a valid value.
- CL\_INVALID\_ARG\_VALUE if *devices* is NULL.
- CL\_DEVICE\_NOT\_FOUND if no OpenCL devices matching *type* were found.

## 2.2 Devices

Class **cl::Device** provides functionality for working with OpenCL devices.

The constructor

```
cl::Device::Device(cl_device_id device)
```

creates an OpenCL device wrapper for a device.

*device* is an OpenCL device id.

The method

```
template <typename T>
cl_int cl::Device::getInfo(cl_device_info name,
                          T * param)
```

gets specific information about the OpenCL device. Table 4.3 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_device\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_device_info</b>	<b>C++ return Type</b>
CL_DEVICE_BUILT_IN_KERNELS	STRING_CLASS
CL_DEVICE_EXTENSIONS	STRING_CLASS
CL_DEVICE_MAX_WORK_ITEM_SIZES	VECTOR_CLASS<::size_t>
CL_DEVICE_NAME	STRING_CLASS
CL_DEVICE_OPENCL_C_VERSION	STRING_CLASS
CL_DEVICE_PARTITION_PROPERTIES	VECTOR_CLASS<cl_device_partition_property>
CL_DEVICE_PARTITION_TYPE	VECTOR_CLASS<cl_device_partition_property>
CL_DEVICE_PROFILE	STRING_CLASS
CL_DEVICE_VENDOR	STRING_CLASS
CL_DEVICE_VERSION	STRING_CLASS
CL_DRIVER_VERSION	STRING_CLASS

Table 2: Differences in cl::Context::getInfo return type vs. *OpenCL Specification* table 4.3

*T* is a compile time argument that is the return for the specific information being queried. It corresponds to the values in table 4.3.

*name* is an enumeration constant that identifies the device information being queried. It can be one of the values specified in table 4.3.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 4.3 is returned. If *param* is NULL, it is ignored.

**cl::Device::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_device_info, name>::param_type
cl::Device::getInfo(void)
```

gets specific information about the OpenCL device. Table 4.3 specifies the information that can be queried.

*name* is an enumeration constant that identifies the device information being queried. It can be one of the values specified in table 4.3.

**cl::Device::getInfo** returns the appropriate value for a given *name* as specified in table 4.3 in conjunction with the table above.

The method

```
cl_int cl::Device::createSubDevices(const cl_device_partition_property *properties,
                                   VECTOR_CLASS<Device>* devices)
```

creates an array of sub-devices that each reference a non-intersecting set of compute units of an OpenCL device.

*properties* specifies how to partition the device. Each property should be an enumeration constant as specified in table 4.4 of the *OpenCL Specification* Version 1.2.

*devices* is a buffer where the OpenCL sub-devices are returned. *devices* must not be null.

**cl::Device::createSubDevices** returns CL\_SUCCESS if the method is executed successfully. Otherwise, it returns an error code as returned by the underlying OpenCL *clCreateSubDevices* call.

## 2.3 Contexts

*cl*

Class **cl::Context** provides functionality for working with OpenCL contexts.

The constructor

```
cl::Context::Context(VECTOR_CLASS<Device>& devices,
                     cl_context_properties * properties = NULL,
                     void (CL_CALLBACK * pfn_notify)(
                         const char * errorinfo,
                         const void * private_info,
                         ::size_t cb,
                         void * user_data) = NULL,
```

```
void * user_data = NULL,
cl_int * err = NULL)
```

creates an OpenCL context.

*devices* is a pointer to a vector of unique devices returned by **cl::Platform::getDevices**. If more than one device is specified, a selection criteria may be applied to determine if the list of devices specified can be used together to create a context.

*properties* specifies a list of context property names and their corresponding values. Each property name is immediately followed by the corresponding desired value. The list is terminated with 0. The list of supported properties is described in table 4.5 of the *OpenCL Specification*. *properties* can be NULL, in which case the platform that is selected is implementation-defined.

*pfn\_notify* is a callback function registered by the application. This callback function is used by the OpenCL implementation to report information on errors that occur in this context. This callback function may be called asynchronously by the OpenCL implementation. It is the application's responsibility to ensure that the callback function is thread-safe. The parameters to the callback function are:

- *errinfo* is a pointer to an error string.
- *private\_info* and *cb* represent a pointer to binary data returned by the OpenCL implementation that can be used to log additional information helpful in debugging the error.
- *user\_data* is a pointer to user supplied data.

If *pfn\_notify* is NULL, no callback function is registered.

*user\_data* is passed as the *user\_data* argument when *pfn\_notify* is called. *user\_data* can be NULL.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Context::Context** returns a valid object of type **cl::Context** and sets *err* to CL\_SUCCESS if it creates the context successfully. Otherwise, it returns one of the following error values in *err*:

- CL\_INVALID\_PROPERTY if context property name in *properties* is not a supported property name, if the value specified for a supported property name is not valid, or if the same property name is specified more than once.
- CL\_INVALID\_VALUE if *devices* is of length zero.
- CL\_INVALID\_VALUE if *pfn\_notify* is NULL but *user\_data* is not NULL.
- CL\_INVALID\_DEVICE if *devices* contains an invalid device.
- CL\_DEVICE\_NOT\_AVAILABLE if a device in *devices* is currently not available even though the device was returned by **cl::Platform::getDevices**.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The constructor

```
cl::Context::Context(cl_device_type type,
                     cl_context_properties * properties = NULL,
                     void (CL_CALLBACK * pfn_notify)(
                         const char * errorinfo,
                         const void * private_info,
```

```

        ::size_t cb,
        void * user_data) = NULL,
void * user_data = NULL,
cl_int * err = NULL)

```

creates an OpenCL context from a device type that identifies the specific devices to use.

*type* is a bit-field that identifies the type of device, as described in table 4.2 in section 4.2 of the *OpenCL Specification* Version 1.2.

*properties* specifies a list of context property names and their corresponding values. Each property name is immediately followed by the corresponding desired value. The list is terminated with 0. The list of supported properties is described in table 4.4. properties can be NULL, in which case the platform that is selected is implementation-defined.

*pfn\_notify* is a callback function registered by the application. This callback function is used by the OpenCL implementation to report information on errors that occur in this context. This callback function may be called asynchronously by the OpenCL implementation. It is the application's responsibility to ensure that the callback function is thread-safe. The parameters to the callback function are:

- *errinfo* is a pointer to an error string.
- *private\_info* and *cb* represent a pointer to binary data that is returned by the OpenCL implementation that can be used to log additional information helpful in debugging the error.
- *user\_data* is a pointer to user supplied data.

If *pfn\_notify* is NULL, no callback function is registered.

*user\_data* is passed as the *user\_data* argument when *pfn\_notify* is called. *user\_data* can be NULL.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Context::Context** returns a valid object of type **cl::Context** and sets *err* to CL\_SUCCESS if it creates the context successfully. Otherwise, it returns one of the following error values in *err*:

- CL\_INVALID\_PROPERTY if context property name in *properties* is not a supported property name, if the value specified for a supported property name is not valid, or if the same property name is specified more than once.
- CL\_INVALID\_VALUE if *pfn\_notify* is NULL but *user\_data* is not NULL.
- CL\_INVALID\_DEVICE\_TYPE if *type* is not a valid value.
- CL\_DEVICE\_NOT\_AVAILABLE if no devices that match *type* and property values specified in *properties* are currently available.
- CL\_DEVICE\_NOT\_FOUND if no devices that match *type* and property values specified in *properties* were found.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```

template <typename T>
cl_int cl::Context::getInfo(cl_context_info name,
                          T * param)

```



gets specific information about the OpenCL context. Table 4.6 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_context\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_context_info</b>	<b>C++ return Type</b>
CL_CONTEXT_DEVICES	VECTOR_CLASS<cl::Device>
CL_CONTEXT_PROPERTIES	VECTOR_CLASS<cl_context_properties>

Table 3: Differences in cl::Context::getInfo return type vs. *OpenCL Specification* table 4.6

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in tables 4.6.

*name* is an enumeration constant that identifies the context information being queried. It can be one of the values specified in table 4.6.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 4.5 is returned. If *param* is NULL, it is ignored.

**cl::Context::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_context_info, name>::param_type
cl::Context::getInfo(void)
```

gets specific information about the OpenCL context. Table 4.6 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_context\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the context information being queried. It can be one of the values specified in table 4.6.

**cl::Context::getInfo** returns the appropriate value for a given *name* as specified in table 4.6.

The method

```
cl_int cl::Context::getSupportedImageFormats(
    cl_mem_flags flags,
    cl_mem_object_type image_type,
    VECTOR_CLASS<ImageFormat> * formats)
```

can be used to get the list of image formats supported by an OpenCL implementation for the context, when the following information about an image memory object is specified:

- Context
- Image type - 2D, or 3D image.
- Image object allocation information

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3 of the *OpenCL Specification* Version 1.2.

*image\_type* describes the image type. It must be either `CL_MEM_OBJECT_IMAGE2D` or `CL_MEM_OBJECT_IMAGE3D`.

*formats* is a pointer to a memory location where the vector of supported image formats is returned. Each entry describes a instance of the class **cl::ImageFormat**, which is a mapping for **cl\_image\_format** structure supported by the OpenCL implementation. If *formats* is NULL, it is ignored.

**cl::Context::getSupportedImageFormats** returns `CL_SUCCESS` on success. Otherwise, it returns one of the following errors:

- `CL_INVALID_VALUE` if *flags* or *image\_type* are not valid.
- `CL_OUT_OF_RESOURCES` if there is a failure to allocate resources required by the OpenCL implementation on the device.
- `CL_OUT_OF_HOST_MEMORY` if there is a failure to allocate resources required by the OpenCL implementation on the host.

## 3. C++ Runtime layer

### 3.1 Memory Objects

Class **cl::Memory** provides a base class for working with OpenCL memory objects. It is used to build buffers and images in the following sections.

The method

```
template <typename T>
cl_int cl::Memory::getInfo(cl_context_info name,
                           T * param)
```

gets specific information about the OpenCL memory object. Table 5.11 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_memory\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_memory_info</b>	<b>C++ return Type</b>
<code>CL_MEM_CONTEXT</code>	<code>cl::Context</code>

Table 4: Differences in **cl::Memory::getInfo** return type vs. *OpenCL Specification* table 5.11

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in tables 5.11.

*name* is an enumeration constant that identifies the context information being queried. It can be one of the values specified in table 5.11.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.11 is returned. If *param* is NULL, it is ignored.

**cl::Memory::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_context_info, name>::param_type
cl::Memory::getInfo(void)
```

gets specific information about the OpenCL memory object. Table 5.11 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_memory\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the memory object information being queried. It can be one of the values specified in table 5.11.

**cl::Memory::getInfo** returns the appropriate value for a given *name* as specified in table 5.11.

The method

```
cl_int cl::Memory::setDestructorCallback(
    void (CL_CALLBACK * pfn_notify)(cl_mem memobj,
                                     void * user_data),
    void * user_data = NULL)
```

registers a user callback function that is called when the memory object is deleted and its resources freed. The description of **clSetMemObjectDestructorCallback** in section 5.4 of the *OpenCL Specification* gives a detailed overview.

*pfn\_notify* is a callback function registered by the application. This callback function may be called asynchronously by the OpenCL implementation. It is the application's responsibility to ensure that the callback function is thread-safe. The parameters to the callback function are:

- *memobj* is the memory object being deleted.
- *user\_data* is a pointer to user supplied data.

*user\_data* is passed as the *user\_data* argument when *pfn\_notify* is called.

**cl::Memory::setDestructorCallback** returns CL\_SUCCESS if executed successfully. Otherwise, it returns one of the following errors:

- CL\_INVALID\_VALUE if *pfn\_notify* is NULL.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.
-

## 3.2 Buffers

Class **cl::Buffer : public Memory** provides functionality for working with OpenCL buffers.

The constructor

```
cl::Buffer::Buffer(  
    const Context& context,  
    cl_mem_flags flags,  
    ::size_t size,  
    void * host_ptr = NULL,  
    cl_int * err = NULL)
```

creates an OpenCL buffer object.

*context* is a valid OpenCL context used to create the buffer object.

*flags* is a bit-field that specifies allocation and usage information, such as the memory arena that used to allocate the buffer object and how it is used. Table 5.3 of the *OpenCL Specification* Version 1.2 describes the valid values for *flags*.

*size* is the size in bytes of the buffer memory object to be allocated.

*host\_ptr* is a pointer to buffer data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be at least *size* bytes.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The constructor

```
cl::Buffer::Buffer(  
    cl_mem_flags flags,  
    ::size_t size,  
    void * host_ptr = NULL,  
    cl_int * err = NULL)
```

creates an OpenCL buffer object in the default context. The default context is constructed via *clCreateContextFromType* with a type of **CL\_DEVICE\_TYPE\_DEFAULT**.

*flags* is a bit-field that specifies allocation and usage information, such as the memory arena that used to allocate the buffer object and how it is used. Table 5.3 of the *OpenCL Specification* Version 1.2 describes the valid values for *flags*.

*size* is the size in bytes of the buffer memory object to be allocated.

*host\_ptr* is a pointer to buffer data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be at least *size* bytes.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The constructor

```
template <typename IteratorType>
cl::Buffer::Buffer(
    IteratorType startIterator,
    IteratorType endIterator,
    bool readonly ,
    bool useHostPtr = true,
    cl_int * err = NULL)
```

creates an initialized OpenCL buffer object.

The given *IteratorType* must be a random access iterator. If *useHostPtr* is true, it must use contiguous storage.

*startIterator* and *endIterator* of the given *IteratorType* provide start and end iterators for the data source.

*readonly* specifies whether the buffer object is readonly (**cl\_mem\_flags** value **CL\_MEM\_READONLY** or **CL\_MEM\_READWRITE**).

*useHostPtr* specifies whether the buffer uses a host pointer (**cl\_mem\_flags** value **CL\_MEM\_USE\_HOST\_PTR**).

**cl::Buffer::Buffer** creates a valid non-zero buffer object and sets *err* to **CL\_SUCCESS** if it creates the buffer object successfully. Otherwise, it returns one of the following error values returned in *err*:

- **CL\_INVALID\_CONTEXT** if context is not a valid context.
- **CL\_INVALID\_VALUE** if values specified in flags are not valid.
- **CL\_INVALID\_BUFFER\_SIZE** if size is 0.
- **CL\_INVALID\_HOST\_PTR** if *host\_ptr* is NULL and **CL\_MEM\_USE\_HOST\_PTR** or **CL\_MEM\_COPY\_HOST\_PTR** are set in flags or if *host\_ptr* is not NULL but **CL\_MEM\_COPY\_HOST\_PTR** or **CL\_MEM\_USE\_HOST\_PTR** are not set in flags.
- **CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE** if there is a failure to allocate memory for buffer object.
- **CL\_OUT\_OF\_RESOURCES** if there is a failure to allocate resources required by the OpenCL implementation on the device.
- **CL\_OUT\_OF\_HOST\_MEMORY** if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl::Buffer cl::Buffer::createSubBuffer(cl_mem_flags flags,
                                         cl_buffer_create_type buffer_create_type,
                                         const void * buffer_create_info,
                                         cl_int * err = NULL)
```

creates a new buffer object from an existing buffer object.

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3 of the *OpenCL Specification* Version 1.2.

*buffer\_create\_type* and *buffer\_create\_info* describe the type of buffer object to be created. The list of supported values for *buffer\_create\_type* and corresponding descriptor for *buffer\_create\_info* are described in table 5.4 of the *OpenCL Specification* Version 1.2.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Buffer::createSubBuffer** returns CL\_SUCCESS in *err* on success. It returns an error code in *err* from the underlying OpenCL *clCreateSubBuffer* call if it fails. Otherwise, it returns one of the following errors in *err*:

- CL\_INVALID\_VALUE if values specified in *flags* are not valid.
- CL\_INVALID\_VALUE if value specified in *buffer\_create\_type* is not valid.
- CL\_INVALID\_VALUE if value specified in *buffer\_create\_info* (for a given *buffer\_create\_type*) is not valid or if *buffer\_create\_info* is NULL.

### 3.2.1 Buffer copy

The method

```
template <typename IteratorType>
cl_int copy(IteratorType startIterator,
            IteratorType endIterator,
            cl::Buffer &buffer)
```

performs a blocking copy to a buffer. The given *IteratorType* must be a random access iterator.

*startIterator* and *endIterator* of the given *IteratorType* provide start and end iterators for the data source.

*buffer* gives the destination buffer.

The method

```
template <typename IteratorType>
cl_int copy(const cl::Buffer &buffer,
            IteratorType startIterator,
            IteratorType endIterator)
```

performs a blocking copy from a buffer.

*buffer* gives the source buffer.

*startIterator* and *endIterator* of the given *IteratorType* provide start and end iterators for the data destination.

### 3.2.2 BufferGL objects

Class **cl::BufferGL : public Buffer** provides functionality for OpenGL buffer interoperability.

The constructor

```
cl::BufferGL::BufferGL(  
    const Context& context,  
    cl_mem_flags flags,  
    GLuint bufobj,  
    cl_int * err = NULL)
```

creates an OpenGL-compatible buffer object.

*context* is a valid OpenCL context used to create the buffer object.

*flags* is a bit-field. Table 5.3 of the *OpenCL Specification* Version 1.2 describes the valid values for *flags*.

*bufobj* is an OpenGL buffer handle.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The method

```
cl_int cl::BufferGL::getObjectInfo(cl_gl_object_type *type,  
                                   GLuint *gl_object_name)
```

gets specific information about an OpenGL buffer object.

*type* returns the type of the GL buffer object, as defined in *OpenCL Specification* Version 1.1, section 9.8.5. If *type* is NULL, it is ignored.

*gl\_object\_name* returns the GL object name used to create the OpenGL renderbuffer object. If *gl\_object\_name* is NULL, it is ignored.

**cl::BufferGL::getObjectInfo** returns CL\_SUCCESS on success.

### 3.2.3 BufferRenderGL objects

Class **cl::BufferRenderGL : public Buffer** provides functionality for OpenGL renderbuffer interoperability.

The constructor

```
cl::BufferRenderGL::BufferRenderGL(  
    const Context& context,  
    cl_mem_flags flags,  
    GLuint bufobj,  
    cl_int * err = NULL)
```

creates an OpenGL-compatible renderbuffer object.

*context* is a valid OpenCL context used to create the buffer object.

*flags* is a bit-field. Table 5.3 describes the valid values for *flags*.

*bufobj* is an OpenGL renderbuffer handle.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The method

```
cl_int cl::BufferRenderGL::getObjectInfo(cl_gl_object_type *type,  
                                           GLuint *gl_object_name)
```

gets specific information about an OpenGL renderbuffer object.

*type* returns the type of the GL renderbuffer object, as defined in *OpenCL Specification* Version 1.1, section 9.8.5.

*gl\_object\_name* returns the GL object name used to create the OpenGL renderbuffer object. If *gl\_object\_name* is NULL, it is ignored.

**cl::BufferRenderGL::getObjectInfo** returns CL\_SUCCESS on success.

## 3.3 Images

Class **cl::Image: public Memory** provides a base class for working with OpenCL image objects. It is used to build 1D, 2D, 3D, and array images in the following sections.

The method

```
template <typename T>  
cl_int cl::Image::getImageInfo(cl_image_info name,  
                                T* param)
```

gets specific information about the OpenCL image object. Table 5.9 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried.

*T* is a compile time argument that is the return for the specific information being queried. It corresponds to the values in table 5.9.

*name* is an enumeration constant that identifies the context information being queried. It can be one of the values specified in table 5.9.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.9 is returned. If *param* is NULL, it is ignored.

**cl::Memory::getImageInfo** returns CL\_SUCCESS on success. Otherwise, it returns:



- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_image_info, name>::param_type
cl::Image::getImageInfo(void)
```

gets specific information about the OpenCL image object. Table 5.9 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried.

