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THE HETEROGENEOUS SYSTEMS EXPERTS

# Channels

Or why the managed_ptr is more complex than it appears

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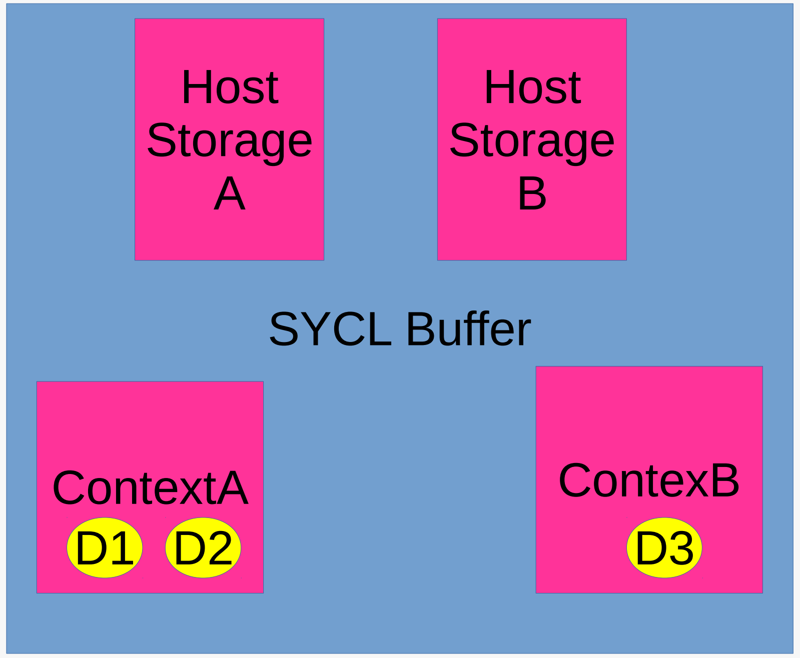
# SYCL Buffers

- In SYCL, buffers represent allocation of memory on the system
  - The user has no control on where the allocation resides
- Data follows execution across devices on the system
  - User can provide hints to where data will be
  - Dataflow patterns can be extracted to optimize performance
- Data cannot be extracted from buffers directly, accessors are used to indicate where access is requested

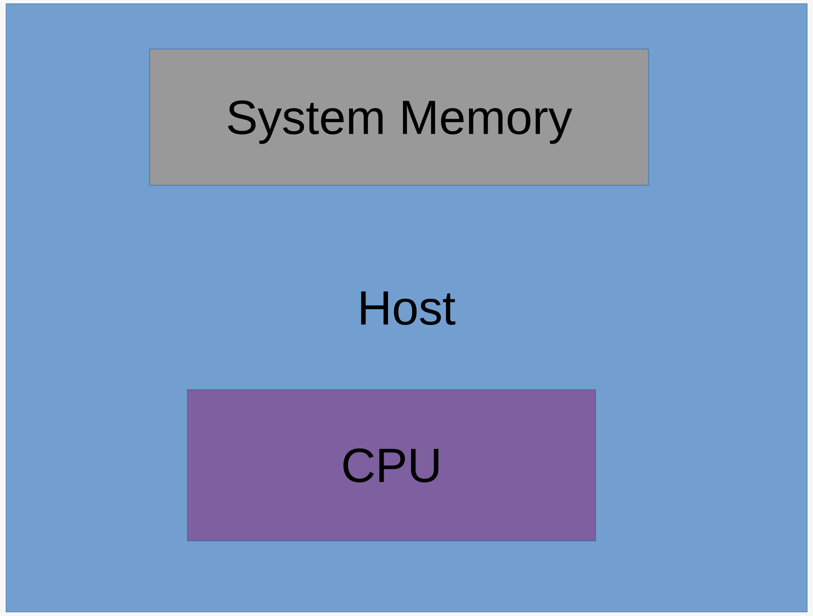
```
buffer<float, 1, CustomAllocator> buf{myPtr, range<1>{1}};
```

# SYCL Buffers – How do they work

- A buffer holds a directory of different copies of the data in different OpenCL contexts and places in host memory
- Last place where data was accessed holds most updated data
- When data is required on different context/host, is moved across the heterogeneous system
- **Data is updated using the most efficient method for the platform**



