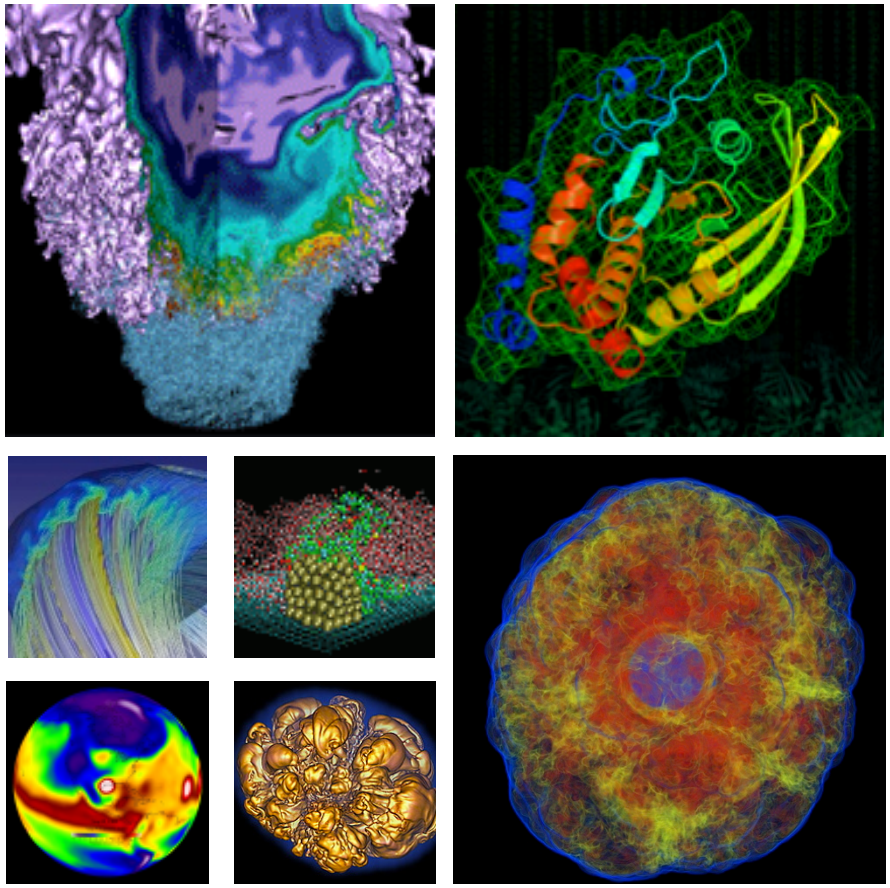
Allinea MAP and Perf-report

New User Training 2017



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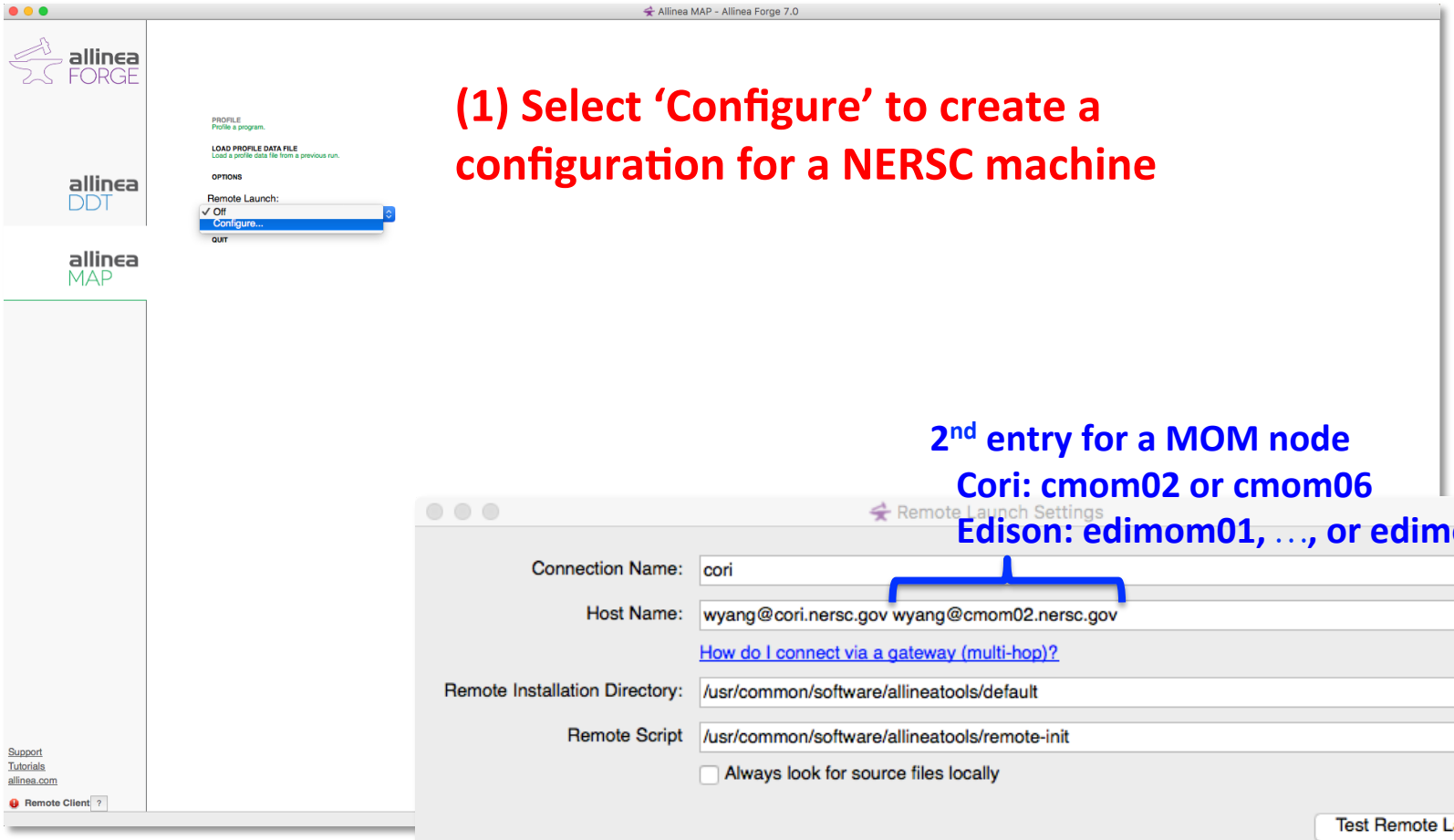
MAP

- **Allinea's parallel profiling tool with GUI**
- **Based on sampling**
  - Source lines are annotated with performance data
  - Time series of performance metrics for all (MPI) processes are displayed
- **4,096 MAP license tokens (MPI tasks)**
  - Shared by other users and among all machines
- **Use NX or Allinea remote client**
- **Reverse connect also works for MAP**
- **For info:**
  - https://www.allinea.com/products/map
  - https://www.nersc.gov/users/software/debugging-and-profiling/MAP/