*name* is an enumeration constant that identifies the memory object information being queried. It can be one of the values specified in table 5.9.

**cl::Image::getImageInfo** returns the appropriate value for a given *name* as specified in table 5.9.

### 3.3.1 Image1D objects

Class **cl::Image1D** : **public Image** provides functionality for working with OpenCL 1D images.

The constructor

```
cl::Image1D::Image1D(Context& context,
                    cl_mem_flags flags,
                    ImageFormat format,
                    ::size_t width,
                    void * host_ptr = NULL,
                    cl_int * err = NULL)
```

creates an OpenCL 1D image object.

*context* is a valid OpenCL context on which the image object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image object being created. It is described in table 5.3 of the *OpenCL Specification* Version 1.2.

*format* is a class that describes format properties of the image to be allocated. **cl::ImageFormat** is a mapping for OpenCL image format descriptor structure **cl\_image\_format**, defined in Section 5.3.1.1 of the *OpenCL Specification* Version 1.2:

```
typedef struct _cl_image_format {
    cl_channel_order  image_channel_order;
    cl_channel_type   image_channel_data_type;
} cl_image_format;
```

*width* gives the width of the image in pixels. It must be greater than or equal to 1.

*host\_ptr* is a pointer to the image data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be  $\geq \text{row\_pitch} * \text{height}$ . The size of each element in bytes must be a power of 2.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Image1D::Image1D** returns a valid non-zero image object and sets *err* to CL\_SUCCESS if it creates the image object successfully. Otherwise, it returns one of the following error values in *err*:

- CL\_INVALID\_CONTEXT if context is not a valid context.
- CL\_INVALID\_VALUE if values specified in flags are not valid.
- CL\_INVALID\_IMAGE\_FORMAT\_DESCRIPTOR if values specified in *format* are not valid.
- CL\_INVALID\_IMAGE\_SIZE if *width* is 0 or exceeds the value specified in CL\_DEVICE\_IMAGE2D\_MAX\_WIDTH for all devices in context or if values specified by *row\_pitch* do not follow rules described in the argument description above.
- CL\_INVALID\_HOST\_PTR if *host\_ptr* is NULL and CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_COPY\_HOST\_PTR are set in flags or if *host\_ptr* is not NULL but CL\_MEM\_COPY\_HOST\_PTR or CL\_MEM\_USE\_HOST\_PTR are not set in flags.
- CL\_IMAGE\_FORMAT\_NOT\_SUPPORTED if the *image\_format* is not supported.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for image object.
- CL\_INVALID\_OPERATION if there are no devices in context that support images (i.e., CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

Class **cl::Image1DArray : public Image** provides functionality for working with arrays of OpenCL 1D images.

The constructor

```
cl::Image1DArray::Image1DArray(Context& context,  
                                cl_mem_flags flags,  
                                ImageFormat format,  
                                ::size_t array_size,  
                                ::size_t width,  
                                ::size_t row_pitch = 0,  
                                void * host_ptr = NULL,  
                                cl_int * err = NULL)
```

creates an OpenCL 1D image array object.

*context* is a valid OpenCL context on which the object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3.

*format* is a class that describes format properties of the image to be allocated. **cl::ImageFormat** is a mapping for the OpenCL structure **cl\_image\_format**. Section 5.3.1.1 gives a detailed description of the image format descriptor.

*array\_size* is the number of images in the image array.

*width* is the width of each image in pixels. This value must be greater than or equal to 1.

*row\_pitch* is the scan-line pitch in bytes. This must be 0 if *host\_ptr* is NULL and can be either 0 or  $\geq \text{width} * \text{size of element in bytes}$  if *host\_ptr* is not NULL. If *host\_ptr* is not NULL and *row\_pitch* = 0, *row\_pitch* is calculated as  $\text{width} * \text{size of element in bytes}$ . If *row\_pitch* is not 0, it must be a multiple of the image element size in bytes.

*host\_ptr* is a pointer to the image data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be  $\geq \text{row\_pitch} * \text{array\_size}$ . The size of each element in bytes must be a power of 2. The image data specified by *host\_ptr* is stored as a linear sequence of adjacent scanlines. Each scanline is stored as a linear sequence of image elements.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Image1DArray::Image1DArray** returns a valid non-zero object and sets *err* to CL\_SUCCESS if it creates the image array object successfully.

Class **cl::Image1DBuffer : public Image** provides functionality for working with OpenCL 1D image buffers.

The constructor

```
cl::Image1DBuffer::Image1DBuffer(Context& context,  
                                cl_mem_flags flags,  
                                ImageFormat format,  
                                ::size_t width,  
                                const Buffer &buffer,  
                                cl_int * err = NULL)
```

creates an OpenCL 1D image buffer object.

*context* is a valid OpenCL context on which the object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3. See the list of error codes for restrictions on how flags may be set.

*format* is a class that describes format properties of the image to be allocated. **cl::ImageFormat** is a mapping for the OpenCL structure **cl\_image\_format**. Section 5.3.1.1 gives a detailed description of the image format descriptor.

*width* is the width of the image in pixels. This value must be greater than or equal to 1.

*buffer* refers to a valid buffer memory object.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Image1DArray::Image1DArray** returns a valid non-zero object and sets *err* to CL\_SUCCESS if it creates the image array object successfully. Otherwise, it returns one of the following error codes:

- CL\_INVALID\_CONTEXT if context is not a valid context.
- CL\_INVALID\_VALUE if values specified in flags are not valid.
- CL\_INVALID\_IMAGE\_FORMAT\_DESCRIPTOR if values specified in image\_format are not valid or if image\_format is NULL.
- CL\_INVALID\_IMAGE\_DESCRIPTOR if values specified in image\_desc are not valid or if image\_desc is NULL.
- CL\_INVALID\_IMAGE\_SIZE if image dimensions specified in image\_desc exceed the minimum maximum image dimensions described in the table of allowed values for param\_name for clGetDeviceInfo for all devices in context.
- CL\_INVALID\_HOST\_PTR if host\_ptr in image\_desc is NULL and CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_COPY\_HOST\_PTR are set in flags or if host\_ptr is not NULL but CL\_MEM\_COPY\_HOST\_PTR or CL\_MEM\_USE\_HOST\_PTR are not set in flags.
- CL\_INVALID\_VALUE if a 1D image buffer is being created and the buffer object was created with CL\_MEM\_WRITE\_ONLY and flags specifies CL\_MEM\_READ\_WRITE or CL\_MEM\_READ\_ONLY, or if the buffer object was created with CL\_MEM\_READ\_ONLY and flags specifies CL\_MEM\_READ\_WRITE or CL\_MEM\_WRITE\_ONLY, or if flags specifies CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_ALLOC\_HOST\_PTR or CL\_MEM\_COPY\_HOST\_PTR.
- CL\_INVALID\_VALUE if a 1D image buffer is being created and the buffer object was created with CL\_MEM\_HOST\_WRITE\_ONLY and flags specifies CL\_MEM\_HOST\_READ\_ONLY, or if the buffer object was created with CL\_MEM\_HOST\_READ\_ONLY and flags specifies CL\_MEM\_HOST\_WRITE\_ONLY, or if the buffer object was created with CL\_MEM\_HOST\_NO\_ACCESS and flags specifies CL\_MEM\_HOST\_READ\_ONLY or CL\_MEM\_HOST\_WRITE\_ONLY.
- CL\_IMAGE\_FORMAT\_NOT\_SUPPORTED if the image\_format is not supported.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for image object.
- CL\_INVALID\_OPERATION if there are no devices in context that support images (i.e. CL\_DEVICE\_IMAGE\_SUPPORT (specified in the table of OpenCL Device Queries for clGetDeviceInfo) is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

### 3.3.2 Image2D objects

Class **cl::Image2D** : **public Image** provides functionality for working with OpenCL 2D images.

The constructor

```
cl::Image2D::Image2D(Context& context,
                       cl_mem_flags flags,
                       ImageFormat format,
                       ::size_t width,
```

```

::size_t height,
::size_t row_pitch = 0,
void * host_ptr = NULL,
cl_int * err = NULL)

```

creates an OpenCL 2D image object.

*context* is a valid OpenCL context on which the image object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3 of the *OpenCL Specification* Version 1.2.

*format* is a class that describes format properties of the image to be allocated. **cl::ImageFormat** is a mapping for the OpenCL structure **cl\_image\_format**. Section 5.3.1.1 gives for a detailed description of the image format descriptor.

*width*, and *height* are the width and height of the image in pixels. Each must be greater than or equal to 1.

*row\_pitch* is the scan-line pitch in bytes. This must be 0 if *host\_ptr* is NULL and can be either 0 or  $\geq \text{width} * \text{size of element in bytes}$  if *host\_ptr* is not NULL. If *host\_ptr* is not NULL and *row\_pitch* = 0, *row\_pitch* is calculated as  $\text{width} * \text{size of element in bytes}$ . If *row\_pitch* is not 0, it must be a multiple of the image element size in bytes.

*host\_ptr* is a pointer to the image data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be  $\geq \text{row\_pitch} * \text{height}$ . The size of each element in bytes must be a power of 2. The image data specified by *host\_ptr* is stored as a linear sequence of adjacent scanlines. Each scanline is stored as a linear sequence of image elements.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Image2D::Image2D** returns a valid non-zero image object and sets *err* to CL\_SUCCESS if it creates the image object successfully. Otherwise, it returns one of the following error values in *err*:

- CL\_INVALID\_CONTEXT if context is not a valid context.
- CL\_INVALID\_VALUE if values specified in flags are not valid.
- CL\_INVALID\_IMAGE\_FORMAT\_DESCRIPTOR if values specified in *format* are not valid.
- CL\_INVALID\_IMAGE\_SIZE if *width* or *height* are 0 or if they exceed values specified in CL\_DEVICE\_IMAGE2D\_MAX\_WIDTH or CL\_DEVICE\_IMAGE2D\_MAX\_HEIGHT respectively for all devices in context or if values specified by *row\_pitch* do not follow rules described in the argument description above.
- CL\_INVALID\_HOST\_PTR if *host\_ptr* is NULL and CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_COPY\_HOST\_PTR are set in flags or if *host\_ptr* is not NULL but CL\_MEM\_COPY\_HOST\_PTR or CL\_MEM\_USE\_HOST\_PTR are not set in flags.
- CL\_IMAGE\_FORMAT\_NOT\_SUPPORTED if the *image\_format* is not supported.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for image object.
- CL\_INVALID\_OPERATION if there are no devices in context that support images (i.e., CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.

- `CL_OUT_OF_HOST_MEMORY` if there is a failure to allocate resources required by the OpenCL implementation on the host.

Class **`cl::Image2DArray`** : **`public Image`** provides functionality for working with arrays of OpenCL 2D images.

The constructor

```
cl::Image2DArray::Image2DArray(Context& context,
                                cl_mem_flags flags,
                                ImageFormat format,
                                ::size_t array_size,
                                ::size_t width,
                                ::size_t height,
                                ::size_t row_pitch = 0,
                                ::size_t slice_pitch = 0,
                                void * host_ptr = NULL,
                                cl_int * err = NULL)
```

creates an OpenCL 2D image array object.

*context* is a valid OpenCL context on which the object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3.

*format* is a class that describes format properties of the image to be allocated. **`cl::ImageFormat`** is a mapping for the OpenCL structure **`cl_image_format`**. Section 5.3.1.1 gives a detailed description of the image format descriptor.

*array\_size* is the number of images in the image array.

*width* and *height* are the width and height of each image in pixels. These must be values greater than or equal to 1.

*row\_pitch* is the scan-line pitch in bytes. This must be 0 if *host\_ptr* is NULL and can be either 0 or  $\geq \text{width} * \text{size of element in bytes}$  if *host\_ptr* is not NULL. If *host\_ptr* is not NULL and *row\_pitch* = 0, *row\_pitch* is calculated as  $\text{width} * \text{size of element in bytes}$ . If *row\_pitch* is not 0, it must be a multiple of the image element size in bytes.

*slice\_pitch* gives the size in bytes of each image in the image array. It must be 0 if *host\_ptr* is NULL. If *host\_ptr* is not NULL, *slice\_pitch* can be either 0 or equal to *row\_pitch*.

*host\_ptr* is a pointer to the image data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be  $\geq \text{slice\_pitch} * \text{array\_size}$ . The size of each element in bytes must be a power of 2. The image data specified by *host\_ptr* is stored as a linear sequence of adjacent scanlines. Each scanline is stored as a linear sequence of image elements.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Image2DArray::Image2DArray** returns a valid non-zero object and sets *err* to CL\_SUCCESS if it creates the image array object successfully.

### 3.3.3 Image3D objects

Class **cl::Image3D** : public **Image** provides functionality for working with OpenCL 3D images.

The constructor

```
cl::Image3D::Image3D(const Context& context,
                      cl_mem_flags flags,
                      ImageFormat format,
                      ::size_t width,
                      ::size_t height,
                      ::size_t depth,
                      ::size_t row_pitch = 0,
                      ::size_t slice_pitch = 0,
                      void * host_ptr = NULL,
                      cl_int * err = NULL)
```

creates an OpenCL 3D image object.

*context* is a valid OpenCL context on which the image object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image memory object being created, as described in table 5.3.

*format* is a class that describes format properties of the image to be allocated. **cl::ImageFormat** is a mapping for the OpenCL structure **cl\_image\_format**. Section 5.3.1.1 gives a detailed description of the image format descriptor.

*width*, and *height* are the width and height of the image in pixels. Each must be greater than or equal to 1.

*depth* is the depth of the image in pixels. This must be a value > 1.

*row\_pitch* is the scan-line pitch in bytes. This must be 0 if *host\_ptr* is NULL and can be either 0 or  $\geq \text{width} * \text{size of element in bytes}$  if *host\_ptr* is not NULL. If *host\_ptr* is not NULL and *row\_pitch* = 0, *row\_pitch* is calculated as  $\text{width} * \text{size of element in bytes}$ . If *row\_pitch* is not 0, it must be a multiple of the image element size in bytes.

*slice\_pitch* is the size in bytes of each 2D slice in the 3D image. This must be 0 if *host\_ptr* is NULL and can be either 0 or  $\geq \text{row\_pitch} * \text{height}$  if *host\_ptr* is not NULL. If *host\_ptr* is not NULL and *slice\_pitch* = 0, *slice\_pitch* is calculated as  $\text{row\_pitch} * \text{height}$ . If *slice\_pitch* is not 0, it must be a multiple of the *row\_pitch*.

*host\_ptr* is a pointer to the image data that may already be allocated by the application. The size of the buffer that *host\_ptr* points to must be  $\geq \text{slice\_pitch} * \text{depth}$ . The size of each element in bytes must be a power of 2.

