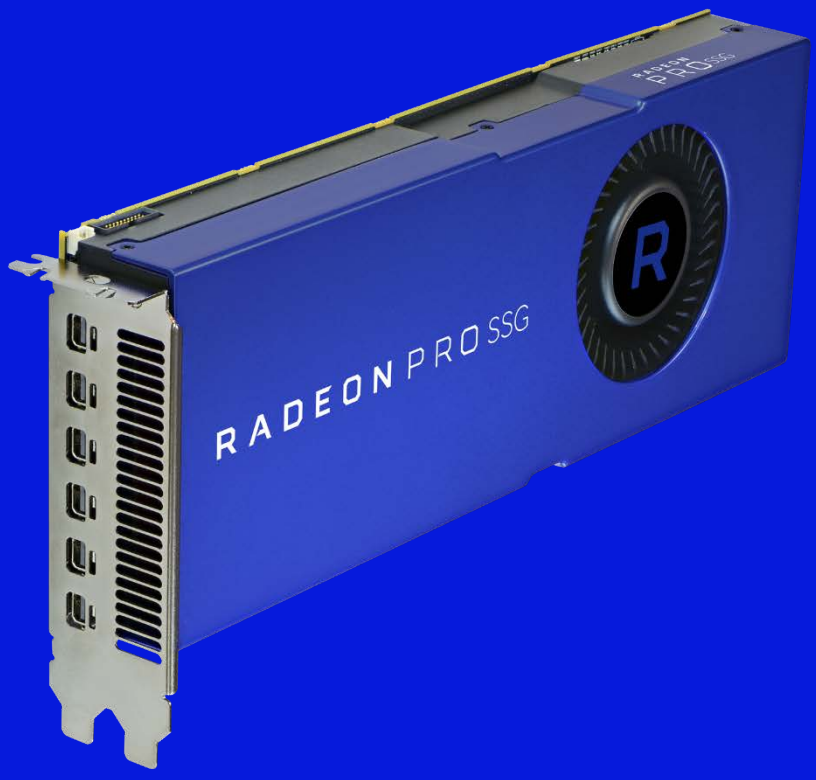
RADEON PRO

Solid State Graphics (SSG)

API User Manual



Contents

1 Introduction

The Radeon™ Pro SSG software library enables peer-to-peer (P2P) data transfers between GPU and Radeon on board SSD devices. It allows a methodology to read OS file data from SSDs to OpenCL™, OpenGL® and DirectX® buffers with very low-latency P2P communication. The development kit version of this library supports only the Microsoft® Windows® 10 operating system.

2 Requirements

To use the development kit version of the SSG library, the following are required:

1.) A Radeon™ Pro SSG Professional Graphics Card
2.) Microsoft® Windows 10 (64 bit) or newer.

3 OpenCL™ Extension Specification

3.1 clCreateSsgFileObjectAMD

The *clCreateSsgFileObjectAMD* function creates a CL file object. Doing so over a file employs the same semantics as when opening the file for reading/writing—that is, read/write privileges are required for that file.

C++

```
cl_file_amd clCreateSsgFileObjectAMD(cl_context         context,
                                     cl_file_flags_amd  flags,
                                     const wchar_t*     file_name,
                                     cl_int*            errcode_ret)
```

Context [in]
A CL context with which to associate the file.

Flags [in]
Access-privilege flag for the file. Currently, only *CL_FILE_READ_ONLY_AMD* and *CL_FILE_WRITE_ONLY_AMD* are supported. Read (or write) privileges are required for the file, subject to the same access rights as when opening any file.

file_name [in]
In Windows: the UTF-16-encoded name of the file to be opened.
In Linux: the UTF-8-encoded name of the file to be opened.

errcode_ret [out]
The return value.

Return Value	Description
CL_SUCCESS	The function executed successfully.
CL_INVALID_FILE_OBJECT_AMD	The file is invalid for OpenCL.

3.2 clGetSsgFileObjectInfoAMD

The *clGetSsgFileObjectInfoAMD* function returns information about a file object.

C++

```
cl_int clGetSsgFileObjectInfoAMD(cl_file_amd      file,
                                 cl_file_info_amd param_name,
                                 size_t           param_value_size,
                                 void*            param_value,
                                 size_t*          param_value_size_ret)
```

file [in]
Specifies the file object of query.

param_name [in]
Specifies the information to query. The table below provides a list of supported *param_name* types and the information that *clGetSsgFileObjectInfoAMD* will return in *param_value*.

cl_file_info_amd	Return Type	Info Returned in *param_value*
CL_FILE_BLOCK_SIZE_AMD	*cl_uint*	Alignment restriction for the file object
CL_FILE_SIZE_AMD	*cl_ulong*	File size in bytes

param_value_size [in]
Size of memory (in bytes) to which *param_value* points. It must be greater than or equal to the size of the return type described in the table above.

param_value [out, optional]
Pointer to the memory region that stores the appropriate result being queried. If *param_value* is NULL, the function ignores this pointer.

param_value_size_ret [out]
Returns the actual size in bytes.

Return Value	Description
CL_SUCCESS	The function executed successfully.
CL_INVALID_FILE_OBJECT_AMD	The file is invalid for OpenCL.

3.3 clRetainSsgFileObjectAMD

The *clRetainSsgFileObjectAMD* function increments the file-object reference count.

C++

```
cl_int clRetainSsgFileObjectAMD(cl_file_amd file)
```

file [in]
Specifies the file object to be retained.