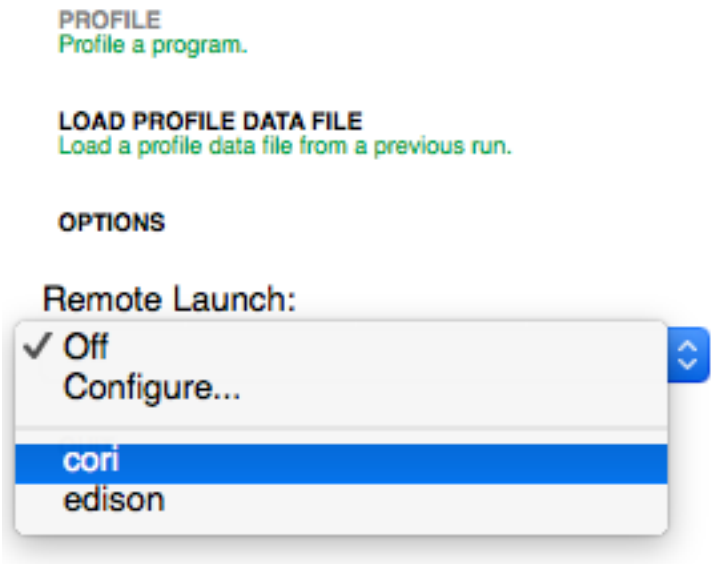
Using Allinea remote client



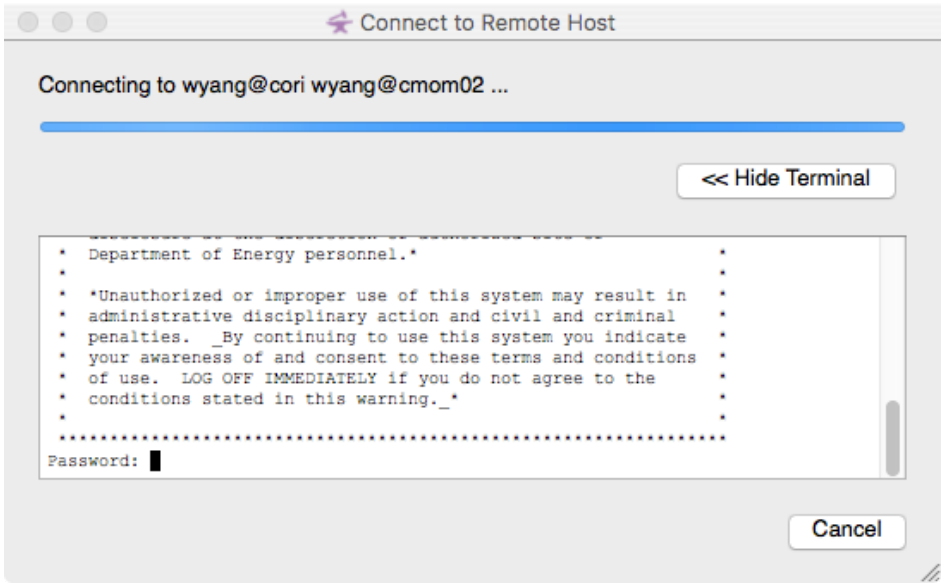
Note that the paths will change for future versions

Using Allinea remote client (Cont'd)

(3) Select a machine



(4) Enter the NIM password

