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High performance tools to debug, profile, and analyze your applications

Accelerate HPC Development with Allinea Performance Tools

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allinea FORGE

allinea DDT

allinea MAP

allinea PERFORMANCE REPORTS

Agenda

- 09:00 – 09:15 Introduction to Allinea Tools
- 09:15 – 09:30 Analyse your Applications on ARCHER
- 09:30 – 09:45 Retrieve Hardware Counters' Data
- 09:45 – 10:15 Write Application-specific Metrics
- 10:15 – 10:30 Wrap-up and questions

- Afternoon: Hands-on coaching on your own codes

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Example: Weather and Forecasting models

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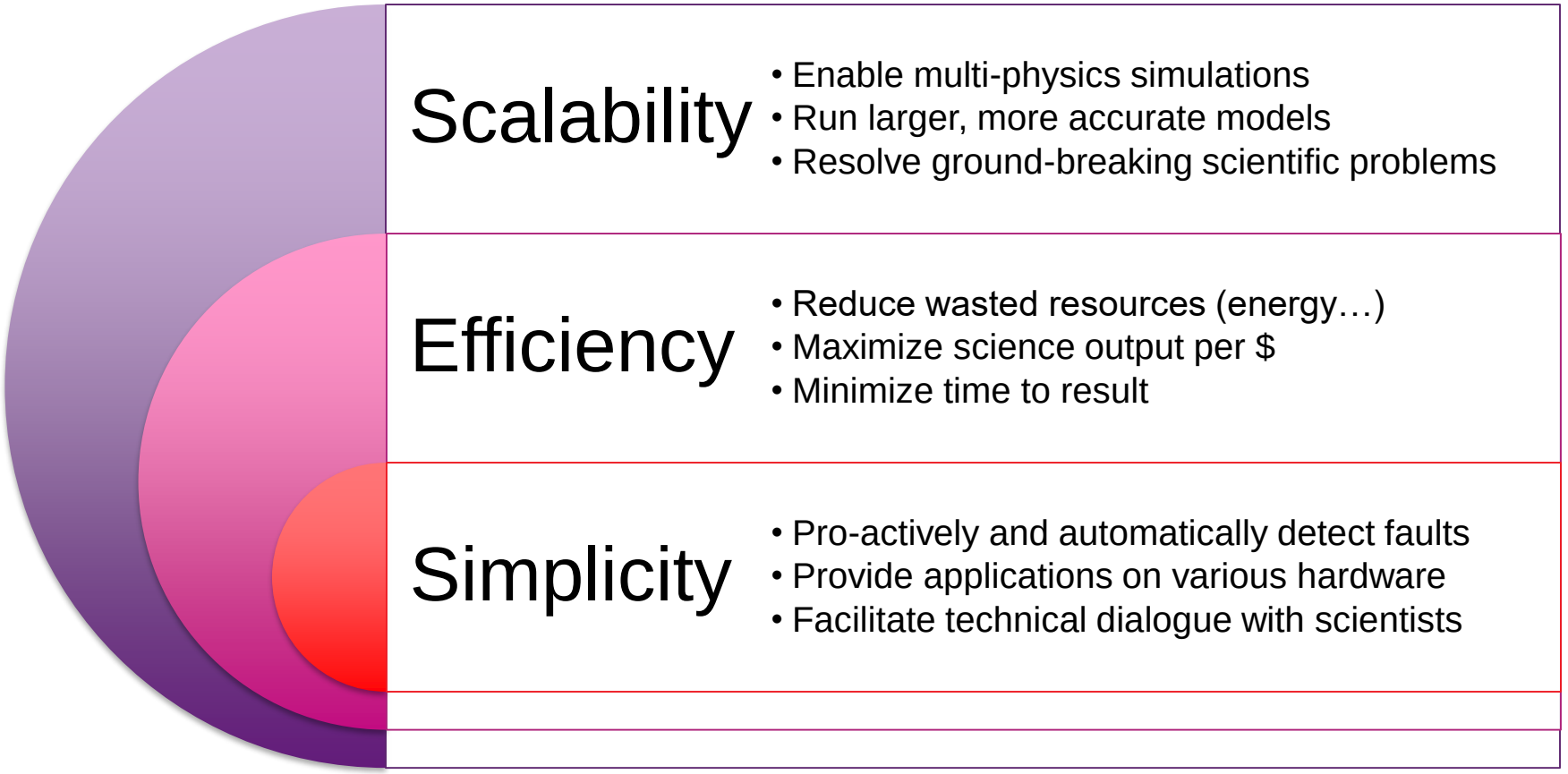
Building blocks for better science