# Traditional views of memory

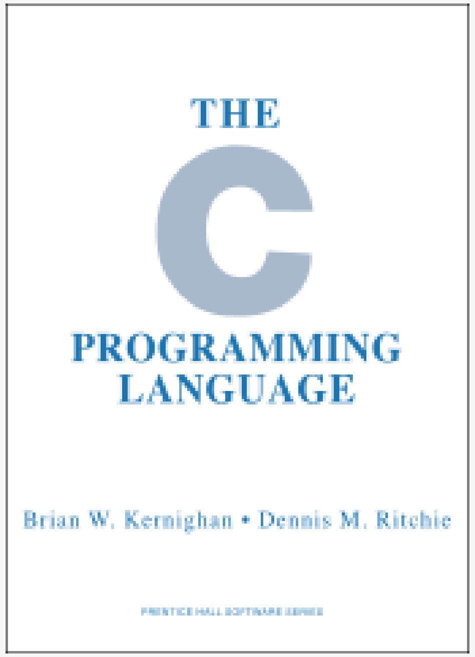


Traditional Computer Model

- Can allocate memory, use it on the CPU

Fortran

C++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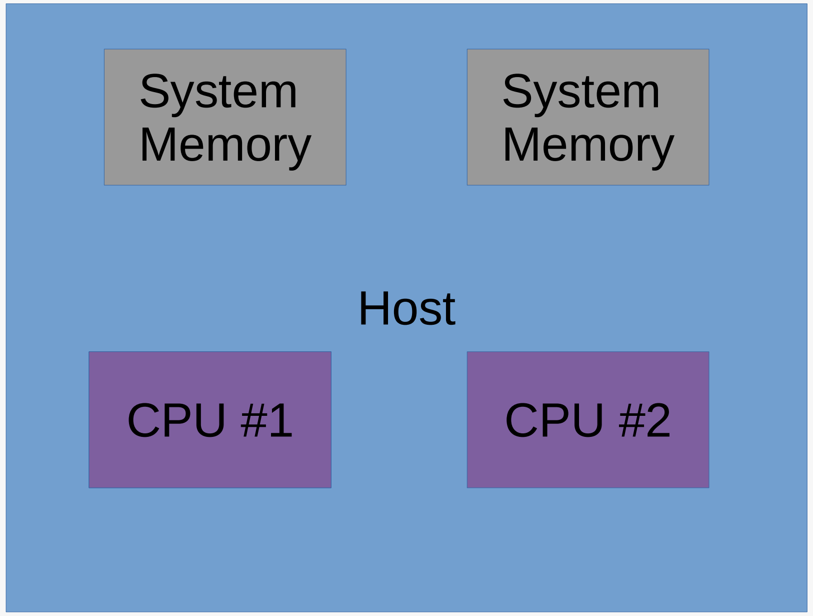
# Slightly more complex...



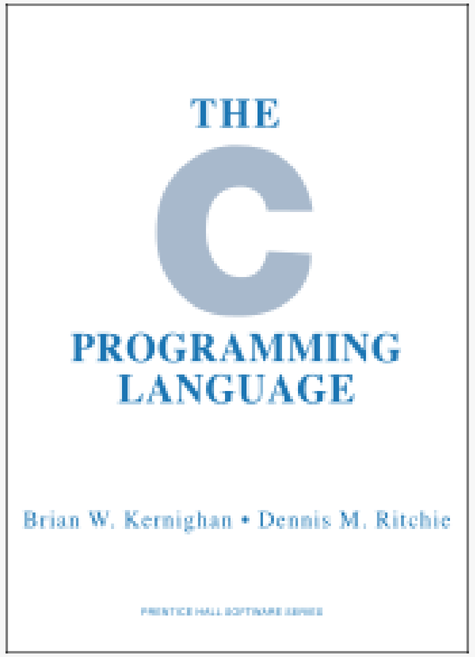
Multi-CPU system

- Can allocate memory anywhere
- Can use it anywhere
- Access time may not be uniform! (NUMA)

