Introduction to HPC

Preparing environment

Radim Janalík

Università della Svizzera italiana

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ICS cluster - icsmaster

- 2 login nodes
  - `icsmaster[01,02]`
- 40 compute nodes
  - `icsnode[01-40]`
  - 24 nodes only with CPU
    - 2 x Intel E5-2650 v3, 20 (2 x 10) cores
    - 64GB RAM
  - 8 nodes with GPU
    - 2 x Intel E5-2650 v3, 20 (2 x 10) cores
    - 1 x NVIDIA GeForce GTX 1080, 2560 CUDA cores
    - 128GB RAM
  - 8 nodes with Intel Xeon Phi comprocessors
    - 2 x Intel E5-2650 v3, 20 (2 x 10) cores
    - 3 x Intel Xeon Phi SC7120P coprocessors, 61 cores
    - 128GB RAM

Accessing icsmaster

- You will receive your login credentials by email
- Connect to the cluster using ssh

```
$ ssh studXX@hpc.ics.usi.ch
```

- To avoid typing the password you can generate ssh-key (on your laptop) and copy it to the cluster

```
$ ssh-keygen -t rsa
$ cat ~/.ssh/id_rsa.pub | ssh studXX@hpc.ics.usi.ch 'cat >> .ssh↩
    /authorized_keys'
```

Accessing icsmaster

- Add host configuration to `~/.ssh/config`

```
Host icsmaster
   Hostname hpc.ics.usi.ch
   Port 22
   User studXX
   IdentityFile ~/.ssh/id_rsa
```

- Now you can connect to icsmaster without password

```
$ ssh icsmaster
```

Moving data

- laptop → icsmaster

```
$ scp file.c icsmaster:~/remote_dir/
$ scp -r local_dir icsmaster:~/remote_dir/
```

- icsmaster → laptop

```
$ scp icsmaster:~/remote_dir/file.c local_dir/
$ scp -r icsmaster:~/remote_dir/ local_dir/
```

Modules

- Software on the cluster is organized into modules
- Before using some program, you have to load a module

```
$ module load gcc/6.1.0
```

- You can unload modules you don't want anymore

```
$ module unload gcc/6.1.0
```

- Or you can swap modules to get different version

```
$ module swap gcc/6.1.0 gcc/5.3.0
```

- List currently loaded modules

```
$ module list
```

- List all available modules

```
$ module avail
```

Editing code

- To edit files on the cluster you can use vim

```
$ vim main.c
```

- For easier moving / editing, you can mount home directory from cluster to your local machine, then you can work with files on the cluster as if it would be on your laptop
  - First install FUSE and SSHFS from `https://osxfuse.github.io`
  - Then you can mount remote directory

```
$ sshfs icsmaster: <mountpoint>
```

  - And unmount

```
$ umount <mountpoint>
```

Compiling code

- Load modules before compiling the code

```
$ module load gcc/6.1.0
```

- Then you can compile the code

```
$ gcc main.c -o main
```

- Pro tip: add `module load ...` to your `~/.bashrc`
  - It will load modules automatically when you log in

Running code

- When you log in to the cluster, you are on login node
  - There are two login nodes
    - `icsmaster01`
    - `icsmaster02`
  - You can use login node to edit and compile your code
  - **But you should never run the code on login node**
- For running your code, there are 40 compute nodes
  - `icsnode[01-40]`
- There are two ways how you can work on compute node
  - Interactive session
  - Batch job

Interactive session

- In interactive session you have direct access to compute node from your terminal
- Interactive session is useful especially for debugging
- When you allocate a node, nobody else can use it at the same time
- But it can take a long time to get access to the node

- First you have to allocate the node
- Let's say you want 1 node for 1 hour

```
$ salloc --nodes=1 --time=01:00:00
```

- Then you can run your app on the compute node

```
$ ./your_app
```

- Or you can use srun that does the allocation automatically

```
$ srun --nodes=1 ./your_app
```

Batch job

- When running batch job, you don't have direct access to the compute node
- You write a script with commands you want execute on the node
- The script is added to a queue and executed later
- Output of the script is written to a file. You can look at is when the job is finished
- Batch job is useful when you have working code and you want to run your app on large data

