GOOPAX Reference

4.0.2

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- gpu_uint64 atomic_sub (gpu_uint64 &ref, gpu_uint64 value)
- gpu_uint64 atomic_cmpxchg (gpu_uint64 &ref, gpu_uint64 cmp, gpu_uint64 value)

4.1.1 Detailed Description

atomic functions are used to atomically modify values in global or local memory.

example:

```
struct foo :
kernel<foo>
{
   void program(resource<int>& a, resource<pair<uint64_t, double»& B)
   {
       atomic_add(a[0], 1);                                  // increments a[0] by 1
       gpu_double x = atomic_xchg(b[12].second, 3.14);       // Writes 3.14 at B[12].second, returns in x the
       previous value
   }
};
```

4.1.2 Function Documentation

4.1.2.1 atomic_add()

```
gpu_uint32 goopax::impl::atomic_add (
            gpu_uint32 & ref,
            const gpu_uint32 value )  [inline]
```

atomic add

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
value	value to add

Returns

previous value

4.1.2.2 atomic_and()

```
gpu_uint32 goopax::impl::atomic_and (
            gpu_uint32 & ref,
            const gpu_uint32 value )  [inline]
```

atomic and

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
value	value to perform and operation with

Returns

previous value

4.1.2.3 atomic_cmpxchg() [1/4]

```
gpu_int32 goopax::impl::atomic_cmpxchg (
            gpu_int32 & ref,
```

```
            gpu_int32 cmp,
            gpu_int32 value )  [inline]
```

atomic compare and exchange

If ref == cmp, write ref = value. Otherwise do nothing.

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
cmp	value to compare with
value	value to write

Returns

previous value

4.1.2.4 atomic_cmpxchg() [2/4]

```
gpu_int64 goopax::impl::atomic_cmpxchg (
            gpu_int64 & ref,
            gpu_int64 cmp,
            gpu_int64 value )  [inline]
```

atomic compare and exchange

If ref == cmp, write ref = value. Otherwise do nothing.

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
cmp	value to compare with
value	value to write

Returns

previous value

4.1.2.5 atomic_cmpxchg() [3/4]

```
gpu_uint32 goopax::impl::atomic_cmpxchg (
            gpu_uint32 & ref,
            gpu_uint32 cmp,
            gpu_uint32 value )  [inline]
```

atomic compare and exchange

If ref == cmp, write ref = value. Otherwise do nothing.

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
cmp	value to compare with
value	value to write

Returns

previous value

4.1.2.6 atomic_cmpxchg() [4/4]

```
gpu_uint64 goopax::impl::atomic_cmpxchg (
            gpu_uint64 & ref,
            gpu_uint64 cmp,
            gpu_uint64 value )  [inline]
```

atomic compare and exchange

If ref == cmp, write ref = value. Otherwise do nothing.

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
cmp	value to compare with
value	value to write

Returns

previous value

4.1.2.7 atomic_load() [1/4]

```
gpu_int32 goopax::impl::atomic_load (
            const gpu_int32 & ref )  [inline]
```

atomic load

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.

Returns

value at location 'ref'

4.1.2.8 atomic_load() [2/4]

```
gpu_int64 goopax::impl::atomic_load (
            const gpu_int64 & ref )  [inline]
```

atomic load

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.

Returns

value at location 'ref'

4.1.2.9 atomic_load() [3/4]

```
gpu_uint32 goopax::impl::atomic_load (
            const gpu_uint32 & ref )  [inline]
```

atomic load

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.

Returns

value at location 'ref'

4.1.2.10 atomic_load() [4/4]

```
gpu_uint64 goopax::impl::atomic_load (
            const gpu_uint64 & ref )  [inline]
```

atomic load

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.

Returns

value at location 'ref'

4.1.2.11 atomic_max()

```
gpu_uint32 goopax::impl::atomic_max (
             gpu_uint32 & ref,
             const gpu_uint32 value )  [inline]
```

atomic max

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
value	value to perform max operation with

Returns

previous value

4.1.2.12 atomic_min()

```
gpu_uint32 goopax::impl::atomic_min (
             gpu_uint32 & ref,
             const gpu_uint32 value )  [inline]
```

atomic min

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
value	value to perform min operation with

Returns

previous value

4.1.2.13 atomic_or()

```
gpu_uint32 goopax::impl::atomic_or (
            gpu_uint32 & ref,
            const gpu_uint32 value )  [inline]
```

atomic or

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
value	value to perform or operation with

Returns

previous value

4.1.2.14 atomic_sub() [1/4]

```
gpu_int32 goopax::impl::atomic_sub (
            gpu_int32 & ref,
            gpu_int32 value )  [inline]
```

atomic sub

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.

Returns

previous value

4.1.2.15 atomic_sub() [2/4]

```
gpu_int64 goopax::impl::atomic_sub (
            gpu_int64 & ref,
            gpu_int64 value )  [inline]
```

atomic sub

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.

Returns

previous value

4.1.2.16 atomic_sub() [3/4]

```
gpu_uint32 goopax::impl::atomic_sub (
            gpu_uint32 & ref,
            gpu_uint32 value )  [inline]
```

atomic sub

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.

Returns

previous value

4.1.2.17 atomic_sub() [4/4]

```
gpu_uint64 goopax::impl::atomic_sub (
            gpu_uint64 & ref,
            gpu_uint64 value )  [inline]
```

atomic sub

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.

Returns

previous value

4.1.2.18 atomic_xchg() [1/3]

```
gpu_double goopax::impl::atomic_xchg (
            gpu_double & ref,
            const gpu_double value )  [inline]
```

atomic exchange

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.
value	value to write

Returns

previous value

4.1.2.19 atomic_xchg() [2/3]

```
gpu_float goopax::impl::atomic_xchg (
            gpu_float & ref,
            const gpu_float value )  [inline]
```

atomic exchange

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.
value	value to write

Returns

previous value

4.1.2.20 atomic_xchg() [3/3]

```
gpu_uint32 goopax::impl::atomic_xchg (
            gpu_uint32 & ref,
            const gpu_uint32 value )  [inline]
```

atomic exchange

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral or floating point type.
value	value to write

Returns

previous value

4.1.2.21 atomic_xor()

```
gpu_uint32 goopax::impl::atomic_xor (
            gpu_uint32 & ref,
            const gpu_uint32 value )  [inline]
```

atomic xor

Parameters

ref	reference to local or global memory address. The value referenced must be of 32 or 64 bit signed or unsigned integral type.
value	value to perform xor operation with

Returns

previous value

4.2 memory resources

Classes

- class resource< T, SIZE_TYPE, is_const >
- class buffer_map< T, is_const >
- class buffer< T, SIZE_TYPE >
- class local_scope_mem< T, SCOPE >
- struct sresource< STR, BASE >

Typedefs

- template<typename T >
  using local_mem = local_scope_mem< T, memory::threadgroup >
- template<typename T >
  using private_mem = local_scope_mem< T, memory::thread >

Enumerations

- enum BUFFER_FLAGS { BUFFER_READ_WRITE = 1, BUFFER_READ_ONLY = 2, BUFFER_WRITE_ONLY = 4, BUFFER_WRITE_DISCARD = 8 }

4.2.1 Detailed Description

4.2.2 Typedef Documentation

4.2.2.1 local_mem

```
using local_mem = local_scope_mem<T, memory::threadgroup>
```

local memory. This memory can be accessed by all threads in the workgroup.

4.2.2.2 private_mem

```
using private_mem = local_scope_mem<T, memory::thread>
```

private memory. Each thread has its own private memory. No other thread can access it.

4.2.3 Enumeration Type Documentation

4.2.3.1 BUFFER_FLAGS

```
enum BUFFER_FLAGS
```

Buffer access flags

Enumerator

BUFFER_READ_WRITE	read/write access
BUFFER_READ_ONLY	read-only access
BUFFER_WRITE_ONLY	write-only access
BUFFER_WRITE_DISCARD	write-only, previous values are not preserved

4.3 OpenCL interoperability

Functions

- static buffer create_from_cl (goopax_device device, _cl_mem *mem)
- cl_platform_id get_cl_platform (goopax_device device)
- cl_context get_cl_context (const goopax_device device)
- cl_command_queue get_cl_queue (const goopax_device device)
- cl_device_id get_cl_device (const goopax_device device)
- vector< string > get_cl_platform_extensions (const goopax_device device)
- vector< string > get_cl_device_extensions (const goopax_device device)
- bool have_cl_platform_extension (const string &s, const goopax_device device)
- bool have_cl_device_extension (const string &s, const goopax_device device)
- template<class BUF >
  cl_mem get_cl_mem (const BUF &buf)
- goopax_device get_device_from_cl_queue (cl_command_queue queue)
- static image_buffer create_from_cl (goopax_device device, _cl_mem *mem)
- static image_array_buffer create_from_cl (goopax_device device, _cl_mem *mem)

4.3.1 Detailed Description

OpenCL interoperability functions. These can be used to use existing OpenCL kernels in conjunktion with GOOPAX.

4.3.2 Function Documentation

4.3.2.1 create_from_cl() [1/3]

```
static buffer create_from_cl (
            goopax_device device,
            _cl_mem * mem )  [inline], [static]
```

create buffer from OpenCL memory buffer

Parameters

device	GOOPAX device
mem	OpenCL memory buffer

4.3.2.2 create_from_cl() [2/3]

```
image_buffer< DIM, T, normalized > create_from_cl (
            goopax_device device,
            _cl_mem * mem )  [inline], [static]
```

Create image buffer from existing OpenCL image.

Parameters

device	goopax device that corresponds to the OpenCL device
mem	OpenCL memory resource

4.3.2.3 create_from_cl() [3/3]

```
image_array_buffer< DIM, T, normalized > create_from_cl (
            goopax_device device,
            _cl_mem * mem )  [inline], [static]
```

Create image array buffer from existing OpenCL image array.

Parameters

device	goopax device that corresponds to the OpenCL device
mem	OpenCL memory resource

4.3.2.4 get_cl_context()

```
cl_context goopax::impl::get_cl_context (
            const goopax_device device )  [inline]
```

Get OpenCL context from goopax device

4.3.2.5 get_cl_device()

```
cl_device_id goopax::impl::get_cl_device (
            const goopax_device device )  [inline]
```

Get OpenCL device from goopax device

4.3.2.6 get_cl_device_extensions()

```
vector<string> goopax::impl::get_cl_device_extensions (
            const goopax_device device )  [inline]
```

Get OpenCL device extensions for the given goopax device

4.3.2.7 get_cl_mem()

```
cl_mem goopax::impl::get_cl_mem (
            const BUF & buf )  [inline]
```

Returns OpenCL memory handle for the goopax buffer or image_buffer

Parameters

buf	buffer, image_buffer, or image_array_buffer

4.3.2.8 get_cl_platform()

```
cl_platform_id goopax::impl::get_cl_platform (
            goopax_device device )  [inline]
```

Get OpenCL platform from goopax device

4.3.2.9 get_cl_platform_extensions()

```
vector<string> goopax::impl::get_cl_platform_extensions (
            const goopax_device device )  [inline]
```

Get OpenCL platform extensions for the given goopax device

4.3.2.10 get_cl_queue()

```
cl_command_queue goopax::impl::get_cl_queue (
            const goopax_device device )  [inline]
```

Get OpenCL queue from goopax device

4.3.2.11 get_device_from_cl_queue()

```
goopax_device goopax::impl::get_device_from_cl_queue (
            cl_command_queue queue )  [inline]
```

Create goopax device from OpenCL queue

4.3.2.12 have_cl_device_extension()

```
bool goopax::impl::have_cl_device_extension (
            const string & s,
            const goopax_device device )  [inline]
```

Test if OpenCL device extension is available for the device.

4.3.2.13 have_cl_platform_extension()

```
bool goopax::impl::have_cl_platform_extension (
            const string & s,
            const goopax_device device )  [inline]
```

Test if OpenCL platform extension is available for the device.

4.4 cpu and gpu functions

CPU functions In the namespace goopax::extra_operators additional function definitions for CPU data types are provided that otherwise are only provided for gpu data types.

Functions

- template<typename T , typename = typename enable_if<is_integral<T>::value>::type>
  Tuint popcount (T i)
- template<typename T , typename = typename enable_if<is_integral<T>::value && (sizeof(typename unrangetype_core<T>::type>
  Tuint clz (T i)
- Tuint clz (uint64_t i)
- template<typename I , typename = typename enable_if<is_integral<I>::value>::type>
  I rotl (I a, Tint b)
- template<typename I , typename = typename enable_if<is_integral<I>::value>::type>
  I rotr (I a, Tint b)
- double sinpi (double x)
- float sinpi (float x)
- half sinpi (half x)
- double cospi (double x)
- float cospi (float x)
- half cospi (half x)
- double tanpi (double x)
- float tanpi (float x)
- half tanpi (half x)
- double asinpi (double x)
- float asinpi (float x)
- half asinpi (half x)
- double acospi (double x)
- float acospi (float x)
- half acospi (half x)
- double atanpi (double x)
- float atanpi (float x)
- half atanpi (half x)
- template<typename T , typename Enable >
  gpu_type< T > min (gpu_type< T > a, gpu_type< T > b)
- template<typename T , typename Enable >
  gpu_type< T > max (gpu_type< T > a, gpu_type< T > b)
- template<typename T >
  gpu_type< T > clamp (gpu_type< T > a, typename enable_if< true, gpu_type< T >>::type b, typename enable_if< true, gpu_type< T >>::type c)
- template<typename T >
  gpu_type< T > clamp (gpu_type< T > a, gpu_type< T > b, gpu_type< T > c)
- template<typename T >
  gpu_type< T > min (gpu_type< T > a, typename unrangetype_core< T >::type b)
- template<typename T >
  gpu_type< T > min (typename unrangetype_core< T >::type a, gpu_type< T > b)
- template<typename T >
  gpu_type< T > max (gpu_type< T > a, typename unrangetype_core< T >::type b)
- template<typename T >
  gpu_type< T > max (typename unrangetype_core< T >::type a, gpu_type< T > b)
- template<typename T , typename = typename enable_if<(is_integral<T>::value && !is_same<T, bool>::value>
  gpu_type< typename make_unsigned< T >::type > abs (gpu_type< T > a)

- template<typename T , typename Enable = typename enable_if<(is_integral<T>::value && !is_same<T, bool>::value> gpu_uint clz (gpu_type< T > a)
- template<typename T , typename Enable = typename enable_if<(is_integral<T>::value && !is_same<T, bool>::value> gpu_uint popcount (gpu_type< T > a)
- template<typename T , typename Enable = typename enable_if<is_integral<T>::value && !is_same<T, bool>::value>::type> gpu_type< T > rotl (gpu_type< T > a, gpu_int b)
- template<typename T , typename Enable = typename enable_if<is_integral<T>::value && !is_same<T, bool>::value>::type> gpu_type< T > rotr (gpu_type< T > a, gpu_int b)

4.4.1 Detailed Description

CPU functions In the namespace goopax::extra_operators additional function definitions for CPU data types are provided that otherwise are only provided for gpu data types.

4.4.2 Function Documentation

4.4.2.1 abs()

```
gpu_type<typename make_unsigned<T>::type> goopax::impl::abs (
            gpu_type< T > a )
```

returns absolute value. if a is an integer, the return type is unsigned.