Return Value	Description

CL_SUCCESS	The function executed successfully.
CL_INVALID_FILE_OBJECT_AMD	The file is invalid for OpenCL.

3.4 clReleaseSsgFileObjectAMD

The *clReleaseSsgFileObjectAMD* function decrements the file-object reference count.

C++

```
cl_int clReleaseSsgFileObjectAMD(cl_file_amd file)
```

file [in]
Specifies the file object to be released.

Return Value	Description
CL_SUCCESS	The function executed successfully.
CL_INVALID_FILE_OBJECT_AMD	The file is invalid for OpenCL.

3.5 clEnqueueReadSsgFileAMD

The *clEnqueueReadSsgFileAMD* function reads from a file object to a CL memory object.

C++

```
cl_int clEnqueueReadSsgFileAMD(cl_command_queue  command_queue,
                               cl_mem            buffer,
                               cl_bool           blocking_read,
                               size_t            buffer_offset,
                               size_t            size,
                               cl_file_amd       file,
                               size_t            file_offset,
                               cl_uint           num_events_in_wait_list,
                               const cl_event*   event_wait_list,
                               cl_event*         event);
```

command_queue [in]
Valid host command-queue in which the read command will be queued. Create the *buffer* and *command_queue* using the same OpenCL context.

buffer [in]
A valid buffer object; *buffer* is the target memory object. Create the *buffer* using either *CL_MEM_ALLOC_HOST_PTR, CL_MEM_USE_HOST_PTR* or *CL_MEM_USE_PERSISTENT_MEM_AMD.*

blocking_read [in]
Indicates whether the read operation is blocking or non-blocking. If *blocking_read* is *CL_TRUE,* the function call won't return until the operation has completed. If *blocking_read* is *CL_FALSE,* the OpenCL implementation will perform a non-blocking read. Because the read is non-blocking, the function can return immediately. The *event* argument causes the function to return an event object, which can be used to query the read command's execution status.

buffer_offset [in]
: Offset (in bytes) in the buffer object to which the function is writing. **It must be a multiple of *CL_FILE_BLOCK_SIZE_AMD.***

size [in]
: Size (in bytes) of data being read. **It must be a multiple of *CL_FILE_BLOCK_SIZE_AMD*.** If the file size isn't a multiple of the block size, read the end of the file by aligning the read size with the next block multiple beyond the file size.

file [in]
: File object from which to copy.

file_offset [in]
: Offset (in bytes) for copying from the file; ***file_offset* must be a multiple of *CL_FILE_BLOCK_SIZE_AMD.***

event_wait_list and *num_events_in_wait_list* [in, optional]
: Specify events that must complete before the *clEnqueueReadSsgFileAMD* command can execute. If *event_wait_list* is NULL, the command will proceed without waiting for events to finish. Also, if *event_wait_list* is NULL, *num_events_in_wait_list* must be 0. Otherwise, the list of events to which *event_wait_list* points must be valid and *num_events_in_wait_list* must be greater than 0. The events specified in *event_wait_list* act as synchronization points, and the contexts associated with events in *event_wait_list* and in *command_queue* must be the same. The memory associated with *event_wait_list* can be reused or freed-up after the function returns.

event [out, optional]
: Returns an event object that identifies the *clEnqueueReadSsgFileAMD* command and can query the command status or queue a wait for the command to finish executing. The *event* argument can be NULL, in which case the application will be unable to query the command status or queue a wait for the command to finish. Unless *event_wait_list* and *event* are both NULL, *event* should avoid referring to an element of the *event_wait_list* array.

Return Value	Description
CL_SUCCESS	The function executed successfully.
CL_INVALID_FILE_OBJECT_AMD	The file is invalid for OpenCL.
CL_INVALID_COMMAND_QUEUE	C*ommand_queue* is an invalid host command queue.
CL_INVALID_CONTEXT	The contexts associated with *command_queue* and *buffer* are different, or the context associated with *command_queue* and the events in *event_wait_list* are different.
CL_INVALID_MEM_OBJECT	The buffer object is invalid.
CL_INVALID_VALUE	The region specified by *buffer_offset*, *file_offset* or *size* is out of bounds or is misaligned with *CL_FILE_BLOCK_SIZE_AMD.*
CL_INVALID_EVENT_WAIT_LIST	*Event_wait_list* is NULL and *num_events_in_wait_list* is greater than 0, *event_wait_list* is not NULL and *num_events_in_wait_list* is 0, or the event objects in *event_wait_list* are invalid.
CL_EXEC_STATUS_ERROR_FOR_EVENTS_IN_WAIT_LIST	Read operations are blocking, and the execution status of at least one event in *event_wait_list* is a negative integer value.

CL_MEM_OBJECT_ALLOCATION_FAILURE
Memory failed to allocate for data store associated with buffer.

3.6 clEnqueueWriteSsgFileAMD

The *clEnqueueWriteSsgFileAMD* function writes directly from a CL memory object to a file object.