Fortran

C++

Custom Allocators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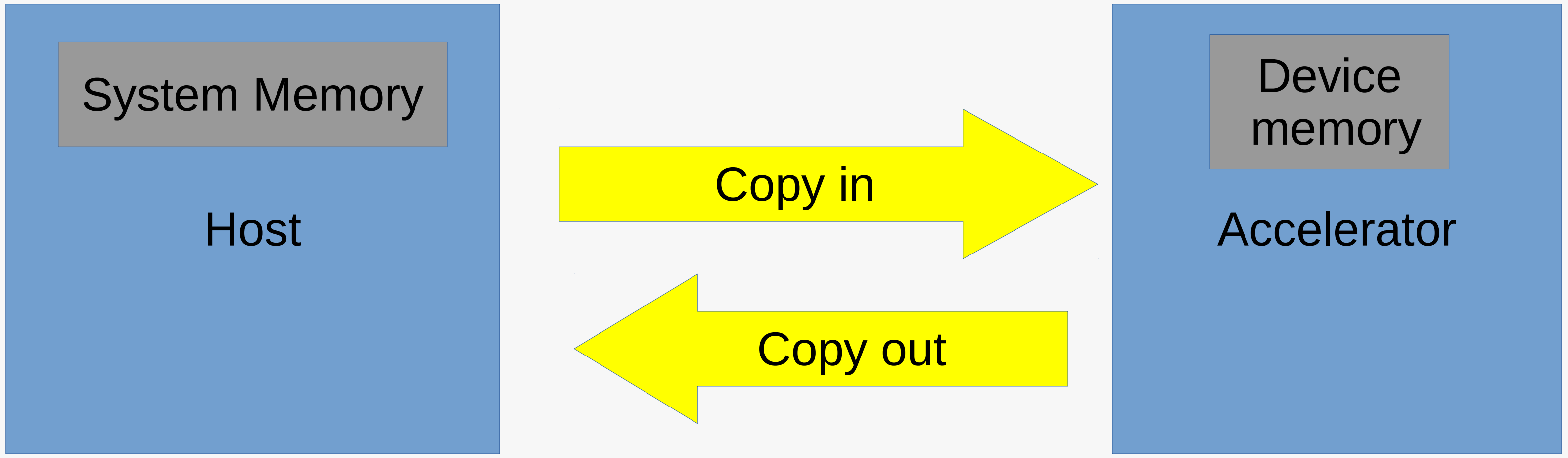
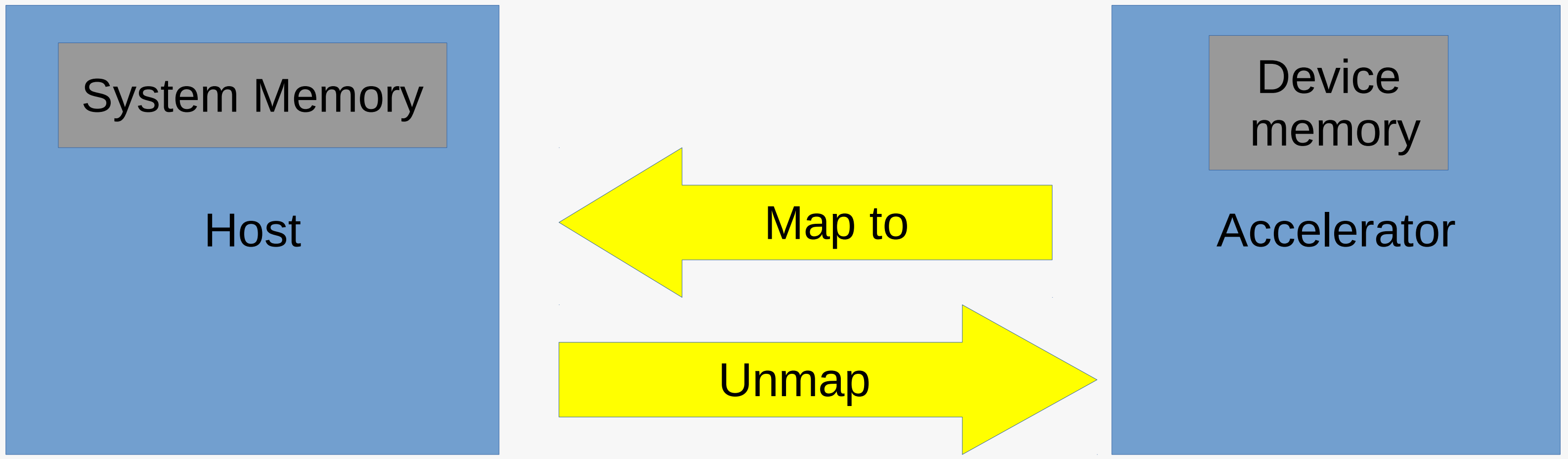
# Separate memory layouts