Batch job

- Job script template

```
#!/bin/bash -l

#SBATCH --job-name=my_job
#SBATCH --time=01:00:00
#SBATCH --nodes=1
#SBATCH --output=%j.out
#SBATCH --error=%j.err

# load modules

# your commands
```

- Add job to a queue

```
$ sbatch job.sh
```

- Show your running and queued jobs

```
$ squeue -u studXX
```

- Cancel job

```
$ scancel <job_id>
```

Reservation

- For the lectures there are some nodes reserved only for the students of this class
- Use argument `--reservation=HPC_tuesday` or `--reservation=HPC_wednesday`

```
$ salloc --reservation=HPC_tuesday
$ srun --reservation=HPC_tuesday ./your_app
```

- Use the reservation only in the class
- When the reservation is not active, you would wait forever
- In class

```
$ srun --reservation=HPC_tuesday ./your_app
```

- At home

```
$ salloc --nodes=1 --time=01:00:00
$ ./your_app
```

Git repository with source codes

- We prepared for you git repository with source codes for this lecture
  - `https://github.com/rjanalik/HPC_2017`
- Clone the repository on both icsmaster and your laptop

```
$ git clone https://github.com/rjanalik/HPC_2017.git
```

- Later we will update the repository with source codes for other lectures and assignments
- To download the latest version use

```
$ git pull
```

BLAS and LAPACK on OS X

- BLAS and LAPACK libraries are already installed on your Mac
- To link BLAS library, add `-lblas` switch to `gcc`

```
$ gcc blas.c -o blas -lblas
$ ./blas
```

- For LAPACK add `-lblas` and `-llapack`

```
$ g++ -c -Wall main.cpp -o main.o
$ g++ main.o -o testprog -lblas -llapack
$ ./testprog
```

OpenMPI on OS X

- To compile and run MPI applications on your Mac you have to build OpenMPI first
- To not mess up system directories I compile everything in `~/Apps`
  - It makes your life easier when you decide to remove it
  - Feel free to use your favourite directory instead of `~/Apps`
- Download the latest version from `https://www.open-mpi.org/software/ompi/v3.0/`

```
$ cd ~/Apps
$ wget https://www.open-mpi.org/software/ompi/v3.0/downloads/↩
    openmpi-3.0.0.tar.gz
$ tar -zxf openmpi-3.0.0.tar.gz
```

- Configure, build and install the library
- Don't forget about `--prefix`

```
$ cd openmpi-3.0.0/
$ ./configure --prefix=$HOME/Apps/openmpi-3.0.0
$ make all
$ make install
```

OpenMPI on OS X

- Now you have OpenMPI library installed in `~/Apps/openmpi-3.0.0`
- To use it you have to add `bin` direcotry to variable `$PATH`

```
$ export PATH=$PATH:$HOME/Apps/openmpi-3.0.0/bin
```

- You can add this export to `~/.bashrc` so you don't have to do it every time you open terminal

- Now you can try if it works

```
$ mpicc mpi_hello.c -o mpi_hello
$ mpirun -np 2 ./mpi_hello
```

Intel Math Kernel Library

- Intel Math Kernel Library is part of Parallel Studio XE Cluster Edition
- Download and register at `https://software.intel.com/en-us/intel-parallel-studio-xe`
- Choose Intel Parallel Studio XE Cluster Edition
- Choose Version: 2018 Initial Release
- Install Intel Parallel Studio XE Cluster Edition
- e.g. `gunzip parallel_studio_xe_2018_cluster_edition.tgz`

Intel MKL installation & usage

- Before using MKL set the environment variables

```
$ . /opt/intel/mkl/bin/mklvars.sh intel64
$ . /opt/intel/bin/compilervars.sh intel64
```

- Compile with

```
$ gcc dgemm_example.c -lmkl_intel_lp64 -lmkl_core  -↩
    lmkl_sequential -lm -o dgemm_example
```

- Run

```
$ ./dgemm_example
```

- After successful execution

```
Deallocating memory;  Example completed.
```