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About Allinea

- Allinea: leading toolkit for HPC application developers

- As of December 2016 Allinea is now part of ARM
  - Objective: continue to be the trusted HPC Tools leader in tools across every platform

- This means:
  - The **same team** will continue to work with you, our customers and partners, and the wider HPC community
  - Being part of ARM gives us strength to **deliver on our roadmap faster**
  - We remain 100% committed to providing **cross-platform tools for HPC**
  - Our engineering roadmap is **aligned with upcoming architectures** from every vendor

Allinea's vision

- **Helping maximize HPC efficiency**

  Reduce HPC systems operating costs
  Resolve cutting-edge challenges
  Promote Efficiency (as opposed to Utilization)
  Transfer knowledge to HPC communities

- **Helping the HPC community design the best applications**

  Reach highest levels of performance and scalability
  Improve scientific code quality and accuracy

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Where to find Allinea tools

Over 65% of Top 100 HPC systems

- From small to very large tools provision

6 of the Top 10 HPC systems

- From 1,000 to 700,000 core tools usage

Future leadership systems

- Millions of cores usage

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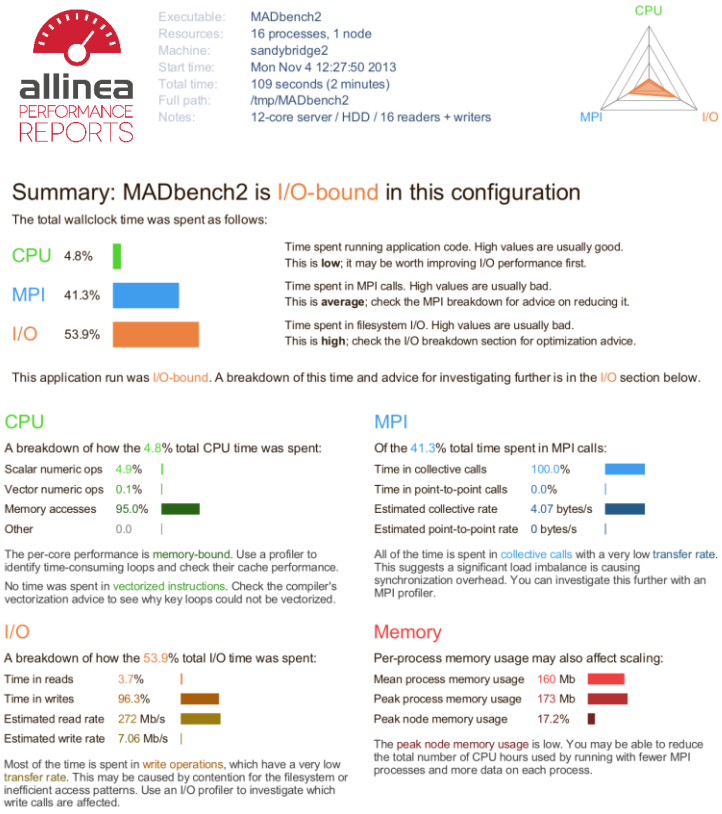
“Learn” with Allinea Performance Reports



- Very simple start-up
- No source code needed
- Fully scalable, very low overhead
- Rich set of metrics
- Powerful data analysis