4.4.2.2 acospi() [1/3]

```
double goopax::impl::acospi (
            double x )  [inline]
```

acos(x) / PI

4.4.2.3 acospi() [2/3]

```
float goopax::impl::acospi (
            float x )  [inline]
```

acos(x) / PI

4.4.2.4 acospi() [3/3]

```
half goopax::impl::acospi (
            half x )  [inline]
```

acos(x) / PI

4.4.2.5 asinpi() [1/3]

```
double goopax::impl::asinpi (
            double x )  [inline]
```

asin(x) / PI

4.4.2.6 asinpi() [2/3]

```
float goopax::impl::asinpi (
            float x )  [inline]
```

asin(x) / PI

4.4.2.7 asinpi() [3/3]

```
half goopax::impl::asinpi (
            half x )  [inline]
```

asin(x) / PI

4.4.2.8 atanpi() [1/3]

```
double goopax::impl::atanpi (
            double x )  [inline]
```

acos(x) / PI

4.4.2.9 atanpi() [2/3]

```
float goopax::impl::atanpi (
            float x )  [inline]
```

acos(x) / PI

4.4.2.10 atanpi() [3/3]

```
half goopax::impl::atanpi (
            half x )  [inline]
```

acos(x) / PI

4.4.2.11 clamp() [1/2]

```
gpu_type<T> goopax::impl::clamp (
            gpu_type< T > a,
            gpu_type< T > b,
            gpu_type< T > c )
```

clamping a to range (b,c). Similar to max(min(a, c), b)

4.4.2.12 clamp() [2/2]

```
gpu_type<T> goopax::impl::clamp (
            gpu_type< T > a,
            typename enable_if< true, gpu_type< T >>::type b,
            typename enable_if< true, gpu_type< T >>::type c )
```

clamping a to range (b,c). Similar to max(min(a, c), b)

4.4.2.13 clz() [1/3]

```
gpu_uint goopax::impl::clz (
            gpu_type< T > a )
```

Counts the number of leading zeros in the given value of integral type

4.4.2.14 clz() [2/3]

```
Tuint goopax::impl::clz (
            T i )
```

Counts the number of leading zeros in the given value of integral type

4.4.2.15 clz() [3/3]

```
Tuint goopax::impl::clz (
            uint64_t i )  [inline]
```

Counts the number of leading zeros in the given value of integral type

4.4.2.16 cospi() [1/3]

```
double goopax::impl::cospi (
            double x )  [inline]
```

cos(x∗PI)

4.4.2.17 cospi() [2/3]

```
float goopax::impl::cospi (
            float x )  [inline]
```

cos(x∗PI)

4.4.2.18 cospi() [3/3]

```
half goopax::impl::cospi (
            half x )  [inline]
```

cos(x∗PI)

4.4.2.19 max() [1/3]

```
gpu_type< T > max (
            gpu_type< T > a,
            gpu_type< T > b )
```

maximum of both numbers

4.4.2.20 max() [2/3]

```
gpu_type<T> goopax::impl::max (
            gpu_type< T > a,
            typename unrangetype_core< T >::type b )
```

4.4.2.21 max() [3/3]

```
gpu_type<T> goopax::impl::max (
            typename unrangetype_core< T >::type a,
            gpu_type< T > b )
```

4.4.2.22 min() [1/3]

```
gpu_type< T > min (
            gpu_type< T > a,
            gpu_type< T > b )
```

minimum of both numbers

4.4.2.23 min() [2/3]

```
gpu_type<T> goopax::impl::min (
            gpu_type< T > a,
            typename unrangetype_core< T >::type b )
```

4.4.2.24 min() [3/3]

```
gpu_type<T> goopax::impl::min (
            typename unrangetype_core< T >::type a,
            gpu_type< T > b )
```

4.4.2.25 popcount() [1/2]

```
gpu_uint goopax::impl::popcount (
             gpu_type< T > a )
```

Counts the number of bits

4.4.2.26 popcount() [2/2]

```
Tuint goopax::impl::popcount (
             T i )
```

Counts the number of bits in the given value of integral type

4.4.2.27 rotl() [1/2]

```
gpu_type<T> goopax::impl::rotl (
             gpu_type< T > a,
             gpu_int b )
```

rotate left

4.4.2.28 rotl() [2/2]

```
I goopax::impl::rotl (
             I a,
             Tint b )
```

rotate left

4.4.2.29 rotr() [1/2]

```
gpu_type<T> goopax::impl::rotr (
             gpu_type< T > a,
             gpu_int b )
```

rotate right

4.4.2.30 rotr() [2/2]

```
I goopax::impl::rotr (
             I a,
             Tint b )
```

rotate right

4.4.2.31 sinpi() [1/3]

```
double goopax::impl::sinpi (
            double x )  [inline]
```

sin(x∗PI)

4.4.2.32 sinpi() [2/3]

```
float goopax::impl::sinpi (
            float x )  [inline]
```

sin(x∗PI)

4.4.2.33 sinpi() [3/3]

```
half goopax::impl::sinpi (
            half x )  [inline]
```

sin(x∗PI)

4.4.2.34 tanpi() [1/3]

```
double goopax::impl::tanpi (
            double x )  [inline]
```

tan(x∗PI)

4.4.2.35 tanpi() [2/3]

```
float goopax::impl::tanpi (
            float x )  [inline]
```

tan(x∗PI)

4.4.2.36 tanpi() [3/3]

```
half goopax::impl::tanpi (
            half x )  [inline]
```

tan(x∗PI)

4.5 CUDA interoperability

Functions

- static buffer create_from_cuda (goopax_device device, void ∗mem, size_t size)
- CUdevice get_cuda_device (goopax_device device)

4.5.1 Detailed Description

4.5.2 Function Documentation

4.5.2.1 create_from_cuda()

```
static buffer create_from_cuda (
            goopax_device device,
            void * mem,
            size_t size )  [inline], [static]
```

create buffer from CUDA buffer

Parameters

device	GOOPAX device
pointer	to CUDA device memory
size	size in number of elements of type T

4.5.2.2 get_cuda_device()

```
CUdevice goopax::impl::get_cuda_device (
            goopax_device device )  [inline]
```

get CUDA device from GOOPAX device

Parameters

device	GOOPAX device

Returns

CUDA device

4.6 Thread numbers

querying the current thread id

- gpu_uint thread_id_in_warp ()
- gpu_uint warp_id_in_group ()
- gpu_uint local_id ()
- gpu_uint group_id ()
- gpu_uint global_id ()

querying the thread layout of the current kernel

- Tuint warp_size ()
- Tuint local_size ()
- Tuint num_groups ()
- Tuint global_size ()
- Tuint num_subthreads ()
- Tuint max_local_mem ()

4.6.1 Detailed Description

These functions can be used to query the thread layout, the number of threads, and the id of the current thread. All functions may only be called within a kernel.

The threads are organized hierarchically:

- Programming normally occurs at the level of individual threads.
- A warp contains individual threads that execute SIMD instructions. Threads within a warp cannot branch into if clauses or loops without all other threads in the warp waiting. The functions ballot() and shuffle() can be used for fast inner-warp communication
- A workgroup contains one or more warps. Threads within a workgroup can communicate via local memory
- The total number of threads consists of multiple workgroups. Threads of different workgroups can only communicate via global memory by using atomic access functions.

4.6.2 Function Documentation

4.6.2.1 global_id()

```
gpu_uint goopax::impl::gpu_thread::global_id ( )  [inline]
```

Returns the total thread ID on the GPU. Equals group_id()∗local_size() + local_id(). May only be called in a GPU kernel.

4.6.2.2 global_size()

```
Tuint goopax::impl::gpu_thread::global_size ( )  [inline]
```

Returns the total number of threads on the GPU. Equals local_size()∗num_groups(). May only be called in a GPU kernel

4.6.2.3 group_id()

```
gpu_uint goopax::impl::gpu_thread::group_id ( )  [inline]
```

Returns the workgroup ID. May only be called in a GPU kernel.

4.6.2.4 local_id()

```
gpu_uint local_id ( )  [inline]
```

Returns the local thread ID in the workgroup. May only be called in a GPU kernel.

Returns the local thread ID in the workgroup. May only be called in a GPU kernel.

4.6.2.5 local_size()

```
Tuint local_size ( )  [inline]
```

Returns the workgroup size. May only be called in a GPU kernel

Returns the workgroup size. May only be called in a GPU kernel

4.6.2.6 max_local_mem()

```
Tuint goopax::impl::gpu_thread::max_local_mem ( )  [inline]
```

Returns the maximum amount of local memory for each workgroup. May only be called in a GPU kernel

4.6.2.7 num_groups()

```
Tuint goopax::impl::gpu_thread::num_groups ( )  [inline]
```

Returns the number of workgroups. May only be called in a GPU kernel

4.6.2.8 num_subthreads()

```
Tuint goopax::impl::gpu_thread::num_subthreads ( )  [inline]
```

Returns the instruction level parallelization that works best for the GPU. May only be called in a GPU kernel

4.6.2.9 thread_id_in_warp()

```
gpu_uint goopax::impl::gpu_thread::thread_id_in_warp ( )  [inline]
```

Returns the id in the current warp. May only be called in a GPU kernel.

4.6.2.10 warp_id_in_group()

```
gpu_uint goopax::impl::gpu_thread::warp_id_in_group ( )  [inline]
```

Returns the warp id in the current group. May only be called in a GPU kernel.

4.6.2.11 warp_size()

```
Tuint warp_size ( )  [inline]
```

Returns the warp size of the device for which the kernel is being built. May only be called in a GPU kernel. The warp size is typically the SIMD instruction width. Threads within a warp cannot branch into loops and if-clauses without all other threads waiting for them to finish.

Returns the warp size of the device for which the kernel is being built. May only be called in a GPU kernel. The warp size is typically the SIMD instruction width. Threads within a warp cannot branch into loops and if-clauses without all other threads waiting for them to finish.

4.7 Device

Classes

- class goopax_device

  Goopax device. This class is used to reference the physical devices in the system.

Enumerations

- enum envmode { ,
  env_CPU = 1, env_CL = 2, env_CUDA = 4, env_METAL = 8,
  env_GPU = 0xfffe, env_ALL = 0xffffffff }

Functions

- envmode operator| (envmode a, envmode b)
- goopax_device get_current_build_device ()
- vector< goopax_device > devices (envmode backend=env_GPU)
- goopax_device default_device (envmode backend=env_GPU)

4.7.1 Detailed Description

4.7.2 Enumeration Type Documentation

4.7.2.1 envmode

`enum envmode`

Specifies which backend to use. When multiple backends are set, CUDA and METAL will be preferred over CL for devices that support them.

Enumerator

env_CPU	CPU backend.
env_CL	OpenCL backend.
env_CUDA	CUDA backend.
env_METAL	Metal backend.
env_GPU	Any GPU backend.
env_ALL	Any backend, CPU and GPU.

4.7.3 Function Documentation

4.7.3.1 default_device()

```
goopax_device goopax::impl::default_device (
            envmode backend = env_GPU )  [inline]
```

Get the fastest available device for the given backend(s)

Returns

best suitable device. If no usable device is found, the returned value will be default-constructed, and goopax_device::valid() will return false on it.

Parameters

backend	which backend(s) to use.

4.7.3.2 devices()

```
vector<goopax_device> goopax::impl::devices (
            envmode backend = env_GPU )  [inline]
```

Get vector of available devices for the given backend(s) Devices that are both CUDA and OpenCL capable will show up both for the env_CUDA and for the env_CL backend, but they will only be returned once if the both env_CL and env_CUDA flags are selected. Equally, devices that support the Metal backend may also show up if the env_CL backend is selected without the env_METAL backend.

Returns

vector of devices. If no usable devices are found, an empty list is returned.

Parameters

backend	which backend(s) to use.

4.7.3.3 get_current_build_device()

```
goopax_device goopax::impl::get_current_build_device ( )  [inline]
```

Returns the device for which the current kernel is being built. Only valid while building kernel.

4.7.3.4 operator"" | ()

```
envmode goopax::operator| (
            envmode a,
            envmode b )  [inline]
```

4.8 Gather return values

Classes

- struct gather_add< T >
- struct gather_min< T >
- struct gather_max< T >

4.8.1 Detailed Description

gather types. These types can be used to gather values from the GPU threads to return values from GPU kernels. Some types are predefined here. User-defined types can be added accordingy. See the predefined types in gather.h for how this is done. If used as return type or reference argument of the program() function of GPU kernels, values are returned as goopax_future when the kernel is called.

4.9 OpenGL interoperability

Functions

- void flush_gl_interop (goopax_device device)
- static buffer create_from_gl (goopax_device device, unsigned int GLres, BUFFER_FLAGS flags=BUFFER_READ_WRITE)
- static image_buffer create_from_gl (goopax_device device, unsigned int GLres, IMAGE_FLAGS flags=IMAGE_READ_WRITE, unsigned int GLtarget=(DIM==1 ? 0x0DE0 :(DIM==2 ? 0x0DE1 :0x806F)), int miplevel=0)
- static image_array_buffer create_from_gl (goopax_device device, unsigned int GLres, IMAGE_FLAGS flags=IMAGE_READ_WRITE, unsigned int GLtarget=(DIM==1 ? 0x0DE0 :(DIM==2 ? 0x0DE1 :0x806F)), int miplevel=0)

4.9.1 Detailed Description

4.9.2 Function Documentation

4.9.2.1 create_from_gl() [1/3]

```
buffer< T, SIZE_TYPE > create_from_gl (
            goopax_device device,
            unsigned int GLres,
            BUFFER_FLAGS flags = BUFFER_READ_WRITE )  [inline], [static]
```

Create goopax buffer from existing OpenGL buffer

Parameters

device	goopax device
GLres	buffer ID of OpenGL buffer
flags	access type

4.9.2.2 create_from_gl() [2/3]

```
image_buffer< DIM, T, normalized > create_from_gl (
            goopax_device device,
            unsigned int GLres,
            IMAGE_FLAGS flags = IMAGE_READ_WRITE,
            unsigned int GLtarget = (DIM == 1 ? 0x0DE0 : (DIM == 2 ? 0x0DE1 : 0x806F)),
            int miplevel = 0 )  [inline], [static]
```

Creates image that is linked to existing OpenGL image.

Parameters

device	goopax device that contains the OpenGL image
GLres	OpenGL resource ID
flags	access type. Must be one of IMAGE_READ_WRITE, IMAGE_READ_ONLY, IMAGE_WRITE_ONLY, IMAGE_WRITE_DISCARD
GLtarget	OpenGL target. Defaults to GL_TEXTURE_1D or GL_TEXTURE_2D for 1D/2D images.
miplevel	OpenGL miplevel of the texture. Defaults to 0.

4.9.2.3 create_from_gl() [3/3]

```
image_array_buffer< DIM, T, normalized > create_from_gl (
            goopax_device device,
            unsigned int GLres,
            IMAGE_FLAGS flags = IMAGE_READ_WRITE,
            unsigned int GLtarget = (DIM == 1 ? 0x0DE0 : (DIM == 2 ? 0x0DE1 : 0x806F)),
            int miplevel = 0 )  [inline], [static]
```

Creates image array that is linked to existing OpenGL image.

Parameters

device	goopax device that contains the OpenGL image
GLres	OpenGL resource ID
flags	access type. Must be one of IMAGE_READ_WRITE, IMAGE_READ_ONLY, IMAGE_WRITE_ONLY, IMAGE_WRITE_DISCARD
GLtarget	OpenGL target. Defaults to GL_TEXTURE_1D or GL_TEXTURE_2D for 1D/2D images.
miplevel	OpenGL miplevel of the texture. Defaults to 0.

4.9.2.4 flush_gl_interop()

```
void goopax::impl::flush_gl_interop (
            goopax_device device )  [inline]
```

Must be called before calling OpenGL functions on shared OpenGL buffers or images that exist on the given device.

4.10 Math

Functions

- template<typename T , typename = typename enable_if<is_floating_point<T>::value>::type>
  gpu_type< T > pow (gpu_type< T > a, int ENUM, unsigned int DENOM=1)
- template<int ENUM, unsigned int DENOM, class T , class ENABLE = typename enable_if<is_floating_point<T>::value>::type>
  gpu_type< T > pow (const gpu_type< T > a)
- template<class T , class ENABLE = typename enable_if<is_floating_point<T>::value>::type>
  gpu_type< T > pow (const gpu_type< T > a, const gpu_type< T > b)
- template<class T , class D , class ENABLE = typename enable_if<is_floating_point<T>::value && is_floating_point<D>::value>::type>
  gpu_type< T > pow (const gpu_type< T > a, const D b)
- gpu_half sqrt (gpu_half a)

  Square root.
- gpu_float sqrt (gpu_float a)

  Square root.
- gpu_double sqrt (gpu_double a)

  Square root.
- gpu_half cbrt (gpu_half a)

  Cubic root.
- gpu_float cbrt (gpu_float a)

  Cubic root.
- gpu_double cbrt (gpu_double a)

  Cubic root.