Host-directed accelerator model:

- Data is off-loaded on the device
- Host allocates on device
- No mapped pointers

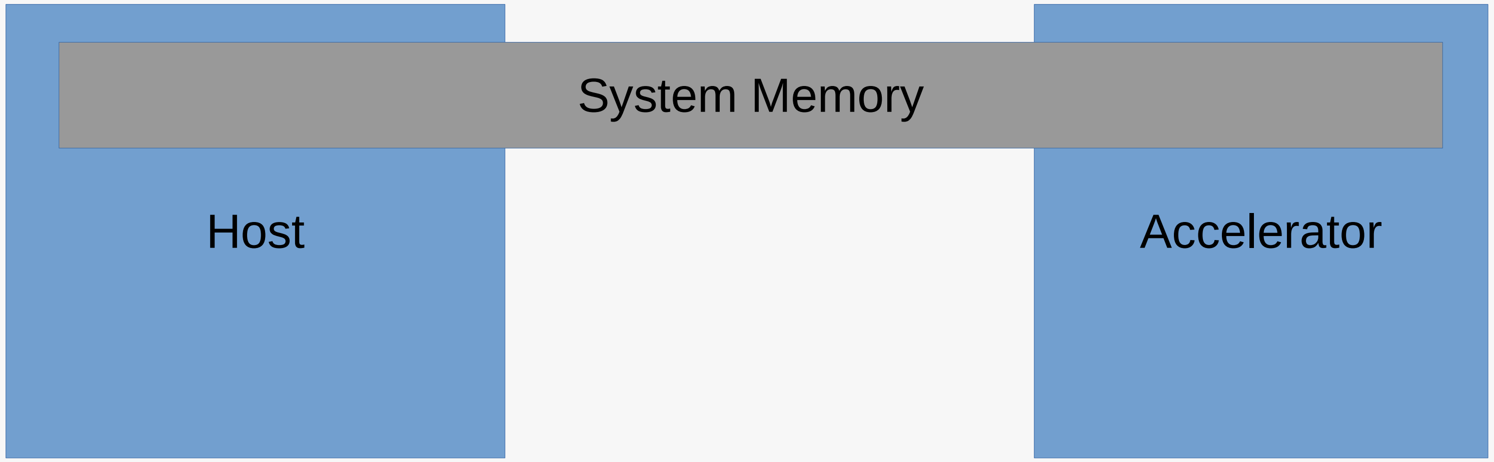
# Partially accessible pointers



Host-directed model

- Data is off-loaded on the device
- Host allocates on device
- Mapped pointer access device on host

# The illusion of memory



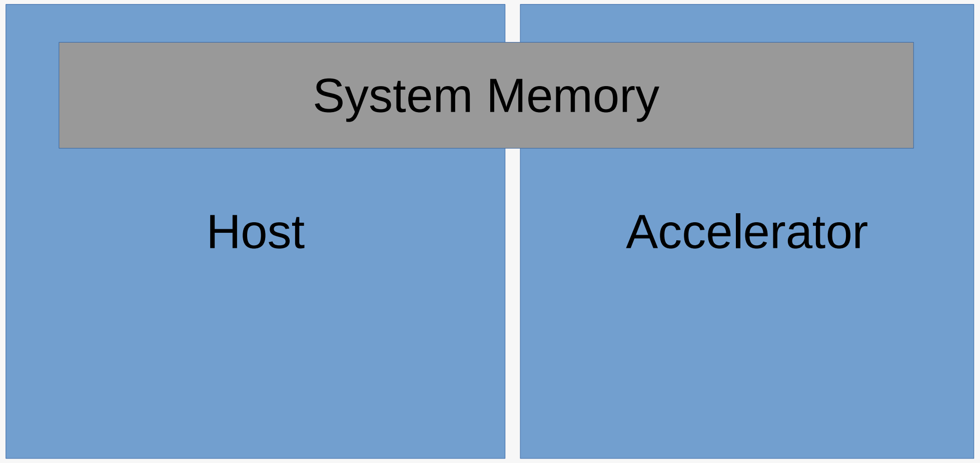
2.0

UVA

Virtual Shared memory

- Illusion of coherent access, performance impact
- Special malloc function
- System handles transparently access in host and accelerator
- No atomics or concurrent access across devices