The image data specified by *host\_ptr* is stored as a linear sequence of adjacent 2D slices. Each 2D slice is a linear sequence of adjacent scanlines. Each scanline is a linear sequence of image elements.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Image3D::Image3D** returns a valid non-zero image object and sets *err* to CL\_SUCCESS if it creates the image object successfully. Otherwise, it returns one of the following error values in *err*:

- CL\_INVALID\_CONTEXT if context is not a valid context.
- CL\_INVALID\_VALUE if values specified in flags are not valid.
- CL\_INVALID\_IMAGE\_FORMAT\_DESCRIPTOR if values specified in *format* are not valid.
- CL\_INVALID\_IMAGE\_SIZE if *width*, *height* are 0 or if *depth* <= 1 or if they exceed values specified in CL\_DEVICE\_IMAGE3D\_MAX\_WIDTH, CL\_DEVICE\_IMAGE3D\_MAX\_HEIGHT or CL\_DEVICE\_IMAGE3D\_MAX\_DEPTH respectively for all devices in context or if values specified by *row\_pitch* and *slice\_pitch* do not follow rules described in the argument description above.
- CL\_INVALID\_HOST\_PTR if *host\_ptr* is NULL and CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_COPY\_HOST\_PTR are set in flags or if *host\_ptr* is not NULL but CL\_MEM\_COPY\_HOST\_PTR or CL\_MEM\_USE\_HOST\_PTR are not set in flags.
- CL\_IMAGE\_FORMAT\_NOT\_SUPPORTED if the *image\_format* is not supported.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for image object.
- CL\_INVALID\_OPERATION if there are no devices in context that support images (i.e. CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

### 3.3.4 ImageGL objects

Class **cl::ImageGL : public Image** provides functionality for OpenGL image interoperability. This class abstracts all OpenGL image objects (texture buffer objects, 1D texture objects, 1D texture array objects, 2D texture objects, 2D texture array objects, and 3D texture objects).

The constructor

```
cl::ImageGL::ImageGL(Context& context,  
                      cl_mem_flags flags,  
                      GLenum target,  
                      GLint miplevel,  
                      GLuint texobj,  
                      cl_int * err = NULL)
```

creates an OpenGL image object.

*context* is a valid OpenCL context on which the image object is to be created.

*flags* is a bit-field that specifies allocation and usage information about the image object being created and is described in table 5.3 of the *OpenCL Specification* Version 1.2.



*target* is an OpenGL texture type, as defined in section 9.8.3 of the *OpenCL Specification* Version 1.1.

*miplevel* is the mipmap level to be used.

*texobj* is the name of an OpenGL texture object.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::ImageGL::ImageGL** returns a valid non-zero image object and sets *err* to CL\_SUCCESS if it creates the image object successfully.

## 3.4 Samplers

Class **cl::Sampler** provides functionality for working with OpenCL samplers.

The constructor

```
cl::Sampler::Sampler(const Context& context,  
                      cl_bool normalized_coords,  
                      cl_addressing_mode addressing_mode,  
                      cl_filter_mode filter_mode,  
                      cl_int * err = NULL)
```

creates an OpenCL sampler object. Refer to section 6.11.13.1 for a detailed description of how samplers work.

*context* must be a valid OpenCL context.

*normalized\_coords* determines if the image coordinates specified are normalized (if *normalized\_coords* is CL\_TRUE) or not (if *normalized\_coords* is CL\_FALSE).

*addressing\_mode* specifies how out-of-range image coordinates are handled when reading from an image. It can be CL\_ADDRESS\_MIRRORED\_REPEAT, CL\_ADDRESS\_REPEAT, CL\_ADDRESS\_CLAMP\_TO\_EDGE, CL\_ADDRESS\_CLAMP, or CL\_ADDRESS\_NONE.

*filtering\_mode* specifies the type of filter that must be applied when reading an image. It can be CL\_FILTER\_NEAREST, or CL\_FILTER\_LINEAR.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Sampler::Sampler** constructs a valid non-zero sampler object and sets *err* to CL\_SUCCESS if it creates the sampler object successfully. Otherwise, it returns one of the following error values in *err*:

- CL\_INVALID\_CONTEXT if *context* is not a valid context.
- CL\_INVALID\_VALUE if an argument value for *addressing\_mode*, *filter\_mode*, or *normalized\_coords* is not valid.
- CL\_INVALID\_OPERATION if images are not supported by any device associated with *context* (i.e., CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.

- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
template <typename T>
cl_int cl::Sampler::getInfo(cl_sampler_info name,
                             T * param)
```

gets specific information about the OpenCL Sampler. Table 5.12 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_sampler\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_sampler_info</b>	<b>C++ return Type</b>
CL_SAMPLER_CONTEXT	cl::Context

Table 5: Differences in cl::Sampler::getInfo return type vs. *OpenCL Specification* table 5.12

*T* is a compile time argument that is the return for the specific information being queried. It corresponds to the values in tables 5.12.

*name* is an enumeration constant that identifies the sampler information being queried. It can be one of the values specified in table 5.12.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.12 is returned.

If *param* is NULL, it is ignored.

**cl::Sampler::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_sampler_info, name>::param_type
cl::Sampler::getInfo(void)
```

gets specific information about the OpenCL sampler. Table 5.12 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_sampler\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the sampler information being queried. It can be one of the values specified in table 5.12.

**cl::Sampler::getInfo** returns the appropriate value for a given *name* as specified in table 5.12.

## 3.5 Programs

Class **cl::Program** provides functionality for working with OpenCL programs.

Class **cl::Program** provides two public typedefs for working with source files and binaries, respectively

```
typedef VECTOR_CLASS<std::pair<const void*, ::size_t> > Binaries
```

and

```
typedef VECTOR_CLASS<std::pair<const char*, ::size_t> > Sources
```

The constructor

```
cl::Program::Program(const STRING_CLASS& source,  
                      cl_int * err = NULL)
```

creates and builds an OpenCL program object in the default context.

*source* is the program source code.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The constructor

```
cl::Program::Program(const STRING_CLASS& source,  
                      bool build,  
                      cl_int * err = NULL)
```

creates an OpenCL program object.

*source* is the program source code.

*bool* is a flag that indicates whether to build the program.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The constructor

```
cl::Program::Program(const Context& context,  
                      const STRING_CLASS& source,  
                      bool build,  
                      cl_int * err = NULL)
```

creates an OpenCL program object for an OpenCL context.

*context* must be a valid OpenCL context.

*source* is the program source code.

*bool* is a flag that indicates whether to build the program.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

The constructor

```
cl::Program::Program(const Context& context,  
                      const Sources& sources,  
                      cl_int * err = NULL)
```

creates an OpenCL program object for a context and loads the source code specified by the text strings in each element of the vector *sources* into the program object.

*context* must be a valid OpenCL context.

*sources* is a vector of source/size tuples that make up the source code.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Program::Program** returns a valid program object and sets *err* to CL\_SUCCESS if it creates the program object successfully. Otherwise, it returns one of the following error values returned in *err*:

- CL\_INVALID\_CONTEXT if *context* is not a valid context.
- CL\_INVALID\_VALUE if *sources* contains zero entries or if any entry in *sources* contains a tuple with NULL. CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The constructor

```
cl::Program::Program(const Context& context,  
                      const VECTOR_CLASS<Device>& devices,  
                      const Binaries& binaries,  
                      VECTOR_CLASS<cl_int> * binaryStatus = NULL,  
                      cl_int * err = NULL)
```

creates an OpenCL program object for a context and loads the binary bits specified by the binary in each element of the vector *binaries* into the program object.

*context* must be a valid OpenCL context.

*devices* is a list of devices. *devices* must be of non-zero length and each device specified by *devices* must be associated with *context*. The *binaries* are loaded for devices specified in this list. The devices associated with the program object will be the given *devices*.

*binaries* is a vector of program binaries to be loaded for devices specified by *devices*. For each *devices*[*i*], the program binary for that device is *binaries*[*i*].

*binary\_status* returns whether the program binary for each device specified in *devices* was loaded successfully. If *binary\_status* is NULL, it is ignored. If non-NULL, *binary\_status* will be resized to match the length of

*devices*. *binary\_status[i]* returns CL\_SUCCESS if the binary for *devices[i]* is successfully loaded or CL\_INVALID\_BINARY if program *binaries[i]* is NULL.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Program::Program** returns a valid program object and sets *err* to CL\_SUCCESS if it creates the program object successfully. Otherwise, it returns one of the following error values returned in *err*:

- CL\_INVALID\_CONTEXT if *context* is not a valid context.
- CL\_INVALID\_VALUE if *devices* is of length zero or if the length of *binaries* is not equal to the length of *devices* or if any entry in *binaries* is not valid..
- CL\_INVALID\_DEVICE if OpenCL devices listed in *devices* are not in the list of devices associated with context.
- CL\_INVALID\_BINARY if an invalid program binary was encountered for any device. *binaryStatus* returns specific status for each device.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The constructor

```
cl::Program::Program(const Context& context,  
                     const VECTOR_CLASS<Device>& devices,  
                     STRING_CLASS& kernelNames,  
                     cl_int * err = NULL)
```

creates an OpenCL program object with a set of built-in kernel names for a context.

*context* must be a valid OpenCL context.

*devices* is a vector list of devices that are in *context*. *devices* must be of non-zero length and each device specified by *devices* must be associated with *context*. The binaries are loaded for devices specified in this list. The devices associated with the program object will be the given *devices*.

*kernelNames* is a semi-colon separated list of built-in kernel names.

**cl::Program::Program** returns a valid program object and sets *err* to CL\_SUCCESS if it creates the program object successfully.

The method

```
cl_int cl::Program::build(const VECTOR_CLASS<Device>& devices,  
                        const char * options = NULL,  
                        (CL_CALLBACK * pfn_notify)  
                        (cl_program,  
                        void * user_data) = NULL,  
                        void * data = NULL)
```

builds (compiles and links) a program executable from the program source or binary for all the devices or specific devices in the OpenCL context associated with program.

*devices* is a list of devices associated with program. If *devices* is of length zero, the program executable is built for all devices associated with program for which a source or binary has been loaded. If *devices* is of non-zero length, the program executable is built for devices specified in the list for which a source or binary has been loaded.

*options* is a pointer to a string that describes the build options to be used for building the program executable. Section 5.6.4 of the *OpenCL Specification* Version 1.2 describes the supported options.

*pfn\_notify* is a function pointer to a notification routine. The notification routine is a callback function that an application can register and which is called when the program executable has been built (successfully or unsuccessfully). If *pfn\_notify* is not NULL, **cl::Program::build** does not need to wait for the build to complete and can return immediately. If *pfn\_notify* is NULL, **cl::Program::build** does not return until the build has completed. This callback function may be called asynchronously by the OpenCL implementation. It is the application's responsibility to ensure that the callback function is thread-safe.

*data* is passed as an argument when *pfn\_notify* is called. *data* can be NULL.

**cl::Program::build** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_VALUE if *pfn\_notify* is NULL but *data* is not NULL.
- CL\_INVALID\_DEVICE if OpenCL devices listed in *devices* are not in the list of devices associated with program
- CL\_INVALID\_BINARY if program is created with the **cl::Program::Program** taking a list of binaries and devices listed in *devices* do not have a valid program binary loaded.
- CL\_INVALID\_BUILD\_OPTIONS if the build options specified by options are invalid.
- CL\_INVALID\_OPERATION if the build of a program executable for any of the devices listed in *devices* by a previous call to **cl::Program::build** for program has not completed.
- CL\_COMPILER\_NOT\_AVAILABLE if program is created from source and a compiler is not available, i.e., CL\_DEVICE\_COMPILER\_AVAILABLE specified in table 4.3 is set to CL\_FALSE.
- CL\_BUILD\_PROGRAM\_FAILURE if there is a failure to build the program executable. This error is returned if **cl::Program::build** does not return until the build has completed.
- CL\_INVALID\_OPERATION if there are kernel objects attached to program.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::Program::build(const char * options = NULL,
                        (CL_CALLBACK * pfn_notify)
                        (cl_program,
                        void * user_data) = NULL,
                        void * data = NULL)
```

builds (compiles and links) a program executable from the program source or binary in the OpenCL context associated with program.

*options* is a pointer to a string that describes the build options to be used for building the program executable. The list of supported options is described in section 5.6.4 of the *OpenCL Specification* Version 1.2.

*pfn\_notify* is a function pointer to a notification routine. The notification routine is a callback function that an application can register and which is called when the program executable has been built (successfully or unsuccessfully). If *pfn\_notify* is not NULL, **cl::Program::build** does not need to wait for the build to complete and can return immediately. If *pfn\_notify* is NULL, **cl::Program::build** does not return until the build has completed. This callback function may be called asynchronously by the OpenCL implementation. The application must ensure that the callback function is thread-safe.

*data* is passed as an argument when *pfn\_notify* is called. *data* can be NULL.

**cl::Program::build** returns CL\_SUCCESS on success.

The method

```
cl_int cl::Program::compile(const char * options = NULL,
                           (CL_CALLBACK * pfn_notify)
                           (cl_program,
                            void * user_data) = NULL,
                           void * data = NULL)
```

compiles (but does not link) a program executable from the program source or binary in the OpenCL context associated with program.

*options* is a pointer to a string that describes the compilation options to be used for building the program executable. Section 5.6.4 of the *OpenCL Specification* Version 1.2 describes the list of supported options.

*pfn\_notify* is a function pointer to a notification routine. The notification routine is a callback function that an application can register and which is called when the program executable has been built (successfully or unsuccessfully). If *pfn\_notify* is not NULL, **cl::Program::compile** does not need to wait for the build to complete and can return immediately. If *pfn\_notify* is NULL, **cl::Program::compile** does not return until the build has completed. This callback function may be called asynchronously by the OpenCL implementation. It is the application's responsibility to ensure that the callback function is thread-safe.

*data* is passed as an argument when *pfn\_notify* is called. *data* can be NULL.

**cl::Program::compile** returns CL\_SUCCESS on success.

The function

```
cl::Program linkProgram(Program input1,
                        Program input2,
                        const char * options = NULL,
                        (CL_CALLBACK * pfn_notify)
                        (cl_program,
                         void * user_data) = NULL,
                        void * data = NULL,
                        cl_int *err = NULL)
```

links programs *input1* and *input2*.

*input1* and *input2* are program objects.

*options* is a pointer to a string that describes the compilation options to be used for linking the program executable. The list of supported options is described in section 5.6.4 of the *OpenCL Specification 1.2*.

*pfn\_notify* is a function pointer to a notification routine. The notification routine is a callback function registered by the application which is called when the program executable has been built (successfully or unsuccessfully). If *pfn\_notify* is not NULL, **cl::Program::linkProgram** does not need to wait for the build to complete and can return immediately. If *pfn\_notify* is NULL, **cl::Program::linkProgram** does not return until the build has completed. This callback function may be called asynchronously by the OpenCL implementation. The application must ensure that the callback function is thread-safe.

*data* is passed as an argument when *pfn\_notify* is called. *data* can be NULL.

**linkProgram** returns CL\_SUCCESS if executed successfully.

The function

```
cl::Program linkProgram(VECTOR_CLASS<Program> InputPrograms,
                        const char * options = NULL,
                        (CL_CALLBACK * pfn_notify)
                        (cl_program,
                        void * user_data) = NULL,
                        void * data = NULL,
                        cl_int *err = NULL)
```

links a set of programs.

*InputPrograms* is a set of program objects.

*options* is a pointer to a string that describes the compilation options to be used for linking the program executable. The list of supported options is described in section 5.6.4 of the *OpenCL Specification Version 1.2*.

*pfn\_notify* is a function pointer to a notification routine. The notification routine is a callback function registered by the application which is called when the program executable has been built (successfully or unsuccessfully). If *pfn\_notify* is not NULL, **cl::Program::linkProgram** does not need to wait for the build to complete and returns immediately. If *pfn\_notify* is NULL, **cl::Program::linkProgram** does not return until the build has completed. This callback function may be called asynchronously by the OpenCL implementation. The application must ensure that the callback function is thread-safe.

*data* is passed as an argument when *pfn\_notify* is called. *data* can be NULL.

**linkProgram** returns CL\_SUCCESS if executed successfully.

The method

```
template <typename T>
```



```
cl_int cl::Program::getInfo(cl_program_info name,
                             T * param)
```

gets specific information about the OpenCL Program. Table 5.13 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_program\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_program_info</b>	<b>C++ return Type</b>
CL_PROGRAM_BINARIES	VECTOR_CLASS<char *>
CL_PROGRAM_BINARY_SIZES	VECTOR_CLASS<::size_t>
CL_PROGRAM_CONTEXT	cl::Context
CL_PROGRAM_DEVICES	VECTOR_CLASS<cl::Device>
CL_PROGRAM_KERNEL_NAMES	STRING_CLASS
CL_PROGRAM_SOURCE	STRING_CLASS

Table 6: Differences in **cl::Program::getInfo** return type vs. *OpenCL Specification* table 5.13

*T* is a compile time argument that is the return for the specific information being queried. It corresponds to the values in table 5.13.

*name* is an enumeration constant that identifies the program information being queried. It can be one of the values specified in table 5.13.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.13 is returned. If *param* is NULL, it is ignored.

**cl::Program::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_program_info, name>::param_type
cl::Program::getInfo(void)
```

gets specific information about the OpenCL program. Table 5.13 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_program\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the program information being queried. It can be one of the values specified in table 5.13.