4.10.1 Detailed Description

4.10.2 Function Documentation

4.10.2.1 pow() [1/4]

```
gpu_type<T> goopax::impl::pow (
            const gpu_type< T > a )
```

Returns a to the power (ENUM/DENOM).

4.10.2.2 pow() [2/4]

```
gpu_type<T> goopax::impl::pow (
            const gpu_type< T > a,
            const D b )
```

Returns a to the power b.

4.10.2.3 pow() [3/4]

```
gpu_type<T> goopax::impl::pow (
            const gpu_type< T > a,
            const gpu_type< T > b )
```

Returns a to the power b.

4.10.2.4 pow() [4/4]

```
gpu_type<T> goopax::impl::pow (
            gpu_type< T > a,
            int ENUM,
            unsigned int DENOM = 1 )  [inline]
```

Returns a to the power (ENUM/DENOM).

4.11 debugging

Classes

- class gpu_ostream

Macros

- #define gpu_assert(...) ::goopax::impl::gpu_assert_impl((__VA_ARGS__), __FILE__, __LINE__, #__VA_ARGS__);

4.11.1 Detailed Description

For debugging, various methods are provided. The gpu_ostream streaming class can be used to provide output from within a kernel. The gpu_assert macro can be placed in kernels for validity checks. The checknan data type does extensive automatic error checks on memory access.

4.11.2 Macro Definition Documentation

4.11.2.1 gpu_assert

```
#define gpu_assert(
              ...  ) ::goopax::impl::gpu_assert_impl((__VA_ARGS__), __FILE__, __LINE__, #__VA_ARGS__);
```

asserts that the given value of type gpu_bool is true. If not, an error message is displayed, and an exception is thrown.

4.12 Types

Classes

- struct gettype< T, EIF >

  type info and type conversion mechanism With the gettype struct, CPU and GPU types can be converted to each other, and type information obtained typename gettype<T>::cpu converts T to the corresponding CPU type. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. typename gettype<T>::gpu converts T to the corresponding GPU type. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. gettype<↩ T>::size provides the size of type T in bytes. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. typename gettype<T>::template change<U>::type changes the type of T to type U while preserving CPU/↩ GPU/debug mode. If T is CPU type, the resulting type is also a CPU type. If T is GPU type, the resulting type is a GPU type. If T is debug data type, the resulting type is also a debug data type.
- class gpu_type< T, scope >

4.12.1 Detailed Description

gpu types, used in gpu kernels.

4.13 Operators

Functions

- template<typename T , memory::scope memscope>
  gpu_type< T, memscope > cond (const gpu_bool &c, const gpu_type< T, memscope > &a, const gpu_type< T, memscope > &b)
- template<typename V1 , typename V2 , typename BOOL , typename = typename enable_if<is_container<V1>::value && is_container<V2>::value>::type>
  auto cond (const BOOL &c, const V1 &a, const V2 &b) -> typename changetype< V1, typename remove_reference< decltype(cond(c, a[0], b[0]))>::type >::type
- template<class A >
  A cond (gpu_bool c, const A &a, const A &b, typename enable_if< is_gpu_struct< A >::value &&is_same< typename get_X_type< A >::type, xtype_gpu >::value >::type *=nullptr)
- template<class A >
  A cond (bool c, const A &a, const A &b, typename enable_if< is_gpu_struct< A >::value &&is_checknan< typename get_X_type< A >::type >::value >::type *=nullptr)
- template<class A >
  A cond (bool c, const A &a, const A &b, typename enable_if< is_gpu_struct< A >::value &&is_same< typename get_X_type< A >::type, xtype_int >::value >::type *=nullptr)

4.13.1 Detailed Description

4.13.2 Function Documentation

4.13.2.1 cond() [1/5]

```
A goopax::impl::cond (
            bool c,
            const A & a,
            const A & b,
            typename enable_if< is_gpu_struct< A >::value &&is_checknan< typename get_X_type< A >::type >::value >::type *  = nullptr )
```

conditional operator.

Parameters

c	condition
a	input value a
b	input value b
return	c ? a : b

4.13.2.2 cond() [2/5]

```
A goopax::impl::cond (
```

```
            bool c,
            const A & a,
            const A & b,
            typename enable_if< is_gpu_struct< A >::value &&is_same< typename get_X_type< A
>::type, xtype_int >::value >::type *  = nullptr )
```

conditional operator.

Parameters

c	condition
a	input value a
b	input value b
return	c ? a : b

4.13.2.3 cond() [3/5]

```
auto goopax::impl::cond (
            const BOOL & c,
            const V1 & a,
            const V2 & b ) -> typename changetype<V1, typename remove_reference<decltype(cond(c,
a[0], b[0]))>::type>::type   [inline]
```

conditional function, overload for vectors and arrays

4.13.2.4 cond() [4/5]

```
gpu_type< T, memscope > cond (
            const gpu_bool & c,
            const gpu_type< T, memscope > & a,
            const gpu_type< T, memscope > & b )  [inline]
```

conditional operator conditional function. Returns c ? a : b

conditional function. Returns c ? a : b

4.13.2.5 cond() [5/5]

```
A goopax::impl::cond (
            gpu_bool c,
            const A & a,
            const A & b,
            typename enable_if< is_gpu_struct< A >::value &&is_same< typename get_X_type< A
>::type, xtype_gpu >::value >::type *  = nullptr )
```

conditional operator.

Parameters

c	condition
a	input value a
b	input value b
return	c ? a : b

4.14 Image

Classes

- class image_buffer_map< DIM, T, is_const >
- class image_array_buffer_map< DIM, T, is_const >
- class image_buffer< DIM, T, normalized >
- class image_array_buffer< DIM, T, normalized >
- class image_resource< DIM, T, normalized >
- class image_array_resource< DIM, T, normalized >

Typedefs

- template<unsigned int DIM, typename T >
  using const_image_buffer_map = image_buffer_map< DIM, T, true >

Enumerations

- enum IMAGE_FLAGS { IMAGE_READ_WRITE = 1, IMAGE_READ_ONLY = 2, IMAGE_WRITE_ONLY = 4, IMAGE_WRITE_DISCARD = 8 }

4.14.1 Detailed Description

4.14.2 Typedef Documentation

4.14.2.1 const_image_buffer_map

```
using const_image_buffer_map = image_buffer_map<DIM, T, true>
```

4.14.3 Enumeration Type Documentation

4.14.3.1 IMAGE_FLAGS

```
enum IMAGE_FLAGS
```

Image access flags

Enumerator

IMAGE_READ_WRITE	read/write access
IMAGE_READ_ONLY	read-only access
IMAGE_WRITE_ONLY	write-only access
IMAGE_WRITE_DISCARD	write-only, previous values are not preserved

4.15 Kernel

Classes

- class goopax_future_info
- class goopax_future< T >
- class goopax_future< void >
- struct full_kernel
- struct kernel< K >

  kernel class to derive gpu kernels from

4.15.1 Detailed Description

GPU kernels are inherited from kernel. The entry point to the GPU kernel is provided by the function 'program'. However, GPU kernels can call other functions, so they are not limited to the body of function 'program'.

Example:

```
struct my_kernel :
   kernel<my_kernel>
{
   void program(resource<int>& A)
   {
       A[global_id()] = 5;   // This is executed on the GPU
   }
};
```

4.16 Loops

Macros

- #define gpu_if(...) for (::goopax::impl::gpu_if_clause __goopax_if_obj(::goopax::impl::Elsedata, __FILE__, __LINE__, false_type(), __VA_ARGS__); __goopax_if_obj.loopvar < 1; ++__goopax_if_obj.loopvar)
- #define gpu_elseif(...) for (::goopax::impl::gpu_if_clause __goopax_if_obj(::goopax::impl::Elsedata, __FILE__, __LINE__, true_type(), __VA_ARGS__); __goopax_if_obj.loopvar < 1; ++__goopax_if_obj.loopvar)
- #define gpu_else gpu_elseif(true)
- #define gpu_while(...) for (::goopax::impl::infinite_loop LOOP(__FILE__, __LINE__, __VA_ARGS__); LOOP.loop_do_continue(); LOOP.loop_set_next(__VA_ARGS__))

Functions

- template<typename comp_t = std::less<void>, typename func_t >
  void gpu_for (typename first_argument< func_t >::type begin, typename first_argument< func_t >::type end, typename step_type< func_t >::type step, func_t func)

  gpu for loop.
- template<typename comp_t = std::less<void>, typename func_t >
  void gpu_for_local (typename first_argument< func_t >::type begin, typename first_argument< func_t >::type end, typename step_type< func_t >::type step, func_t func)
- template<typename comp_t = std::less<void>, typename func_t >
  void gpu_for_global (typename first_argument< func_t >::type begin, typename first_argument< func_t >::type end, typename step_type< func_t >::type step, func_t func)
- template<typename comp_t = std::less<void>, typename func_t >
  void gpu_for_group (typename first_argument< func_t >::type begin, typename first_argument< func_t >::type end, typename step_type< func_t >::type step, func_t func)

4.16.1 Detailed Description

Loops in gpu kernels can be achieved by the use of gpu_for or gpu_while statements. Alternatively, small loops that don't depend on gpu variables may also be implemented as standard C++ for/while loops. This will lead to explicit unrolling of the loop.

The usage of the gpu_for loop is different from C++ for loops and looks like this:

```
gpu_for(0, 10, [&](gpu_uint k)
{
  <do something> // k runs from 0 to 9
});
```

Step sizes can be provided as a third argumend:

```
gpu_for(0, 10, 2, [&](gpu_int k)
{
   <do something> // only runs over even numbers form 0 to 8
});
```

The comparison operator can be specified as a template argument (defaults to std::less<>):

```
gpu_for<std::less_equal<»(0, 10, 2, [&](gpu_int k)
{
   <do something> // only runs over even numbers form 0 to 10
});
```

4.16.2 Macro Definition Documentation

4.16.2.1 gpu_else

```
#define gpu_else gpu_elseif(true)
```

gpu_elseif must follow a gpu_if or gpu_elseif block. The block following the gpu_elseif statement is executed by all threads that did not execute the previous if blocks.

4.16.2.2 gpu_elseif

```
#define gpu_elseif(
              ... ) for (::goopax::impl::gpu_if_clause __goopax_if_obj(::goopax::impl::↩
Elsedata, __FILE__, __LINE__, true_type(), __VA_ARGS__); __goopax_if_obj.loopvar < 1; ++__↩
goopax_if_obj.loopvar)
```

gpu_elseif, must follow a gpu_if or gpu_elseif block. The block following the gpu_elseif() statement is executed by all threads for which the argument is true.

4.16.2.3 gpu_if

```
#define gpu_if(
              ... ) for (::goopax::impl::gpu_if_clause __goopax_if_obj(::goopax::impl::↩
Elsedata, __FILE__, __LINE__, false_type(), __VA_ARGS__); __goopax_if_obj.loopvar < 1; ++__↩
goopax_if_obj.loopvar)
```

gpu_if, to be used in kernels. Takes gpu_bool as input. The block following the gpu_if() statement is executed by all threads for which the argument is true.

4.16.2.4 gpu_while

```
#define gpu_while(
              ... ) for (::goopax::impl::infinite_loop LOOP(__FILE__, __LINE__, __VA_ARGS__);
LOOP.loop_do_continue(); LOOP.loop_set_next(__VA_ARGS__))
```

while loop.

4.16.3 Function Documentation

4.16.3.1 gpu_for_global()

```
void goopax::impl::gpu_for_global (
             typename first_argument< func_t >::type begin,
             typename first_argument< func_t >::type end,
             typename step_type< func_t >::type step,
             func_t func )  [inline]
```

gpu loop, parallelized over all threads

4.16.3.2 gpu_for_group()

```
void goopax::impl::gpu_for_group (
             typename first_argument< func_t >::type begin,
             typename first_argument< func_t >::type end,
             typename step_type< func_t >::type step,
             func_t func )  [inline]
```

gpu loop, parallelized over workgroups

4.16.3.3 gpu_for_local()

```
void goopax::impl::gpu_for_local (
             typename first_argument< func_t >::type begin,
             typename first_argument< func_t >::type end,
             typename step_type< func_t >::type step,
             func_t func )  [inline]
```

gpu loop, parallelized over threads in workgroup.

4.17 operators

4.17.1 Detailed Description

These functions are defined to add CPU pendants for GPU functions, for which no CPU function is provided by standard C++.

4.18 Reinterpret

Functions

- template<class TO , class FROM >
  TO reinterpret (const FROM &from)

  bit-wise conversion
- template<typename TO , typename TFROM , typename SIZE_FROM >
  TO reinterpret (const buffer< TFROM, SIZE_FROM > &from)

  Reinterpreting buffer value type.

4.18.1 Detailed Description

The reinterpret functions provide functionalities for bit-wise conversion between data types without changing the underlying representation. Various types can be converted into each other: intrinsic types to goopax structs, goopax structs to std::vectors of other goopax structs, vectors to intrinsic types, etc. The sizes of the source value and the destination value must match, otherwise the compiler will report an error. If the source type is an std::vector, the size is checked at runtime. If the destination type is an std::vector, its size is chosen so that it matches the source type. If the source type is an CPU type, the destination type must also be a CPU type. If the source type is a GPU type, the destination type must also be a GPU type.

4.18.2 Function Documentation

4.18.2.1 reinterpret() [1/2]

```
TO reinterpret (
            const buffer< TFROM, SIZE_FROM > & from )  [inline]
```

Reinterpreting buffer value type.

Changes the buffer value type without changing the data content. The returned buffer points to the same memory buffer as the original buffer.

Parameters

TO	destination type
from	source buffer

4.18.2.2 reinterpret() [2/2]

```
TO reinterpret (
            const FROM & from )  [inline]
```

bit-wise conversion

Reinterpret bits into another type.

Parameters

TO	destination type
from	source This function reinterprets the input parameter into another type. FROM and TO must have the same size. They may be CPU type, GPU type, std::vector, or goopax struct type.

Example: gpu_double a = 17; std::array<gpu_int, 2> b = reinterpret<std::array<gpu_int, 2> >(a); gpu_uint64 c = reinterpret<gpu_uint64> c;

4.19 random numbers

Classes

- class WELL512
- class WELL512lib

4.19.1 Detailed Description

Random numbers can be generated with the WELL512 random number generator. The current implementation is optimized for high thoughput, but it has the limitation that random numbers are generated in 512 bit blocks. To use the random number generator, a pair of classes need to be instantiated: The WELL512 class in host code and the WELL512lib class in device code. The WELL512 class is used for storing the random seed between kernel calls, the WELL512lib class provides the actual generator of the random numbers. See the pi example program for an example implementation.

4.20 goopax struct types

Classes

- struct goopax_struct_type< std::array< T, N > >

  std::array and derived classes

Functions

- template<typename T >
  output_goopax_struct_helper< T > output_goopax_struct (const T &t)

4.20.1 Detailed Description

here some C++ types are prepared to be used as goopax struct. Other struct types need to be prepared in a similar way before they can be used to store memory in goopax.

4.20.2 Function Documentation

4.20.2.1 output_goopax_struct()

```
output_goopax_struct_helper< T > output_goopax_struct (
            const T & t )
```

Outputs the contents of a goopax struct.

Outputs the contents of a goopax struct.