# What we all ideally want

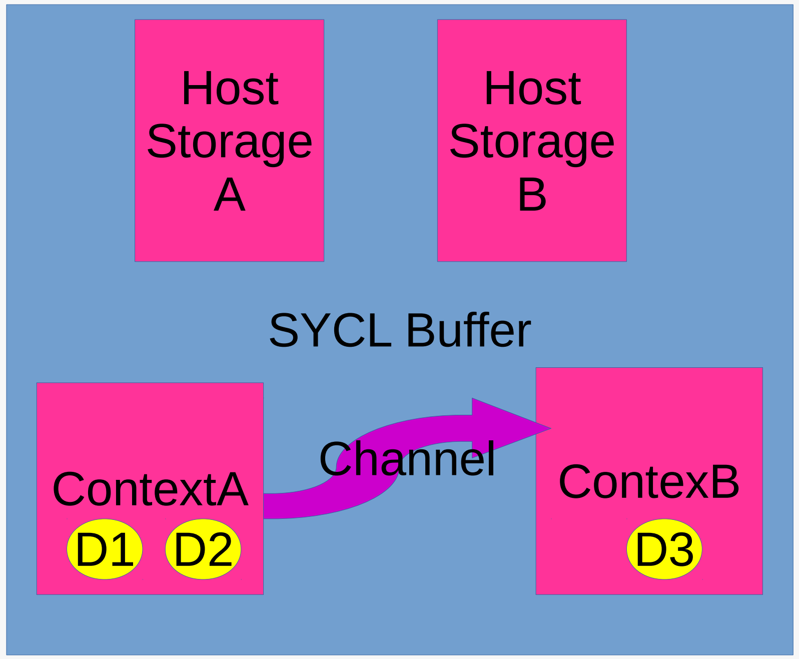


Real shared memory access

- Device an accelerator share physical memory
- Atomic operations are possible in all levels
- Hardware complexity is much higher

# Implementing the SYCL buffer

- When data is required in a different context, we need to open a **channel** from the previous one to the new one
- This channel represents the fastest way of communicating SYCL contexts
- The actor can be either in the new context or in the old one
  - The new context can **get** the information from thew previous one
  - The old context can **put** information on the new one



# Is a SYCL buffer the right abstraction for C++?

- SYCL buffers have some limitations
  - Group Working on improvements for next specification
- **SYCL implementations shipped to an specific system, implementor nows all possible connections between OpenCL contexts or devices**
- Is this the case in C++?
  - Offering a generic managed_ptr would need each implementor to provide its own implementation or customization point
  - Some vendors or libraries may implement optimized channels for execution for a certain platform, how do they integrate their solutions to work with the managed_ptr?

