Math 4997-3

Lecture 18: Distributed implementation of the heat equation I

Patrick Diehl 

https://www.cct.lsu.edu/~pdiehl/teaching/2021/4997/

Reminder

Lecture 17

What you should know from last lecture

- How to use components and actions to make remote function calls

Compile HPX with network support

Parcelports [1]

To compile HPX using network support use following CMake option `-DHPX_WITH_NETWORKING=ON` and choose one of the following parcel ports:

- `HPX_WITH_PARCELPORT_MPI` (Message Passing Interface[1])
- `HPX_WITH_PARCELPORT_LIBFABRIC` (Libfabric[2])
- `HPX_WITH_PARCELPORT_TCP` (Transmission Control Protocol)

Compile HPX with the MPI parcel port:

```
cmake -DCMAKE_BUILD_TYPE=Release \
      -DHPX_WITH_NETWORKING=ON   \
      -DHPX_WITH_PARCELPORT_MPI=ON ..
```

[1] https://www.open-mpi.org/

[2] https://ofiwg.github.io/libfabric/

Running distributed HPX applications

Using srun

```
srun -p <partition> -N <number-of-nodes> my_hpx
```

Example:

```
srun -p marvin -N 2 ./bin/hello_world
```

Using a batch job

```
#!/usr/bin/env bash
#SBATCH -o hostname_%j.out
#SBATCH -t 0-00:02
#SBATCH -p marvin
#SBATCH -N 2

srun ~/demo_hpx/bin/hello_world
```

Example:

```
sbatch example.sbatch
```

HPX features

Getting topology information[3]

- `hpx::find_here`
  Get the global address of the locality the function is called on.
- `hpx::find_all_localities`
  Get the global addresses of all available localities.
- `hpx::find_remote_localities`
  Get the global addresses of all available remote localities.
- `hpx::get_num_localities`
  Get the number of all available localities.
- `hpx::find_locality`
  Get the global address of any locality hosting the component.
- `hpx::get_colocation_id`
  Get the locality hosting the object with the given address.

[3] https://stellar-group.github.io/hpx/docs/sphinx/latest/html/manual/writing_distributed_hpx_applications.html

Update the 1D heat equation code

Adding serialization functionality

```
struct partition_data
{
private:

friend class hpx::serialization::access;

template <typename Archive>
void serialize(Archive& ar, const unsigned int version)
{
    ar & data_ & size_ & min_index_;
}

};
```

Reducing the overhead of copying I


```
struct partition_server
  : hpx::components::component_base<partition_server>
{

enum partition_type
{
   left_partition, middle_partition, right_partition
};

};
```

Reducing the overhead of copying II

```
partition_data get_data(partition_type t) const
{
    switch (t)
    {
     case left_partition:
        return partition_data(data_, data_.size()-1);

     case middle_partition:
        break;

     case right_partition:
        return partition_data(data_, 0);

     default:
         HPX_ASSERT(false);
         break;
    }
         return data_;
}
```

Reducing the overhead of copying III

```
struct partition : hpx::components::client_base<
        partition, partition_server>
{
  //We pass no the type of the partition to the action
  // to avoid copying the mid partition as it is on
  // the same locality
  hpx::future<partition_data> get_data(
        partition_server::partition_type t) const
  {
        partition_server::get_data_action act;
        return hpx::async(act, get_id(), t);
  }

};
```

Reducing the overhead of copying IIII

```
return dataflow(
  hpx::launch::async,
  unwrapping(
    [left, middle, right](partition_data const& l,
      partition_data const& m,
      partition_data const& r)
        {
          HPX_UNUSED(left);
          HPX_UNUSED(right);

          return partition(middle.get_id(),
              heat_part_data(l, m, r));
        }
        ),
    left.get_data(partition_server::left_partition),
    middle.get_data(partition_server::middle_partition),
    right.get_data(partition_server::right_partition)
);
```