**cl::Program::getInfo** returns the appropriate value for a given *name* as specified in table 5.13.

The method

```
template <typename T>
cl_int cl::Program::getBuildInfo(cl_program_build_info name,
                                  T * param)
```

returns build information for each device in the program object. Table 5.14 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_program\_build\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_program_build_info</b>	<b>C++ return Type</b>
CL_PROGRAM_BUILD_LOG	STRING_CLASS
CL_PROGRAM_BUILD_OPTIONS	STRING_CLASS

Table 7: Differences in `cl::Program::getBuildInfo` return type vs. *OpenCL Specification* table 5.14

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in tables 5.14.

*name* is an enumeration constant that identifies the program build information being queried. It can be one of the values specified in table 5.14.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.14 is returned. If *param* is NULL, it is ignored.

**cl::Program::getBuildInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_program_info, name>::param_type
cl::Program::getBuildInfo(void)
```

returns build information for each device in the program object. Table 5.14 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_program\_build\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the program information being queried. It can be one of the values specified in table 5.14.

**cl::Program::getBuildInfo** returns the appropriate value for a given *name* as specified in table 5.14.

The method

```
cl_int cl::Program::createKernels(const VECTOR_CLASS<Kernel> * kernels)
```

creates kernel objects (i.e., objects of type **cl::Kernel**, see section 3.6 below) for all kernels in the program.

*kernels* is a pointer to a vector where the kernel objects for *kernels* in the program are returned.

**c::Program::createKernels** returns CL\_SUCCESS if the kernel objects were successfully allocated. Otherwise, it returns one of the following errors:

- CL\_INVALID\_PROGRAM\_EXECUTABLE if there is no successfully built executable for any device in program.

- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

## 3.6 Kernels

Class **cl::Kernel** provides functionality for working with OpenCL kernels.

The constructor

```
cl::Kernel::Kernel(const Program& program,
                    const char * name,
                    cl_int * err = NULL)
```

creates a kernel object.

*program* is a program object with a successfully built executable.

*name* is a function name in the program declared with the **\_\_kernel** qualifier.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::Kernel::Kernel** returns a valid kernel object and sets *err* to CL\_SUCCESS if it creates the kernel object successfully. Otherwise, it returns one of the following error values returned in *err*:

- CL\_INVALID\_PROGRAM if program is not a valid program object.
- CL\_INVALID\_PROGRAM\_EXECUTABLE if there is no successfully built executable for program.
- CL\_INVALID\_KERNEL\_NAME if *name* is not found in program.
- CL\_INVALID\_KERNEL\_DEFINITION if the function definition for **\_\_kernel** function given by *name* such as the number of arguments, the argument types are not the same for all devices for which the program executable has been built.
- CL\_INVALID\_VALUE if *name* is NULL.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
template <typename T>
cl_int cl::Kernel::getInfo(cl_kernel_info name,
                          T * param)
```

gets specific information about the OpenCL kernel. Table 5.15 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_kernel\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_kernel_info</b>	<b>C++ return Type</b>
CL_KERNEL_ATTRIBUTES	STRING_CLASS

CL_KERNEL_CONTEXT	cl::Context
CL_KERNEL_FUNCTION_NAME	STRING_CLASS
CL_KERNEL_PROGRAM	cl::Program

Table 8: Differences in cl::Kernel::getInfo return type vs. OpenCL Specification table 5.15

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in table 5.15.

*name* is an enumeration constant that identifies the kernel information being queried. It can be one of the values specified in table 5.15.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.15 is returned. If *param* is NULL, it is ignored.

**cl::Kernel::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_kernel_info, name>::param_type
cl::Kernel::getInfo(void)
```

gets specific information about the OpenCL kernel. Table 5.15 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_kernel\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the kernel information being queried. It can be one of the values specified in table 5.15.

**cl::Kernel::getInfo** returns the appropriate value for a given *name* as specified in table 5.15.

The method

```
template <typename T>
cl_int cl::Kernel::getArgInfo(cl_uint argIndex,
                             cl_kernel_arg_info name,
                             T * param)
```

gets specific information about an OpenCL kernel argument. Table 5.17 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_kernel\_arg\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_kernel_arg_info</b>	<b>C++ return Type</b>
CL_KERNEL_ARG_NAME	STRING_CLASS
CL_KERNEL_ARG_TYPE_NAME	STRING_CLASS

Table 9: Differences in cl::Kernel::getArgInfo return type vs. OpenCL Specification table 5.17

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in table 5.15.

*argIndex* is the index of the kernel argument being queried.

*name* is an enumeration constant that identifies the kernel argument information being queried. It can be one of the values specified in table 5.17.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.17 is returned. If *param* is NULL, it is ignored.

**cl::Kernel::getArgInfo** returns CL\_SUCCESS on success.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_kernel_arg_info, name>::param_type
cl::Kernel::getArgInfo(xl_uint argIndex, cl_int* err)
```

gets specific information about an OpenCL kernel argument. Table 5.15 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_kernel\_arg\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the kernel information being queried. It can be one of the values specified in table 5.17.

*argIndex* is the index of the kernel argument being queried.

**cl::Kernel::getArgInfo** returns the appropriate value for a given *name* as specified in table 5.17.

The method

```
template <typename T>
cl_int cl::Kernel::getWorkGroupInfo(cl_kernel_work_group_info name,
                                     T* param)
```

gets specific information about the OpenCL kernel object that may be specific to a device. Table 5.16 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_kernel\_work\_group\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_kernel_work_group_info</b>	<b>C++ return Type</b>
CL_KERNEL_COMPILE_WORK_GROUP_SIZE	cl::size_t<3> <sup>2</sup>

Table 10: Differences in cl::Kernel::getWorkGroupInfo return type vs. *OpenCL Specification* table 5.16

<sup>2</sup> cl::size\_t<3> is a internal type that can be treated as a 3D array whose components correspond to x,y,z values of the work-group size.

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in tables 5.16.

*name* is an enumeration constant that identifies the kernel information being queried. It can be one of the values specified in table 5.16.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.16 is returned. If *param* is NULL, it is ignored.

**cl::Kernel::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_kernel_work_group_info, name>::param_type
cl::Kernel::getWorkGroupInfo(void)
```

gets specific information about the OpenCL kernel object that may be specific to a device. Table 5.16 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_kernel\_work\_group\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the kernel information being queried. It can be one of the values specified in table 5.16.

**cl::Kernel::getWorkGroupInfo** returns the appropriate value for a given *name* as specified in table 5.16.

The method

```
template <typename T>
cl_int cl::Kernel::setArg(cl_uint index,
                          T value)
```

sets the argument value for a specific argument of a kernel.

*T* is a compile time argument that determines the type of a kernel argument being set. It can be one of the following:

- A **cl::Memory** object. e.g. a **cl::Buffer** or **cl::Image3D** would be possible values.
- A **cl::Sampler** object.
- A value of type **cl::LocalSpaceArg**<sup>3</sup>, which corresponds to an argument of **\_\_local** in the kernel object.
- A constant value that is passed by value to the kernel.

*index* is the argument index. Arguments to the kernel are referred by indices that go from 0 for the leftmost argument to *n* - 1, where *n* is the total number of arguments declared by a kernel.

---

<sup>3</sup> The function **cl::LocalSpaceArg** **cl::Local**(::size\_t) can be used to construct arguments specifying the size of a **Local** kernel argument. For example, **cl::Local**(100) would allocate sizeof(cl\_char) \* 100 of local memory.

*value* is the data that should be used as the argument value for argument specified by *index*.

**cl::Kernel::setArg** returns CL\_SUCCESS if the function was executed successfully. Otherwise, it returns one of the following errors:

- CL\_INVALID\_ARG\_INDEX if *index* is not a valid argument index.
- CL\_INVALID\_MEM\_OBJECT for an argument declared to be a memory object when the specified *value* is not a valid memory object.
- CL\_INVALID\_SAMPLER for an argument declared to be of type *cl::Sampler* when the specified *value* is not a valid sampler object.

### 3.6.1 Kernel functors

Kernel functors provide additional functionality to simplify kernel invocations. The template

```
template <typename T0, typename T1 = detail::NullType, typename T2 = detail::NullType,
    typename T3 = detail::NullType, typename T4 = detail::NullType, typename T5 = detail::NullType,
    typename T6 = detail::NullType, typename T7 = detail::NullType, typename T8 = detail::NullType,
    typename T9 = detail::NullType, typename T10 = detail::NullType, typename T11 = detail::NullType,
    typename T12 = detail::NullType, typename T13 = detail::NullType, typename T14 = detail::NullType,
    typename T15 = detail::NullType, typename T16 = detail::NullType, typename T17 = detail::NullType,
    typename T18 = detail::NullType, typename T19 = detail::NullType, typename T20 = detail::NullType,
    typename T21 = detail::NullType, typename T22 = detail::NullType, typename T23 = detail::NullType,
    typename T24 = detail::NullType, typename T25 = detail::NullType, typename T26 = detail::NullType,
    typename T27 = detail::NullType, typename T28 = detail::NullType, typename T29 = detail::NullType,
    typename T30 = detail::NullType, typename T31 = detail::NullType>
struct make_kernel :: detail::functionImplementation<T0, T1, T2, T3, T4, T5, T6, T7, T8, T9, T10,
    T11, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22, T23, T24, T25, T26, T27, T28, T29, T30, T31>
cl::make_kernel::make_kernel(
    const Program &program,
    const STRING_CLASS name,
    cl_int *err = NULL)
```

makes a kernel functor for a kernel with 1 to 32 arguments.

*T0* to *T31* are the kernel argument types.

*program* is the OpenCL program that defines the kernel.

*name* is the name of the kernel functor.

*err* returns an appropriate error code. If *err* is NULL, no error is returned.

The template

```
template <typename T0, typename T1 = detail::NullType, typename T2 = detail::NullType,
    typename T3 = detail::NullType, typename T4 = detail::NullType, typename T5 = detail::NullType,
    typename T6 = detail::NullType, typename T7 = detail::NullType, typename T8 = detail::NullType,
```

```

typename T9 = detail::NullType, typename T10 = detail::NullType, typename T11 = detail::NullType,
typename T12 = detail::NullType, typename T13 = detail::NullType, typename T14 = detail::NullType,
typename T15 = detail::NullType, typename T16 = detail::NullType, typename T17 = detail::NullType,
typename T18 = detail::NullType, typename T19 = detail::NullType, typename T20 = detail::NullType,
typename T21 = detail::NullType, typename T22 = detail::NullType, typename T23 = detail::NullType,
typename T24 = detail::NullType, typename T25 = detail::NullType, typename T26 = detail::NullType,
typename T27 = detail::NullType, typename T28 = detail::NullType, typename T29 = detail::NullType,
typename T30 = detail::NullType, typename T31 = detail::NullType>
struct make_kernel :: detail::functionImplementation<T0, T1, T2, T3, T4, T5, T6, T7, T8, T9, T10,
T11, T12, T13, T14, T15, T16, T17, T18, T19, T20, T21, T22, T23, T24, T25, T26, T27, T28, T29, T30, T31>
cl::make_kernel::make_kernel(
    const Kernel kernel,
    cl_int *err = NULL)

```

makes a kernel functor for the given *kernel* with 1 to 32 arguments.

*T0* to *T31* are the kernel argument types.

*err* returns an appropriate error code. If *err* is NULL, no error is returned.

The overloaded operator () for a kernel functor invocation takes one of the following forms:

```

Event operator() ( EnqueueArgs& args,
                  T0 t0, T1 t1 = NullType, ..., T31 t31 = NullType)
Event operator() ( EnqueueArgs& args,
                  const Event& waitEvent,
                  T0 t0, T1 t1 = NullType, ..., T31 t31 = NullType )
Event operator() ( EnqueueArgs &args,
                  const VECTOR_CLASS<Event>& waitEvents,
                  T0 t0, T1 t1 = NullType, ..., T31 t31 = NullType )

```

The first enqueues the kernel's arguments, invokes the kernel, and returns an event object representing the kernel execution. The second and third forms are similar, but the second waits for the completion of the given *waitEvent* before invoking the kernel, while the third waits for completion of all *waitEvents* before invoking the kernel.

For example, suppose *myKernelProgram* is a Program with a string defining the source for kernel *myKernel*, and suppose *myKernel* takes three Buffer arguments (two input buffers and an output buffer). Then:

```

typedef cl::make_kernel <cl::Buffer&, cl::Buffer&, cl::Buffer&> KernelType;
std::function<KernelType::type_> myKernel = KernelType(myKernelProgram, "myKernel");

```

constructs kernel functor *myKernel*. Similarly, using *auto* (for C++11 users):

```

auto myKernel = cl::make_kernel<cl::Buffer&, cl::Buffer&, cl::Buffer&> (myKernelProgram,
                                                                    "myKernel");

```

To invoke the kernel with enqueued input buffers *inBuf1* and *inBuf2* of size *n* and output buffer *outBuf*:

```

myKernel(cl::EnqueueArgs(cl::NDRange(n), cl::NDRange(n)), inBuf1, inBuf2, outBuf);

```



Class **EnqueueArgs** is described in the next subsection below.

Due to the way the parameter state of the underlying kernel objects is defined, functors that reference the same kernel object must not be called concurrently.

### 3.6.2 EnqueueArgs

Class **cl::EnqueueArgs** parameterizes argument dispatch. Its constructors, listed below, allow for orthogonal overloading of dispatch parameters and parameter count for functors. If a single event is passed, **EnqueueArgs** constructs a list of one event for the enqueue. If a vector of events is passed, it constructs a list of input event dependencies. Argument dispatch occurs through the default queue or through a specified queue.

The constructors for **EnqueueArgs** are:

```
cl::EnqueueArgs::EnqueueArgs(NDRange global)
cl::EnqueueArgs::EnqueueArgs(NDRange global, NDRange local)
cl::EnqueueArgs::EnqueueArgs(NDRange offset, NDRange global, NDRange local)

cl::EnqueueArgs::EnqueueArgs(Event e, NDRange global)
cl::EnqueueArgs::EnqueueArgs(Event e, NDRange global, NDRange local)
cl::EnqueueArgs::EnqueueArgs(Event e, NDRange offset, NDRange global, NDRange local)

cl::EnqueueArgs::EnqueueArgs(const VECTOR_CLASS<Event> &events, NDRange global)
cl::EnqueueArgs::EnqueueArgs(const VECTOR_CLASS<Event> &events, NDRange global,
    NDRange local)
cl::EnqueueArgs::EnqueueArgs(const VECTOR_CLASS<Event> &events, NDRange offset,
    NDRange global, NDRange local)

cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue, NDRange global)
cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue, NDRange global, NDRange local)
cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue, NDRange offset, NDRange global,
    NDRange local)

cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue, Event e, NDRange global)
cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue, Event e, NDRange global,
    NDRange local)
cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue, Event e, NDRange offset,
    NDRange global, NDRange local)

cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue,
    const VECTOR_CLASS<Event> &events, NDRange global)
cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue,
    const VECTOR_CLASS<Event> &events, NDRange global, NDRange local)
cl::EnqueueArgs::EnqueueArgs(CommandQueue &queue,
    const VECTOR_CLASS<Event> &events, NDRange offset, NDRange global,
    NDRange local)
```

*global* is a global work size corresponding to the *global\_work\_size* argument of the underlying OpenCL **EnqueueNDRangeKernel** call.

*local* is a local work size corresponding to the *local\_work\_size* argument of the underlying OpenCL **EnqueueNDRangeKernel** call. If *local* is not specified, a NULL *local\_work\_size* is used.

*offset* is an offset corresponding to the *global\_work\_offset* argument of the underlying OpenCL **EnqueueNDRangeKernel** call. If *offset* is not specified, a NULL *global\_work\_offset* is used.

*e* is an **Event** that must be completed before the **EnqueueArgs** may be executed, and similarly *events* is a list of events that must be completed before the **EnqueueArgs** may be executed. If neither *e* nor *events* is specified, the **EnqueueArgs** is executed without waiting on any events.

*queue* is a **CommandQueue** to which the **EnqueueArgs** is submitted. If *queue* is not specified, **EnqueueArgs** is submitted to the default queue.

## 3.7 Events

Class **cl::Event** provides functionality for working with OpenCL events.

The method

```
template <typename T>
cl_int cl::Event::getInfo(cl_event_info name,
T* param)
```

gets specific information about the OpenCL event. Table 5.18 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_event\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

cl_event_info	C++ return Type
CL_EVENT_CONTEXT	cl::Context
CL_EVENT_COMMAND_QUEUE	cl::CommandQueue

Table 11: Differences in **cl::Event::getInfo** return type vs. *OpenCL Specification* table 5.18

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in tables 5.18.

*name* is an enumeration constant that identifies the event information being queried. It can be one of the values specified in table 5.18.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.18 is returned. If *param* is NULL, it is ignored.

**cl::Event::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_event_info, name>::param_type
cl::Event::getInfo(void)
```

gets specific information about an OpenCL event. Table 5.18 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_event\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the event information being queried. It can be one of the values specified in table 5.18.

**cl::Event::getInfo** returns the appropriate value for a given *name* as specified in table 5.18.

The method

```
template <typename T>
cl_int cl::Event::getProfilingInfo(cl_profiling_info name,
                                   T* param)
```

returns profiling information for the command associated with event. Table 5.19 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried.

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in tables 5.19.

*name* is an enumeration constant that identifies the profiling information being queried. It can be one of the values specified in table 5.19.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.19 is returned. If *param* is NULL, it is ignored.