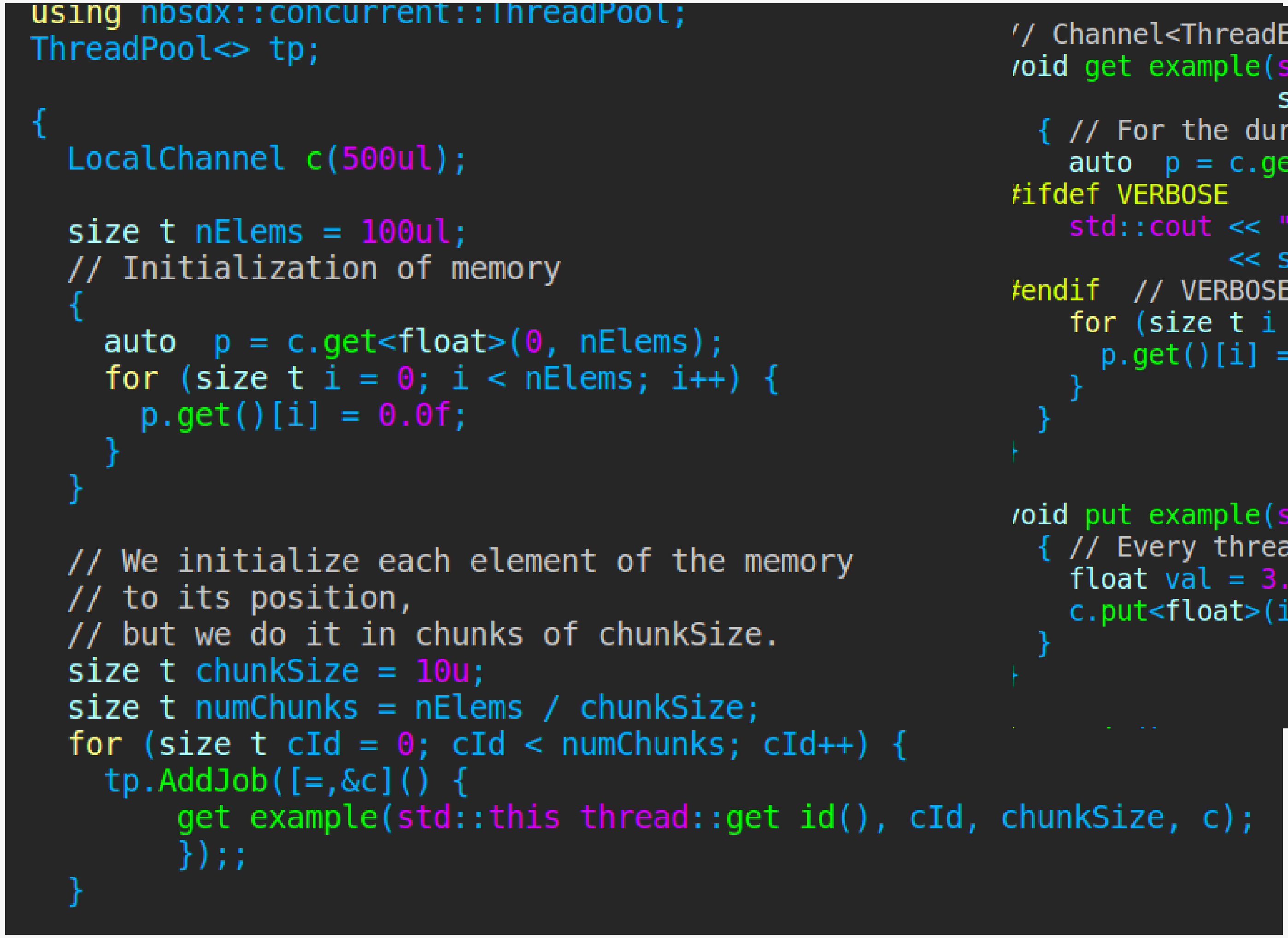
# The Channel interface

- A channel is a simple interface, defines:
  - An asynchronous put method to put data on a channel
  - A blocking get method that gets data from the channel
- The get method returns an object that has access to some portion of memory in the channel
  - Only one side of the channel can access a **locked_page**