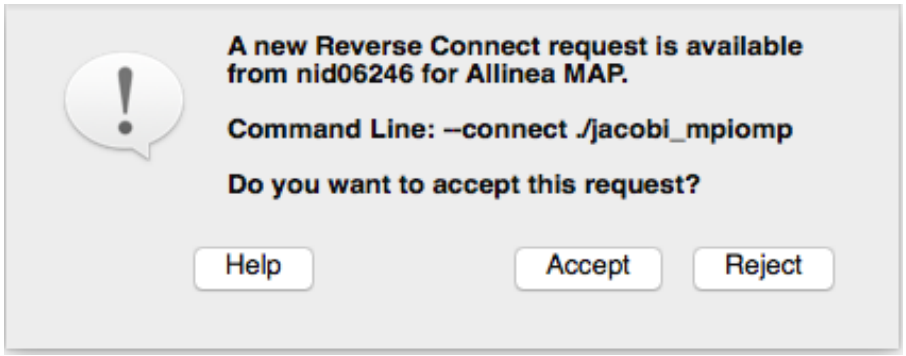


Using Allinea remote client (Cont'd)

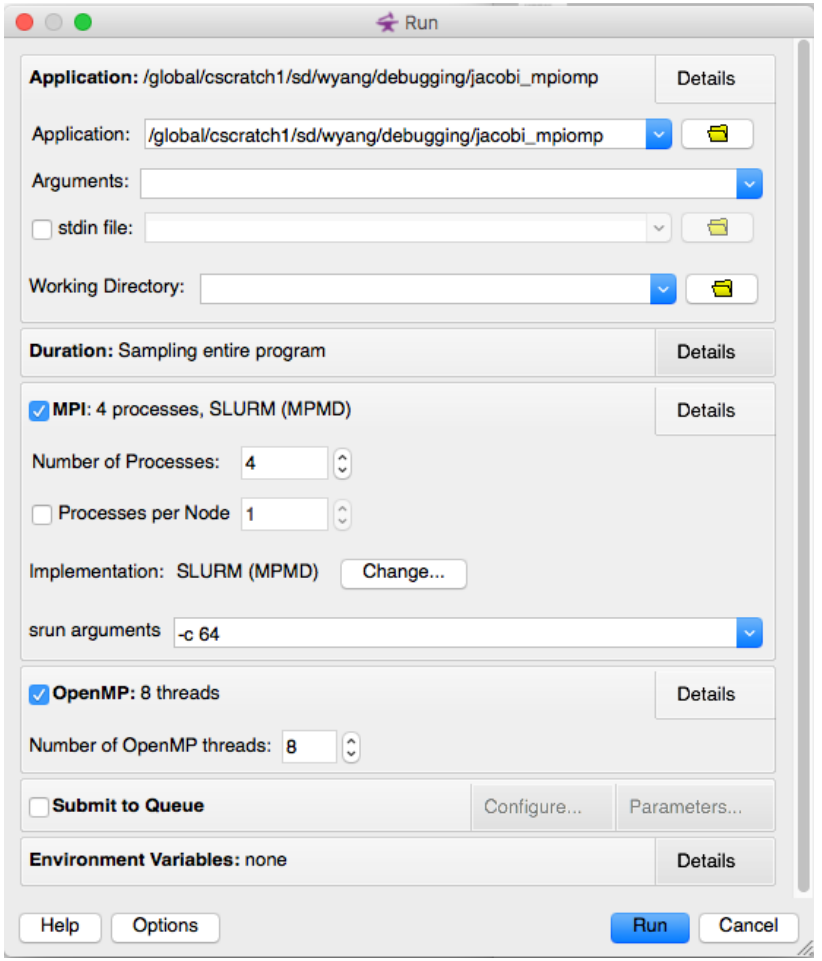
(5) Submit a batch job on a NERSC machine and start DDT

```
$ salloc -N 1 -t 30:00 -p debug -C knl
...
$ module load allineatools
$ map --connect ./jacobi_mpiomp
```