**cl::Event::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- CL\_INVALID\_VALUE if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_profiling_info, name>::param_type
cl::Event::getProfilingInfo(void)
```

returns profiling information for the command associated with event. Table 5.19 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried.

*name* is an enumeration constant that identifies the profiling information being queried. It can be one of the values specified in table 5.19.

**cl::Event::getProfilingInfo** returns the appropriate value for a given *name* as specified in table 5.19.

The method

```
cl_int cl::Event::wait(void)
```

waits on the host thread for the command associated with the particular event to complete.

**cl::Event::wait** returns CL\_SUCCESS if the function was executed successfully. Otherwise, it returns one of the following errors:

- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::Event::setCallback(cl_int type,  
                             void (CL_CALLBACK * pfn_notify)  
                             (cl_event event,  
                              cl_int command_exec_status,  
                              void * user_data),  
                             void * user_data = NULL)
```

registers a user callback function for a specific command execution status. The registered callback function is called when the execution status of command associated with event changes to the execution status specified by *command\_exec\_status*.

*type* specifies the command execution status for which the callback is registered. The command execution callback mask values for which a callback can be registered are: CL\_COMPLETE. There is no guarantee that the callback functions registered for various execution status values for an event is called in the exact order that the execution status of a command changes.

*pfn\_notify* is the event callback function registered by the application. This callback function may be called asynchronously by the OpenCL implementation. It is the application's responsibility to ensure that the callback function is thread-safe. The parameters to the callback function are:

- *event* is the event object for which the callback function is invoked.
- *command\_exec\_status* represents the execution status of command for which this callback function is invoked. Refer to table 5.15 for the command execution status values. If the callback is called as the result of the command associated with event being abnormally terminated, an appropriate error code for the error that caused the termination is passed to *command\_exec\_status* instead.
- *user\_data* is a pointer to user supplied data.

*user\_data* is passed as the *user\_data* argument when *pfn\_notify* is called. *user\_data* can be NULL.

**cl::Event::setCallback** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_VALUE if *pfn\_notify* is NULL or if *command\_exec\_callback\_type* is not a valid command execution status.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.

- `CL_OUT_OF_HOST_MEMORY` if there is a failure to allocate resources required by the OpenCL implementation on the host.

The static method

```
static cl_int cl::Event::waitForEvents(const VECTOR_CLASS<Event>& events)
```

waits on the host thread for commands identified by event objects in *events* to complete. A command is considered complete if its execution status is `CL_COMPLETE` or a negative value. The events specified in *events* act as synchronization points.

**cl::Event::waitForEvents** returns `CL_SUCCESS` if the function was executed successfully. Otherwise, it returns one of the following errors:

- `CL_INVALID_VALUE` if *events* is of length zero.
- `CL_INVALID_CONTEXT` if events specified in *events* do not belong to the same context.
- `CL_INVALID_EVENT` if event objects specified in *events* are not valid event objects.
- `CL_OUT_OF_RESOURCES` if there is a failure to allocate resources required by the OpenCL implementation on the device.
- `CL_OUT_OF_HOST_MEMORY` if there is a failure to allocate resources required by the OpenCL implementation on the host.

## 3.8 User Events

Class **cl::UserEvent : public Event** provides functionality for working with OpenCL user events.

The constructor

```
cl::UserEvent::UserEvent(Context& context,  
                          cl_int * err = NULL)
```

creates a user event object. User events allow applications to enqueue commands that wait on a user event to finish before the command is executed by the device.

*context* must be a valid OpenCL context.

*err* returns an appropriate error code. If *err* is `NULL`, no error code is returned.

**cl::UserEvent::UserEvent** returns a valid object and sets *err* to `CL_SUCCESS` if it creates the user event object successfully. Otherwise, it returns one of the following error values returned in *err*:

- `CL_INVALID_CONTEXT` if *context* is not a valid context.
- `CL_OUT_OF_RESOURCES` if there is a failure to allocate resources required by the OpenCL implementation on the device.
- `CL_OUT_OF_HOST_MEMORY` if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

**cl\_int cl::UserEvent::setStatus(cl\_int status)**

sets the execution status of a user event object.

*status* specifies the new execution status to be set and can be CL\_COMPLETE or a negative integer value to indicate an error.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::UserEvent::setStatus** returns CL\_SUCCESS if the function was executed successfully.

Otherwise, it returns one of the following errors:

- CL\_INVALID\_VALUE if the *status* is not CL\_COMPLETE or a negative integer value.
- CL\_INVALID\_OPERATION if the *status* for event has already been changed by a previous call to **cl::UserEvent::setStatus**.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

## 3.9 Command Queues

Class **cl::NDRange** provides functionality for working with global and local NDRanges, as described in section 5.1 of the *OpenCL Specification*. This is a necessary type for certain enqueue commands.

The constructor

**cl::NDRange::NDRange(::size\_t size0)**

returns a 1D range.

*size0* describes the number of global or local work-items in dimension 0.

The constructor

**cl::NDRange::NDRange (::size\_t size0,  
::size\_t size1)**

returns a 2D range.

*size0* describes the number of global or local work-items in dimension 0.

*size1* describes the number of global or local work-items in dimension 1.

The constructor

**cl::NDRange::NDRange (::size\_t size0,  
::size\_t size1,  
::size\_t size2)**

returns a 3D range.

*size0* describes the number of global or local work-items in dimension 0.

*size1* describes the number of global or local work-items in dimension 1.

*size2* describes the number of global or local work-items in dimension 2.

The operator

```
cl::NDRange::operator const ::size_t * () const
```

returns a pointer to an array of, 1, 2, or 3 elements of the range.

The method

```
::size_t cl::NDRange::dimensions(void)
```

returns the number of dimensions defined in the range.

Class **cl::CommandQueue** provides functionality for working with OpenCL command-queues.

The constructor

```
cl::CommandQueue::CommandQueue(  
    const Context& context,  
    const Device& device,  
    cl_command_queue_properties properties = 0,  
    cl_int * err = NULL)
```

creates a command-queue on a specific device.

*device* must be a device associated with context. It can either be in the list of devices specified when context is created using **cl::Context::Context**.

*properties* specifies a list of properties for the command-queue. This is a bit-field and is described in table 5.1 of the *OpenCL Specification* Version 1.2. Only command-queue properties specified in table 5.1 can be set in properties; otherwise the value specified in properties is considered to be not valid.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::CommandQueue::CommandQueue** returns a valid command-queue and sets *err* to CL\_SUCCESS if it creates the command-queue successfully. Otherwise, it returns one of the following error values returned in *err*:

- CL\_INVALID\_CONTEXT if context is not a valid context.
- CL\_INVALID\_DEVICE if device is not a valid device or is not associated with context.
- CL\_INVALID\_VALUE if values specified in properties are not valid.
- CL\_INVALID\_QUEUE\_PROPERTIES if values specified in properties are valid but are not supported by the device.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.

- **CL\_OUT\_OF\_HOST\_MEMORY** if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
template <typename T>
cl_int cl::CommandQueue::getInfo(cl_command_queue_info name,
                                   T* param)
```

gets specific information about an OpenCL command queue. Table 5.2 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table below lists **cl\_command\_queue\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

<b>cl_command_queue_info</b>	<b>C++ return Type</b>
CL_QUEUE_CONTEXT	cl::Context
CL_QUEUE_DEVICE	cl::Device

Table 12: Differences in **cl::CommandQueue::getInfo** return type vs. *OpenCL Specification* table 5.2

*T* is a compile time argument that is the return type for the specific information being queried. It corresponds to the values in table 5.2.

*name* is an enumeration constant that identifies the command-queue information being queried. It can be one of the values specified in table 5.2.

*param* is a pointer to a memory location where the appropriate values for a given *name* as specified in table 5.2 is returned. If *param* is NULL, it is ignored.

**cl::CommandQueue::getInfo** returns CL\_SUCCESS on success. Otherwise, it returns:

- **CL\_INVALID\_VALUE** if *name* is not one of the supported values.

The method

```
template <cl_int name> typename
detail::param_traits<detail::cl_command_queue_info, name>::param_type
cl::CommandQueue::getInfo(void)
```

gets specific information about the OpenCL command-queue. Table 5.2 of the *OpenCL Specification* Version 1.2 specifies the information that can be queried. The table above lists **cl\_command\_queue\_info** values that differ in return type between the OpenCL C API and the OpenCL C++ API.

*name* is an enumeration constant that identifies the command-queue information being queried. It can be one of the values specified in table 5.2.

**cl::CommandQueue::getInfo** returns the appropriate value for a given *name* as specified in table 5.2.

The methods

```
cl_int cl::CommandQueue::enqueueReadBuffer(
    const Buffer& buffer,
```



```

    cl_bool blocking_read,
    ::size_t offset,
    ::size_t size,
    const void * ptr,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)

```

and

```

cl_int cl::CommandQueue::enqueueWriteBuffer(
    const Buffer& buffer,
    cl_bool blocking_write,
    ::size_t offset,
    ::size_t size,
    const void * ptr,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)

```

enqueue a command to read from a buffer object to host memory or to write to a buffer object from host memory.

*buffer* refers to a valid buffer object.

*blocking\_read* and *blocking\_write* indicate if the read and write operations are blocking or nonblocking.

If *blocking\_read* is CL\_TRUE (i.e., the read command is blocking),

**cl::CommandQueue::enqueueReadBuffer** does not return until the buffer data has been read and copied into memory pointed to by *ptr*.

If *blocking\_read* is CL\_FALSE (i.e., the read command is non-blocking),

**cl::CommandQueue::enqueueReadBuffer** queues a non-blocking read command and returns. The contents of the buffer to which *ptr* points cannot be used until the read command has completed. The event argument returns an event object which can be used to query the execution status of the read command. When the read command has completed, the contents of the buffer that *ptr* points to can be used by the application.

If *blocking\_write* is CL\_TRUE, the OpenCL implementation copies the data referred to by *ptr* and enqueues the write operation in the command-queue. The memory pointed to by *ptr* can be reused by the application after the **cl::CommandQueue::enqueueWriteBuffer** call returns.

If *blocking\_write* is CL\_FALSE, the OpenCL implementation will use *ptr* to perform a nonblocking write. As the write is non-blocking the implementation can return immediately. The memory pointed to by *ptr* cannot be reused by the application after the call returns. The event argument returns an event object which can be used to query the execution status of the write command. When the write command has completed, the memory pointed to by *ptr* can then be reused by the application.

*offset* is the offset in bytes in the buffer object to read from or write to.

*size* is the size in bytes of data being read or written.

*ptr* is the pointer to buffer in host memory where data is to be read into or to be written from.

*events* is the list of events that need to complete before this particular command can be executed. If *events* is NULL or of zero length, then this particular command does not wait on any event to complete. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular read / write command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueReadBuffer** and **cl::CommandQueue::enqueueWriteBuffer** return CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with command-queue and buffer are not the same or if the context associated with command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if buffer is not a valid buffer object.
- CL\_INVALID\_VALUE if the region being read or written specified by (offset, size) is out of bounds or if *ptr* is a NULL value.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if buffer is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with buffer.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The methods

```
cl_int cl::CommandQueue::enqueueReadBufferRect(
    const Buffer& buffer,
    cl_bool blocking_read,
    const size_t<3> buffer_offset,
    const size_t<3> host_offset,
    const size_t<3> region,
    ::size_t buffer_row_pitch,
    ::size_t buffer_slice_pitch,
    ::size_t host_row_pitch,
    ::size_t host_slice_pitch,
    void * ptr,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

and

```
cl_int cl::CommandQueue::enqueueWriteBufferRect(
    const Buffer& buffer,
    cl_bool blocking_write,
    const size_t<3> & buffer_offset,
```

```

const size_t<3> & host_offset,
const size_t<3>& region,
::size_t buffer_row_pitch,
::size_t buffer_slice_pitch,
::size_t host_row_pitch,
::size_t host_slice_pitch,
void * ptr,
const VECTOR_CLASS<Event> * events = NULL,
Event * event = NULL)

```

enqueue command to read a 2D or 3D rectangular region from a buffer object to host memory or write a 2D or 3D rectangular region of a buffer object from host memory.

*buffer* refers to a valid buffer object.

*blocking\_read* and *blocking\_write* indicate if the read and write operations are blocking or nonblocking.

If *blocking\_read* is CL\_TRUE (i.e., the read command is blocking),

**cl::CommandQueue::enqueueReadBufferRect** does not return until the buffer data has been read and copied into memory pointed to by *ptr*.

If *blocking\_read* is CL\_FALSE (i.e., the read command is non-blocking),

**cl::CommandQueue::enqueueReadBufferRect** queues a non-blocking read command and returns. The contents of the buffer that *ptr* points to cannot be used until the read command has completed. The event argument returns an event object which can be used to query the execution status of the read command. When the read command has completed, the contents of the buffer that *ptr* points to can be used by the application.

If *blocking\_write* is CL\_TRUE, the OpenCL implementation copies the data referred to by *ptr* and enqueues the write operation in the command-queue. The memory pointed to by *ptr* can be reused by the application after the **cl::CommandQueue::enqueueWriteBufferRect** call returns.

If *blocking\_write* is CL\_FALSE, the OpenCL implementation will use *ptr* to perform a nonblocking write. As the write is non-blocking the implementation can return immediately. The memory pointed to by *ptr* cannot be reused by the application after the call returns. The event argument returns an event object which can be used to query the execution status of the write command. When the write command has completed, the memory pointed to by *ptr* can then be reused by the application.

*buffer\_origin* defines the (x, y, z) offset in the memory region associated with buffer. For a 2D rectangle region, the z value given by *buffer\_origin*[2] should be 0. The offset in bytes is computed as *buffer\_origin*[2] \* *buffer\_slice\_pitch* + *buffer\_origin*[1] \* *buffer\_row\_pitch* + *buffer\_origin*[0].

*host\_origin* defines the (x, y, z) offset in the memory region pointed to by *ptr*. For a 2D rectangle region, the z value given by *host\_origin*[2] should be 0. The offset in bytes is computed as *host\_origin*[2] \* *host\_slice\_pitch* + *host\_origin*[1] \* *host\_row\_pitch* + *host\_origin*[0].

*region* defines the (width, height, depth) in bytes of the 2D or 3D rectangle being read or written. For a 2D rectangle copy, the depth value given by *region*[2] should be 1.

*buffer\_row\_pitch* is the length of each row in bytes to be used for the memory region associated

with *buffer*. If *buffer\_row\_pitch* is 0, *buffer\_row\_pitch* is computed as *region*[0].

*buffer\_slice\_pitch* is the length of each 2D slice in bytes to be used for the memory region associated with *buffer*. If *buffer\_slice\_pitch* is 0, *buffer\_slice\_pitch* is computed as *region*[1] \* *buffer\_row\_pitch*.

*host\_row\_pitch* is the length of each row in bytes to be used for the memory region pointed to by *ptr*. If *host\_row\_pitch* is 0, *host\_row\_pitch* is computed as *region*[0].

*host\_slice\_pitch* is the length of each 2D slice in bytes to be used for the memory region pointed to by *ptr*. If *host\_slice\_pitch* is 0, *host\_slice\_pitch* is computed as *region*[1] \* *host\_row\_pitch*.

*ptr* is the pointer to *buffer* in host memory where data is to be read into or to be written from.

*events* specifies the events that need to complete before this particular command can be executed. If *events* is NULL or of zero length, then this particular command does not wait on any event to complete. If *events* is not NULL and non-zero length, the list of events must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular read / write command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueReadBufferRect** and **cl::CommandQueue::enqueueWriteBufferRect** return CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with command-queue and *buffer* are not the same or if the context associated with command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *buffer* is not a valid buffer object.
- CL\_INVALID\_VALUE if the region being read or written specified by (*buffer\_offset*, *region*) is out of bounds.
- CL\_INVALID\_VALUE if *ptr* is a NULL value.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *buffer* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *buffer*.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueCopyBuffer(  
    const Buffer & src,  
    const Buffer & dst,  
    ::size_t src_offset,  
    ::size_t dst_offset,  
    ::size_t size,
```

```
const VECTOR_CLASS<Event> * events = NULL,
Event * event = NULL)
```

enqueues a command to copy a buffer object identified by *src* to another buffer object identified by *dst*. The OpenCL context associated with command-queue, *src* and *dst* must be the same.

*src* refers to the offset where to begin copying data from *src*.

*dst* refers to the offset where to begin copying data into *dst*.

*size* refers to the size in bytes to copy.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete. **cl::CommandQueue::enqueueBarrier** can be used instead.

**cl::ComamndQueue::enqueueCopyBuffer** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with the command-queue, *src* and *dst* are not the same or if the context associated with the command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *src* and *dst* are not valid buffer objects.
- CL\_INVALID\_VALUE if *src*, *dst*, *size*, *src* + *size* or *dst* + *size* require accessing elements outside the *src* and *dst* buffer objects respectively.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *src* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *dst* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue.
- CL\_MEM\_COPY\_OVERLAP if *src* and *dst* are the same buffer object and the source and destination regions overlap.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *src* or *dst*.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueCopyBufferRect(
```

```

const Buffer& src_buffer,
const Buffer& dst_buffer,
const size_t<3>& src_origin,
const size_t<3>& dst_origin,
const size_t<3>& region,
::size_t src_row_pitch,
::size_t src_slice_pitch,
::size_t dst_row_pitch,
::size_t dst_slice_pitch,
const VECTOR_CLASS<Event> * events = NULL,
Event * event = NULL)

```

enqueues a command to copy a 2D or 3D rectangular region from the buffer object identified by *src* to a 2D or 3D region in the buffer object identified by *dst*. The OpenCL context associated with the command-queue, *src* and *dst* must be the same.