C++

```
cl_int clEnqueueWriteSsgFileAMD(cl_command_queue command_queue,
                                cl_mem           buffer,
                                cl_bool          blocking_write,
                                size_t           buffer_offset,
                                size_t           size,
                                cl_file_amd      file,
                                size_t           file_offset,
                                cl_uint          num_events_in_wait_list,
                                const cl_event*  event_wait_list,
                                cl_event*        event);
```

command_queue [in]
Valid host command queue in which the write command will be queued. Create the *command_queue* and *buffer* with the same OpenCL context.

buffer [in]
A valid buffer object. *Buffer* is the copy-source memory object. Create the buffer with either *CL_MEM_ALLOC_HOST_PTR, CL_MEM_USE_HOST_PTR* or *CL_MEM_USE_PERSISTENT_MEM_AMD.*

blocking_write [in]
Indicates whether the write operation is blocking or non-blocking. If *blocking_write* is *CL_TRUE,* the function call will not return until the operation is complete. If *blocking_write* is *CL_FALSE,* the OpenCL implementation will perform a non-blocking write, and can return immediately. The *event* argument returns an event object that can query the execution status of the write command.

buffer_offset [in]
Offset (in bytes) in the buffer object being read. **It must be a multiple of *CL_FILE_BLOCK_SIZE_AMD.***

size [in]
Size (in bytes) of the data being written. **It must be a multiple of *CL_FILE_BLOCK_SIZE_AMD.*** If the file size is not a multiple of the block size, write to the end of the file by aligning the write size with the next block multiple beyond the file size.

file [in]
File object to which the copy is initiated.

file_offset [in]
Offset (in bytes) for copying to the file. **It must be a multiple of *CL_FILE_BLOCK_SIZE_AMD.***

event_wait_list and *num_events_in_wait_list* [in, optional]
Specify events that must complete before *clEnqueueWriteSsgFileAMD* can execute. If *event_wait_list* is NULL, the command will proceed without waiting for events to finish executing. If e*vent_wait_list* is NULL, *num_events_in_wait_list* must be 0; otherwise, the list of events to which *event_wait_list* points must be valid and *num_events_in_wait_list* must be greater than 0. The events specified in *event_wait_list* act as

synchronization points, and the contexts associated with events in *event_wait_list* and *command_queue* must be the same. Memory associated with *event_wait_list* can be reused or freed-up after the function returns.

event [out, optional]
Returns an event object that identifies the *clEnqueueWriteSsgFileAMD* command and can query or queue a wait for this command to finish executing. The *event* argument can be NULL, in which case the application will be unable to query the command status or queue a wait for the command to finish. Unless the *event_wait_list* and *event* arguments are NULL, the *event* argument should avoid referring to an element of the *event_wait_list* array.

Return Value	Description
CL_SUCCESS	The function executed successfully.
CL_INVALID_FILE_OBJECT_AMD	The file is invalid for OpenCL.
CL_INVALID_COMMAND_QUEUE	*Command_queue* is an invalid host command queue.
CL_INVALID_CONTEXT	The contexts associated with *command_queue* and *buffer* are different, or the contexts associated with *command_queue* and the events in *event_wait_list* are different.
CL_INVALID_MEM_OBJECT	The buffer object is invalid.
CL_INVALID_VALUE	The region specified by *buffer_offset*, *file_offset* or *size* is out of bounds or misaligned with *CL_FILE_BLOCK_SIZE_AMD.*
CL_INVALID_EVENT_WAIT_LIST	Either *event_wait_list* is NULL and *num_events_in_wait_list* is greater than 0, *event_wait_list* is not NULL and *num_events_in_wait_list* is 0, or event objects in *event_wait_list* are invalid.
CL_EXEC_STATUS_ERROR_FOR_EVENTS_IN_WAIT_LIST	Write operations are blocking and the execution status of at least one event in *event_wait_list* is a negative integer value.
CL_MEM_OBJECT_ALLOCATION_FAILURE	Memory failed to allocate for data store associated with *buffer.*

4 OpenCL Performance Guidelines and Caveats

The following guidelines and caveats will optimize for the greatest performance from OpenCL.

- For best performance, create the target resources with the flag *CL_MEM_USE_PERSISTENT_MEM_AMD.*
- Because of OS limitations, persistent memory must be referenced by the GPU once before it truly becomes resident in GPU memory. A one-time performance drop may be experienced the first time the buffer is used as a file-transfer target if the GPU has yet to access the resource. Clear the buffer using *clEnqueueFillBuffer* to generate such a reference.
- The persistent-memory heap available to all applications is 128 MB. If the heap is entirely consumed, the run time will silently fall back to standard allocations. If the data set is larger than 100 MB, the application should employ the persistent-memory allocation as a staging buffer and

copy the internal device memory to the destination buffer. Internal device copies will execute at full memory-controller speed, which varies from 100 GB/s to 500 GB/s depending on the GPU type.

- The copy size, buffer offset and file offset must adhere to the SSD's alignment restrictions. Discover these restrictions by calling *clGetSsgFileObjectInfoAMD.*