(6) Accept the request



(7) Set parameters and run



How to profile with MAP

The module name will change to 'forge' for future versions

- **Build a statically-linked executable**

```
$ module load allineatools
$ make-profiler-libraries --lib-type=static
$ ftn -c -g -O3 -qopenmp jacobi_mpiomp.f90
$ ftn -O3 -qopenmp jacobi_mpiomp.o -Wl,@./allinea-profiler.ld -o jacobi_mpiomp
```

Build 2 static libs that MAP needs

Use the MAP-provided option file

- **Build a dynamically-linked executable**

```
$ ftn -c -g -O3 -qopenmp jacobi_mpiomp.f90
$ ftn -dynamic -O3 -qopenmp jacobi_mpiomp.o -Wl,--eh-frame-hdr
```

- **Run**

```
$ salloc -N 1 -t 30:00 -p debug -C knl

$ module load allineatools

$ map ./jacobi_mpiomp
$ map --profile srun -n 8 -c 32 ./jacobi_mpiomp

$ ls -l
-rw------- 1 wyang wyang 1253277 Feb 22 09:36 miniGhost_flat_96p_6n_2t_2017-02-22_09-16.map
$ map miniGhost_flat_96p_6n_2t_2017-02-22_09-16.map
```

GUI mode

Command-line mode

Profiling results saved in a file

To view it

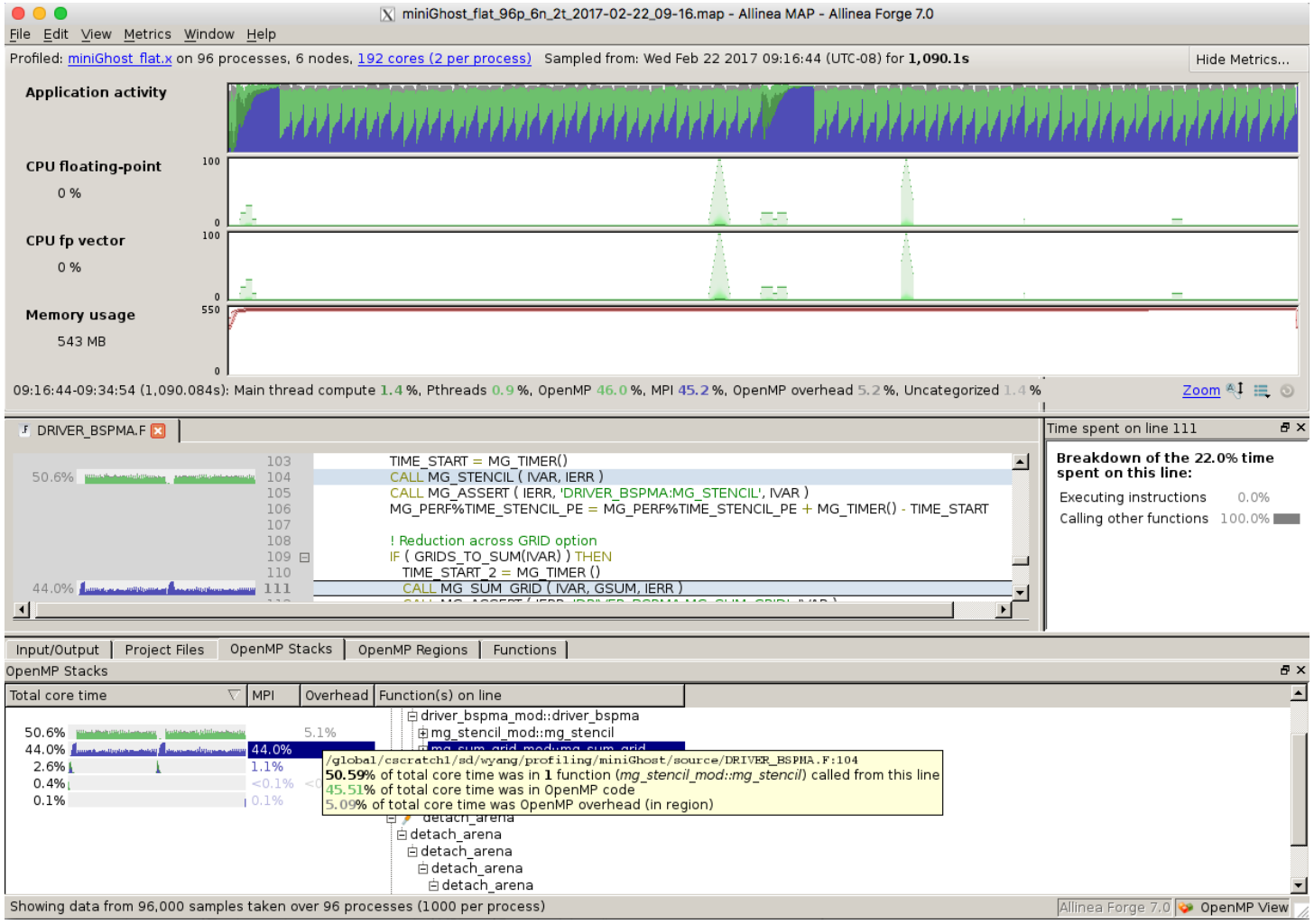
Using numactl on KNL

- Avoid using numactl with MAP/7.0, as in

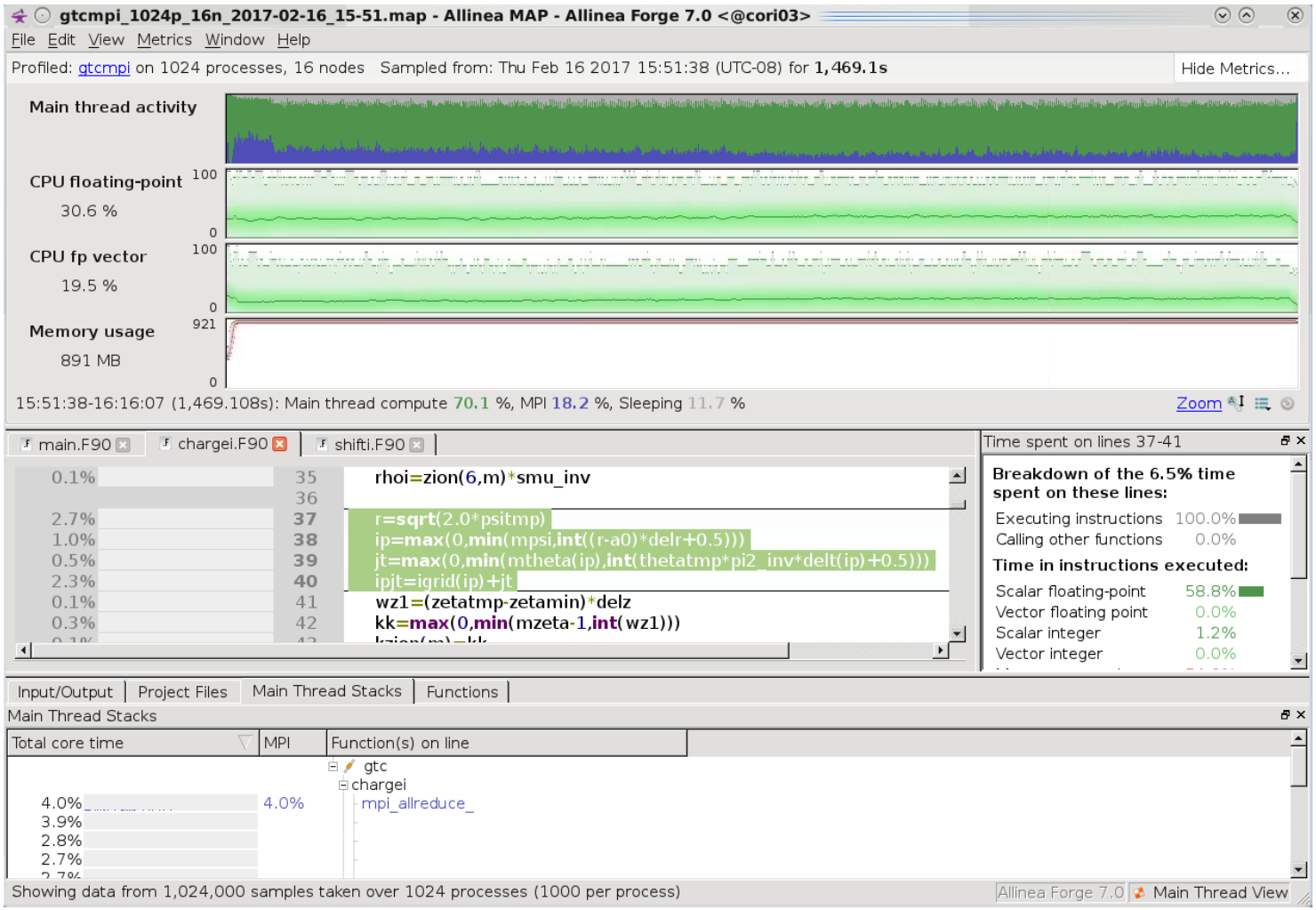
```
$ map srun –n ... numactl ... ./a.out
```