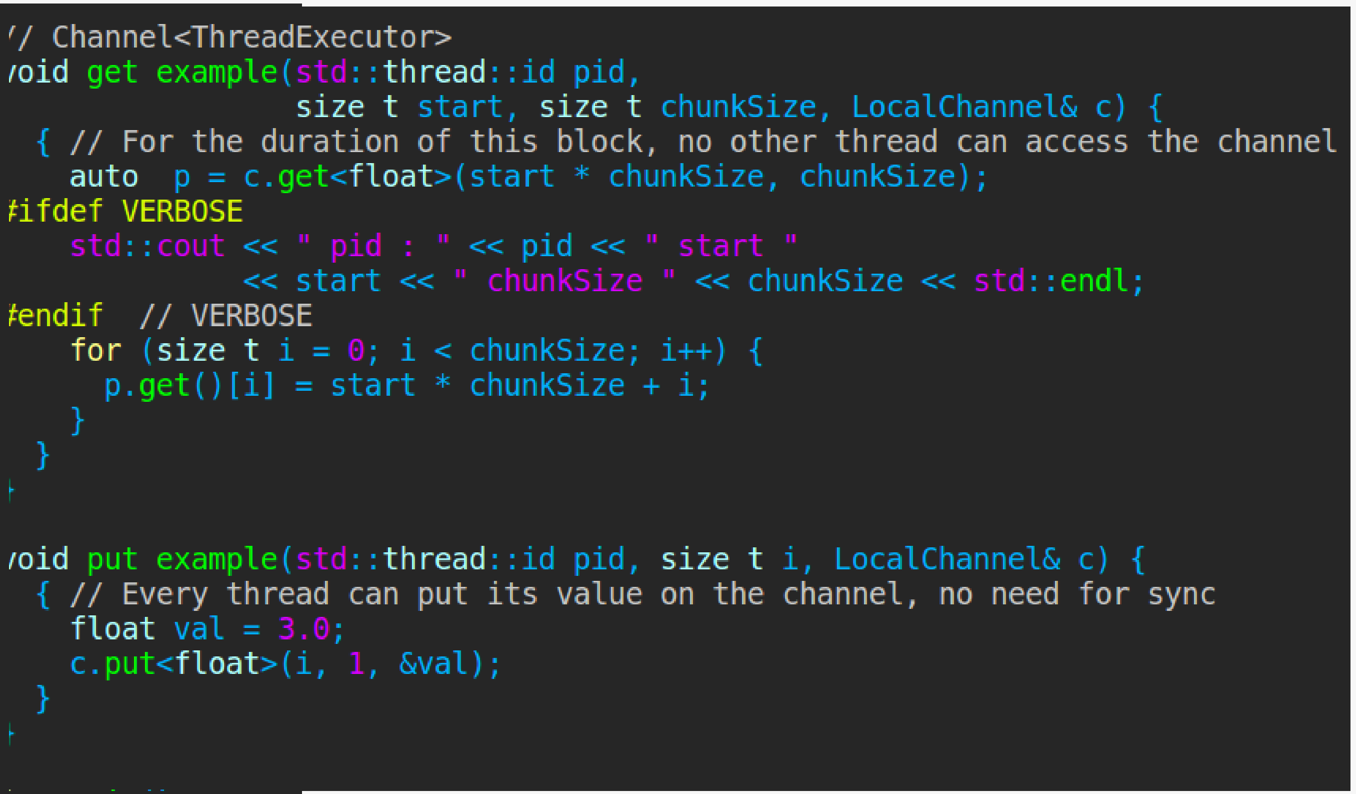
This constructor should optionally take a size in bytes

```
/** Channel.
 * Generic Channel interface
 */
template<channels ChannelT>
class Channel {

  public:
    Channel() = default;
    Channel(const Channel&) = default;
    Channel(Channel&&) = default;
    ~Channel() = default;

    // Put
    template<typename U>
    void put(off t off, size t nElems, U * ptr) = delete;

    // Get
    template<typename T>
    locked page<T> get(off t offset, size t nElems) = delete;
};

using LocalChannel = Channel<channels::Local>;
using MPIChannel = Channel<channels::MPI>;
```

# A trivial example using Threads



```
using nbsdx::concurrent::ThreadPool;
ThreadPool<> tp;

{
  LocalChannel c(500ul);

  size t nElems = 100ul;
  // Initialization of memory
  {
    auto  p = c.get<float>(0, nElems);
    for (size t i = 0; i < nElems; i++) {
      p.get()[i] = 0.0f;
    }
  }

  // We initialize each element of the memory
  // to its position,
  // but we do it in chunks of chunkSize.
  size t chunkSize = 10u;
  size t numChunks = nElems / chunkSize;
  for (size t cId = 0; cId < numChunks; cId++) {
    tp.AddJob([=,&c]() {
        get example(std::this thread::get id(), cId, chunkSize, c);
        });;
  }
```



```
/ Channel<ThreadExecutor>
/oid get example(std::thread::id pid,
                 size t start, size t chunkSize, LocalChannel& c) {
  { // For the duration of this block, no other thread can access the channel
    auto  p = c.get<float>(start * chunkSize, chunkSize);
ifdef VERBOSE
    std::cout << " pid : " << pid << " start "
              << start << " chunkSize " << chunkSize << std::endl;
endif  // VERBOSE
    for (size t i = 0; i < chunkSize; i++) {
      p.get()[i] = start * chunkSize + i;
    }
  }


/oid put example(std::thread::id pid, size t i, LocalChannel& c) {
  { // Every thread can put its value on the channel, no need for sync
    float val = 3.0;
    c.put<float>(i, 1, &val);
  }
```

## Using Execution Contexts

- Execution agents from a given Execution Context can obtain an allocator from the Execution Context
- In order for an execution agent to access memory from a different Execution Context, a Channel is required.
- Custom implementations for pairs of Execution Contexts can be provided
- **Developers can implement their own Channels for two given Execution Context**
  - This facilitates the creation of third-party libraries
- Not required if your system is fully coherent
  - But even if it is, developers can create a channel to connect a third-party device

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## Thanks for Listening

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