5 AMD Code Sample for OpenCL

```
// Create file.
cl_int      clStatus  = CL_SUCCESS;
cl_file_amd clSsgFile = clCreateSsgFileObjectAMD(m_clContext,
                                        CL_FILE_READ_ONLY_AMD, FILE_NAME, &clStatus);
if (clStatus != CL_SUCCESS) {
        std::cout << "Error: Unable to create file handle." << std::endl;
        return;
}

// Get the file-size information.
size_t   retSize = 0;
LARGE_INTEGER  SsgFileSize;
clStatus = clGetSsgFileObjectInfoAMD(clSsgFile, CL_FILE_SIZE_AMD,
                        sizeof(SsgFileSize), &SsgFileSize, &retSize);
if (clStatus != CL_SUCCESS) {
        std::cout << "Error: Unable to retrieve file size." << std::endl;
        return;
}
if (retSize != sizeof(SsgFileSize)) {
        std::cout << "Error: Invalid file size info returned." << std::endl;
        return;
}

// Get the sector-size information.
// Allocated buffer must align with the sector size for best performance.
cl_uint sectorSize = 0;
clStatus = clGetSsgFileObjectInfoAMD(clSsgFile, CL_FILE_BLOCK_SIZE_AMD,
                        sizeof(sectorSize), &sectorSize, &retSize);
if (clStatus != CL_SUCCESS) {
        std::cout << "Error: Unable to retrieve file size." << std::endl;
        return;
}
if (retSize != sizeof(sectorSize)) {
        std::cout << "Error: Invalid sector size info returned." << std::endl;
        return;
}

// Create buffer.
cl_mem clBuffer = clCreateBuffer(m_clContext, CL_MEM_ USE_PERSISTENT_MEM_AMD,
                                    DATA_SIZE_IN_BYTES, nullptr, &clStatus);
if (clStatus != CL_SUCCESS) {
        std::cout << "Error: Unable to create buffer." << std::endl;
        return;
}

// Read information from the file; BUFF_OFFSET, SIZE_TO_READ and FILE_OFFSET must
// align with the sector size.
clStatus = clEnqueueReadSsgFileAMD(m_clCommandQueue, clBuffer, CL_TRUE, BUFF_OFFSET,
                                SIZE_TO_READ, clSsgFile, FILE_OFFSET, 0, NULL, NULL);
if (clStatus != CL_SUCCESS) {
        std::cout << "Error: Data transfer failed." << std::endl;
}

// Release the file when you're done with it.
clStatus = clReleaseSsgFileObjectAMD(clSsgFile);
if (clStatus != CL_SUCCESS) {
        std::cout << "Warning: Unable to release file." << std::endl;
}

// Release the buffer when you're done with it.
clStatus = clReleaseBuffer(clBuffer);
if (clStatus != CL_SUCCESS) {
        std::cout << "Warning: Unable to release buffer." << std::endl;
}
```

6 OpenGL® Extension Specification

This OpenGL extension accelerates the data transfer between GPU and SSD devices. It introduces a new file object that operates on the file in an SSD. The result of a file operation (read or write) can be any named buffer object. GL file objects employ the same semantics as when the file is opened for reading/writing—that is, the file must have read/write privileges.

6.1 glCreateFileAMD

The *glCreateFileAMD* function creates a GL file object. Doing so over a file employs the same semantics as when the file is opened for reading/writing—that is, the file must have read/write privileges.

C++

```
GLfilehandleAMD  glCreateFileAMD(GLchar* name, GLenum mode);
```

name [in]
Name of the file to open or create. The file name supports only UTF-8; wide-character Unicode strings are currently unsupported.

mode [in]
Mode in which the file is to be created: *GL_READ_ONLY, GL_WRITE_ONLY* or *GL_READ_WRITE.*

Return Value	Description
NULL	The function is unable to create/open the file.

6.2 glReleaseFileAMD

The *glReleaseFileAMD* function detaches the native handle from a GL file and closes the GL file object.

C++

```
GLvoid glReleaseFileAMD(GLfilehandleAMD file);
```

file [in]
The GL file to be released and closed.

Error	Description
INVALID_OPERATION	The file object is invalid.

6.3 glGetFileParameteri64vAMD

The *glGetFileParameteri64vAMD* function returns the properties of the GL file.

C++

```
GLvoid glGetFileParameteri64vAMD(GLfilehandleAMD file,
                                 GLenum          pname,
                                 GLuint64*       params);
```

file [in]
The GL file for which properties are required.

pname [in]
The property information being requested. It must be *GL_FILE_BLOCK_SIZE_AMD* or *GL_FILE_SIZE_AMD.*

params [out]
The value of the property requested.

Error	Description
INVALID_VALUE	The file object is invalid.
INVALID_ENUM	The requested property is not *GL_FILE_BLOCK_SIZE_AMD.*

6.4 glReadFileAMD

The *glReadFileAMD* function reads from the specified file into the destination buffer. It can be synchronous or asynchronous. Combining a number of read operations asynchronously yields better performance.

C++

```
GLvoid glReadFileAMD(GLuint          dstBuffer,
                     GLfilehandleAMD file,
                     GLuint64        bufferOffset,
                     GLuint64        fileOffset,
                     GLuint64        size,
                     GLsync*         sync);
```

dstBuffer [in]
A valid named buffer object that will hold the read result. **The best performance is obtained by creating the buffer with the *MAP_PERSISTENT_BIT* flag but without *CLIENT_STORAGE_BIT.***

file [in]
The GL file from which information is being read.

bufferOffset [in]
Location in the buffer from which data (of width *size,* in bytes) will be read. **It must be a multiple of *GL_FILE_BLOCK_SIZE_AMD.***

fileOffset [in]
Location in the file from which data (of width *size,* in bytes) will be read into the buffer. **It must be a multiple of *GL_FILE_BLOCK_SIZE_AMD.***

size [in]
The amount of information (in bytes) being read. **It must be a multiple of *GL_FILE_BLOCK_SIZE_AMD*.** If the file size is not a multiple of the block size, read the end of the file by aligning the read size with the next block multiple beyond the file size.