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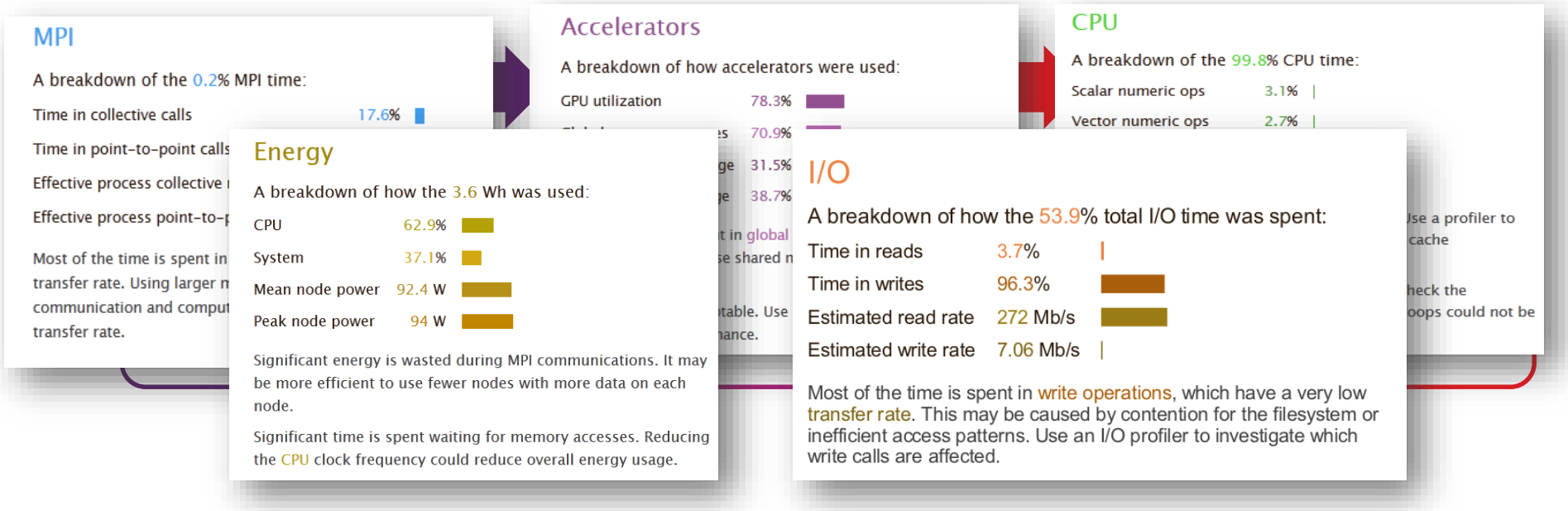
Maintaining a high efficiency production



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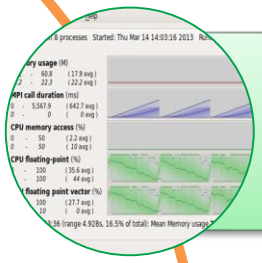
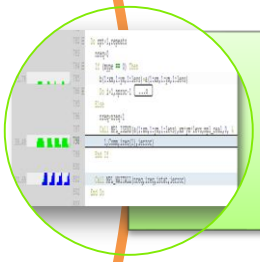
Allinea MAP: Performance made easy



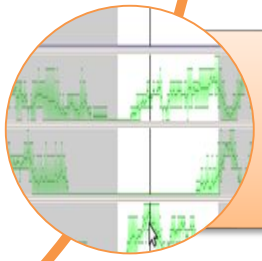
Low overhead measurement

- Accurate, non-intrusive application performance profiling
- Seamless – no instrumentation required



Easy to use

- Source code viewer pinpoints bottleneck locations
- Zoom in to explore iterations, functions and loops
- Re-compile with “-g” and profile by adding “map” to the mpirun command



Deep

- Measures CPU, communication, I/O and memory to identify problem causes
- Identifies vectorization and cache performance

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Allinea MAP and tracing tools: a great synergy

Simple optimization with Allinea MAP

- Characterize performance at-scale with a lightweight tool
- See which lines of code are hotspots
- Identify common problems at once

Prepare optimization strategy with Allinea MAP

- Identify loop(s) to instrument
- Identify performance counter(s) to record
- Document performance issues to communicate to profiling experts

Fine tune the code with tracing tool

- Retrieve low-level details using traces
- Fix up CPU usage to make the code fly

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Getting started on ARCHER: Set the environment

- Load the Allinea tools modules

```
$ module load allinea/7.0 allinea-reports/7.0
```

- Use the temporary licence for the workshop:

```
$ export ALLINEA_LICENCE_DIR=/fs4/y14/shared/allinea_licence
```

- Copy the NPB archive

```
$ cp /fs4/y14/shared/tutorial/NPB3.3-MZ-MPI.tar.gz .
$ tar xzvf NPB3.3-MZ-MPI.tar.gz
$ cd NPB3.3-MZ-MPI
```

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Getting started: Prepare the code for profiling on Cray

- Compile the MAP wrapper libraries

```
$ mkdir allinea_libs
$ cd allinea_libs
$ make-profiler-libraries
$ cd ..
```

The “make-profiler-libraries” command will display instructions to compile the application.