*src\_origin* defines the (x, y, z) offset in the memory region associated with *src\_buffer*. For a 2D rectangle region, the z value given by *src\_origin*[2] should be 0. The offset in bytes is computed as *src\_origin*[2] \* *src\_slice\_pitch* + *src\_origin*[1] \* *src\_row\_pitch* + *src\_origin*[0].

*dst\_origin* defines the (x, y, z) offset in the memory region associated with *dst\_buffer*. For a 2D rectangle region, the z value given by *dst\_origin*[2] should be 0. The offset in bytes is computed as *dst\_origin*[2] \* *dst\_slice\_pitch* + *dst\_origin*[1] \* *dst\_row\_pitch* + *dst\_origin*[0].

*region* defines the (width, height, depth) in bytes of the 2D or 3D rectangle being copied. For a 2D rectangle, the depth value given by *region*[2] should be 1.

*src\_row\_pitch* is the length of each row in bytes to be used for the memory region associated with *src\_buffer*. If *src\_row\_pitch* is 0, *src\_row\_pitch* is computed as *region*[0].

*src\_slice\_pitch* is the length of each 2D slice in bytes to be used for the memory region associated with *src\_buffer*. If *src\_slice\_pitch* is 0, *src\_slice\_pitch* is computed as *region*[1] \* *src\_row\_pitch*.

*dst\_row\_pitch* is the length of each row in bytes to be used for the memory region associated with *dst\_buffer*. If *dst\_row\_pitch* is 0, *dst\_row\_pitch* is computed as *region*[0].

*dst\_slice\_pitch* is the length of each 2D slice in bytes to be used for the memory region associated with *dst\_buffer*. If *dst\_slice\_pitch* is 0, *dst\_slice\_pitch* is computed as *region*[1] \* *dst\_row\_pitch*.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueCopyBufferRect** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with the command-queue, *src\_buffer* and *dst\_buffer* are not the same or if the context associated with the command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *src\_buffer* and *dst\_buffer* are not valid buffer objects.
- CL\_INVALID\_VALUE if (*src\_offset*, region) or (*dst\_offset*, region) require accessing elements outside the *src\_buffer* and *dst\_buffer* buffer objects respectively.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *src\_buffer* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *dst\_buffer* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue.
- CL\_MEM\_COPY\_OVERLAP if *src\_buffer* and *dst\_buffer* are the same buffer object and the source and destination regions overlap.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *src\_buffer* or *dst\_buffer*.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
template<typename PatternType>
cl_int cl::CommandQueue::enqueueFillBuffer(const Buffer& buffer,
                                           PatternType pattern,
                                           ::size_t offset,
                                           ::size_t size,
                                           const VECTOR_CLASS<Event>* events = NULL,
                                           Event* event = NULL) const
```

enqueues a command to fill a buffer object with a pattern of a given size.

*PatternType* must be an OpenCL data type.

*buffer* specifies the buffer to be filled.

*pattern* specifies the pattern.

*offset* specifies the offset into the buffer where filling begins.

*size* specifies the size of the pattern.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not

NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueFillBuffer** returns CL\_SUCCESS on success.

The methods

```
cl_int cl::CommandQueue::enqueueReadImage(  
    const Image& image,  
    cl_bool blocking_read,  
    const size_t<3>& origin,  
    const size_t<3>& region,  
    ::size_t row_pitch,  
    ::size_t slice_pitch,  
    void * ptr,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

and

```
cl_int cl::CommandQueue::enqueueWriteImage(  
    const Image& image,  
    cl_bool blocking_write,  
    const size_t<3>& origin,  
    const size_t<3>& region,  
    ::size_t row_pitch,  
    ::size_t slice_pitch,  
    const void * ptr,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

enqueues commands to read from a 2D or 3D image object to host memory or write to a 2D or 3D image object from host memory.

*image* refers to a valid 2D or 3D image object.

*blocking\_read* and *blocking\_write* indicate if the read and write operations are blocking or nonblocking.

If *blocking\_read* is CL\_TRUE (i.e., the read command is blocking),

**cl::CommandQueue::enqueueReadImage** does not return until the buffer data has been read and copied into memory pointed to by *ptr*.

If *blocking\_read* is CL\_FALSE (i.e., the read command is non-blocking),

**cl::CommandQueue::enqueueReadImage** queues a non-blocking read command and returns. The contents of the buffer to which *ptr* points cannot be used until the read command has completed. The event argument



returns an event object that can be used to query the execution status of the read command. When the read command has completed, the contents of the buffer that *ptr* points to can be used by the application.

If *blocking\_write* is CL\_TRUE, the OpenCL implementation copies the data referred to by *ptr* and enqueues the write command in the command-queue. The memory pointed to by *ptr* can be reused by the application after the **cl::CommandQueue::enqueueWriteImage** call returns.

If *blocking\_write* is CL\_FALSE, the OpenCL implementation will use *ptr* to perform a nonblocking write. As the write is non-blocking the implementation can return immediately. The memory pointed to by *ptr* cannot be reused by the application after the call returns. The event argument returns an event object which can be used to query the execution status of the write command. When the write command has completed, the memory pointed to by *ptr* can then be reused by the application.

*origin* defines the (x, y, z) offset in pixels in the image from where to read or write. If image is a 2D image object, the z value given by *origin*[2] must be 0.

*region* defines the (width, height, depth) in pixels of the 2D or 3D rectangle being read or written. If image is a 2D image object, the depth value given by *region*[2] must be 1.

*row\_pitch* in **cl::CommandQueue::enqueueReadImage** and *input\_row\_pitch* in **cl::CommandQueue::enqueueWriteImage** is the length of each row in bytes. This value must be greater than or equal to the element size in bytes \* width. If *row\_pitch* (or *input\_row\_pitch*) is set to 0, the appropriate row pitch is calculated based on the size of each element in bytes multiplied by width.

*slice\_pitch* in **cl::CommandQueue::enqueueReadImage** and *input\_slice\_pitch* in **cl::CommandQueue::enqueueWriteImage** is the size in bytes of the 2D slice of the 3D region of a 3D image being read or written respectively. This must be 0 if image is a 2D image. This value must be greater than or equal to *row\_pitch* \* height. If *slice\_pitch* (or *input\_slice\_pitch*) is set to 0, the appropriate slice pitch is calculated based on the *row\_pitch* \* height.

*ptr* is the pointer to a buffer in host memory where image data is to be read from or to be written to.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and of nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueReadImage** and **cl::CommandQueue::enqueueWriteImage** return CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with the command-queue and image are not the same or if the context associated with the command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if image is not a valid image object.
- CL\_INVALID\_VALUE if the region being read or written specified by *origin* and *region* is out of bounds or if *ptr* is a NULL value.

- CL\_INVALID\_VALUE if image is a 2D image object and *origin*[2] is not equal to 0 or *region*[2] is not equal to 1 or *slice\_pitch* is not equal to 0.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_INVALID\_IMAGE\_SIZE if image dimensions (image width, height, specified or compute row and/or slice pitch) for image are not supported by device associated with queue.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with image.
- CL\_INVALID\_OPERATION if the device associated with the command-queue does not support images (i.e., CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueCopyImage(
    const Image& src_image,
    const Image& dst_image,
    const size_t <3>& src_origin,
    const size_t <3>& dst_origin,
    const size_t<3>& region,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a command to copy image objects.

*src\_image* and *dst\_image* can be 2D or 3D image objects allowing us to perform the following actions:

- Copy a 2D image object to a 2D image object.
- Copy a 2D image object to a 2D slice of a 3D image object.
- Copy a 2D slice of a 3D image object to a 2D image object.
- Copy a 3D image object to a 3D image object.

The OpenCL context associated with command-queue, *src\_image* and *dst\_image* must be the same.

*src\_origin* defines the starting (x, y, z) location in pixels in *src\_image* from where to start the data copy. If *src\_image* is a 2D image object, the z value given by *src\_origin*[2] must be 0.

*dst\_origin* defines the starting (x, y, z) location in pixels in *dst\_image* from where to start the data copy. If *dst\_image* is a 2D image object, the z value given by *dst\_origin*[2] must be 0

*region* defines the (width, height, depth) in pixels of the 2D or 3D rectangle to copy. If *src\_image* or *dst\_image* is a 2D image object, the depth value given by *region*[2] must be 1.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

It is currently a requirement that the *src\_image* and *dst\_image* image memory objects for **cl::CommandQueue::enqueueCopyImage** must have the exact same image format (i.e., the **cl\_image\_format** descriptor specified when *src\_image* and *dst\_image* are created must match).

**cl::CommandQueue::enqueueCopyImage** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with the command-queue, *src\_image* and *dst\_image* are not the same or if the context associated with the command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *src\_image* and *dst\_image* are not valid image objects.
- CL\_IMAGE\_FORMAT\_MISMATCH if *src\_image* and *dst\_image* do not use the same image format.
- CL\_INVALID\_VALUE if the 2D or 3D rectangular region specified by *src\_origin* and *src\_origin* + *region* refers to a region outside *src\_image*, or if the 2D or 3D rectangular region specified by *dst\_origin* and *dst\_origin* + *region* refers to a region outside *dst\_image*.
- CL\_INVALID\_VALUE if *src\_image* is a 2D image object and *src\_origin*[2] is not equal to 0 or *region*[2] is not equal to 1.
- CL\_INVALID\_VALUE if *dst\_image* is a 2D image object and *dst\_origin*[2] is not equal to 0 or *region*[2] is not equal to 1.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_INVALID\_IMAGE\_SIZE if image dimensions (image width, height, specified or compute row and/or slice pitch) for *src\_image* are not supported by device associated with queue.
- CL\_INVALID\_IMAGE\_SIZE if image dimensions (image width, height, specified or compute row and/or slice pitch) for *dst\_image* are not supported by device associated with queue.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *src\_image* or *dst\_image*.
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueFillImage(const Image& image,
                                           cl_float4 fillColor,
                                           const size_t<3>& origin,
                                           const size_t<3>& region,
                                           const VECTOR_CLASS<Event> * events = NULL,
                                           Event * event = NULL)
```

enqueues a command to fill an image object with a given fill color.

*image* is a valid image object.

*fill\_color* is the four component RGBA fill color.

*origin* defines the (x, y, z) offset in pixels in the image to fill. If *image* is a 2D image object, the z value given by *origin*[2] must be 0.

*region* defines the (width, height, depth) in pixels of the 2D or 3D rectangle to fill. If *image* is a 2D image object, the depth value given by *region*[2] must be 1.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueFillImage** returns CL\_SUCCESS on success.

The method

```
cl_int cl::CommandQueue::enqueueCopyImageToBuffer(  
    const Image& src_image,  
    const Buffer& dst_buffer,  
    const size_t <3>& src_origin,  
    const size_t <3>& region,  
    const ::size_t dst_offset,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

enqueues a command to copy an image object to a buffer object. The OpenCL context associated with the command-queue, *src\_image* and *dst\_buffer* must be the same.

*src\_image* is a valid image object.

*dst\_buffer* is a valid buffer object.

*src\_origin* defines the (x, y, z) offset in pixels in the image from where to copy. If *src\_image* is a 2D image object, the z value given by *src\_origin*[2] must be 0.

*region* defines the (width, height, depth) in pixels of the 2D or 3D rectangle to copy. If *src\_image* is a 2D image object, the depth value given by *region*[2] must be 1.

*dst\_offset* refers to the offset where to begin copying data into *dst\_buffer*. The size in bytes of the region to be copied referred to as *dst\_cb* is computed as width \* height \* depth \* bytes/image element if *src\_image* is a 3D image object and is computed as width \* height \* bytes/image element if *src\_image* is a 2D image object.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not

NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueCopyImageToBuffer** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with the command-queue, *src\_image* and *dst\_buffer* are not the same or if the context associated with the command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *src\_image* is not a valid image object or *dst\_buffer* is not a valid buffer object.
- CL\_INVALID\_VALUE if the 2D or 3D rectangular region specified by *src\_origin* and *src\_origin* + *region* refers to a region outside *src\_image*, or if the region specified by *dst\_offset* and *dst\_offset* + *dst\_cb* to a region outside *dst\_buffer*.
- CL\_INVALID\_VALUE if *src\_image* is a 2D image object and *src\_origin*[2] is not equal to 0 or *region*[2] is not equal to 1.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *dst\_buffer* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue. CL\_INVALID\_IMAGE\_SIZE if image dimensions (image width, height, specified or compute row and/or slice pitch) for *src\_image* are not supported by device associated with queue.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *src\_image* or *dst\_buffer*.
- CL\_INVALID\_OPERATION if the device associated with the command-queue does not support images (i.e., CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueCopyBufferToImage(
    const Buffer& src_buffer,
    const Image& dst_image,
    const ::size_t src_offset,
    const size_t <3>& dst_origin,
    const size_t<3>& region,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a command to copy a buffer object to an image object. The OpenCL context associated with the command-queue, *src\_buffer* and *dst\_image* must be the same.

*src\_buffer* is a valid buffer object.

*dst\_image* is a valid image object.

*src\_offset* refers to the offset where to begin copying data from *src\_buffer*.

*dst\_origin* refers to the (x, y, z) offset in pixels where to begin copying data to *dst\_image*. If *dst\_image* is a 2D image object, the z value given by *dst\_origin*[2] must be 0.

*region* defines the (width, height, depth) in pixels of the 2D or 3D rectangle to copy. If *dst\_image* is a 2D image object, the depth value given by *region*[2] must be 1. The size in bytes of the region to be copied from *src\_buffer* referred to as *src\_cb* is computed as width \* height \* depth \* bytes/image element if *dst\_image* is a 3D image object and is computed as width \* height \* bytes/image element if *dst\_image* is a 2D image object.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueCopyBufferToImage** returns CL\_SUCCESS on success. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with the command-queue, *src\_buffer* and *dst\_image* are not the same or if the context associated with the command-queue and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *src\_buffer* is not a valid buffer object or *dst\_image* is not a valid image object.
- CL\_INVALID\_VALUE if the 2D or 3D rectangular region specified by *dst\_origin* and *dst\_origin* + *region* refer to a region outside *dst\_image*, or if the region specified by *src\_offset* and *src\_offset* + *src\_cb* refer to a region outside *src\_buffer*.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *src\_buffer* is a sub-buffer object and offset specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with queue. CL\_INVALID\_IMAGE\_SIZE if image dimensions (image width, height, specified or compute row and/or slice pitch) for *dst\_image* are not supported by device associated with queue.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *src\_buffer* or *dst\_image*.
- CL\_INVALID\_OPERATION if the device associated with the command-queue does not support images (i.e., CL\_DEVICE\_IMAGE\_SUPPORT specified in table 4.3 is CL\_FALSE).
- CL\_OUT\_OF\_RESOURCES if there is a failure to allocate resources required by the OpenCL implementation on the device.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
void * cl::CommandQueue::enqueueMapBuffer(
    const Buffer& buffer,
    cl_bool blocking_map,
    cl_map_flags flags,
    ::size_t offset,
    ::size_t size,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL,
    cl_int * err = NULL)
```

enqueues a command to map a region of the buffer object given by *buffer* into the host address space and returns a pointer to this mapped region.

*blocking\_map* indicates if the map operation is *blocking* or *non-blocking*.

If *blocking\_map* is CL\_TRUE, **cl::CommandQueue::enqueueMapBuffer** does not return until the specified region in *buffer* can be mapped.

If *blocking\_map* is CL\_FALSE (i.e., the map operation is non-blocking), the pointer to the mapped region returned by **cl::CommandQueue::enqueueMapBuffer** cannot be used until the map command has completed. The *event* argument returns an event object that can be used to query the execution status of the map command. When the map command is completed, the application can access the contents of the mapped region using the pointer returned by **cl::CommandQueue::enqueueMapBuffer**.

*map\_flags* is a bit-field and can be set to CL\_MAP\_READ to indicate that the region specified by (*offset*, *size*) in the buffer object is being mapped for reading, and/or CL\_MAP\_WRITE to indicate that the region specified by (*offset*, *size*) in the buffer object is being mapped for writing.

*buffer* is a valid buffer object. The OpenCL context associated with *command\_queue* and *buffer* must be the same.

*offset* and *size* are the offset in bytes and the size of the region in the buffer object that is being mapped.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::CommandQueue::enqueueMapBuffer** returns a pointer to the mapped region and sets *err* to CL\_SUCCESS on success.

A NULL pointer is returned otherwise with one of the following error values returned in *err*:

- CL\_INVALID\_CONTEXT if context associated with the *command queue* and *buffer* are not the same or if the context associated with the *command queue* and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *buffer* is not a valid buffer object.
- CL\_INVALID\_VALUE if region being mapped given by (*offset*, *size*) is out of bounds or if values specified in *map\_flags* are not valid.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if *buffer* is a sub-buffer object and *offset* specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with *queue*.
- CL\_MAP\_FAILURE if there is a failure to map the requested region into the host address space. This error cannot occur for buffer objects created with CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_ALLOC\_HOST\_PTR.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *buffer*.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The pointer returned maps a region starting at *offset* and is at least *size* bytes in size. The result of a memory access outside this region is undefined.

The method

```
void * cl::CommandQueue::enqueueMapImage(  
    const Image& image,  
    cl_bool blocking_map,  
    cl_map_flags map_flags,  
    ::size_t<3>& origin,  
    ::size_t<3>& region,  
    ::size_t * row_pitch,  
    ::size_t * slice_pitch,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL,  
    cl_int * err = NULL)
```

enqueues a command to map a region in the image object given by *image* into the host address space and returns a pointer to this mapped region.