sync [in]
Sync the object for non-blocking operation. If *sync* is NULL, read operations will execute in blocking mode and the function call will return only after the operation is complete. Otherwise, the function will use non-blocking mode and will return immediately; a valid GL sync object will also be returned in this case, to be used in a *WaitSync* call to synchronize file operations. **Non-blocking mode is only valid when the buffer is created with the *MAP_PERSISTENT_BIT* flag but without *CLIENT_STORAGE_BIT.***

Error	Description
INVALID_VALUE	The file object is invalid.
INVALID_VALUE	Invalid buffer-object name.
INVALID_VALUE	The sum of *bufferOffset* and *size* exceeds the size of the target buffer.
INVALID_VALUE	The *fileOffset, size* and *bufferOffset* values are not multiples of *GL_FILE_BLOCK_SIZE_AMD.*
INVALID_OPERATION	Failure to access the file with the specified *fileOffset* and *size* values.
INVALID_OPERATION	The *sync* argument isn't NULL and the buffer object wasn't created with the *MAP_PERSISTENT_BIT* flag but without *CLIENT_STORAGE_BIT.*

6.5 glWriteFileAMD

The *glWriteFileAMD* function writes multiple target regions to the file. The write source is a named buffer with specified offsets.

C++

```
GLvoid glWriteFileAMD(GLuint           srcBuffer,
                      GLfilehandleAMD  file,
                      GLuint64         bufferOffset,
                      GLuint64         fileOffset,
                      GLuint64         size,
                      GLsync*          sync);
```

srcBuffer [in]
A valid named buffer object containing the information desired to be written to a file. **The best performance is obtained by creating the buffer with the *MAP_PERSISTENT_BIT* flag but without *CLIENT_STORAGE_BIT.***

file [in]
The GL file to which the information is written.

bufferOffset [in]
Location in the buffer from which data (of width *size,* in bytes) will be read. **It must be a multiple of *GL_FILE_BLOCK_SIZE_AMD.***

fileOffset [in]
File location to which data (of width *size,* in bytes) will be written. **It must be a multiple of *GL_FILE_BLOCK_SIZE_AMD.***

size [in]
Amount of information (in bytes) being written. **It must be a multiple of *GL_FILE_BLOCK_SIZE_AMD.*** If the file size is not a multiple of the block size, read the end of the file by aligning the read size with the next block multiple beyond the file size.

sync [in]
Sync the object for non-blocking operation. If *sync* is NULL, the write operation will execute in blocking mode and the function call will return only after the operation is complete. Otherwise, the function will use non-blocking mode and will return immediately; a valid GL sync object will also be returned in this case, to be used in a *WaitSync* call to synchronize file operations. **Non-blocking mode is only valid when the buffer is created with the *MAP_PERSISTENT_BIT* flag but without *CLIENT_STORAGE_BIT.***

Error	Description
INVALID_VALUE	The file object is invalid.
INVALID_VALUE	Invalid buffer-object name.
INVALID_VALUE	The sum of *bufferOffset* and *size* exceeds the size of the target buffer.
INVALID_VALUE	The *fileOffset, size* and *bufferOffset* values are not multiples of *GL_FILE_BLOCK_SIZE_AMD.*
INVALID_OPERATION	Failure to access file with specified *fileOffset* and *size.*
INVALID_OPERATION	The *sync* argument isn't NULL and buffer object wasn't created with the *MAP_PERSISTENT_BIT* flag but without *CLIENT_STORAGE_BIT.*

7 OpenGL Performance Guidelines and Caveats

The following guidelines and caveats will help realize the greatest performance from OpenGL.

- The copy size, buffer offset and file offset must adhere to the SSD's alignment restrictions. Discover these restrictions by calling *glGetFileParameteri64vAMD.*
- Performing multiple asynchronous reads/writes will yield better performance than synchronous operations. For asynchronous reads/writes, multiple read/writes share the same sync object, and sync object must be initialized before passing it to *glReadFileAMD/glWriteFileAMD.* Otherwise, asynchronous reads/writes will fail.
- OpenGL divides the video memory into two parts: local visible memory and local invisible memory. Access to local visible memory enables the highest performance, but this memory is only 256 MB and the system reserves most of it. The application can only allocate about 100 MB; attempts to allocate more than the unallocated local visible memory will fail. Access to local invisible memory is slower than to local visible memory, but the application can allocate the video memory in large amounts. The allocation of local invisible memory can be several gigabytes, depending on the video-memory size.
- OpenGL provides a way to allocate the local visible memory: *glNamedBufferStorage(bufferID, bufferSize, dataPointer, GL_MAP_READ_BIT|GL_MAP_WRITE_BIT|GL_MAP_PERSISTENT_BIT).* Set the *GL_MAP_READ_BIT|GL_MAP_WRITE_BIT|GL_MAP_PERSISTENT_BIT* flag.

- The *glNamedBufferStorage()* API can also allocate local invisible memory; just set the *GL_MAP_READ_BIT* or *GL_MAP_WRITE_BIT* flag without setting *GL_MAP_PERSISTENT_BIT.*
- OpenGL also provides other ways to allocate local invisible memory: *glBufferData* and *glBufferSubData.*
- Only when the buffer is created in local visible video memory (using *glNamedBufferStorage* with the *GL_MAP_READ_BIT* | *GL_MAP_WRITE_BIT* | *GL_MAP_PERSISTENT_BIT* flag set) will read/write operations work in asynchronous mode. Otherwise, the driver will ignore the sync object.