- Edit the config/make.def file and edit the following lines to add the extra parameters in bold

Line 11:
```
COMPILER = -Gfast –homp –N 255
```

Line 62:
```
F_LIB = -dynamic –L/path/to/allinea_libs
    \ -lmap-sampler-pmpi -lmap-sampler
    \ -Wl,--eh-frame-hdr
    \ -Wl,-rpath=/path/to/allinea_libs
```

- Compile bt-mz

```
$ make bt-mz CLASS=C NPROCS=24
```

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Getting started: Submit the job to profile the application

- Copy a job script

```
$ cp /fs4/y14/shared/job.archer bin/
$ cd bin/
```

- Edit “job.archer” to have the following lines instead of the execution command line 29
  - To run Allinea Performance Reports:

```
module load allinea-reports/7.0
export ALLINEA_LICENCE_DIR=/fs4/y14/shared/allinea_licence
perf-report aprun -n 24 ./bt-mz_C.24
```

  - Or to run Allinea MAP:

```
module load allinea/7.0
export ALLINEA_LICENCE_DIR=/fs4/y14/shared/allinea_licence
map --profile aprun -n 24 ./bt-mz_C.24
```

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Default Metrics – Background

- Already covered the introduction to profiling
- Basic metrics for understanding performance

Activity Timeline

- What happens over time
- Breakdown of % by CPU / MPI / I/O / Overheads

CPU Instructions

- What type of instructions are being executed
- FP / Integer / Memory / Vector / Branch

I/O Breakdown

- Time spent in reads / writes
- Data for Posix I/O

MPI Time Breakdown

- Rate of calls (send / recv / collectives)
- Data communicated and time taken

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Advanced Metrics

New Metrics:

- Energy (RAPL + IPMI)
- Lustre I/O metrics
- PAPI hardware counters

New Capabilities:

- Custom metrics interface
- JSON export

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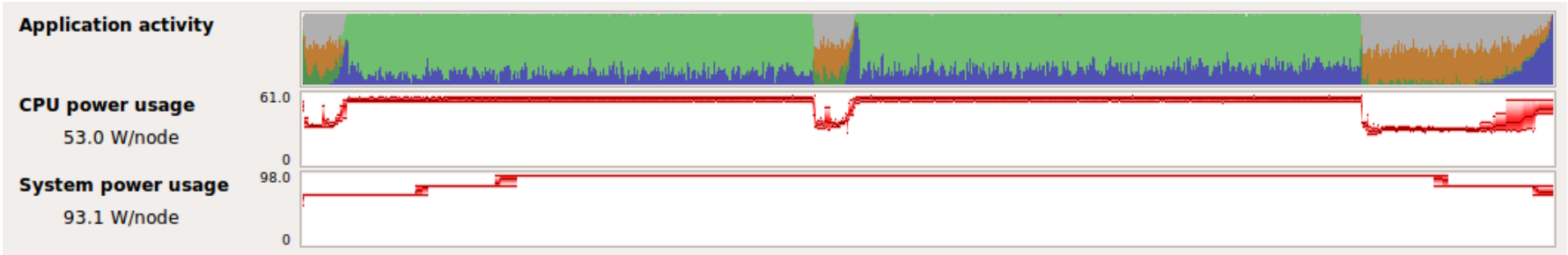
Energy Profiling

- Want to link energy consumption to application activity
- Two ways of collecting energy information
  - RAPL – CPU centric energy data on Intel CPUs (after Sandy Bridge)
  - IPMI – Node level energy collection on compatible hardware
- If available MAP will report this energy data