4.21 Thread_communication

Functions

- template<typename T , typename = typename enable_if<is_same<T, typename gettype<T>::gpu>::value>::type>
  T shuffle (T value, gpu_uint source_thread, Tuint width)

  Exchanges values between threads in the workgroup.
- vector< gpu_uint > ballot (gpu_bool value, Tuint width)

  collect booleans from threads of the workgroup into integer bitset
- gpu_bool work_group_all (gpu_bool b)
- gpu_bool work_group_any (gpu_bool b)
- template<typename G >
  G::gpu_value_type work_group_reduce (typename G::gpu_value_type value, Tuint width)
- template<typename T , typename = typename enable_if<!is_same<T, bool>::value>::type>
  gpu_type< T > work_group_reduce_add (gpu_type< T > b, Tuint width)
- template<typename gpuT >
  gpuT work_group_reduce_add (gpuT b, Tuint width)
- template<typename T >
  gpu_type< T > work_group_reduce_min (gpu_type< T > b, Tuint width)
- template<typename gpuT >
  gpuT work_group_reduce_min (gpuT b, Tuint width)
- template<typename T >
  gpu_type< T > work_group_reduce_max (gpu_type< T > b, Tuint width)
- template<typename gpuT >
  gpuT work_group_reduce_max (gpuT b, Tuint width)
- template<typename T >
  gpu_type< T > work_group_scan_exclusive_add (gpu_type< T > val)
- template<typename T >
  gpu_type< T > work_group_scan_inclusive_add (gpu_type< T > val)
- template<typename T >
  gpu_type< T > work_group_scan_exclusive_min (gpu_type< T > val)
- template<typename T >
  gpu_type< T > work_group_scan_inclusive_min (gpu_type< T > val)
- template<typename T >
  gpu_type< T > work_group_scan_exclusive_max (gpu_type< T > val)
- template<typename T >
  gpu_type< T > work_group_scan_inclusive_max (gpu_type< T > val)

4.21.1 Detailed Description

These functions are provided to exchange data between threads in the workgroup.

4.21.2 Function Documentation

4.21.2.1 ballot()

```
vector<gpu_uint> goopax::impl::ballot (
            gpu_bool value,
            Tuint width ) [inline]
```

collect booleans from threads of the workgroup into integer bitset

Parameters

value	boolean to contribute from the current thread
width	sub-group width for the ballot operation. width must be a power of 2 and must not exceed local_size(). For nvidia GPUs using the CUDA backend, it is suggested that width has a value of 32 or less, in order to take advantage of CUDA's warp shuffle functions.

Returns

bitset of the threads involved. If width <= 32, a vector of size 1 is returned, otherwise a vector of size width/32 is returned.

4.21.2.2 shuffle()

```
T goopax::impl::shuffle (
            T value,
            gpu_uint source_thread,
            Tuint width )
```

Exchanges values between threads in the workgroup.

value T goopax struct data type

Parameters

value	value to share to other threads
source_thread	the value is read from this thread within the sub-group. source_thread must have a value between 0 and width-1.
width	sub-group width in which to exchange the values. width must be a power of 2 and/or equal to local_size(). width must not exceed local_size(). For nvidia GPUs using the CUDA backend, it is suggested that width has a value of 32 or less, in order to take advantage of CUDA's warp shuffle functions.

Returns

value read from thread 'source_thread'

4.21.2.3 work_group_all()

```
gpu_bool goopax::impl::work_group_all (
            gpu_bool b )  [inline]
```

Returns true if b is true for all threads in the workgroup.

Parameters

b	input value

Returns

the resulting boolean or over the threads

4.21.2.4 work_group_any()

```
gpu_bool goopax::impl::work_group_any (
            gpu_bool b )  [inline]
```

Returns true if b is true for any thread in the workgroup.

Parameters

b	input value

Returns

the resulting boolean and over the threads

4.21.2.5 work_group_reduce()

```
G::gpu_value_type work_group_reduce (
            typename G::gpu_value_type value,
            Tuint width )
```

reduce operation for user defined gather operator

Parameters

G	gather operator type. See the pre-defined gather types in the file 'goopax/gather.h' as examples.
value	input value from the current thread. May be any gpu type, including goopax struct types
width	sub-group width for the gather operation. width must be a power of 2 and/or equal to local_size(). width must not exceed local_size().

Returns

result of the gather operation

4.21.2.6 work_group_reduce_add() [1/2]

```
gpu_type<T> goopax::impl::work_group_reduce_add (
            gpu_type< T > b,
            Tuint width )
```

reduce operation 'add'

Parameters

value	input value
width	sub-group width for the gather operation. width must be a power of 2 and must not exceed local_size().
return	result of the gather operation

4.21.2.7 work_group_reduce_add() [2/2]

```
gpuT goopax::impl::work_group_reduce_add (
            gpuT b,
            Tuint width )
```

reduce operation 'add'

Parameters

value	input value
width	sub-group width for the gather operation. width must be a power of 2 and must not exceed local_size().
return	result of the gather operation

4.21.2.8 work_group_reduce_max() [1/2]

```
gpu_type<T> goopax::impl::work_group_reduce_max (
            gpu_type< T > b,
            Tuint width )
```

reduce operation 'max'

Parameters

value	input value
width	sub-group width for the gather operation. width must be a power of 2 and must not exceed local_size().
return	result of the gather operation

4.21.2.9 work_group_reduce_max() [2/2]

```
gpuT goopax::impl::work_group_reduce_max (
            gpuT b,
            Tuint width )
```

reduce operation 'max'

Parameters

value	input value
width	sub-group width for the gather operation. width must be a power of 2 and must not exceed local_size().
return	result of the gather operation

4.21.2.10 work_group_reduce_min() [1/2]

```
gpu_type<T> goopax::impl::work_group_reduce_min (
            gpu_type< T > b,
            Tuint width )
```

reduce operation 'min'

Parameters

value	input value
width	sub-group width for the gather operation. width must be a power of 2 and must not exceed local_size().
return	result of the gather operation

4.21.2.11 work_group_reduce_min() [2/2]

```
gpuT goopax::impl::work_group_reduce_min (
            gpuT b,
            Tuint width )
```

reduce operation 'min'

Parameters

value	input value
width	sub-group width for the gather operation. width must be a power of 2 and must not exceed local_size().
return	result of the gather operation

4.21.2.12 work_group_scan_exclusive_add()

```
gpu_type<T> goopax::impl::work_group_scan_exclusive_add (
            gpu_type< T > val )
```

Does an exclusive scan operation.

Parameters

val	input value from the current thread

Returns

the resulting value equals the sum of all values provided by threads 0 to local_id()-1

4.21.2.13 work_group_scan_exclusive_max()

```
gpu_type<T> goopax::impl::work_group_scan_exclusive_max (
            gpu_type< T > val )
```

Does an exclusive scan operation.

Parameters

val	input value from the current thread

Returns

the resulting value equals the maximum of all values provided by threads 0 to local_id()-1

4.21.2.14 work_group_scan_exclusive_min()

```
gpu_type<T> goopax::impl::work_group_scan_exclusive_min (
            gpu_type< T > val )
```

Does an exclusive scan operation.

Parameters

val	input value from the current thread

Returns

the resulting value equals the minimum of all values provided by threads 0 to local_id()-1

4.21.2.15 work_group_scan_inclusive_add()

```
gpu_type<T> goopax::impl::work_group_scan_inclusive_add (
            gpu_type< T > val )
```

Does an inclusive scan operation.

Parameters

val	input value from the current thread

Returns

the resulting value equals the sum of all values provided by threads 0 to local_id()

4.21.2.16 work_group_scan_inclusive_max()

```
gpu_type<T> goopax::impl::work_group_scan_inclusive_max (
            gpu_type< T > val )
```

Does an inclusive scan operation.

Parameters

val	input value from the current thread

Returns

the resulting value equals the maximum of all values provided by threads 0 to local_id()

4.21.2.17 work_group_scan_inclusive_min()

```
gpu_type<T> goopax::impl::work_group_scan_inclusive_min (
            gpu_type< T > val )
```

Does an inclusive scan operation.

Parameters

val	input value from the current thread

Returns

the resulting value equals the minimum of all values provided by threads 0 to local_id()

Chapter 5

Class Documentation

5.1 buffer< T, SIZE_TYPE > Class Template Reference

Public Types

- using resource_type = resource< T, SIZE_TYPE >

  type of resource that matches to the buffer type

Public Member Functions

- goopax_device get_device () const
- size_type size () const
- template<typename SRC_SIZE_TYPE >
  void copy (const buffer< T, SRC_SIZE_TYPE > &src, typename enable_if< true, SRC_SIZE_TYPE >::type count, SIZE_TYPE start_dest, typename enable_if< true, SRC_SIZE_TYPE >::type start_src)
- template<typename SRC_SIZE_TYPE >
  void copy (const buffer< T, SRC_SIZE_TYPE > &src)
- void copy_to_host (T *p, size_t beginpos, size_t endpos) const
- void copy_to_host (T *p) const
- void copy_from_host (const T *p, size_t beginpos, size_t endpos)
- void copy_from_host (const T *p)
- template<class V , class ENABLE = typename enable_if<is_container<V>::value>::type>
  buffer & operator= (const V &v)
- void fill (T value, size_type begin, size_type end)
- void fill (T value)
- template<typename = void>
  T min (const size_type begin, const size_type end) const
- template<typename = void>
  T min () const
- template<typename = void>
  T max (const size_type begin, const size_type end) const
- template<typename = void>
  T max () const
- template<typename = void>
  T sum (const size_type begin, const size_type end) const
- template<typename = void>
  T sum () const

- buffer & operator= (initializer_list< T > il)
- vector< value_type > to_vector () const
- template<class V , class ENABLE = typename enable_if<is_container<V>::value>::type>
  buffer (goopax_device device, const V &v)
- template<class IT , typename = typename std::iterator_traits<IT>::value_type>
  buffer (goopax_device device, const IT &a, const IT &b)
- buffer (goopax_device device, initializer_list< value_type > il)
- buffer (goopax_device device, size_t size, T *host_ptr=nullptr, BUFFER_FLAGS flags=BUFFER_READ_↩
  WRITE)
- buffer (buffer &&)=default

  move semantics
- buffer & operator= (buffer &&)=default

  move semantics
- buffer ()=default

Static Public Member Functions

- static buffer create_from_gl (goopax_device device, unsigned int GLres, BUFFER_FLAGS flags=BUFFER↩
  _READ_WRITE)
- static buffer create_from_cl (goopax_device device, _cl_mem *mem)
- static buffer create_from_cuda (goopax_device device, void *mem, size_t size)

Friends

- template<typename TO , typename TFROM , typename SIZE_FROM >
  TO reinterpret (const buffer< TFROM, SIZE_FROM > &from)

  Reinterpreting buffer value type.
- ostream & operator<< (ostream &s, const buffer &b)

5.1.1 Detailed Description

template<typename T, typename SIZE_TYPE>
class goopax::impl::buffer< T, SIZE_TYPE >

buffer class. Used to allocate memory on the device

Template Parameters

T	value type. This can either be a CPU intrinsic type, or a goopax struct type.
SIZE_TYPE	This can be a 32 bit or 64 bit integer type. 32 bit types give better performance. 64 bit types must be used for very large memory buffers. Goopax will throw an exception if buffers are allocated that are too large for the given size type. The default is 32 bit unsigned int.
is_const	only read access is allowed. This has the same effect as using a const reference of the resource as kernel parameter.

5.1.2 Constructor & Destructor Documentation

5.1.2.1 buffer() [1/5]

```
buffer (
            goopax_device device,
            const V & v )  [inline]
```

initialize from std::vector

5.1.2.2 buffer() [2/5]

```
buffer (
            goopax_device device,
            const IT & a,
            const IT & b )  [inline]
```

initialize from begin/end pointer

5.1.2.3 buffer() [3/5]

```
buffer (
            goopax_device device,
            initializer_list< value_type > il )  [inline]
```

initialize from initialization list

5.1.2.4 buffer() [4/5]

```
buffer (
            goopax_device device,
            size_t size,
            T * host_ptr = nullptr,
            BUFFER_FLAGS flags = BUFFER_READ_WRITE )  [inline]
```

initialize with size

Parameters

device	device on which to allocate memory
host_ptr	pointer to host memory. If supplied, the buffer will be linked to the given address in host memory. host_ptr must point to a memory region that is at least size∗sizeof(T) bytes long. The data may or may not be buffered during a kernel call, depending on the device driver. After the kernel has finished, the data is synchronized and can be accessed by the host.
flags	access flags

5.1.2.5 buffer() [5/5]

```
buffer ( )  [default]
```

default constructor. The buffer cannot be used until replaced by a buffer that has been properly initialized.

5.1.3 Member Function Documentation

5.1.3.1 copy() [1/2]

```
void copy (
            const buffer< T, SRC_SIZE_TYPE > & src )  [inline]
```

copy data from one buffer to another buffer

Parameters

src	source buffer

5.1.3.2 copy() [2/2]

```
void copy (
            const buffer< T, SRC_SIZE_TYPE > & src,
            typename enable_if< true, SRC_SIZE_TYPE >::type count,
            SIZE_TYPE start_dest,
            typename enable_if< true, SRC_SIZE_TYPE >::type start_src )  [inline]
```

copy data from one buffer to another buffer

Parameters

src	source buffer
count	number of elements to copy
start_dest	start position in destination buffer
start_src	start position in source buffer

5.1.3.3 copy_from_host() [1/2]

```
void copy_from_host (
            const T * p )  [inline]
```

copy data from host

Parameters

p	pointer in host memory

5.1.3.4 copy_from_host() [2/2]

```
void copy_from_host (
            const T * p,
            size_t beginpos,
            size_t endpos )  [inline]
```

copy data from host memory

Parameters

p	pointer in host memory
beginpos	start position in device memory
endpos	next to last position in device memory

5.1.3.5 copy_to_host() [1/2]

```
void copy_to_host (
            T * p ) const  [inline]
```

copy data to host

Parameters

p	pointer in host memory

5.1.3.6 copy_to_host() [2/2]

```
void copy_to_host (
            T * p,
            size_t beginpos,
            size_t endpos ) const  [inline]
```

copy data to host

Parameters

p	pointer in host memory
beginpos	start position in device memory
endpos	next to last position in device memory

5.1.3.7 fill() [1/2]

```
void fill (
            T value )  [inline]
```

Fill buffer with value

Parameters

value	value to fill

5.1.3.8 fill() [2/2]

```
void fill (
            T value,
            size_type begin,
            size_type end )  [inline]
```

Fill buffer with value

Parameters

value	value to fill
begin	begin of fill region
end	next to last element to fill

5.1.3.9 get_device()

```
goopax_device get_device ( ) const  [inline]
```

Returns device on which the buffer is allocated.

5.1.3.10 max() [1/2]

```
T max ( ) const  [inline]
```

Finds maximum value

5.1.3.11 max() [2/2]

```
T max (
            const size_type begin,
            const size_type end ) const  [inline]
```

Finds maximum value

5.1.3.12 min() [1/2]

```
T min ( ) const  [inline]
```

Finds minimum value

5.1.3.13 min() [2/2]

```
T min (
            const size_type begin,
            const size_type end ) const  [inline]
```

Finds minimum value

5.1.3.14 operator=() [1/2]

```
buffer& operator= (
            const V & v )  [inline]
```

copy data from std::vector

5.1.3.15 operator=() [2/2]

```
buffer& operator= (
            initializer_list< T > il )  [inline]
```

assign data via initialization list

5.1.3.16 size()

```
size_type size ( ) const  [inline]
```

Buffer size

5.1.3.17 sum() [1/2]

```
T sum ( ) const  [inline]
```

Calculates the sum of all values

5.1.3.18 sum() [2/2]

```
T sum (
            const size_type begin,
            const size_type end ) const  [inline]
```

Calculates the sum of all values in the given range

5.1.3.19 to_vector()

```
vector<value_type> to_vector ( ) const  [inline]
```

returns a std::vector that holds a copy of the data

5.1.4 Friends And Related Function Documentation

5.1.4.1 operator<<

```
ostream& operator<< (
            ostream & s,
            const buffer< T, SIZE_TYPE > & b )  [friend]
```

Output the buffer content.