8 AMD Code Sample for OpenGL

```
// Create file: FILE_NAME is the file path.
GLfilehandleAMD hSsgFileFile = glCreateFileAMD(FILE_NAME, GL_READ_ONLY);
if (hSsgFileFile != NULL) {
        std::cout << "Error: Unable to open the file." << std::endl;
        return;
}

// Get the file-size information.
GLuint64 fileSize = 0;
glGetFileParameteri64vAMD(hSsgFileFile, GL_FILE_SIZE_AMD, &fileSize);
if (glGetError() != GL_NO_ERROR) {
        std::cout << "Error: Unable to retrieve file size." << std::endl;
        return;
}

// Get the file-system information.
GLuint64 sectorSize = 0;
glGetFileParameteri64vAMD(hSsgFileFile, GL_FILE_BLOCK_SIZE_AMD, &sectorSize);
if (sectorSize == 0) {
        std::cout << "Error: Unable to retrieve block size." << std::endl;
        return;
}

// Create buffer.
GLuint oglBuffer;
glCreateBuffers(1, &oglBuffer);
glNamedBufferStorage(oglBuffer, SIZE_TO_READ, nullptr,
        GL_MAP_READ_BIT | GL_MAP_WRITE_BIT | GL_MAP_PERSISTENT_BIT);
if (glGetError() != GL_NO_ERROR) {
        std::cout << "Error: Failed to allocate openGL buffer." << std::endl;
        return;
}

// Read information from the file; BUFF_OFFSET, SIZE_TO_READ and FILE_OFFSET must
// align with the sector size.
glReadFileAMD(oglBuffer, hSsgFileFile, BUFF_OFFSET, FILE_OFFSET, SIZE_TO_READ, nullptr);
if (glGetError() != GL_NO_ERROR) {
        std::cout << "Error: Failed to read data from the file." << std::endl;
        return;
}

// Release the file when you're done with it.
glReleaseFileAMD(hSsgFileFile);
if (glGetError() != GL_NO_ERROR) {
        std::cout << "Warning: Unable to release file." << std::endl;
}

// Release the buffer when you're done with it.
glDeleteBuffers(1, oglBuffer);
if (glGetError() != GL_NO_ERROR) {
        std::cout << "Warning: Unable to release buffer." << std::endl;
}
```

9 DirectX™ 11 Extension Specification

The DirectX 11 extension accelerates the data transfer between GPU and SSD devices. It introduces a new interface that operates on the file in an SSD. The result of the operation (read or write) can be any named buffer object. The DirectX file object employs the same semantics as when the file is opened for reading/writing—that is, the file must have read/write privileges.

C++

```
class IAmdDxExtSSG : public IAmdDxExtInterface
{
public:
    // Version information.
    virtual HRESULT GetExtensionVersion(AmdDxSsgVersion* pVersion) = 0;

    // Open or create a file and get an SSG file handle for it.
    // The handle will be used later in data-transfer calls.
    virtual HRESULT CreateFile(const WCHAR* pFileName, AmdDxSsgFileAccess fileAccess,
                               AmdDxSsgFileHandle* phFile) = 0;

    // Release a file when it's no longer in use.
    virtual HRESULT ReleaseFile(AmdDxSsgFileHandle hFile) = 0;

    // Get the file-size information.
    // The file transfer in the SSG extension requires that the transfer size and offset
    // align with the block boundary.
    virtual HRESULT GetFileInfo(AmdDxSsgFileHandle hFile, AmdDxSsgFileInfo* pInfo) = 0;

    // Create an event to use in asynchronous file transfer.
    virtual HRESULT CreateEvent(AmdDxSsgEventHandle* phEvent) = 0;

    // Delete an event.
    virtual HRESULT DestroyEvent(AmdDxSsgEventHandle hEvent) = 0;

    // Wait for an asynchronous file transfer to complete.
    // The event handle should have been submitted in a previous transfer call.
    virtual HRESULT WaitEvent(AmdDxSsgEventHandle hEvent) = 0;

    // P2P transfer of file data to a D3D11 buffer.
    virtual HRESULT ReadBufferFromFile(ID3D11Buffer* pBuffer, AmdDxSsgFileHandle hFile,
                                       UINT numRegions, AmdDxSsgRegionDesc* pRegions,
                                       AmdDxSsgEventHandle hEvent) = 0;

    // P2P transfer of D3D11 buffer data to a file.
    virtual HRESULT WriteBufferToFile(ID3D11Buffer* pBuffer, AmdDxSsgFileHandle hFile,
                                      UINT numRegions, AmdDxSsgRegionDesc* pRegions,
                                      AmdDxSsgEventHandle hEvent) = 0;
};
```

9.1 GetExtensionVersion

The *GetExtensionVersion* function returns the SSG extension version information.

C++

```
HRESULT GetExtensionVersion(AmdDxExtVersion* pExtVersion);
```

pExtVersion [in]
Address pointer to the returned version information.

Remarks
The *extVersionMajor/Minor* values will increase as the extension interface expands to add new functions. The *liquidFlashBuild* number indicates the functional improvement in the Liquid Flash library. This value is also necessary to determine the library version when a customer reports a problem.

Return Value	Description
S_OK	The function succeeded.
E_INVALIDARG	The *pExtVersion* value is NULL.

9.2 CreateFile

The *CreateFile* function creates a DirectX file object. Using it over a file employs the same semantics as when the file is opened for reading/writing— that is, the file must have read/write privileges.