- Use '--mem-bind=map_mem:1' etc., with srun, instead of using 'numactl --mem_bind=1', etc.
- No equivalent for --preferred=1 for now.
- A workaround will be available with a new Slurm.

MAP results


miniGhost_flat_96p_6n_2t_2017-02-22_09-16.map - Allinea MAP - Allinea Forge 7.0
File Edit View Metrics Window Help
Profiled: miniGhost_flat.x on 96 processes, 6 nodes, 192 cores (2 per process) Sampled from: Wed Feb 22 2017 09:16:44 (UTC-08) for 1,090.1s
Hide Metrics...
Application activity
CPU floating-point
0 %
CPU fp vector
0 %
Memory usage
543 MB
09:16:44-09:34:54 (1,090.084s): Main thread compute 1.4 %, Pthreads 0.9 %, OpenMP 46.0 %, MPI 45.2 %, OpenMP overhead 5.2 %, Uncategorized 1.4 %
Zoom
DRIVER_BSPMA.F
TIME_START = MG_TIMER()
CALL MG_STENCIL (IVAR, IERR)
CALL MG_ASSERT (IERR, 'DRIVER_BSPMA:MG_STENCIL', IVAR)
MG_PERF%TIME_STENCIL_PE = MG_PERF%TIME_STENCIL_PE + MG_TIMER() - TIME_START
! Reduction across GRID option
IF (GRIDS_TO_SUM(IVAR)) THEN
TIME_START_2 = MG_TIMER ()
CALL MG_SUM_GRID (IVAR, GSUM, IERR)
Time spent on line 111
Breakdown of the 22.0% time spent on this line:
Executing instructions 0.0%
Calling other functions 100.0%
Input/Output
Project Files
OpenMP Stacks
OpenMP Regions
Functions
OpenMP Stacks
Total core time
MPI
Overhead
Function(s) on line
driver_bspma_mod::driver_bspma
mg_stencil_mod::mg_stencil
/global/cscratch1/sd/wyang/profiling/miniGhost/source/DRIVER_BSPMA.F:104
50.59% of total core time was in 1 function (mg_stencil_mod::mg_stencil) called from this line
45.51% of total core time was in OpenMP code
5.09% of total core time was OpenMP overhead (in region)
detach_arena
Showing data from 96,000 samples taken over 96 processes (1000 per process)
Allinea Forge 7.0
OpenMP View