5.1.4.2 reinterpret

```
TO reinterpret (
            const buffer< TFROM, SIZE_FROM > & from )  [friend]
```

Reinterpreting buffer value type.

Changes the buffer value type without changing the data content. The returned buffer points to the same memory buffer as the original buffer.

Parameters

TO	destination type
from	source buffer

5.2 buffer_map< T, is_const > Class Template Reference

Inherits map_base.

Public Member Functions

- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  value_type * begin ()
- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  value_type * end ()
- const value_type * begin () const
- const value_type * end () const

- Tsize_t size () const
- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  value_type * data ()
- const value_type * data () const
- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  value_type & operator[ ] (size_t k)
- const value_type & operator[ ] (size_t k) const
- template<typename SIZE_TYPE , typename = typename enable_if<is_const, SIZE_TYPE>::type>
  buffer_map (const buffer< T, SIZE_TYPE > &buf, size_t begin, size_t end)
- template<typename SIZE_TYPE , typename = typename enable_if<is_const, SIZE_TYPE>::type>
  buffer_map (const buffer< T, SIZE_TYPE > &buf)
- template<typename SIZE_TYPE >
  buffer_map (buffer< T, SIZE_TYPE > &buf, size_t begin, size_t end)
- template<typename SIZE_TYPE >
  buffer_map (buffer< T, SIZE_TYPE > &buf)

5.2.1 Detailed Description

template<typename T, bool is_const = false>
class goopax::impl::buffer_map< T, is_const >

buffer map. Can be used to access buffers from host code. For performance reasons, buffer maps should not be called within a loop, but before the loop, if possible. buffer maps must be out of scope before the buffer is used in a kernel call or in another operation.

Template Parameters

T	value type, must match the buffer value type
is_const	if true, allows mapping of const buffers

5.2.2 Constructor & Destructor Documentation

5.2.2.1 buffer_map() [1/4]

```
buffer_map (
            const buffer< T, SIZE_TYPE > & buf,
            size_t begin,
            size_t end )  [inline]
```

constructor. Maps the buffer to host memory.

Parameters

buf	buffer to map.
begin	first index
end	last+1 index

5.2.2.2 buffer_map() [2/4]

```
buffer_map (
            const buffer< T, SIZE_TYPE > & buf )  [inline]
```

constructor. Maps the buffer to host memory.

Parameters

buf	buffer to map.

5.2.2.3 buffer_map() [3/4]

```
buffer_map (
            buffer< T, SIZE_TYPE > & buf,
            size_t begin,
            size_t end )  [inline]
```

constructor. Maps the buffer to host memory.

Parameters

buf	buffer to map.
begin	first index
end	last+1 index

5.2.2.4 buffer_map() [4/4]

```
buffer_map (
            buffer< T, SIZE_TYPE > & buf )  [inline]
```

constructor. Maps the buffer to host memory.

Parameters

buf	buffer to map.

5.2.3 Member Function Documentation

5.2.3.1 begin() [1/2]

```
value_type* begin ( )  [inline]
```

begin pointer, const

5.2.3.2 begin() [2/2]

```
const value_type* begin ( ) const  [inline]
```

begin pointer

5.2.3.3 data() [1/2]

```
value_type* data ( )  [inline]
```

same as begin()

5.2.3.4 data() [2/2]

```
const value_type* data ( ) const  [inline]
```

same as begin()

5.2.3.5 end() [1/2]

```
value_type* end ( )  [inline]
```

end pointer, const

5.2.3.6 end() [2/2]

```
const value_type* end ( ) const  [inline]
```

end pointer

5.2.3.7 operator[]() [1/2]

```
value_type& operator[] (
            size_t k )  [inline]
```

accesses element k

Parameters

k	element to get reference to

5.2.3.8 operator[]() [2/2]

```
const value_type& operator[] (
            size_t k ) const  [inline]
```

accesses element k

Parameters

k	element to get const reference to

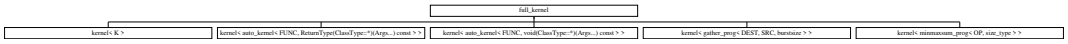
5.2.3.9 size()

```
Tsize_t size ( ) const  [inline]
```

size of memory region

5.3 full_kernel Struct Reference

Inheritance diagram for full_kernel:



Public Member Functions

- void force_compile (goopax_device device)
  force compilation of kernel. Only useful for performance measurements and other occasions.
- full_kernel (full_kernel &&b) noexcept
  move semantics
- full_kernel & operator= (full_kernel &&b) noexcept
  move semantics

overriding default thread numbers

- void force_local_size (goopax_device device, Tint local_size)
  set the local size for this kernel for the specified device.
- void force_global_size (goopax_device device, Tint global_size)
  set the global size for this kernel for the specified device.

5.3.1 Detailed Description

kernel base

5.4 gather_add< T > Struct Template Reference

Inherits gather_base< T >.

Static Public Member Functions

- static T init ()
- template<class U >
  static U op (const U &a, const U &b)

5.4.1 Detailed Description

template<class T>
struct goopax::impl::gather_add< T >

returns the sum of all values.

5.4.2 Member Function Documentation

5.4.2.1 init()

```
static T init ( )  [inline], [static]
```

null element of the operation, used by buffer::sum() operation.

5.4.2.2 op()

```
static U op (
            const U & a,
            const U & b )  [inline], [static]
```

here the operation is defined.

5.5 gather_max< T > Struct Template Reference

Inherits gather_base< T >.

5.5.1 Detailed Description

template<class T>
struct goopax::impl::gather_max< T >

returns the maximum of all values

5.6 gather_min< T > Struct Template Reference

Inherits gather_base< T >.

5.6.1 Detailed Description

template<class T>
struct goopax::impl::gather_min< T >

returns the minimum of all values

5.7 gettype< T, EIF > Struct Template Reference

type info and type conversion mechanism With the gettype struct, CPU and GPU types can be converted to each other, and type information obtained typename gettype<T>::cpu converts T to the corresponding CPU type. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. typename gettype<T>::gpu converts T to the corresponding GPU type. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. gettype<↩ T>::size provides the size of type T in bytes. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. typename gettype<T>::template change<U>::type changes the type of T to type U while preserving CPU/GPU/debug mode. If T is CPU type, the resulting type is also a CPU type. If T is GPU type, the resulting type is a GPU type. If T is debug data type, the resulting type is also a debug data type.

5.7.1 Detailed Description

template<typename T, typename EIF = void>
struct goopax::impl::gettype< T, EIF >

type info and type conversion mechanism With the gettype struct, CPU and GPU types can be converted to each other, and type information obtained typename gettype<T>::cpu converts T to the corresponding CPU type. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. typename gettype<T>::gpu converts T to the corresponding GPU type. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. gettype<↩ T>::size provides the size of type T in bytes. T can be CPU type, GPU type, or CPU debug type, or a goopax struct type. typename gettype<T>::template change<U>::type changes the type of T to type U while preserving CPU/GPU/debug mode. If T is CPU type, the resulting type is also a CPU type. If T is GPU type, the resulting type is a GPU type. If T is debug data type, the resulting type is also a debug data type.

5.8 goopax_device Class Reference

Goopax device. This class is used to reference the physical devices in the system.

Public Member Functions

- bool valid () const

  checks if the device is valid. This will return false if the device is default-constructed. or if default_device() did not find
- envmode get_envmode () const

  returns the backend type that is used to access this device
- size_t global_memory_total () const

  Total amount of global memory.
- size_t global_memory_free () const

  Free global memmory, or numeric_limits<size_t>::max() if unknown.
- Tuint cache_line () const

  Size of global memory cache line, in bytes, or 0 if unknown.
- Tuint cache_size () const

  Size of global memory cache size, in bytes, or 0 if unknown.
- Tuint max_registers () const

  Number of registers per thread, or 0 if unknown.
- template<typename T >
  Tbool support_atomics (T) const

  Returns true if the device support atomic operations on type T.
- Tbool support_svm () const

  Returns true if the device supports shared memory addressing between the host and potentially other devices.
- Tbool support_svm_mapfree () const

  Returns true if the device supports shared memory addressing between the host and potentially other devices.
- Tbool support_svm_atomics () const

  Returns true if the device supports shared memory addressing between the host and potentially other devices.
- bool support_images () const

  Returns true if images are supported by the device.
- void wait_all () const

  Waits for all kernels that currently running or pending to finish on the device.
- Tbool finished_all () const

  Tests if all kernels on the device have finished.
- bool operator== (goopax_device b) const

  tests if two devices are the same
- bool operator!= (goopax_device b) const

  tests if two devices are different
- goopax_device & operator= (const goopax_device &b)
- goopax_device (const goopax_device &b)

overriding default thread numbers

- void force_local_size (Tuint value)

  changes the default local size for this device.
- void force_global_size (Tuint value)

  changes the default global size for this device.

default thread numbers

These default values are used if they are not overridden

- Tuint default_local_size () const

  local size
- Tuint default_num_subthreads () const

  instruction level parallelism

- Tuint default_num_groups () const
  number of thread groups
- Tuint default_global_size () const
  total number of threads. Equals local_size∗num_groups
- Tuint default_local_mem () const
  Size of local memory.

floating point support

- Tbool support_type (half) const
  Returns true if the device supports half precision.
- Tbool support_type (float) const
  Returns true if the device supports single precision floating points.
- Tbool support_type (double) const
  Returns true if the device supports double precision floating points.

denormalization support

- Tbool support_fp_denorm (half) const
  Returns true if the device supports denormalized numbers for gpu_half.
- Tbool support_fp_denorm (float) const
  Returns true if the device supports denormalized numbers for gpu_float.
- Tbool support_fp_denorm (double) const
  Returns true if the device supports denormalized numbers for gpu_double.

device information

- const char ∗ vendor () const
  Vendor name.
- const char ∗ name () const
  device name
- double max_frequency () const
  max device frequency
- Tuint warp_size () const
  Returns the warp size of the device. This is typically the SIMD instruction width. Threads within a warp cannot branch into loops and if-clauses without all other threads waiting for them to finish.

5.8.1 Detailed Description

Goopax device. This class is used to reference the physical devices in the system.

5.8.2 Constructor & Destructor Documentation

5.8.2.1 goopax_device()

```
goopax_device (
            const goopax_device & b )  [inline]
```

copy constructor

5.8.3 Member Function Documentation

5.8.3.1 operator=()

```
goopax_device& operator= (
            const goopax_device & b )  [inline]
```

copy operator

5.9 EX::goopax_exception Struct Reference

base exception thrown by goopax

Inherits exception.

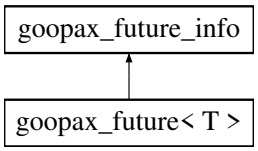
Inherited by EX::assertion, EX::backend, EX::general, EX::integrity, EX::memory, EX::syntax, and EX::user.

5.9.1 Detailed Description

base exception thrown by goopax

5.10 goopax_future< T > Class Template Reference

Inheritance diagram for goopax_future< T >:



Public Member Functions

- void wait ()
  wait for kernel to finish
- T get ()
  wait for kernel to finish and get value
- goopax_future ()=default
  default constructor
- goopax_future (goopax_future &&)=default
  move semantics
- goopax_future & operator= (goopax_future &&)=default
  move semantics

5.10.1 Detailed Description

template<typename T>
class goopax::impl::goopax_future< T >

future class for gather return values

Template Parameters

T	return type. May be a C++ intrinsic type, or a goopax struct type

5.10.2 Member Function Documentation

5.10.2.1 get()

```
T get ( )  [inline]
```

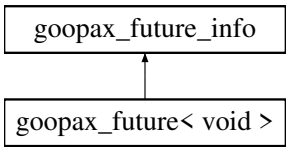
wait for kernel to finish and get value

Returns

value gathered from all threads and combined using the gather operation

5.11 goopax_future< void > Class Template Reference

Inheritance diagram for goopax_future< void >:



Public Member Functions

- void wait ()
  wait for kernel to finish
- goopax_future ()=default
  default constructor
- goopax_future (goopax_future &&)=default
  move semantics
- goopax_future & operator= (goopax_future &&)=default
  move semantics

5.11.1 Detailed Description

template<>
class goopax::impl::goopax_future< void >

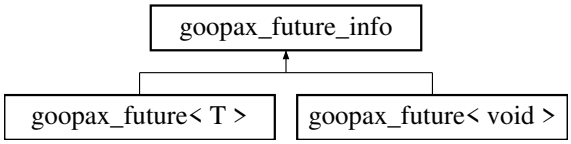
future class, Returned from kernels that don't return a value.

Template Parameters

T	return type. May be a C++ intrinsic type, or a goopax struct type

5.12 goopax_future_info Class Reference

Inheritance diagram for goopax_future_info:



Public Member Functions

- bool finished () const
  returns true if kernel has finished execution
- size_t local_size () const
  number of threads per workgroup
- size_t global_size () const
  total number of threads
- size_t num_groups () const
  number of workgroups

5.12.1 Detailed Description

Common future class base, provides information about the kernel execution.

5.13 goopax_struct_type< std::array< T, N > > Struct Template Reference

std::array and derived classes

5.13.1 Detailed Description

template<typename T, size_t N>
struct goopax::goopax_struct_type< std::array< T, N > >

std::array and derived classes

5.14 gpu_ostream Class Reference

Public Member Functions

- gpu_ostream (ostream &os0)

Friends

- gpu_ostream & operator<< (gpu_ostream &out, const string &s)
  output string
- template<class T >
  gpu_ostream & operator<< (gpu_ostream &out, const gpu_type< T > &val)
  output gpu value
- template<typename T , typename = typename enable_if<is_fundamental<T>::value || is_half<T>::value>::type>
  gpu_ostream & operator<< (gpu_ostream &s, T a)
  output cpu value
- template<class V >
  gpu_ostream & operator<< (typename enable_if< is_container< V >::value, gpu_ostream >::type &out, const V &v)
  output STL vector
- gpu_ostream & operator<< (gpu_ostream &out, const char *s)
  output C-style string
- gpu_ostream & operator<< (gpu_ostream &s, ostream &(*__pf)(ostream &))
  output endl/flush
- gpu_ostream & operator<< (gpu_ostream &s, decltype(&hex) h)
  modify stream, e.g. by hex or dec modifyers
- template<class T , class TA >
  gpu_ostream & operator<< (gpu_ostream &out, const checknan< T, TA > &val)
  output cpu debug value

5.14.1 Detailed Description

Streaming class that can be used from within GPU kernels. The usage is similar to std::ostream The output is written to the std::ostream object specified in the constructor. The output may be delayed until wait() has been called for the kernel/device The order in which concurrent threads write is undefined. The output of any thread is only interrupted by other threads when 'endl' or 'flush' is used. If the output should not be interrupted, use "\n" instead of endl.

5.14.2 Constructor & Destructor Documentation

5.14.2.1 gpu_ostream()

```
gpu_ostream (
            ostream & os0 )  [inline]
```

Constructor.

Parameters

os0	std::ostream object to which the output is passed.

5.15 gpu_type< T, scope > Class Template Reference

Inherits wrapper< TYPE, IMPL >.