*image* is a valid image object. The OpenCL context associated with the *command queue* and *image* must be the same.

*blocking\_map* indicates if the map operation is *blocking* or *non-blocking*.

If *blocking\_map* is CL\_TRUE, **cl::CommandQueue::enqueueMapImage** does not return until the specified region in *image* is mapped.

If *blocking\_map* is CL\_FALSE (i.e., the map operation is non-blocking), the pointer to the mapped region returned by **cl::CommandQueue::enqueueMapImage** cannot be used until the map command has completed.



The *event* argument returns an event object that can be used to query the execution status of the map command. When the map command is completed, the application can access the contents of the mapped region using the pointer returned by **cl::CommandQueue::enqueueMapImage**.

*map\_flags* is a bit-field and can be set to CL\_MAP\_READ to indicate that the region specified by (*origin*, *region*) in the image object is being mapped for reading, and/or CL\_MAP\_WRITE to indicate that the region specified by (*origin*, *region*) in the image object is being mapped for writing.

*origin* and *region* define the (*x*, *y*, *z*) offset in pixels and (*width*, *height*, *depth*) in pixels of the 2D or 3D rectangle region that is to be mapped. If *image* is a 2D image object, the *z* value given by *origin*[2] must be 0 and the *depth* value given by *region*[2] must be 1.

*row\_pitch* returns the scan-line pitch in bytes for the mapped region. This must be a non-NULL value.

*slice\_pitch* returns the size in bytes of each 2D slice for the mapped region. For a 2D image, zero is returned if this argument is not NULL. For a 3D image, *slice\_pitch* must be a non-NULL value.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

*err* returns an appropriate error code. If *err* is NULL, no error code is returned.

**cl::CommandQueue::enqueueMapImage** returns a pointer to the mapped region and sets *err* to CL\_SUCCESS on success. It returns NULL otherwise, with one of the following error values returned in *err*:

- CL\_INVALID\_CONTEXT if context associated with the *command queue* and *image* are not the same or if context associated with the *command queue* and events in *events* are not the same.
- CL\_INVALID\_MEM\_OBJECT if *image* is not a valid image object.
- CL\_INVALID\_VALUE if region being mapped given by (*origin*, *origin+region*) is out of bounds or if values specified in *map\_flags* are not valid.
- CL\_INVALID\_VALUE if *image* is a 2D image object and *origin*[2] is not equal to 0 or *region*[2] is not equal to 1.
- CL\_INVALID\_VALUE if *row\_pitch* is NULL.
- CL\_INVALID\_VALUE if *image* is a 3D image object and *slice\_pitch* is NULL.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_INVALID\_IMAGE\_SIZE if image dimensions (image width, height, specified or compute row and/or slice pitch) for *image* are not supported by device associated with *queue*.
- CL\_MAP\_FAILURE if there is a failure to map the requested region into the host address space. This error cannot occur for image objects created with CL\_MEM\_USE\_HOST\_PTR or CL\_MEM\_ALLOC\_HOST\_PTR.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with *buffer*.

- **CL\_INVALID\_OPERATION** if the device associated with the *command queue* does not support images (i.e., **CL\_DEVICE\_IMAGE\_SUPPORT** specified in table 4.3 is **CL\_FALSE**).
- **CL\_OUT\_OF\_HOST\_MEMORY** if there is a failure to allocate resources required by the OpenCL implementation on the host.

The pointer returned maps a 2D or 3D region starting at *origin* and is at least  $(row\_pitch * region[1] + region[0])$  pixels in size for a 2D image, and is at least  $(slice\_pitch * region[2] + row\_pitch * region[1] + region[0])$  pixels in size for a 3D image. The result of a memory access outside this region is undefined.

If the image object is created with **CL\_MEM\_USE\_HOST\_PTR** set in *mem\_flags*, the following will be true:

- The *host\_ptr* specified in **cl::Image{2D|3D}** is guaranteed to contain the latest bits in the region being mapped when the **cl::CommandQueue::enqueueMapImage** command has completed.
- The pointer value returned by **cl::CommandQueue::enqueueMapImage** is derived from the *host\_ptr* specified when the image object is created.

Mapped image objects are unmapped using **cl::CommandQueue::enqueueUnmapMemObject**. This is described in the following text.

```
cl_int cl::CommandQueue::enqueueUnmapMemObject(
    const Memory& memory,
    void * mapped_ptr,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a command to unmap a previously mapped region of a memory object. Reads or writes from the host using the pointer returned by **cl::CommandQueue::enqueueMapBuffer**, or **cl::CommandQueue::enqueueMapImage** are considered to be complete.

*memobj* is a valid memory object. The OpenCL context associated with *command\_queue* and *memobj* must be the same.

*mapped\_ptr* is the host address returned by a previous call to **cl::CommandQueue::enqueueMapBuffer**, or **cl::CommandQueue::enqueueMapImage** for *memobj*.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command-queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete. **Cl::CommandQueue::enqueueBarrier** can be used instead.

**cl::CommandQueue::enqueueUnmapMemObject** returns CL\_SUCCESS on success. Otherwise it returns one of the following errors:

- CL\_INVALID\_MEM\_OBJECT if *memobj* is not a valid memory object.
- CL\_INVALID\_VALUE if *mapped\_ptr* is not a valid pointer returned by **cl::CommandQueue::enqueueMapBuffer**, or **cl::CommandQueue::enqueueMapImage** for *memobj*.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.
- CL\_INVALID\_CONTEXT if context associated with the *command queue* and *memobj* are not the same or if the context associated with the *command queue* and events in *events* are not the same.

**cl::CommandQueue::enqueueMapBuffer**, and **cl::CommandQueue::enqueueMapImage** increments the mapped count of the memory object. The initial mapped count value of the memory object is zero. Multiple calls to **cl::CommandQueue::enqueueMapBuffer**, or **cl::CommandQueue::enqueueMapImage** on the same memory object will increment this mapped count by appropriate number of calls.

**cl::CommandQueue::enqueueUnmapMemObject** decrements the mapped count of the memory object.

**cl::CommandQueue::enqueueMapBuffer**, and **cl::CommandQueue::enqueueMapImage** act as synchronization points for a region of the buffer object being mapped.

The method

```
cl_int cl::CommandQueue::enqueueMarkerWithWaitList(
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a marker command that waits for completion of a list of events.

*events* specifies a list of events. If NULL or empty, the marker command waits for the completion of all previously enqueued commands.

*event* returns an event object that identifies this command. It can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueMarkerWithWaitList** returns CL\_SUCCESS on success.

The method

```
cl_int cl::CommandQueue::enqueueBarrierWithWaitList(
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a barrier command that waits for completion of a list of events.

*events* specifies a list of events. If NULL or empty, the barrier command waits for the completion of all previously enqueued commands.

*event* returns an event object that identifies this command. It can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueBarrierWithWaitList** returns CL\_SUCCESS on success.

The method

```
cl_int cl::CommandQueue::enqueueMigrateMemObjects(  
    const VECTOR_CLASS<Memory> &memObjects,  
    cl_mem_migration_flags flags,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

enqueues a command indicating with which device a set a memory objects should be associated.

*memObjects* specifies a set of memory objects.

*flags* specifies migration flags, as in table 5.10 of the *OpenCL Specification* Version 1.2. It must be nonempty.

*events* specifies a list of events on which the command waits. If NULL, the command does not wait.

*event* returns an event object that identifies this command. It can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueMigrateMemObjects** returns CL\_SUCCESS on success. Otherwise, it returns the error status from the underlying *clEnqueueMigrateMemObjects* call.

The method

```
cl_int cl::CommandQueue::enqueueNDRangeKernel(  
    const Kernel& kernel,  
    const NDRange& offset,  
    const NDRange& global,  
    const NDRange& local,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

enqueues a command to execute a kernel on a device.

*kernel* is a valid kernel object. The OpenCL context associated with *kernel* and the *command queue* must be the same.

*offset* can be used to specify an array of *work\_dim* unsigned values that describe the offset used to calculate the global ID of a work-item. If *offset* is cl::NULLRange, the global IDs start at offset (0, 0, ... 0).

*global* points to an array of *work\_dim* unsigned values that describe the number of global work-items in *work\_dim* dimensions that will execute the kernel function. The total number of global work-items is computed as  $global[0] * \dots * global[work\_dim - 1]$ .

*local* points to an array of *work\_dim* unsigned values that describe the number of work-items that make up a work-group (also referred to as the size of the work-group) that will execute the kernel specified by *kernel*. The total number of work-items in a work-group is computed as  $local[0] * \dots * local[work\_dim - 1]$ . The total number of work-items in the work-group must be less than or equal to the CL\_DEVICE\_MAX\_WORK\_GROUP\_SIZE value specified in table 4.3 and the number of work-items specified in  $local[0], \dots, local[work\_dim - 1]$  must be less than or equal to the corresponding values specified by CL\_DEVICE\_MAX\_WORK\_ITEM\_SIZES[0], ..., CL\_DEVICE\_MAX\_WORK\_ITEM\_SIZES[*work\_dim* - 1]. The explicitly specified *local* determines how to break the global work-items specified by *global* into appropriate work-group instances. If *local* is specified, the values specified in  $global[0], \dots, global[work\_dim - 1]$  must be evenly divisible by the corresponding values specified in  $local[0], \dots, local[work\_dim - 1]$ .

The work-group size to be used for *kernel* can also be specified in the program source using the `__attribute__((reqd_work_group_size(X, Y, Z)))` qualifier (refer to section 6.8.2). In this case the size of work group specified by *local* must match the value specified by the `reqd_work_group_size` attribute qualifier.

*local* can also be a `cl::NULLRange` value in which case the OpenCL implementation will determine how to be break the global work-items into appropriate work-group instances.

These work-group instances are executed in parallel across multiple compute units or concurrently on the same compute unit.

Each work-item is uniquely identified by a global identifier. The global ID, which can be read inside the kernel, is computed using the value given by *global\_work\_size* and *global\_work\_offset*. In addition, a work-item is also identified within a work-group by a unique local ID. The local ID, which can also be read by the kernel, is computed using the value given by *local\_work\_size*. The starting local ID is always (0, 0, ..., 0).

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueBarrier** can be used instead.

**cl::CommandQueue::enqueueNDRangeKernel** returns CL\_SUCCESS if the kernel execution was successfully queued. Otherwise, it returns one of the following errors:

- CL\_INVALID\_PROGRAM\_EXECUTABLE if there is no successfully built program executable available for device associated with the *command queue*.
- CL\_INVALID\_KERNEL if *kernel* is not a valid kernel object.

- CL\_INVALID\_CONTEXT if context associated with the *command queue* and *kernel* are not the same or if the context associated with the *command queue* and events in *events* are not the same.
- CL\_INVALID\_KERNEL\_ARGS if the kernel argument values have not been specified.
- CL\_INVALID\_GLOBAL\_WORK\_SIZE if *global* is cl::NULLRange, or if any of the values specified in *global* [0], ... *global* [*work\_dim* – 1] are 0 or exceed the range given by the sizeof(size\_t) for the device on which the kernel execution is enqueued.
- CL\_INVALID\_GLOBAL\_OFFSET if the value specified in *global* + the corresponding values in *global* for any dimensions is greater than the sizeof(size\_t) for the device on which the kernel execution is enqueued.
- CL\_INVALID\_WORK\_GROUP\_SIZE if *local* is specified and number of work-items specified by *global* is not evenly divisible by size of work-group given by *local* or does not match the work-group size specified for *kernel* using the \_\_attribute\_\_((reqd\_work\_group\_size(X, Y, Z))) qualifier in program source.
- CL\_INVALID\_WORK\_GROUP\_SIZE if *local* is specified and the total number of work-items in the work-group computed as *local* [0] \* ... *local* [*work\_dim* – 1] is greater than the value specified by CL\_DEVICE\_MAX\_WORK\_GROUP\_SIZE in table 4.3.
- CL\_INVALID\_WORK\_GROUP\_SIZE if *local* is NULL and the \_\_attribute\_\_((reqd\_work\_group\_size(X, Y, Z))) qualifier declares the work-group size for *kernel* in the program source.
- CL\_INVALID\_WORK\_ITEM\_SIZE if the number of work-items specified in any of *local* [0], ... *local* [*work\_dim* – 1] is greater than the corresponding values specified by CL\_DEVICE\_MAX\_WORK\_ITEM\_SIZES[0], .... CL\_DEVICE\_MAX\_WORK\_ITEM\_SIZES[*work\_dim* – 1].
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if a sub-buffer object is specified as the value for an argument that is a buffer object and the *offset* specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with *queue*.
- CL\_INVALID\_IMAGE\_SIZE if an image object is specified as an argument value and the image dimensions (image width, height, specified or compute row and/or slice pitch) are not supported by device associated with *queue*.
- CL\_OUT\_OF\_RESOURCES if there is a failure to queue the execution instance of *kernel* on the command-queue because of insufficient resources needed to execute the kernel. For example, the explicitly specified *local* causes a failure to execute the kernel because of insufficient resources such as registers or local memory. Another example would be the number of read-only image args used in *kernel* exceed the CL\_DEVICE\_MAX\_READ\_IMAGE\_ARGS value for device or the number of write-only image args used in *kernel* exceed the CL\_DEVICE\_MAX\_WRITE\_IMAGE\_ARGS value for device or the number of samplers used in *kernel* exceed CL\_DEVICE\_MAX\_SAMPLERS for device.

- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with image or buffer objects specified as arguments to *kernel*.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in events are not valid events.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueTask(
    const Kernel& kernel,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a command to execute a kernel on a device. The kernel is executed using a single work-item.

*kernel* is a valid kernel object. The OpenCL context associated with *kernel* and *command-queue* must be the same.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueBarrier** can be used instead.

**cl::CommandQueue::enqueueTask** is equivalent to calling **cl::CommandQueue::enqueueNDRangeKernel** with *work\_dim* = 1, *global* = NULLRange, *global* [0] set to 1 and *local* [0] set to 1.

**Cl::CommandQueue::enqueueTask** returns CL\_SUCCESS if the kernel execution was successfully queued. Otherwise, it returns one of the following errors:

- CL\_INVALID\_PROGRAM\_EXECUTABLE if there is no successfully built program executable available for device associated with the *command queue*.
- CL\_INVALID\_KERNEL if *kernel* is not a valid kernel object.
- CL\_INVALID\_CONTEXT if context associated with the *command queue* and *kernel* are not the same or if the context associated with the *command queue* and events in *events* are not the same.
- CL\_INVALID\_KERNEL\_ARGS if the kernel argument values have not been specified.
- CL\_INVALID\_WORK\_GROUP\_SIZE if a work-group size is specified for *kernel* using the `__attribute__((reqd_work_group_size(X, Y, Z)))` qualifier in program source and is not (1, 1, 1).
- CL\_MISALIGNED\_SUB\_BUFFER\_OFFSET if a sub-buffer object is specified as the value for an argument that is a buffer object and the *offset* specified when the sub-buffer object is created is not aligned to CL\_DEVICE\_MEM\_BASE\_ADDR\_ALIGN value for device associated with *queue*.

- **CL\_INVALID\_IMAGE\_SIZE** if an image object is specified as an argument value and the image dimensions (image width, height, specified or compute row and/or slice pitch) are not supported by device associated with *queue*.
- **CL\_OUT\_OF\_RESOURCES** if there is a failure to queue the execution instance of *kernel* on the command-queue because of insufficient resources needed to execute the kernel.
- **CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE** if there is a failure to allocate memory for data store associated with image or buffer objects specified as arguments to *kernel*.
- **CL\_INVALID\_EVENT\_WAIT\_LIST** if event objects in events are not valid events.
- **CL\_OUT\_OF\_HOST\_MEMORY** if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueNativeKernel(
    void (*user_func)(void *),
    std::pair<void*, ::size_t> args,
    const VECTOR_CLASS<Memory> * mem_objects = NULL,
    const VECTOR_CLASS<const void *> * mem_locs = NULL,
    const VECTOR_CLASS<Event> * events = NULL,
    Event * event = NULL)
```

enqueues a command to execute a native C/C++ function not compiled using the OpenCL compiler.

A native user function can only be executed on a command queue created on a device that has **CL\_EXEC\_NATIVE\_KERNEL** capability set in **CL\_DEVICE\_EXECUTION\_CAPABILITIES** as specified in table 4.3.

*user\_func* is a pointer to a host-callable user function.

*args* is tuple containing a pointer to the args list that *user\_func* should be called with and the is the size in bytes of the argument list that *args* points to.

The data pointed to by *args.fst* and *args.snd* bytes in size is copied and a pointer to this copied region is passed to *user\_func*. The copy needs to be done because the memory objects (*cl\_mem* values) that *args* may contain need to be modified and replaced by appropriate pointers to global memory. When **cl::CommandQueue::enqueueNativeKernel** returns, the memory region pointed to by *args* can be reused by the application.

*mem\_objects* is a list of valid buffer objects. The buffer object values specified in *mem\_objects* are memory objects (*cl::Memory* values) returned by **cl::Buffer**.

*mem\_loc* is a vector of appropriate locations that *args* points to where memory objects (*cl::Memory* values) are stored. Before the user function is executed, the memory object handles are replaced by pointers to global memory.