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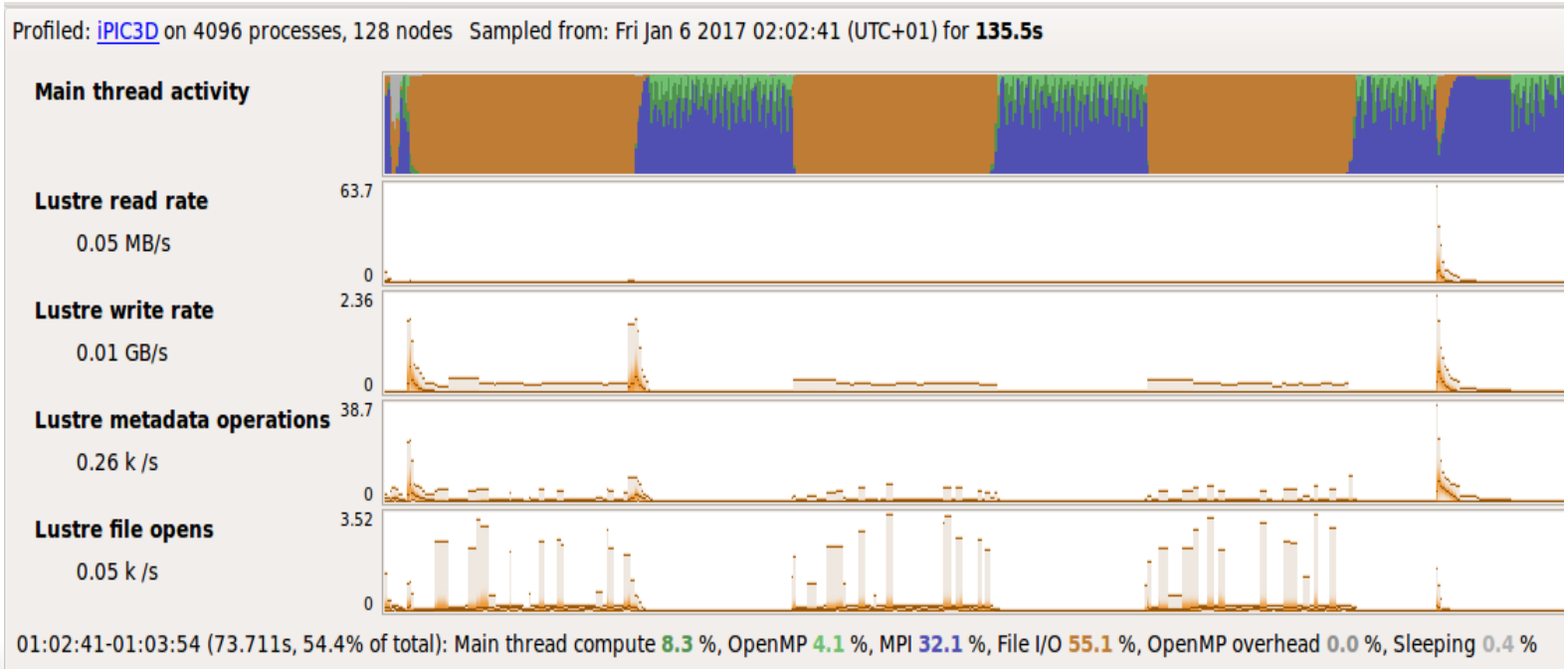
Lustre I/O Metrics

- Query the kernel for Lustre data activity
- Stores read / write rates, volume, file opens and metadata activity



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PAPI Hardware Counters

- Metric to interface with the PAPI library

- Limited to a subset of hardware counters
  - Select a PAPI ‘profile’ for the run
  - Configure in .allinea/map/metrics/PAPI.config

```
# Custom metric set
# Possible values are
#    Overview             : FLOPS and cycles per instruction
#    CacheMisses          : L1, L2, L3 total cache misses. Fallback of data
#                           cache misses if total cache misses unavailable.
#    BranchPrediction     : Total and mispredicted branch instructions
#    FloatingPoint        : Scalar and vector floating point instructions.
# Recommendation is Overview
set = Overview
```