Public Member Functions

- template<typename EA = void, typename EB = typename enable_if< true , EA>::type>
  gpu_bool operator== (const gpu_type &b) const

  Compare two GPU values for equality.
- template<typename EA = void, typename EB = typename enable_if< true , EA>::type>
  gpu_bool operator!= (const gpu_type &b) const

  Compare two GPU values for inequality.
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_bool operator< (const gpu_type &b) const

  Compare two GPU values.
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_bool operator>= (const gpu_type &b) const

  Compare two GPU values.
- template<typename EA = void, typename EB = typename enable_if< is_bool , EA>::type>
  gpu_bool operator&& (const gpu_type &b) const

  boolean AND
- template<typename EA = void, typename EB = typename enable_if< is_bool , EA>::type>
  gpu_bool operator|| (const gpu_type &b) const

  boolean OR
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator+ (const gpu_type &b) const

  addition
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator* (const gpu_type &b) const

  multiplication
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator/ (const gpu_type &b) const

  division
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type operator& (const gpu_type &b) const

  bitwise AND
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type operator| (const gpu_type &b) const

  bitwise OR
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type operator^ (const gpu_type &b) const

  bitwise xor
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator<< (const gpu_uint &b) const

  left shift

- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator>> (const gpu_uint &b) const

  right shift
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type operator% (const gpu_type &b) const

  modulo operator
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator- (const gpu_type &b) const
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator- () const
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type operator+ () const
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_bool operator> (const gpu_type &b) const
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_bool operator<= (const gpu_type &b) const
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator++ ()
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator-- ()
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type operator++ (int)
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type operator-- (int)
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type & operator+= (const gpu_type &b)

  addition
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type & operator-= (const gpu_type &b)

  subtraction
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type & operator*= (const gpu_type &b)

  multiplication
- template<typename EA = void, typename EB = typename enable_if< !is_bool , EA>::type>
  gpu_type & operator/= (const gpu_type &b)

  division
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator&= (const gpu_type &b)

  bitwise AND
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator|= (const gpu_type &b)

  bitwise OR
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator^= (const gpu_type &b)

  bitwise XOR
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator<<= (const gpu_uint &b)

  left shift
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator>>= (const gpu_uint &b)

  right shift
- template<typename EA = void, typename EB = typename enable_if< is_int , EA>::type>
  gpu_type & operator%= (const gpu_type &b)

  modulo

- void gpu_break ()
- void gpu_continue ()
- gpu_type ()
- template<typename U >
  gpu_type (const struct wrapper< gpu_type< U >, gpu_writer_base_impl > &b)
- gpu_type (T d)
- template<typename U , typename = typename enable_if<is_half<T>::value && is_arithmetic<U>::value>::type>
  gpu_type (U d)
- template<typename TA , typename BT >
  gpu_type (const checknan< BT, TA > &d)
- template<typename B , typename FOO = typename enable_if<(((is_int && is_integral<B>::value && !is_same<B, bool>::value>
  gpu_type (const gpu_type< B > &b)
- gpu_type (const gpu_type &b)
- gpu_type & operator= (const gpu_type &b)

5.15.1 Detailed Description

template<typename T, memory::scope scope>
class goopax::impl::gpu_type< T, scope >

GPU data type, used in GPU kernels to store values in registers.

Template Parameters

T	corresponding CPU intrinsic type. Pointers are represented as gpu_type<T*> or gpu_type<const T*>, where T is a CPU intrinsic type or a goopax struct type.

5.15.2 Constructor & Destructor Documentation

5.15.2.1 gpu_type() [1/7]

```
gpu_type ( )  [inline]
```

default constructor for uninitialized variable.

5.15.2.2 gpu_type() [2/7]

```
gpu_type (
            const struct wrapper< gpu_type< U >, gpu_writer_base_impl > & b )  [inline],
[explicit]
```

explicit type conversion

5.15.2.3 gpu_type() [3/7]

```
gpu_type (
            T d )  [inline]
```

conversion from CPU type

5.15.2.4 gpu_type() [4/7]

```
gpu_type (
            U d )  [inline]
```

conversion from CPU type

5.15.2.5 gpu_type() [5/7]

```
gpu_type (
            const checknan< BT, TA > & d )  [inline]
```

conversion from CPU debug type

5.15.2.6 gpu_type() [6/7]

```
gpu_type (
            const gpu_type< B > & b )  [inline]
```

Implicit type conversion The type conversion rules are stricter than the standard C/C++ type conversion rules to avoid unintended performance loss: Integer values are only implicitly converted to integers of at least the same size or to floating point numbers. floating point numbers are only implicitly converted to other floating point numbers of at least the same size. Other conversions need to be done explicitly, with static_cast, or C/C++ style cast.

5.15.2.7 gpu_type() [7/7]

```
gpu_type (
            const gpu_type< T, scope > & b )  [inline]
```

copy constructor

5.15.3 Member Function Documentation

5.15.3.1 gpu_break()

```
void gpu_break ( )  [inline]
```

Break from loop. Only valid on loop variables. Calling gpu_break() on non-loop variables results in an error.

5.15.3.2 gpu_continue()

```
void gpu_continue ( )  [inline]
```

Continue loop. Only valid on loop variables. Calling gpu_continue() on non-loop variables results in an error.

5.15.3.3 operator+()

```
gpu_type operator+ ( ) const  [inline]
```

unary +

5.15.3.4 operator++() [1/2]

```
gpu_type& operator++ ( )  [inline]
```

increment

5.15.3.5 operator++() [2/2]

```
gpu_type operator++ (
            int  )  [inline]
```

increment

5.15.3.6 operator-() [1/2]

```
gpu_type operator- ( ) const  [inline]
```

unary -

5.15.3.7 operator-() [2/2]

```
gpu_type operator- (
            const gpu_type< T, scope > & b ) const  [inline]
```

subtract

5.15.3.8 operator--() [1/2]

```
gpu_type& operator-- ( )  [inline]
```

decrement

5.15.3.9 operator--() [2/2]

```
gpu_type operator-- (
            int  )  [inline]
```

decrement

5.15.3.10 operator<=()

```
gpu_bool operator<= (
            const gpu_type< T, scope > & b ) const  [inline]
```

comparison

5.15.3.11 operator=()

```
gpu_type& operator= (
            const gpu_type< T, scope > & b )  [inline]
```

assignment operator

5.15.3.12 operator>()

```
gpu_bool operator> (
            const gpu_type< T, scope > & b ) const  [inline]
```

comparison

5.16 image_array_buffer< DIM, T, normalized > Class Template Reference

Inherits image_buffer_base< DIM, IS_ARRAY, T, normalized >.

Classes

- struct image_slice

  Reference to single image in the image array.

Public Member Functions

- size_type array_size () const
- image_slice< false > operator[] (size_type imagenum)
- image_slice< true > operator[] (size_type imagenum) const
- void copy (const image_array_buffer &b, array< size_type, DIM+1 > src_origin, array< size_type, DIM+1 > dest_origin, array< size_type, DIM+1 > region)
- void copy (const image_array_buffer &b)
- void copy_to_host (T *p, array< size_type, DIM+1 > origin, array< size_type, DIM+1 > region, array< size_type, DIM > pitchdim=makearray< size_type, DIM >(0)) const
- void copy_to_host (T *p) const
- vector< value_type > to_vector () const
- void copy_from_host (const T *p, array< size_type, DIM+1 > origin, array< size_type, DIM+1 > region, array< size_type, DIM > pitchdim=makearray< size_type, DIM >(0))
- image_array_buffer ()
- image_array_buffer (goopax_device device, size_type num_images, const array< size_type, DIM > size, IMAGE_FLAGS flags=IMAGE_READ_WRITE, value_type *host_ptr=nullptr, array< size_type, DIM > pitchdim=makearray< size_type, DIM >(0))
- void fill (T value, array< size_type, DIM+1 > origin, array< size_type, DIM+1 > region)
- void fill (T value)

Static Public Member Functions

- static image_array_buffer create_from_gl (goopax_device device, unsigned int GLres, IMAGE_FLAGS flags=IMAGE_READ_WRITE, unsigned int GLtarget=(DIM==1 ? 0x0DE0 :(DIM==2 ? 0x0DE1 :0x806F)), int miplevel=0)
- static image_array_buffer create_from_cl (goopax_device device, _cl_mem *mem)

5.16.1 Detailed Description

template<unsigned int DIM, typename T, bool normalized>
class goopax::impl::image_array_buffer< DIM, T, normalized >

/ Image array. The image will be allocated on the device.

Template Parameters

DIM	Number of dimensions. Must be 1 or 2.
T	Element data type. Must be std::array<C, N>, or other goopax struct of identical types. C: channel type (int32_t, int16_t, int8_t, uint32_t, uint16_t, uint8_t, float, half), N: number of channels (must be 4 at the moment).
normalized	if set to true, image values are normalized to floats in the range 0..1 for unsigned channel types, or -1..1 for signed channel types. Defaults to false if the channel data type allows unnormalized access

5.16.2 Constructor & Destructor Documentation

5.16.2.1 image_array_buffer() [1/2]

```
image_array_buffer ( )  [inline]
```

default constructor. Image must not be used until replaced by a real image.

5.16.2.2 image_array_buffer() [2/2]

```
image_array_buffer (
            goopax_device device,
            size_type num_images,
            const array< size_type, DIM > size,
            IMAGE_FLAGS flags = IMAGE_READ_WRITE,
            value_type * host_ptr = nullptr,
            array< size_type, DIM > pitchdim = makearray<size_type, DIM>(0) )  [inline]
```

Allocated image array on the device.

Parameters

device	device to allocate image on
num_devices	number of images in the array
size	image dimensions
flags	must be one of IMAGE_READ_WRITE, IMAGE_READ_ONLY, IMAGE_WRITE_ONLY, IMAGE_WRITE_DISCARD
host_ptr	if used, image array will be linked to the specified address in host memory.
pitchdim	pitch size in pixels

5.16.3 Member Function Documentation

5.16.3.1 array_size()

```
size_type array_size ( ) const  [inline]
```

Number of images in the array

5.16.3.2 copy() [1/2]

```
void copy (
            const image_array_buffer< DIM, T, normalized > & b )  [inline]
```

copy image array

5.16.3.3 copy() [2/2]

```
void copy (
            const image_array_buffer< DIM, T, normalized > & b,
            array< size_type, DIM+1 > src_origin,
            array< size_type, DIM+1 > dest_origin,
            array< size_type, DIM+1 > region )  [inline]
```

copy image array The last indices in src_origin, dest_origin, and region refer to the image slice, i.e., for 1D image arrays, coordinates in the form {x, imagenum} are passed, for 2D image arrays, coordinates in the form {x, y, imagenum} are passed.

Parameters

b	source image array
src_origin	offset in source image array
dest_origin	offset in destination image array
region	size of image array patch.

5.16.3.4 copy_from_host()

```
void copy_from_host (
            const T * p,
            array< size_type, DIM+1 > origin,
            array< size_type, DIM+1 > region,
            array< size_type, DIM > pitchdim = makearray<size_type, DIM>(0) )  [inline]
```

copy image array from host memory

Parameters

p	pointer in host memory
origin	image offset in device
region	size of image patch
pitchdim	full image dimensions in host memory. If filled with zeros, will be calculated from image size

5.16.3.5 copy_to_host() [1/2]

```
void copy_to_host (
            T * p ) const  [inline]
```

copy image array to host memory

Parameters

p	pointer to host memory

5.16.3.6 copy_to_host() [2/2]

```
void copy_to_host (
            T * p,
            array< size_type, DIM+1 > origin,
            array< size_type, DIM+1 > region,
            array< size_type, DIM > pitchdim = makearray<size_type, DIM>(0) ) const  [inline]
```

copy image array to host memory.

Parameters

p	pointer to host memory
origin	offset in device image
region	size of image patch
pitchdim	full image dimensions in host memory. If filled with zeros, will be calculated from image size

5.16.3.7 fill() [1/2]

```
void fill (
            T value )  [inline]
```

FIll image array

Parameters

value	color to fill

5.16.3.8 fill() [2/2]

```
void fill (
            T value,
            array< size_type, DIM+1 > origin,
            array< size_type, DIM+1 > region )  [inline]
```

FIll image array

Parameters

value	color to fill
origin	origin in destination image. The last value specifies the image number in the array.
region	size of image patch to fill. The last value is the number of images to fill in the array.

5.16.3.9 operator[]() [1/2]

```
image_slice<false> operator[] (
            size_type imagenum )  [inline]
```

selects one image of the image array

5.16.3.10 operator[]() [2/2]

```
image_slice<true> operator[] (
            size_type imagenum ) const  [inline]
```

selects one image of the image array

5.16.3.11 to_vector()

```
vector<value_type> to_vector ( ) const  [inline]
```

returns a std::vector that holds a copy of the data

5.17 image_array_buffer_map< DIM, T, is_const > Class Template Reference

Inherits map_base.

Public Member Functions

- array< Tuint, DIM > dimensions () const
- Tsize_t array_size () const
- image_buffer_map< DIM, T, is_const > operator[] (Tsize_t slice)
- image_buffer_map< DIM, T, true > operator[] (Tsize_t slice) const
- template<bool normalized, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  image_array_buffer_map (image_array_buffer< DIM, T, normalized > &buf)
- template<bool normalized, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  image_array_buffer_map (image_array_buffer< DIM, T, normalized > &buf, array< Tuint, DIM+1 > origin, array< Tuint, DIM+1 > region)
- template<bool normalized, typename EIF = void, typename = typename enable_if<is_const, EIF>::type>
  image_array_buffer_map (const image_array_buffer< DIM, T, normalized > &buf)
- template<bool normalized, typename EIF = void, typename = typename enable_if<is_const, EIF>::type>
  image_array_buffer_map (const image_array_buffer< DIM, T, normalized > &buf, array< Tuint, DIM+1 > origin, array< Tuint, DIM+1 > region)

5.17.1 Detailed Description

template<unsigned int DIM, typename T, bool is_const = false>
class goopax::impl::image_array_buffer_map< DIM, T, is_const >

Maps an image buffer array to host memory

5.17.2 Constructor & Destructor Documentation

5.17.2.1 image_array_buffer_map() [1/4]

```
image_array_buffer_map (
            image_array_buffer< DIM, T, normalized > & buf )  [inline]
```

constructor.

Parameters

buf	image array that is to be mapped to host memory

5.17.2.2 image_array_buffer_map() [2/4]

```
image_array_buffer_map (
            image_array_buffer< DIM, T, normalized > & buf,
            array< Tuint, DIM+1 > origin,
            array< Tuint, DIM+1 > region )  [inline]
```

constructor.

Parameters

buf	image array that is to be mapped to host memory
origin	of image region. The last element is the first array index
region	size of image region. The last element specifies the number of images.

5.17.2.3 image_array_buffer_map() [3/4]

```
image_array_buffer_map (
            const image_array_buffer< DIM, T, normalized > & buf )  [inline]
```

constructor.

Parameters

buf	image array that is to be mapped to host memory

5.17.2.4 image_array_buffer_map() [4/4]

```
image_array_buffer_map (
            const image_array_buffer< DIM, T, normalized > & buf,
            array< Tuint, DIM+1 > origin,
            array< Tuint, DIM+1 > region )  [inline]
```

constructor.

Parameters

buf	image array that is to be mapped to host memory
origin	of image region. The last element is the first array index
region	size of image region. The last element specifies the number of images.

5.17.3 Member Function Documentation

5.17.3.1 array_size()

```
Tsize_t array_size ( ) const  [inline]
```

number of images in the array map

5.17.3.2 dimensions()

```
array<Tuint, DIM> dimensions ( ) const  [inline]
```

image dimensions of the image map.

5.17.3.3 operator[]() [1/2]

```
image_buffer_map<DIM, T, is_const> operator[] (
            Tsize_t slice )  [inline]
```

accessing image slice in the image array

Parameters

slice	image number in the array

Returns

image map to the image

5.17.3.4 operator[]() [2/2]

```
image_buffer_map<DIM, T, true> operator[] (
            Tsize_t slice ) const  [inline]
```

accessing image slice in the image array

Parameters

slice	image number in the array

Returns

image map to the image

5.18 image_array_resource< DIM, T, normalized > Class Template Reference

Inherits image_resource_base< DIM, IS_ARRAY, T, normalized >.

Classes

- struct image_slice

  Reference to single image in the image array.

Public Member Functions

- image_slice< image_array_resource & > operator[] (size_type imagenum)
- image_slice< const image_array_resource & > operator[] (size_type imagenum) const
- image_array_resource (const buffer_type &tex)

5.18.1 Detailed Description

template<unsigned int DIM, typename T, bool normalized>
class goopax::impl::image_array_resource< DIM, T, normalized >

Image array resources. Used for accessing an image_array_buffer from the kernel code.