*events* specifies events that need to complete before this particular command can be executed. If *events* is NULL or of length zero, then this particular command does not wait on any event to complete. If *events* is not



NULL and a nonzero length, the list of events pointed to by *events* must be valid. The events specified in *events* act as synchronization points. The context associated with events in *events* and the command queue must be the same.

*event* returns an event object that identifies this particular copy command and can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete. **cl::CommandQueue::enqueueBarrier** can be used instead.

**Cl::CommandQueue::enqueueNativeKernel** returns CL\_SUCCESS if the user function execution instance was successfully queued. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if context associated with the *command queue* and events in *events* are not the same.
- CL\_INVALID\_VALUE if *user\_func* is NULL.
- CL\_INVALID\_VALUE if *args.fst* is a NULL value and *args.snd* > 0, or if *args.fst* is a NULL value and then length of *mem\_objects* > 0.
- CL\_INVALID\_VALUE if *args.fst* is not NULL and *args.snd* is 0.
- CL\_INVALID\_VALUE if the length of *mem\_objects* > 0 and *mem\_locs* is NULL.
- CL\_INVALID\_VALUE if length of *mem\_objects* is 0 and *mem\_locs* is not NULL.
- CL\_INVALID\_OPERATION if *device* cannot execute the native kernel.
- CL\_INVALID\_MEM\_OBJECT if one or more memory objects specified in *mem\_objects* are not valid or are not buffer objects.
- CL\_OUT\_OF\_RESOURCES if there is a failure to queue the execution instance of *kernel* on the command-queue because of insufficient resources needed to execute the kernel.
- CL\_MEM\_OBJECT\_ALLOCATION\_FAILURE if there is a failure to allocate memory for data store associated with buffer objects specified as arguments to *kernel*.
- CL\_INVALID\_EVENT\_WAIT\_LIST if event objects in *events* are not valid events.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueMarker(Event * event = NULL)
```

enqueues a marker command to the command queue. The command returns an *event* which can be used to queue a wait on this marker (i.e., to wait for all commands queued before the marker to complete).

**cl::CommandQueue::enqueueMarker** returns CL\_SUCCESS if the function is successfully executed. Otherwise, it returns one of the following errors:

- CL\_INVALID\_VALUE if *event* is a NULL value.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueWaitForEvents(  
    const VECTOR_CLASS<Event>& events)
```

enqueues a wait for a specific event or a list of events to complete before any future commands queued in the command queue are executed. Each event in *events* must be a valid event object returned by a previous call to **cl::CommandQueue::enqueue\***.

The events specified in *events* act as synchronization points. The context associated with events in *events* and then *command queue* must be the same.

**cl::CommandQueue::enqueueWaitForEvents** returns CL\_SUCCESS if the function was successfully executed. Otherwise, it returns one of the following errors:

- CL\_INVALID\_CONTEXT if the context associated with *command\_queue* and events in *event\_list* are not the same.
- CL\_INVALID\_VALUE if the length of *events* is 0.
- CL\_INVALID\_EVENT if event objects specified in *events* are not valid events.
- CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::enqueueAcquireGLObjects(  
    const VECTOR_CLASS<Memory>* mem_objects = NULL,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

enqueues a command to acquire OpenCL memory objects created from OpenGL objects.

*mem\_objects* is the list of OpenCL memory objects that correspond to OpenGL objects.

*events* specifies a list of events on which the command waits. If NULL or empty, the command waits for the completion of all previously enqueued commands.

*event* returns an event object that identifies this command. It can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueAcquireGLObjects** returns CL\_SUCCESS on success.

The method

```
cl_int cl::CommandQueue::enqueueReleaseGLObjects(  
    const VECTOR_CLASS<Memory>* mem_objects = NULL,  
    const VECTOR_CLASS<Event> * events = NULL,  
    Event * event = NULL)
```

enqueues a command to release OpenCL memory objects created from OpenGL objects.

*mem\_objects* is the list of OpenCL memory objects that correspond to OpenGL objects.

*events* specifies a list of events on which the command waits. If NULL, the command waits for the completion of all previously enqueued commands.

*event* returns an event object that identifies this command. It can be used to query or queue a wait for this particular command to complete. *event* can be NULL, in which case it will not be possible for the application to query the status of this command or queue a wait for this command to complete.

**cl::CommandQueue::enqueueReleaseGLObjects** returns CL\_SUCCESS on success.

The method

```
cl_int cl::CommandQueue::enqueueBarrier(void)
```

enqueues a barrier operation. The **cl::CommandQueue::enqueueBarrier** command ensures that all queued commands in *command\_queue* have finished execution before the next batch of commands can begin execution. The **cl::CommandQueue::enqueueBarrier** command is a synchronization point.

**cl::CommandQueue::enqueueBarrier** returns CL\_SUCCESS if the function was executed successfully. It returns CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::flush(void)
```

issues all previously queued OpenCL commands in the *command\_queue* to the device.

**cl::CommandQueue::flush** only guarantees that all queued commands to *command\_queue* get issued to the appropriate device. There is no guarantee that they will be complete after **cl::CommandQueue::flush** returns.

**cl::CommandQueue::flush** returns CL\_SUCCESS if the function call was executed successfully. Otherwise it returns CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

The method

```
cl_int cl::CommandQueue::finish(void)
```

blocks until all previously queued OpenCL commands in the *command\_queue* are issued to the associated device and have completed. **cl::CommandQueue::finish** does not return until all queued commands in then *command\_queue* have been processed and completed. **cl::CommandQueue::finish** is also a synchronization point.

**cl::CommandQueue::finish** returns CL\_SUCCESS if the function call was executed successfully. Otherwise it returns CL\_OUT\_OF\_HOST\_MEMORY if there is a failure to allocate resources required by the OpenCL implementation on the host.

## 4. Exceptions

The use of C++ exceptions can provide a structured approach to error handling for large applications. The C++ API provides the ability to use C++ exceptions to track and handle errors generated by the underlying OpenCL C API. However, the use of C++ exceptions is not universal and their use should be optional. In the case that exceptions are not used, the resulting application must compile and work without exception support.

By default, C++ exceptions are not enabled and the OpenCL error code is returned, or set, as per the underlying C API. To enable the use of exceptions, the user must explicitly define preprocessor macro:

### **`__CL_ENABLE_EXCEPTIONS`**

Once enabled, an error (i.e., a value other than `CL_SUCCESS`) originally reported via return value instead will be reported by throwing an exception of class `cl::Error`. By default, the method `cl::Error::what()` returns a const pointer to a string naming the particular C API call that reported the error (e.g., "clGetDeviceInfo", "clGetPlatformInfo", and so on).

To override the default behavior for `cl::Error::what()`, define the preprocessor macro:

### **`__CL_USER_OVERRIDE_ERROR_STRINGS`**

and provide string constants for each preprocessor macro defined in Table 11. Most macros apply to both OpenCL 1.1 and OpenCL 1.2; these have a blank Version column in the table. Macros marked V1.2 in the Version column are defined for OpenCL 1.2 only. Macros marked V1.1 in the Version column are defined for OpenCL 1.1 only; the corresponding OpenCL APIs are deprecated, and the user must define

### **`__CL_USE_DEPRECATED_OPENCL_1_1_APIS`**

to use these V1.1 macros.

Preprocessor macro name	Default value	Version
<code>__BUILD_PROGRAM_ERR</code>	"clBuildProgram"	
<code>__COMPILE_PROGRAM_ERR</code>	"clCompileProgram"	V1.2
<code>__COPY_ERR</code>	"clCopy"	
<code>__CREATE_BUFFER_ERR</code>	"clCreateBuffer"	
<code>__CREATE_COMMAND_QUEUE_ERR</code>	"clCreateCommandQueue"	
<code>__CREATE_CONTEXT_ERR</code>	"clCreateContext"	
<code>__CREATE_CONTEXT_FROM_TYPE_ERR</code>	"clCreateContextFromType"	
<code>__CREATE_GL_BUFFER_ERR</code>	"clCreateFromGLBuffer"	
<code>__CREATE_GL_RENDER_BUFFER_ERR</code>	"clCreateFromGLBuffer"	
<code>__CREATE_GL_TEXTURE_2D_ERR</code>	"clCreateFromGLTexture2D"	V1.1
<code>__CREATE_GL_TEXTURE_3D_ERR</code>	"clCreateFromGLTexture3D"	V1.1
<code>__CREATE_GL_TEXTURE_ERR</code>	"clCreateFromGLTexture"	V1.2
<code>__CREATE_IMAGE2D_ERR</code>	"clCreateImage2D"	V1.1
<code>__CREATE_IMAGE3D_ERR</code>	"clCreateImage3D"	V1.1
<code>__CREATE_IMAGE_ERR</code>	"clCreateImage"	V1.2
<code>__CREATE_KERNELS_IN_PROGRAM_ERR</code>	"clCreateKernelsInProgram"	
<code>__CREATE_KERNEL_ERR</code>	"clCreateKernel"	

__CREATE_PROGRAM_WITH_BINARY_ERR	"clCreateProgramWithBinary"	
__CREATE_PROGRAM_WITH_BUILTIN_KERNELS_ERR	"clCreateProgramWithBuiltinKernels"	V1.2
__CREATE_PROGRAM_WITH_SOURCE_ERR	"clCreateProgramWithSource"	
__CREATE_SAMPLER_ERR	"clCreateSampler"	
__CREATE_SUBBUFFER_ERR	"clCreateSubBuffer"	
__CREATE_SUB_DEVICES_ERR	"clCreateSubDevicesEXT"	!V1.2
__CREATE_SUB_DEVICES_ERR	"clCreateSubDevices"	V1.2
__CREATE_USER_EVENT_ERR	"clCreateUserEvent"	
__ENQUEUE_ACQUIRE_GL_ERR	"clEnqueueAcquireGLObjets"	
__ENQUEUE_BARRIER_ERR	"clEnqueueBarrier"	V1.1
__ENQUEUE_COPY_BUFFER_ERR	"clEnqueueCopyBuffer"	
__ENQUEUE_COPY_BUFFER_RECT_ERR	"clEnqueueCopyBufferRect"	
__ENQUEUE_COPY_BUFFER_TO_IMAGE_ERR	"clEnqueueCopyBufferToImage"	
__ENQUEUE_COPY_IMAGE_ERR	"clEnqueueCopyImage"	
__ENQUEUE_COPY_IMAGE_TO_BUFFER_ERR	"clEnqueueCopyImageToBuffer"	
__ENQUEUE_FILL_BUFFER_ERR	"clEnqueueFillBuffer"	
__ENQUEUE_FILL_IMAGE_ERR	"clEnqueueFillImage"	
__ENQUEUE_MAP_BUFFER_ERR	"clEnqueueMapBuffer"	
__ENQUEUE_MAP_IMAGE_ERR	"clEnqueueMapImage"	
__ENQUEUE_MARKER_ERR	"clEnqueueMarker"	V1.1
__ENQUEUE_MIGRATE_MEM_OBJECTS_ERR	"clEnqueueMigrateMemObjects"	V1.2
__ENQUEUE_NATIVE_KERNEL	"clEnqueueNativeKernel"	
__ENQUEUE_NDRANGE_KERNEL_ERR	"clEnqueueNDRangeKernel"	
__ENQUEUE_READ_BUFFER_ERR	"clEnqueueReadBuffer"	
__ENQUEUE_READ_BUFFER_RECT_ERR	"clEnqueueReadBufferRect"	
__ENQUEUE_READ_IMAGE_ERR	"clEnqueueReadImage"	
__ENQUEUE_RELEASE_GL_ERR	"clEnqueueReleaseGLObjets"	
__ENQUEUE_TASK_ERR	"clEnqueueTask"	
__ENQUEUE_UNMAP_MEM_OBJECT_ERR	"clEnqueueUnmapMemObject"	
__ENQUEUE_WAIT_FOR_EVENTS_ERR	"clEnqueueWaitForEvents"	V1.1
__ENQUEUE_WRITE_BUFFER_ERR	"clEnqueueWriteBuffer"	
__ENQUEUE_WRITE_BUFFER_RECT_ERR	"clEnqueueWriteBufferRect"	
__ENQUEUE_WRITE_IMAGE_ERR	"clEnqueueWriteImage"	
__FINISH_ERR	"clFinish"	
__FLUSH_ERR	"clFlush"	
__GET_COMMAND_QUEUE_INFO_ERR	"clGetCommandQueueInfo"	
__GET_CONTEXT_INFO_ERR	"clGetContextInfo"	
__GET_DEVICE_IDS_ERR	"clGetDeviceIds"	
__GET_DEVICE_INFO_ERR	"clGetDeviceInfo"	
__GET_EVENT_INFO_ERR	"clGetEventInfo"	
__GET_EVENT_PROFILE_INFO_ERR	"clGetEventProfileInfo"	
__GET_GL_OBJECT_INFO_ERR	"clGetGLObjectInfo"	
__GET_IMAGE_INFO_ERR	"clGetImageInfo"	
__GET_KERNEL_ARG_INFO_ERR	"clGetKernelArgInfo"	V1.2
__GET_KERNEL_INFO_ERR	"clGetKernelInfo"	
__GET_KERNEL_WORK_GROUP_INFO_ERR	"clGetKernelWorkGroupInfo"	
__GET_MEM_OBJECT_INFO_ERR	"clGetMemObjectInfo"	
__GET_PLATFORM_IDS_ERR	"clGetPlatformIDs"	
__GET_PLATFORM_INFO_ERR	"clGetPlatformInfo"	

__GET_PROGRAM_BUILD_INFO_ERR	"clGetProgramBuildInfo"	
__GET_PROGRAM_INFO_ERR	"clGetProgramInfo"	
__GET_SAMPLER_INFO_ERR	"clGetSampleInfo"	
__GET_SUPPORTED_IMAGE_FORMATS_ERR	"clGetSupportedImageFormats"	
__IMAGE_DIMENSION_ERR	"Incorrect image dimensions"	V1.2
__RELEASE_ERR	"Release Object"	
__RETAIN_ERR	"Retain Object"	
__SET_COMMAND_QUEUE_PROPERTY_ERR	"clSetCommandQueueProperty"	
__SET_EVENT_CALLBACK_ERR	"clSetEventCallback"	
__SET_KERNEL_ARGS_ERR	"clSetKernelArgs"	
__SET_MEM_OBJECT_DESTRUCTOR_CALLBACK_ERR	"clSetMemObjectDestructorCallback"	
__SET_PRINTF_CALLBACK_ERR	"clSetPrintfCallback"	V1.2
__SET_USER_EVENT_STATUS_ERR	"clSetUserEventStatus"	
__UNLOAD_COMPILER_ERR	"clUnloadCompiler"	V1.1
__VECTOR_CAPACITY_ERR	"Vector capacity error"	
__WAIT_FOR_EVENTS_ERR	"clWaitForEvents"	

Table 13: Preprocessor error macros and their defaults.

## 5. Using the C++ API with the Standard Template Library

The C++ Standard Template Library is an excellent resource for quick access to many useful algorithms and containers, but it is often not used due to compatibility issues across different toolchains and operating systems, among other reasons. The OpenCL C++ wrapper API uses vectors and strings in a number of places. By default, it uses Standard Template Library vector and string classes **std::vector** and **std::string**. However, it also gives the developer the ability to not use these.

The C++ wrapper API provides replacements **cl::vector** for **std::vector** and **cl::string** for **std::string**. It also allows developers to use their own implementations instead.

By default, to avoid issues with backward compatibility, the C++ wrapper uses both **std::vector** and **std::string**. Either can be overridden, with **cl::vector** and **cl::type**; however, the developer should be aware that these types are deprecated. For vectors, the developer can select an alternative version by defining the preprocessor macro:

**\_\_NO\_STD\_VECTOR**

In this case, the following vector type is defined:

```
template cl::vector<typename T,  
                unsigned int N = __MAX_DEFAULT_VECTOR_SIZE>
```

**cl::vector** shares the same interface as **std::vector**, but it has a statically defined space requirement, by default 10 elements. The developer can manually override this allocation by defining the preprocessor macro:

**\_\_MAX\_DEFAULT\_VECTOR\_SIZE N**

where *N* is the number of vector elements to use when allocating values of type **cl::vector**.

By defining the preprocessor macro:

**\_\_USE\_DEV\_VECTOR**

neither **std::vector** nor **cl::vector** classes will be used. Instead, the user must provide the preprocessor definition:

**VECTOR\_CLASS** *typeName*

where *typeName* corresponds to the user's vector class<sup>4</sup>, with an implementation that matches the **std::vector** interface.

For strings, if the preprocessor macro:

---

<sup>4</sup> Few C++ compilers currently support typedef templates and thus the vector type must be given by its name only through the preprocessor macro **VECTOR\_CLASS**.

## **\_\_NO\_STD\_STRING**

is defined, then the string type **cl::string** is used instead of **std::string**. Unlike **cl::vector**, the size of a given string is not defined statically but is allocated at creation. A developer can provide a replacement implementation for **std::string** by defining the preprocessor macro:

## **\_\_USE\_DEV\_STRING**

The developer must provide the following typedef:

```
typedef stringType STRING_CLASS
```

where *stringType* is the user provided alternative for **std::string**, with an implementation that matches the interface for **std::string**.



## 6. Index

This index lists each class, constructor, and method defined by the C++ wrapper API. Methods are listed under their fully qualified names; e.g., the many **getInfo** methods are listed under **cl::Context::getInfo**, **cl::Device::getinfo**, etc., not under **getInfo**.

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