C++

```
HRESULT CreateFile(const WCHAR* pFileName,
             AmdDxSsgFileAccess fileAccess, AmdDxSsgFileHandle* phFile)
```

pFileName [in]
Name of the file to be opened or created.

fileAccess [in]
Request read/write access for the file.

phFile [out]
SSG file handle for use in subsequent data-transfer calls.

Return Value	Description
S_OK	The function succeeded.
E_FAIL	The handle is invalid or refers to an unsupported device.

9.3 ReleaseFile

The *ReleaseFile* function releases the SSG file handle and closes the file.

C++

```
HRESULT ReleaseFile(AmdDxLfFileHandle hFile);
```

hFile [in]
Handle for the SSG file to close.

Remarks
This function will invalidate the *hFile* handle, which then becomes unusable. Avoid calling this function if an asynchronous transfer is in progress.

Return Value	Description
S_OK	The function succeeded.
E_HANDLE	The handle is invalid or the file failed to close.
E_INVALIDARG	The handle is invalid or the file failed to close.

9.4 GetFileInfo

The *GetFileInfo* function retrieves information about the file on disk. Available information includes the file size and sector size. Use the sector size when calculating the buffer-size alignment and the regions desired to be read.

C++

```
HRESULT GetFileInfo(AmdDxLfFileHandle hFile, AmdDxLfFileInfo* pInfo);
```

hFile [in]
Handle for SSG file from which information is to be retrieved.

pInfo [out]
Structure to be filled with the file- and sector-size information.

Return Value	Description
S_OK	The function succeeded.

9.5 CreateEvent

The *CreateEvent* function creates a synchronization event for use during asynchronous file transfers.

C++

```
HRESULT CreateEvent(AmdDxLfEventHandle* phEvent);
```

phEvent [out]
SSG event handle for use in subsequent asynchronous data-transfer calls.

Return value

S_OK	The function succeeded.

9.6 DeleteEvent

The *DeleteEvent* function deletes a synchronization event employed during asynchronous file transfers.

C++

```
HRESULT DeleteEvent(AmdDxLfEventHandle hEvent);
```

hEvent [in]
SSG event handle to be deleted.

Remarks
Avoid deleting an event handle if used in asynchronous file transfers but those transfers finished executing before the event. Once the event handle is deleted, no longer wait on those transfers to finish.

Return Value	Description
S_OK	The function succeeded.
E_INVALIDARG	Unable to delete event handle.

9.7 WaitEvent

The *WaitEvent* function waits for asynchronous file transfers to complete. The synchronization event should have already been used in a previous transfer call.

C++

```
HRESULT WaitEvent(AmdDxLfEventHandle hEvent);
```

hEvent [in]
Handle of SSG event to wait on.

Remarks
The wait time on an event yet to be used in an asynchronous call should be zero.

Return Value	Description
S_OK	The function succeeded.
E_INVALIDARG	Unable to wait on the event.

9.8 ReadBufferFromFile

The *ReadBufferFromFile* function transfers file information to the D3D11 buffer. The call can be synchronous or asynchronous, and it takes one or more regions to fill the destination buffer. Splitting the request into multiple smaller regions can improve performance.

Note: During asynchronous transfers (between the transfer call and the *WaitEvent* call), avoid using the D3D buffer in the D3D pipeline or lock/unlock. Also note that *WaitEvent* is required for every asynchronous transfer. Do not assume that waiting for the last issued transfer means all asynchronous transfers are complete.

C++

```
HRESULT ReadBufferFromFile(ID3D11Buffer*      pBuffer,
                           AmdDxLfFileHandle  hFile,
                           UINT               numRegions,
                           AmdDxLfRegionDesc* pRegions,
                           AmdDxLfEventHandle hEvent);
```

pBuffer [in]
: The D3D11 buffer that will be the transfer destination.

hFile [in]
: SSG file handle that will be the data-transfer source.

numRegions [in]
: Number of elements in *pRegions* array.

pRegions [in]
: Array of regions for the data transfer. Each region contains the file offset to read from, the buffer offset to write to and the size of the data to write, in bytes. **They must be a multiple of sector-size.**

hEvent [in]
: SSG event handle to wait on. If the call omits an event, the function will be synchronous and will return after the data transfer is complete. If the call includes an event, the function will return immediately, and the caller is responsible for waiting on this event to ensure the data transfer is complete.

Return Value	Description
S_OK	The function succeeded.
E_HANDLE	The file object is invalid.
E_INVALIDARG	The file object is invalid.
E_FAIL	The sum of *dstOffset* and *length* exceeds the size of the target buffer.
E_FAIL	The value of *srcOffset, length* or *dstOffset* is not a multiple of *GL_FILE_BLOCK_SIZE_AMD.*
E_FAIL	The function failed to access the file with the specified *srcOffset* and *length* values.

9.9 WriteBufferToFile

The *WriteBufferToFile* function transfers information from the D3D11 buffer to a file. The call can be synchronous or asynchronous. It takes one or more regions for writing to the file. Splitting the request into multiple smaller regions can improve performance.

Note: During asynchronous transfers (between a transfer call and a *WaitEvent* call), avoid using the D3D buffer in the D3D pipeline or lock/unlock. Also note that *WaitEvent* is required for every asynchronous transfer. Do not assume that waiting for the last issued transfer means all asynchronous transfers are complete.