Template Parameters

DIM	Number of dimensions. Must be 1 or 2.
T	Element data type. Must be std::array<C, N>, or other goopax struct of identical types. C: channel type (int32_t, int16_t, int8_t, uint32_t, uint16_t, uint8_t, float, half), N: number of channels (must be 4 at the moment).
normalized	if set to true, image values are normalized to floats in the range 0..1 for unsigned channel types, or -1..1 for signed channel types. Defaults to false if the channel data type allows unnormalized access

5.18.2 Constructor & Destructor Documentation

5.18.2.1 image_array_resource()

```
image_array_resource (
            const buffer_type & tex )  [inline]
```

constructor.

Parameters

tex	image_array_buffer to link to. The template parameters of the image_array_buffer and the image_array_resource must match

5.18.3 Member Function Documentation

5.18.3.1 operator[]() [1/2]

```
image_slice<image_array_resource&> operator[] (
            size_type imagenum )  [inline]
```

access image slice

Parameters

imagenum	image number in the array

Returns

image slice

5.18.3.2 operator[]() [2/2]

```
image_slice<const image_array_resource&> operator[] (
            size_type imagenum ) const  [inline]
```

access image slice (const)

Parameters

imagenum	image number in the array

Returns

image slice

5.19 image_buffer< DIM, T, normalized > Class Template Reference

Inherits image_buffer_base< DIM, IS_ARRAY, T, normalized >.

Public Types

- using map_type = image_buffer_map< DIM, T >
  < *pixe element type*

Public Member Functions

- goopax_device get_device () const
  < *returns the device that the image is allocated on*
- void copy (const image_buffer &b, array< size_type, DIM > src_origin, array< size_type, DIM > dest_origin, array< size_type, DIM > region)
- void copy (const image_buffer &b)
- void copy_to_host (T *p, array< size_type, DIM > origin, array< size_type, DIM > region, array< size_type, DIM - 1 > pitchdim=makearray< size_type, DIM - 1 >(0)) const
- vector< value_type > to_vector () const
- void copy_from_host (const T *p, array< size_type, DIM > origin, array< size_type, DIM > region, array< size_type, DIM - 1 > pitchdim=makearray< size_type, DIM - 1 >(0))
- void copy_from_host (const T *p)
- void fill (T value, array< size_type, DIM > origin, array< size_type, DIM > region)
- void fill (T value)
- image_buffer (goopax_device device, const array< size_type, DIM > size, IMAGE_FLAGS flags=IMAGE_READ_WRITE, value_type *host_ptr=nullptr, array< size_type, DIM - 1 > pitchdim=makearray< size_type, DIM - 1 >(0))
- image_buffer ()

Static Public Member Functions

- static image_buffer create_from_gl (goopax_device device, unsigned int GLres, IMAGE_FLAGS flags=IMAGE_READ_WRITE, unsigned int GLtarget=(DIM==1 ? 0x0DE0 :(DIM==2 ? 0x0DE1 :0x806F)), int miplevel=0)
- static image_buffer create_from_cl (goopax_device device, _cl_mem *mem)

5.19.1 Detailed Description

template<unsigned int DIM, typename T, bool normalized>
class goopax::impl::image_buffer< DIM, T, normalized >

/ Image container. The image will be allocated on the device.

Template Parameters

DIM	Number of dimensions. Must be 1, 2, od 3.
T	Element data type. Must be std::array<C, N>, or other goopax struct of identical types. C: channel type (int32_t, int16_t, int8_t, uint32_t, uint16_t, uint8_t, float, half), N: number of channels (must be 4 at the moment).
normalized	if set to true, image values are normalized to floats in the range 0..1 for unsigned channel types, or -1..1 for signed channel types. Defaults to false if the channel data type allows unnormalized access

5.19.2 Constructor & Destructor Documentation

5.19.2.1 image_buffer() [1/2]

```
image_buffer (
            goopax_device device,
            const array< size_type, DIM > size,
            IMAGE_FLAGS flags = IMAGE_READ_WRITE,
            value_type * host_ptr = nullptr,
            array< size_type, DIM - 1 > pitchdim = makearray<size_type, DIM - 1>(0) )  [inline]
```

Allocated image on the device.

Parameters

device	device to allocate image on
size	size of image
flags	must be one of IMAGE_READ_WRITE, IMAGE_READ_ONLY, IMAGE_WRITE_ONLY, IMAGE_WRITE_DISCARD
host_ptr	if used, image will be linked to the specified address in host memory.
pitchdim	pitch size in pixels

5.19.2.2 image_buffer() [2/2]

```
image_buffer ( )  [inline]
```

default constructor. Image must not be used until replaced by a real image.

5.19.3 Member Function Documentation

5.19.3.1 copy() [1/2]

```
void copy (
            const image_buffer< DIM, T, normalized > & b )  [inline]
```

copy image from another image with the same type and dimensions.

5.19.3.2 copy() [2/2]

```
void copy (
            const image_buffer< DIM, T, normalized > & b,
            array< size_type, DIM > src_origin,
            array< size_type, DIM > dest_origin,
            array< size_type, DIM > region )  [inline]
```

copy image region from another image of the same type.

Parameters

b	source image
src_origin	origin in source image
dest_origin	origin in ∗this
region	size of image region to copy

5.19.3.3 copy_from_host() [1/2]

```
void copy_from_host (
            const T * p )  [inline]
```

copy whole image from host.

Parameters

p	source address in host memory

5.19.3.4 copy_from_host() [2/2]

```
void copy_from_host (
            const T * p,
```

```
            array< size_type, DIM > origin,
            array< size_type, DIM > region,
            array< size_type, DIM - 1 > pitchdim = makearray<size_type, DIM - 1>(0) )  [inline]
```

copy image region from host.

Parameters

p	source address in host memory
origin	origin of image in device
region	size of image region
pitchdim	row pitch dimensions (2D images) or row pitch+slice pitch dimensions (3D images), in pixels. If values are 0, the pitch is calculated from region

5.19.3.5 copy_to_host()

```
void copy_to_host (
            T * p,
            array< size_type, DIM > origin,
            array< size_type, DIM > region,
            array< size_type, DIM - 1 > pitchdim = makearray<size_type, DIM - 1>(0) ) const
[inline]
```

copy image region to host.

Parameters

p	destination address in host memory
origin	origin of image in device
region	size of image region
pitchdim	row pitch dimensions (2D images) or row pitch+slice pitch dimensions (3D images), in pixels.

5.19.3.6 fill() [1/2]

```
void fill (
            T value )  [inline]
```

FIll image array

Parameters

value	color to fill

5.19.3.7 fill() [2/2]

```
void fill (
            T value,
            array< size_type, DIM > origin,
            array< size_type, DIM > region )  [inline]
```

FIll image array

Parameters

value	color to fill
origin	origin in destination image.
region	size of image patch to fill.

5.19.3.8 to_vector()

```
vector<value_type> to_vector ( ) const  [inline]
```

returns a std::vector that holds a copy of the data

5.20 image_buffer_map< DIM, T, is_const > Class Template Reference

Inherits map_base.

Public Member Functions

- array< Tuint, DIM > dimensions () const
- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  value_type & operator[ ] (array< Tuint, DIM > pos)
- const value_type & operator[ ] (array< Tuint, DIM > pos) const
- template<bool normalized, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  image_buffer_map (image_buffer< DIM, T, normalized > &buf)
- template<bool normalized, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  image_buffer_map (image_buffer< DIM, T, normalized > &buf, array< Tuint, DIM > origin, array< Tuint, DIM > region)
- template<bool normalized, typename EIF = void, typename = typename enable_if<is_const, EIF>::type>
  image_buffer_map (const image_buffer< DIM, T, normalized > &buf)
- template<bool normalized, typename EIF = void, typename = typename enable_if<is_const, EIF>::type>
  image_buffer_map (const image_buffer< DIM, T, normalized > &buf, array< Tuint, DIM > origin, array< Tuint, DIM > region)

5.20.1 Detailed Description

template<unsigned int DIM, typename T, bool is_const = false>
class goopax::impl::image_buffer_map< DIM, T, is_const >

Maps an image buffer to host memory and provides access to the image from the host.

5.20.2 Constructor & Destructor Documentation

5.20.2.1 image_buffer_map() [1/4]

```
image_buffer_map (
            image_buffer< DIM, T, normalized > & buf )  [inline]
```

constructor.

Parameters

buf	image that is to be mapped to host memory

5.20.2.2 image_buffer_map() [2/4]

```
image_buffer_map (
            image_buffer< DIM, T, normalized > & buf,
            array< Tuint, DIM > origin,
            array< Tuint, DIM > region )  [inline]
```

constructor.

Parameters

buf	image that is to be mapped to host memory
origin	begin of image region
region	size of image region

5.20.2.3 image_buffer_map() [3/4]

```
image_buffer_map (
            const image_buffer< DIM, T, normalized > & buf )  [inline]
```

constructor.

Parameters

buf	const image that is to be mapped to host memory.

5.20.2.4 image_buffer_map() [4/4]

```
image_buffer_map (
            const image_buffer< DIM, T, normalized > & buf,
            array< Tuint, DIM > origin,
            array< Tuint, DIM > region )  [inline]
```

constructor.

Parameters

buf	image that is to be mapped to host memory
origin	begin of image region
region	size of image region

5.20.3 Member Function Documentation

5.20.3.1 dimensions()

```
array<Tuint, DIM> dimensions ( ) const  [inline]
```

dimensions of image map

5.20.3.2 operator[]() [1/2]

```
value_type& operator[] (
            array< Tuint, DIM > pos )  [inline]
```

image access from host

Parameters

pos	position in image

Returns

reference to image pixel

5.20.3.3 operator[]() [2/2]

```
const value_type& operator[] (
            array< Tuint, DIM > pos ) const  [inline]
```

image access from host

Parameters

pos	position in image

Returns

reference to image pixel

5.21 image_resource< DIM, T, normalized > Class Template Reference

Inherits image_resource_base< DIM, IS_ARRAY, T, normalized >.

Public Member Functions

- access_type read (array< size_type, DIM > pos) const
- template<typename U , typename = typename enable_if<allow_sampler, U>::type>
  access_type read (array< U, DIM > pos, sampler_mode sampler) const
- template<typename POS , typename = typename enable_if<is_same<typename POS::value_type, size_type>::value>::type>
  access_type read (POS pos) const
- template<typename POS , typename = typename enable_if<allow_sampler, POS>::type>
  access_type read (POS pos, sampler_mode sampler) const
- void write (array< size_type, DIM > pos, access_type colors)
- template<typename POS , typename = typename enable_if<is_same<typename POS::value_type, size_type>::value>::type>
  void write (POS pos, access_type colors)
- image_resource (buffer_type &tex)

Static Public Attributes

- static constexpr bool allow_sampler = base_t::allow_sampler(normalized)

  true if samplers are allowed for the channel data type.

5.21.1 Detailed Description

template<unsigned int DIM, typename T, bool normalized>
class goopax::impl::image_resource< DIM, T, normalized >

Image resources. Used for accessing an image_buffer from the kernel code.

Template Parameters

DIM	Number of dimensions. Must be 1, 2, or 3.
T	Element data type. Must be std::array<C, N>, or other goopax struct of identical types. C: channel type (int32_t, int16_t, int8_t, uint32_t, uint16_t, uint8_t, float, half), N: number of channels (must be 4 at the moment).
normalized	if set to true, image values are normalized to floats in the range 0..1 for unsigned channel types, or -1..1 for signed channel types. Defaults to false if the channel data type allows unnormalized access

5.21.2 Constructor & Destructor Documentation

5.21.2.1 image_resource()

```
image_resource (
            buffer_type & tex )  [inline]
```

constructor.

Parameters

tex	image_buffer to link to. The template parameters of the image_buffer and the image_resource must match

5.21.3 Member Function Documentation

5.21.3.1 read() [1/4]

```
access_type read (
            array< size_type, DIM > pos ) const  [inline]
```

read from image

Parameters

pos	image position
return	pixel at the given position

5.21.3.2 read() [2/4]

```
access_type read (
            array< U, DIM > pos,
            sampler_mode sampler ) const  [inline]
```

read from image with sampler

Parameters

pos	position, may be an array of type gpu_int, gpu_uint, or gpu_float
sampler	mode.
return	pixel

5.21.3.3 read() [3/4]

```
access_type read (
            POS pos ) const  [inline]
```

read pixel.

Parameters

pos	pixel position. May be any container that provides the [] operator
return	pixel at the given position

5.21.3.4 read() [4/4]

```
access_type read (
            POS pos,
            sampler_mode sampler ) const  [inline]
```

read from image with sampler

Parameters

pos	position, may be any container that provides the [] operator, and that holds values of type gpu_int, gpu_uint, or gpu_float
sampler	mode.
return	pixel

5.21.3.5 write() [1/2]

```
void write (
            array< size_type, DIM > pos,
            access_type colors )  [inline]
```

write to image

Parameters

pos	pixel position
colors	pixel color to write

5.21.3.6 write() [2/2]

```
void write (
            POS pos,
            access_type colors )  [inline]
```

write to image

Parameters

pos	pixel position
colors	pixel color to write. May be any container that provides the [] operator

5.22 image_array_buffer< DIM, T, normalized >::image_slice< is_const > Struct Template Reference

Reference to single image in the image array.

Public Member Functions

- array< size_type, DIM > dimensions () const
- template<bool C2, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  void copy (const image_slice< C2 > &b, array< size_type, DIM > src_origin, array< size_type, DIM > dest_origin, array< size_type, DIM > region)
- template<bool C2, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  void copy (const image_slice< C2 > &b)
- void copy_to_host (T *p, array< size_type, DIM > origin, array< size_type, DIM > region, size_type row_↩ pitch=0) const
- void copy_to_host (T *p) const
- vector< value_type > to_vector () const
- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  void copy_from_host (const T *p, array< size_type, DIM > origin, array< size_type, DIM > region, size_type row_pitch=0)
- template<typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  void copy_from_host (const T *p)

5.22.1 Detailed Description

template<unsigned int DIM, typename T, bool normalized>
template<bool is_const>
struct goopax::impl::image_array_buffer< DIM, T, normalized >::image_slice< is_const >

Reference to single image in the image array.

5.22.2 Member Function Documentation

5.22.2.1 copy() [1/2]

```
void copy (
            const image_slice< C2 > & b )  [inline]
```

copy from other image size

5.22.2.2 copy() [2/2]

```
void copy (
            const image_slice< C2 > & b,
            array< size_type, DIM > src_origin,
            array< size_type, DIM > dest_origin,
            array< size_type, DIM > region )  [inline]
```

copy from other image slice

Parameters

src_origin	offset in source image
dest_origin	offset in destination image
region	size of image patch to copy

5.22.2.3 copy_from_host() [1/2]

```
void copy_from_host (
            const T * p )  [inline]
```

copy image slice from host memoryx

5.22.2.4 copy_from_host() [2/2]

```
void copy_from_host (
            const T * p,
            array< size_type, DIM > origin,
            array< size_type, DIM > region,
            size_type row_pitch = 0 )  [inline]
```

copy image slice from host memory

Parameters

p	pointer in host memory
origin	offset in device memory
region	size of image patch
row_pitch	pitch in host memory in pixels. Defaults to region[0]

5.22.2.5 copy_to_host() [1/2]

```
void copy_to_host (
            T * p ) const  [inline]
```

Copy image slice to host memory

5.22.2.6 copy_to_host() [2/2]

```
void copy_to_host (
            T * p,
            array< size_type, DIM > origin,
            array< size_type, DIM > region,
            size_type row_pitch = 0 ) const  [inline]
```

Copy image slice to host memory.

Parameters

p	pointer to host memory
origin	offset in device
region	size of image patch
row_pitch	pitch in host memory in pixels. Defaults to region[0]

5.22.2.7 dimensions()

```
array<size_type, DIM> dimensions ( ) const  [inline]
```

image dimensions

5.22.2.8 to_vector()

```
vector<value_type> to_vector ( ) const  [inline]
```

returns a std::vector that holds a copy of the data

5.23 image_array_resource< DIM, T, normalized >::image_slice< RESREF > Struct Template Reference

Reference to single image in the image array.