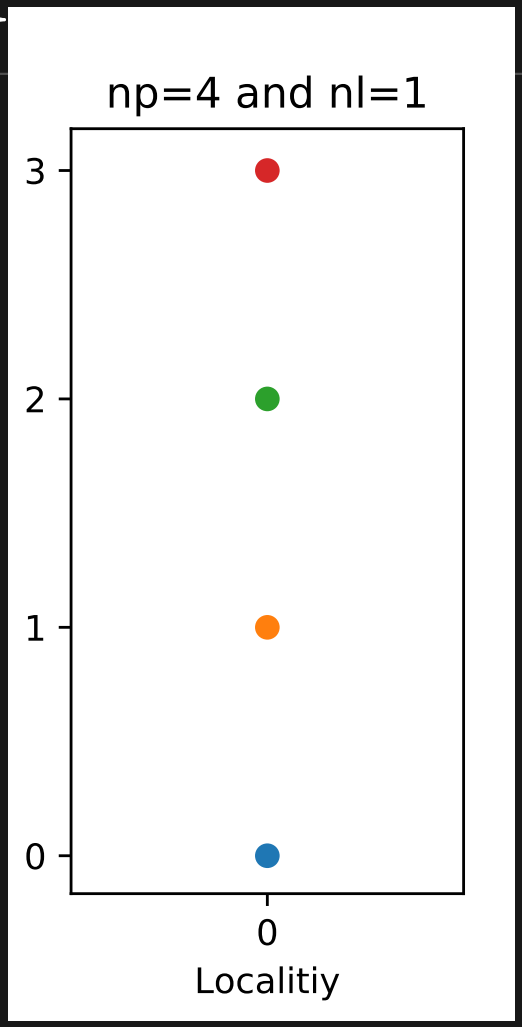
Distributing the work to the localities

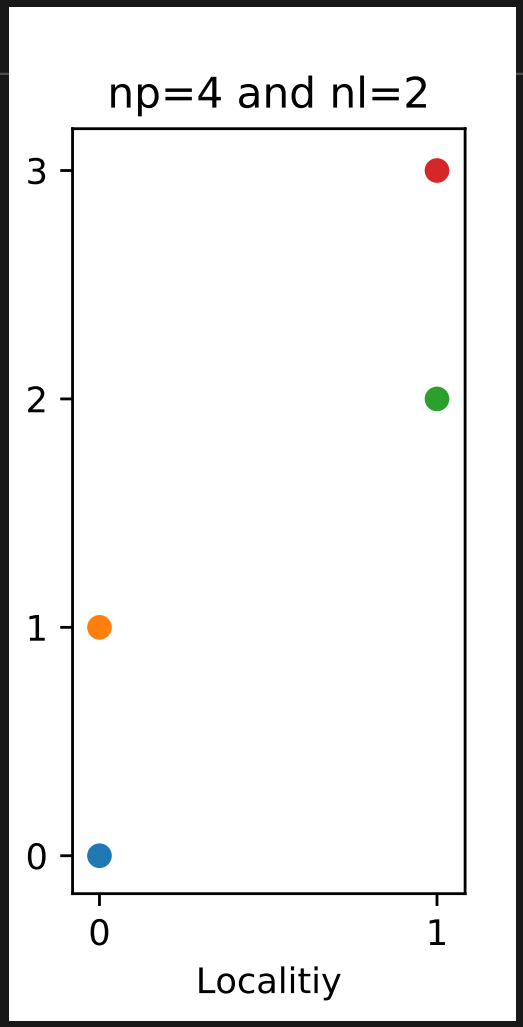
```
// Find all available localities
std::vector<hpx::id_type> localities =
        hpx::find_all_localities();
// Determine the number ol localities
std::size_t nl = localities.size();

// Generate the partition on the localities
// Note before we had hpx::find_here there
for (std::size_t i = 0; i != np; ++i)
  U[0][i]
     = partition(localities[locidx(i, np, nl)],
       nx, double(i));
```

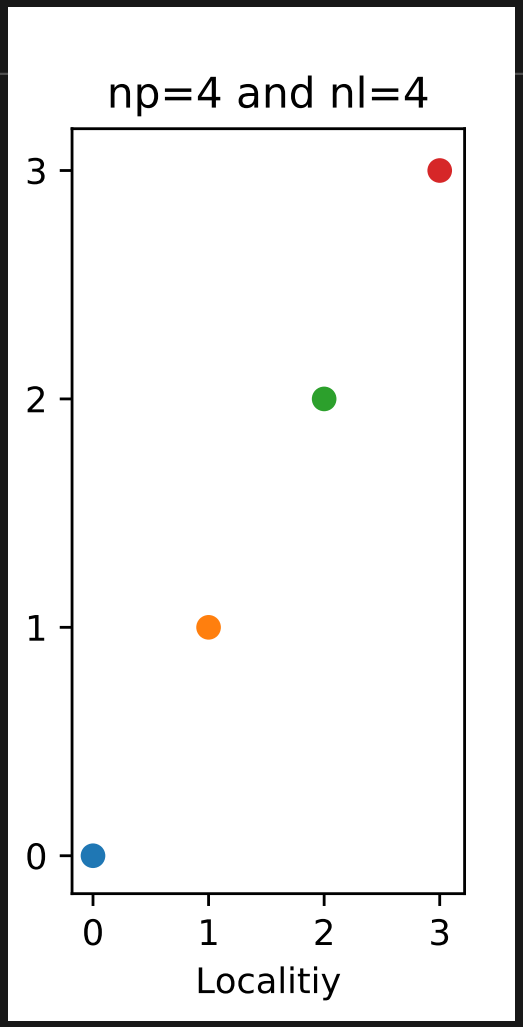
We use `locidx` to decide on which locality the partition is generated.