C++

```
HRESULT WriteBufferToFile(AmdDxLfFileHandle   hFile,
                          ID3D11Buffer*       pBuffer,
                          UINT                numRegions,
                          AmdDxLfRegionDesc*  pRegions,
                          AmdDxLfEventHandle  hEvent);
```

hFile [in]
: Handle for the SSG file that will be the data-transfer destination.

pBuffer [in]
: D3D11 buffer that will be the transfer source.

numRegions [in]
: Number of elements in *pRegions* array.

pRegions [in]
: Array of regions for the data transfer. Each region contains the file offset to write to, the buffer offset to read from and the size of the data to write, in bytes. **They must be a multiple of sector-size.**

hEvent [in]
: SSG event handle to wait on. If the call omits an event, the function will be synchronous and will return after the data transfer is complete. If the call includes an event, the function will return immediately and the caller will be responsible for waiting on this event to ensure the data transfer is complete.

Return Value	Description
S_OK	The function succeeded.
E_HANDLE	The file object is invalid.
E_INVALIDARG	The file object is invalid.
E_FAIL	The sum of *dstOffset* and *length* exceeds the size of target buffer.
E_FAIL	The value of *srcOffset, length* or *dstOffset* is not a multiple of *GL_FILE_BLOCK_SIZE_AMD.*
E_FAIL	The function failed to access the file with the specified *srcOffset* and *length* values.

10 AMD Code Sample for DirectX®

```
// Create module handle.
HMODULE hDxxDll = GetModuleHandle(DXX_DLL_NAME);
if (hDxxExt == NULL) {
        std::cout << "Error: Unable to load DX library." << std::endl;
        return;
}

// Initial function pointer from module.
PFNAmdDxExtCreate11 pAmdDxExtCreate =
     reinterpret_cast<PFNAmdDxExtCreate11>(GetProcAddress(hDxxDll, "AmdDxExtCreate11"));
if (pAmdDxExtCreate == nullptr) {
        std::cout << "Error: Unable to get DX information." << std::endl;
        return;
}

// Create general extension object.
IAmdDxExt* dxExt = nullptr;
pAmdDxExtCreate(D3D11DEVICE, &dxExt);
if (dxExt == nullptr) {
        std::cout << "Error: Unable to get DX extension." << std::endl;
        return;
}

// Get SSG extension interface.
IAmdDxExtSsg* dxSsgExt = static_cast<IAmdDxExtSsg*>
                                        (dxExt->GetExtInterface(AmdDxExtSsgID));
if (dxSsgExt == nullptr) {
        std::cout << "Error: Unable to get DX SSG extension." << std::endl;
        return;
}

// Create SSG file handle.
AmdDxSsgFileHandle hSsgFile;
HRESULT hr = dxSsgExt->CreateFile(FILE_NAME, AmdDxSsgFile_Read, &hSsgFile);
If (FAILED(hr)) {
        std::cout << "Error: Unable to create liquid flash file handle." << std::endl;
        return;
}

// Get the file information: file size and block size.
AmdDxSsgFileInfo dxSsgFileInfo;
hr = dxSsgExt->GetFileInfo(hSsgFile, &dxSsgFileInfo);
if (FAILED(hr)) {
        std::cout << "Error: Unable to retrieve file/block size." << std::endl;
        return;
}

// Create buffer: SIZE_TO_READ.
CComPtr<ID3D11Buffer> pDxBuffer;
D3D11_BUFFER_DESC bufferDesc;
ZeroMemory(&bufferDesc, sizeof(bufferDesc));
bufferDesc.ByteWidth = SIZE_TO_READ;
bufferDesc.Usage = D3D11_USAGE_DEFAULT;
bufferDesc.BindFlags = D3D11_BIND_SHADER_RESOURCE;
bufferDesc.MiscFlags = 0;
bufferDesc.StructureByteStride = 0;
bufferDesc.CPUAccessFlags = 0;

hr = D3D11DEVICE->CreateBuffer(&bufferDesc, NULL, &pDxBuffer);
if (FAILED(hr)) {
        std::cout << "Error: Unable to create dx buffer." << std::endl;
        return;
}
```

```
AmdDxLfRegionDesc regionDesc;
regionDesc.fileOffset = FILE_OFFSET;
regionDesc.bufferOffset = BUFF_OFFSET;
regionDesc.regionSize = dxLFFileInfo.blockSize;

// Read information from the file: BUFF_OFFSET, SIZE_TO_READ and FILE_OFFSET must
// align with the sector size.
hr = dxSsgExt->ReadBufferFromFile(pDxBuffer, hSsgFile, 1, &regionDescs, nullptr);
if (FAILED(hr)) {
        std::cout << "Error: Unable to read data from file." << std::endl;
}

// Release the file when you're done with it.
hr = dxSsgExt->ReleaseFile(hSsgFile);
if (FAILED(hr)) {
        std::cout << "Warning: Unable to release file." << std::endl;
}
```

DISCLAIMER

The information contained herein is for informational purposes only, and is subject to change without notice. While every precaution has been taken in the preparation of this document, it may contain technical inaccuracies, omissions and typographical errors, and AMD is under no obligation to update or otherwise correct this information. Advanced Micro Devices, Inc. makes no representations or warranties with respect to the accuracy or completeness of the contents of this document, and assumes no liability of any kind, including the implied warranties of noninfringement, merchantability or fitness for particular purposes, with respect to the operation or use of AMD hardware, software or other products described herein. No license, including implied or arising by estoppel, to any intellectual property rights is granted by this document. Terms and limitations applicable to the purchase or use of AMD's products are as set forth in a signed agreement between the parties or in AMD's Standard Terms and Conditions of Sale.

Legal Attributions