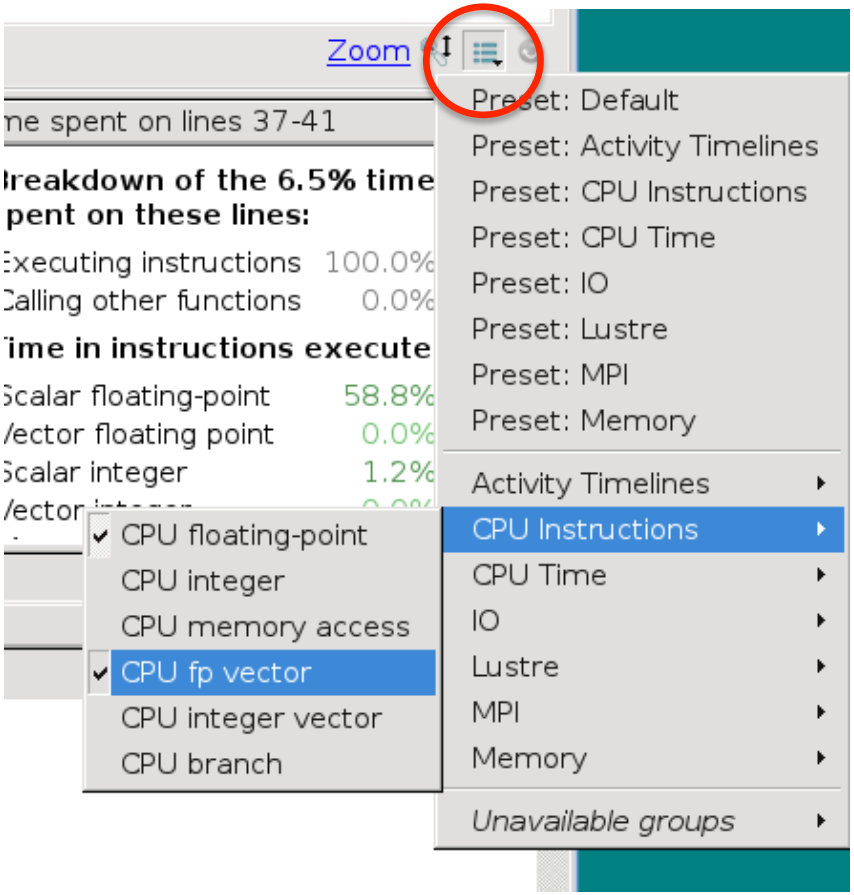
MAP results (Cont'd)



For the selected lines

Adding more metrics to the display panel

- **You can add more performance metrics**



Profiling only part of a program

- **C**
  - Include
    - `#include “mapsampler_api.h”`
    - `allinea_start_sampling()`
    - `allinea_stop_sampling()`
  - -I${ALLINEA_TOOLS_DIR}/${ALLINEA_TOOLS_VERSION}/map/wrapper
  - -L${ALLINEA_TOOLS_DIR}/${ALLINEA_TOOLS_VERSION}/lib/64 -lmap-sampler
- **Fortran**
  - Include
    - `CALL ALLINEA_START_SAMPLING()`
    - `CALL ALLINEA_STOP_SAMPLING()`
  - -L${ALLINEA_TOOLS_DIR}/${ALLINEA_TOOLS_VERSION}/lib/64 -lmap-sampler

- **Before starting your program:**

```
export ALLINEA_SAMPLER_DELAY_START=1
```

Perf-report

- **Newly installed on Cori and Edison**
- **Allinea's tool for a quick characterization of parallel code performance**
  - Based on times spent in 3 areas
  - "Compute-bound," "MPI-bound" or "I/O-bound"
  - Results in html and plain-text files
- **Build exactly the same way as you do with MAP**
- **4,096 license tokens (MPI tasks)**
- **For info:**
  - https://www.allinea.com/products/allinea-performance-reports

How to use perf-report

- **Run under perf-report**

```
$ salloc -N 1 -t 30:00 -p debug -C knl
$ module load allineatools/7.0-rep
$ export OMP_NUM_THREADS=8
$ perf-report srun -n 32 -c 8 ./jacobi_mpiomp
$ ls
miniGhost_flat_96p_6n_2t_2017-02-22_12-26.html
miniGhost_flat_96p_6n_2t_2017-02-22_12-26.txt
```