Define the locality

```
std::size_t locidx(std::size_t i, std::size_t np,
        std::size_t nl)
{
    return i / (np/nl);
}
```







Scaling results

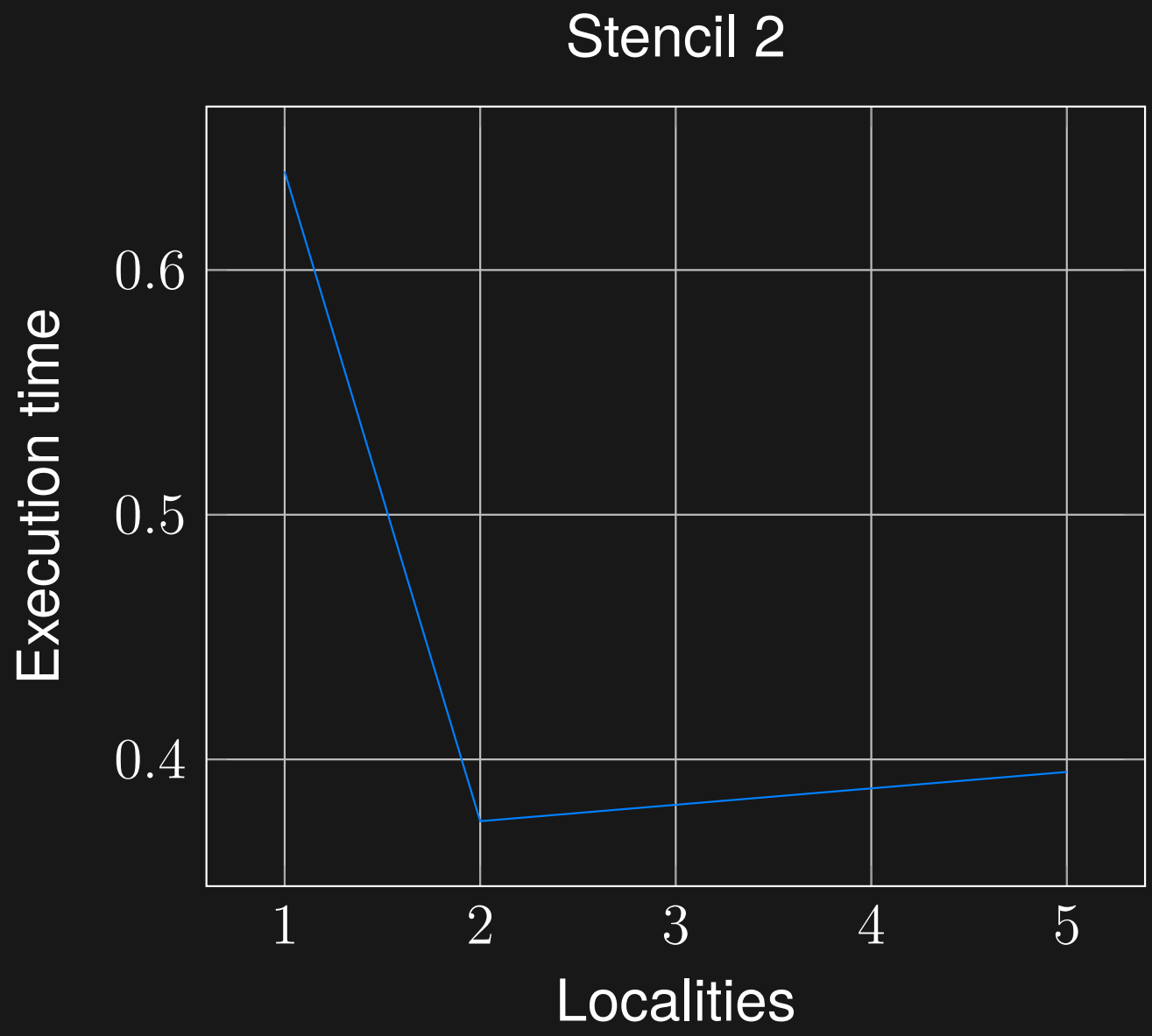
Configuration file

```
#!/usr/bin/env bash

#SBATCH -o hostname_%j.out
#SBATCH -t 00:25:00
#SBATCH -p medusa
#SBATCH -D /home/pdiehl/Compile/hpx-1.3.0/build/bin/
export LD_LIBRARY_PATH
  =$LD_LIBRARY_PATH:
  /home/pdiehl/Compile/hpx-1.3.0/build/lib

module load gcc/8.2.0 boost/1.69.0-gcc8.2.0-release
        mpi/openmpi-x86_64

srun 1d_stencil_6 --nx=1000000 --np=10
```

Running

```
sbatch -N 1,2,3,4,5 stencil.sbatch
```

Distributed scaling



Summary

Summary

After this lecture, you should know

- How to compile HPX using networking
- Receiving topology information

References

References I

[1] Hartmut Kaiser, Maciek Brodowicz, and Thomas Sterling.
Parallex an advanced parallel execution model for scaling-impaired applications.
In *2009 International Conference on Parallel Processing Workshops*, pages 394–401. IEEE, 2009.