Public Member Functions

- access_type read (array< size_type, DIM > pos) const
- template<typename U , typename = typename enable_if<allow_sampler, U>::type>
  access_type read (array< U, DIM > pos, sampler_mode sampler=address_none|filter_nearest) const
- template<typename POS , typename = typename enable_if<is_same<typename POS::value_type, size_type>::value>::type>
  access_type read (POS pos) const
- template<typename POS , typename = typename enable_if<allow_sampler, POS>::type>
  access_type read (POS pos, sampler_mode sampler) const
- template<typename = void, typename = typename enable_if<is_same<RESREF, typename remove_const<RESREF>::type>↩
  ::value>::type>
  void write (array< size_type, DIM > pos, access_type colors)
- template<typename POS , typename = typename enable_if<is_same<typename POS::value_type, size_type>::value>::type>
  void write (POS pos, access_type colors)

5.23.1 Detailed Description

template<unsigned int DIM, typename T, bool normalized>
template<typename RESREF>
struct goopax::impl::image_array_resource< DIM, T, normalized >::image_slice< RESREF >

Reference to single image in the image array.

5.23.2 Member Function Documentation

5.23.2.1 read() [1/4]

```
access_type read (
            array< size_type, DIM > pos ) const  [inline]
```

read from image slice

Parameters

pos	image position
return	pixel at the given position

5.23.2.2 read() [2/4]

```
access_type read (
            array< U, DIM > pos,
            sampler_mode sampler = address_none | filter_nearest ) const  [inline]
```

read from image slice with sampler

Parameters

pos	position, may be an array of type gpu_int, gpu_uint, or gpu_float
sampler	mode.
return	pixel

5.23.2.3 read() [3/4]

```
access_type read (
            POS pos ) const  [inline]
```

read pixel.

Parameters

pos	pixel position. May be any container that provides the [] operator
return	pixel at the given position

5.23.2.4 read() [4/4]

```
access_type read (
            POS pos,
            sampler_mode sampler ) const  [inline]
```

read from image with sampler

Parameters

pos	position, may be any container that provides the [] operator, and that holds values of type gpu_int, gpu_uint, or gpu_float
sampler	mode.
return	pixel

5.23.2.5 write() [1/2]

```
void write (
            array< size_type, DIM > pos,
            access_type colors )  [inline]
```

write to image

Parameters

pos	pixel position
colors	pixel color to write

5.23.2.6 write() [2/2]

```
void write (
            POS pos,
            access_type colors )  [inline]
```

write to image

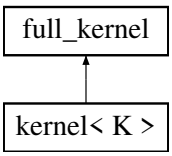
Parameters

pos	pixel position
colors	pixel color to write. May be any container that provides the [] operator

5.24 kernel< K > Struct Template Reference

kernel class to derive gpu kernels from

Inheritance diagram for kernel< K >:



Public Member Functions

- template<class... A>
  auto operator() (goopax_device device, A &&... a)

  Operator (). This starts the gpu kernel on the device. The parameters must match the arguments specified in the function 'program()', exept that cpu types are passed, where gpu types are specified in the function 'program()'. The device may be specified as a first argument. This is optional except if the device cannot be deduced from the other arguments. All buffers must reside on the same device, which is the device on which the kernel is executed.
- template<class... A>
  auto operator() (A &&... a)
- kernel ()
- kernel (kernel &&)=default

  move semantics
- kernel & operator= (kernel &&b)

5.24.1 Detailed Description

template<class K>
struct goopax::impl::ns_param_kernel::kernel< K >

kernel class to derive gpu kernels from

Parameters

K	derived kernel class. If The C++ language standard is < 14, any return type of the kernel must be specified with the RETURN_TYPE template argument. All gpu kernels must be derived from this class, where the new class must be passed as template argument, like so: struct my_kernel : public kernel<my_kernel> { void program(...) {...} };

5.24.2 Constructor & Destructor Documentation

5.24.2.1 kernel()

```
kernel ( )  [inline]
```

constructor

5.24.3 Member Function Documentation

5.24.3.1 operator()()

```
auto operator() (
            A &&...  a )  [inline]
```

Operator (). This starts the gpu kernel on the device. The parameters must match the arguments specified in the function 'program()', exept that cpu types are passed, where gpu types are specified in the function 'program()'. The device is deduced from the buffers that are passed as arguments.

5.24.3.2 operator=()

```
kernel& operator= (
            kernel< K > && b )  [inline]
```

move semantics

5.25 local_scope_mem< T, SCOPE > Class Template Reference

Inherits lds_type< T, goopax::impl::Tuint, SCOPE >.

Public Member Functions

- cpu_size_type size () const
- iterator begin ()
- const_iterator begin () const
- iterator end ()
- const_iterator end () const
- template<typename RESOURCE_SIZE_TYPE , bool is_const>
  void copy (const resource< T, RESOURCE_SIZE_TYPE, is_const > &r, size_type count, typename resource< T, RESOURCE_SIZE_TYPE, is_const >::size_type start_dest, size_type start_src)
- template<typename RESOURCE_SIZE_TYPE , bool is_const>
  void copy (const resource< T, RESOURCE_SIZE_TYPE, is_const > &r)
- template<memory::scope BSCOPE>
  void copy (const local_scope_mem< T, BSCOPE > &b, size_t count, typename local_scope_mem< T, B↩ SCOPE >::size_type start_dest, size_type start_src)
- template<memory::scope BSCOPE>
  void copy (const local_scope_mem< T, BSCOPE > &b)
- void fill (value_type value)
- local_scope_mem (local_scope_mem &&)=default
  move semantics
- local_scope_mem & operator= (local_scope_mem &&)=default
  move semantics
- local_scope_mem (typename gettype< size_type >::cpu size)

5.25.1 Detailed Description

template<typename T, memory::scope SCOPE>
class goopax::impl::local_scope_mem< T, SCOPE >

This class is used for local and private memory.

5.25.2 Constructor & Destructor Documentation

5.25.2.1 local_scope_mem()

```
local_scope_mem (
            typename gettype< size_type >::cpu size )  [inline]
```

constructor.

Parameters

size	size of the local/private memory

5.25.3 Member Function Documentation

5.25.3.1 begin() [1/2]

```
iterator begin ( )  [inline]
```

returns begin() pointer

5.25.3.2 begin() [2/2]

```
const_iterator begin ( ) const  [inline]
```

returns begin() pointer

5.25.3.3 copy() [1/4]

```
void copy (
            const local_scope_mem< T, BSCOPE > & b )  [inline]
```

copy data from another local/private memory. For local memory, the copy operation is done in parallel in the workgroup. For private memory, each thread performs its own copy operation.

Parameters

b	local/private memory to copy data from

5.25.3.4 copy() [2/4]

```
void copy (
            const local_scope_mem< T, BSCOPE > & b,
            size_t count,
            typename local_scope_mem< T, BSCOPE >::size_type start_dest,
            size_type start_src )  [inline]
```

copy data from another local/private memory. For local memory, the copy operation is done in parallel in the workgroup. For private memory, each thread performs its own copy operation.

Parameters

b	local/private memory to copy data from
count	number of elements to copy
start_dest	offset in destination memory
start_src	offset in source memory

5.25.3.5 copy() [3/4]

```
void copy (
            const resource< T, RESOURCE_SIZE_TYPE, is_const > & r )  [inline]
```

copy data from resource. For local memory, the copy operation is done in parallel in the workgroup. For private memory, each thread performs its own copy operation.

Parameters

r	resource to copy data from

5.25.3.6 copy() [4/4]

```
void copy (
            const resource< T, RESOURCE_SIZE_TYPE, is_const > & r,
            size_type count,
            typename resource< T, RESOURCE_SIZE_TYPE, is_const >::size_type start_dest,
            size_type start_src )  [inline]
```

copy data from resource. For local memory, the copy operation is done in parallel in the workgroup. For private memory, each thread performs its own copy operation.

Parameters

r	resource to copy data from
count	size number of values to copy
start_dest	offset in local/private memory
start_src	offset in the source resource

5.25.3.7 end() [1/2]

```
iterator end ( )  [inline]
```

returns end() iterator

5.25.3.8 end() [2/2]

```
const_iterator end ( ) const  [inline]
```

returns end() iterator

5.25.3.9 fill()

```
void fill (
            value_type value )  [inline]
```

fill local/private memory. For local memory, the fill operation is done in parallel over the workgroup.

Parameters

value	value to fill memory with

5.25.3.10 size()

```
cpu_size_type size ( ) const  [inline]
```

size of local/private memory

5.26 numeric_limits< goopax::gpu_type< T > > Struct Template Reference

numeric_limits overload for GPU types

Inherits numeric_limits< T >.

5.26.1 Detailed Description

template<typename T>
struct std::numeric_limits< goopax::gpu_type< T > >

numeric_limits overload for GPU types

5.27 resource< T, SIZE_TYPE, is_const > Class Template Reference

Inherits uav_type< T, gettype< SIZE_TYPE >::cpu, memory::none >.

Public Member Functions

- template<memory::scope BSCOPE, typename EIF = void, typename = typename enable_if<!is_const, EIF>::type>
  void copy (const local_scope_mem< T, BSCOPE > &src, typename local_scope_mem< T, BSCOPE >::size_type count, typename local_scope_mem< T, BSCOPE >::size_type start_dest, size_type start_src=0)
- resource (resource &&)=default
  move semantics
- resource & operator= (resource &&)=default
  move semantics

iterator access

- iterator begin ()
- const_iterator begin () const
- iterator end ()
- const_iterator end () const

constructors

Resources normally need not be constructed by the user. Instead, they are passed as references to the gpu kernel. Resources can, however, be instantiated to be linked to a specific buffer

- resource ()
- resource (buffer_type &a)
- template<typename EIF = void, typename = typename enable_if<is_const, EIF>::type>
  resource (const buffer_type &a)

5.27.1 Detailed Description

template<typename T, typename SIZE_TYPE = Tuint, bool is_const = false>
class goopax::impl::resource< T, SIZE_TYPE, is_const >

Resource type, used to access buffers from device code. Resources are usually provided as arguments for gpu kernels. The template parameters T and SIZE_TYPE must match the corresponding template parameters of the buffer.

Template Parameters

T	value type. This can either be a CPU intrinsic type, or a goopax struct type.
SIZE_TYPE	This can be a 32 bit or 64 bit integer type.
is_const	only read access is allowed. This has the same effect as using a const reference of the resource as kernel parameter.

5.27.2 Constructor & Destructor Documentation

5.27.2.1 resource() [1/3]

```
resource ( )  [inline]
```

default constructor. The resulting resource cannot be used. It has to be replaced by a resource that is linked to a buffer before it can be used.

5.27.2.2 resource() [2/3]

```
resource (
            buffer_type & a )  [inline]
```

constructor. The resource is linked to the provided buffer

Parameters

a	buffer to link resource to. The buffer must exist and be properly initialized before the kernel is first called.

5.27.2.3 resource() [3/3]

```
resource (
            const buffer_type & a )  [inline]
```

constructor. The resource is linked to the provided const buffer This constructor is only available if is_const=true.

Parameters

a	buffer to link resource to. The buffer must exist and be properly initialized before the kernel is first called.

5.27.3 Member Function Documentation

5.27.3.1 begin() [1/2]

```
iterator begin ( )  [inline]
```

returns begin() pointer

5.27.3.2 begin() [2/2]

```
const_iterator begin ( ) const  [inline]
```

returns begin() pointer

5.27.3.3 copy()

```
void copy (
            const local_scope_mem< T, BSCOPE > & src,
            typename local_scope_mem< T, BSCOPE >::size_type count,
            typename local_scope_mem< T, BSCOPE >::size_type start_dest,
            size_type start_src = 0 )  [inline]
```

copy data from local memory or private memory to the resource (i.e. to global memory) For local memory, the copy operation is parallelized over the workgroup. For private memory, the copy operation is performed for the individual threads.

Parameters

src	source
count	number of values to copy
start_dest	offset in resource
start_src	offset in source memory

5.27.3.4 end() [1/2]

```
iterator end ( )  [inline]
```

pointer to the end of the resource

5.27.3.5 end() [2/2]

```
const_iterator end ( ) const  [inline]
```

pointer to the end of the resource

5.28 sresource< STR, BASE > Struct Template Reference

Public Member Functions

- reference operator[ ] (const size_type &pos)
  element access
- const_reference operator[ ] (const size_type &pos) const
  element access

5.28.1 Detailed Description

template<class STR, class BASE>
struct goopax::impl::gpu_struct::sresource< STR, BASE >

base for resource class.

5.29 svm_buffer< T > Class Template Reference

Shared Virtual Memory (called Unified Memory in CUDA)

Public Member Functions

- void map (const T *begin, const T *end, BUFFER_FLAGS flags=BUFFER_READ_WRITE) const
- void map (BUFFER_FLAGS flags=BUFFER_READ_WRITE) const
- void unmap (const T *begin) const
- void unmap () const

  indicate that host access has completed
- svm_buffer (goopax_device device, Tsize_t size, BUFFER_FLAGS flags=BUFFER_READ_WRITE)

5.29.1 Detailed Description

template<typename T>
class goopax::impl::svm_buffer< T >

Shared Virtual Memory (called Unified Memory in CUDA)

5.29.2 Constructor & Destructor Documentation

5.29.2.1 svm_buffer()

```
svm_buffer (
            goopax_device device,
            Tsize_t size,
            BUFFER_FLAGS flags = BUFFER_READ_WRITE )  [inline]
```

Construct svm memory region with shared address space between host and device.

Parameters

device	device that should be able to access the memory
size	size in number of elements of type T
flags	gpu access flags

5.29.3 Member Function Documentation

5.29.3.1 map() [1/2]

```
void map (
            BUFFER_FLAGS flags = BUFFER_READ_WRITE ) const  [inline]
```

prepare memory for host access.

Parameters

flags	host access flags

5.29.3.2 map() [2/2]

```
void map (
            const T * begin,
            const T * end,
            BUFFER_FLAGS flags = BUFFER_READ_WRITE ) const  [inline]
```

prepare memory region for host access.

Parameters

begin	start of mapped region
end	end of mapped region
flags	host access flags

5.29.3.3 unmap()

```
void unmap (
            const T * begin ) const  [inline]
```

indicate that host access has completed

Parameters

begin	begin pointer used when calling map

5.30 WELL512 Class Reference

Public Member Functions

- void seed (goopax_device device, const vector< Tuint32_t > &seed)

5.30.1 Detailed Description

Random number generator, based on the WELL512 algorithm. An object of this class must be instantiated to be used from kernels.

5.30.2 Member Function Documentation

5.30.2.1 seed()

```
void seed (
            goopax_device device,
            const vector< Tuint32_t > & seed )  [inline]
```

Set random seed. All threads will get an additional offset by goopax, so that they all produce different random numbers.

Parameters

device	device for which to set the random seed
seed	seed data, may be any size, maximum 16.

5.31 WELL512lib Class Reference

Public Member Functions

- template<typename T >
  vector< typename gettype< T >::gpu > gen_vec ()
- WELL512lib (WELL512 &well)

5.31.1 Detailed Description

Random number generator, used in device code This object must be linked to an WELL512 object in host code

5.31.2 Constructor & Destructor Documentation

5.31.2.1 WELL512lib()

```
WELL512lib (
            WELL512 & well )  [inline]
```

Constructor. Must be linked to an existing WELL512 object.

Parameters

well	existing WELL512 object.

5.31.3 Member Function Documentation

5.31.3.1 gen_vec()

```
vector<typename gettype<T>::gpu> gen_vec ( )  [inline]
```

Generate uniformly distributed random numbers of type T. With each call, a vector of values is created. For optimal performance, all values in the vector should be used. Floating point values are normalized in the range [0,1). Integer values are equally distributed over all possibly values.

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