  - Don't run with numactl with version 7.0

The module name will change to 'reports' for future versions

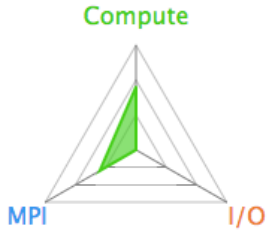
- **Generate a perf-report output from a map file**

```
$ module load allineatools/7.0-rep
$ perf-report miniGhost_flat_96p_6n_2t_2017-02-22_09-16.map
$ ls -l
miniGhost_flat_96p_6n_2t_2017-02-22_09-16.html
miniGhost_flat_96p_6n_2t_2017-02-22_09-16.map
miniGhost_flat_96p_6n_2t_2017-02-22_09-16.txt
```

Perf-report

allinea PERFORMANCE REPORTS

Command:	srun -n 96 --ntasks-per-node=16 -c 16 /tmp/miniGhost_cache.x --scaling 1 --nx 336 --ny 336 --nz 336 --num_vars 40 --num_spikes 1 --debug_grid 1 --report_diffusion 21 --percent_sum 100 --num_tsteps 2 --stencil 24 --comm_method 10 --report_perf 1 --npx 4 --npy 4 --npz 6 --error_tol 8
Resources:	6 nodes (68 physical, 272 logical cores per node)
Memory:	94 GiB per node
Tasks:	96 processes, OMP_NUM_THREADS was 2
Machine:	nid06709
Start time:	Wed Feb 22 2017 10:42:48 (UTC-08)
Total time:	1102 seconds (about 18 minutes)
Full path:	/tmp



Summary: miniGhost_cache.x is Compute-bound in this configuration

Compute	60.1%	Time spent running application code. High values are usually good. This is **average**; check the CPU performance section for advice
MPI	39.9%	Time spent in MPI calls. High values are usually bad. This is **average**; check the MPI breakdown for advice on reducing it
I/O	0.0%	Time spent in filesystem I/O. High values are usually bad. This is **negligible**; there's no need to investigate I/O performance

This application run was Compute-bound. A breakdown of this time and advice for investigating further is in the CPU section below.

Perf-report (cont'd)

CPU

A breakdown of the 60.1% CPU time:

Single-core code	2.0%
OpenMP regions	98.0%
Scalar numeric ops	4.9%
Vector numeric ops	<0.1%
Memory accesses	64.8%

The per-core performance is memory-bound. Use a profiler to identify time-consuming loops and check their cache performance.

No time is spent in vectorized instructions. Check the compiler's vectorization advice to see why key loops could not be vectorized.

MPI

A breakdown of the 39.9% MPI time:

Time in collective calls	97.1%
Time in point-to-point calls	2.9%
Effective process collective rate	5.24 bytes/s
Effective process point-to-point rate	2.88 MB/s

Most of the time is spent in collective calls with a very low transfer rate. This suggests load imbalance is causing synchronization overhead; use an MPI profiler to investigate.

I/O

A breakdown of the 0.0% I/O time:

Time in reads	0.0%
Time in writes	0.0%
Effective process read rate	0.00 bytes/s
Effective process write rate	0.00 bytes/s

No time is spent in I/O operations. There's nothing to optimize here!

OpenMP

A breakdown of the 98.0% time in OpenMP regions:

Computation	89.4%
Synchronization	10.6%
Physical core utilization	46.8%
System load	47.3%

Physical core utilization is low and some cores may be unused. Try increasing OMP_NUM_THREADS to improve performance.

Memory

Per-process memory usage may also affect scaling:

Mean process memory usage	518 MiB
Peak process memory usage	524 MiB
Peak node memory usage	12.0%

The peak node memory usage is very low. Running with fewer MPI processes and more data on each process may be more efficient.

About sample size

- **1,000 samples per (MPI) task by default**
- **With multithreading, the sample size per thread is reduced further**
- **Are they enough for a long running application?**
  - A 30-minute run: ~1 sample per every 2 sec (0.56 Hz vs. GHz of clockcycle)
  - CrayPat's sampling rate: 100 Hz by default
  - If this were for a binomial distribution (i.e., 2 outcomes only), 1,000 samples would be OK (3% of margin of error under 95% confidence level). But it's a multinomial distribution, instead.
- **Can increase the sample size via the ALLINEA_SAMPLER_NUM_SAMPLES environment variable**
- **Can profile only an interesting portion (to have smaller margins of error without having to use a large sample size)**

National Energy Research Scientific Computing Center