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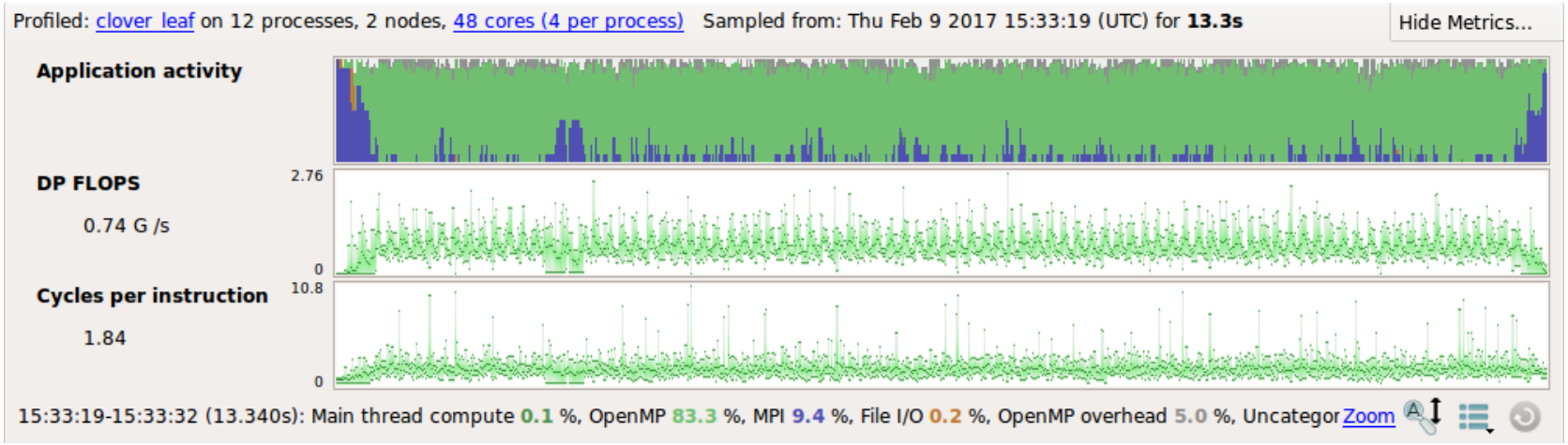
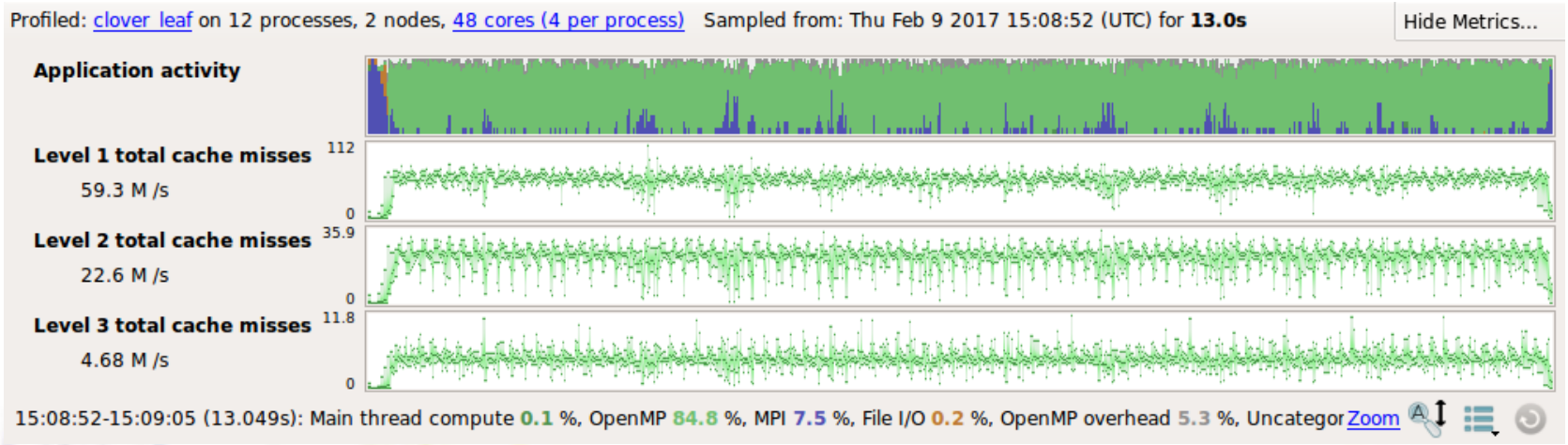
PAPI Metrics: Overview & Cache Misses





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How to use PAPI metrics on ARCHER

- Load the PAPI module

```
$ module load papi
```

- Install the Allinea PAPI library

```
$ cd /home/y07/y07/cse/allinea/forge/7.0
$ ./papi_install.sh
```

  Should pick up the PAPI lib

  Select ‘P’ for Personal install

  By default, this will be installed in $HOME/.allinea/map/metrics/ but $HOME is not accessible on the compute nodes … let’s copy it in /work

```
$ cp $HOME/.allinea/ /work/y14/y14/$USER/
```

- Export the following environment variables in the job script

```
$ export ALLINEA_CONFIG_DIR=/work/y14/y14/$USER/.allinea/
$ export ALLINEA_PAPI_CONFIG=
                \ /work/y14/y14/$USER/.allinea/map/metrics/PAPI.config
```

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New Capabilities: Custom Metrics in MAP

Addition of a custom metrics interface

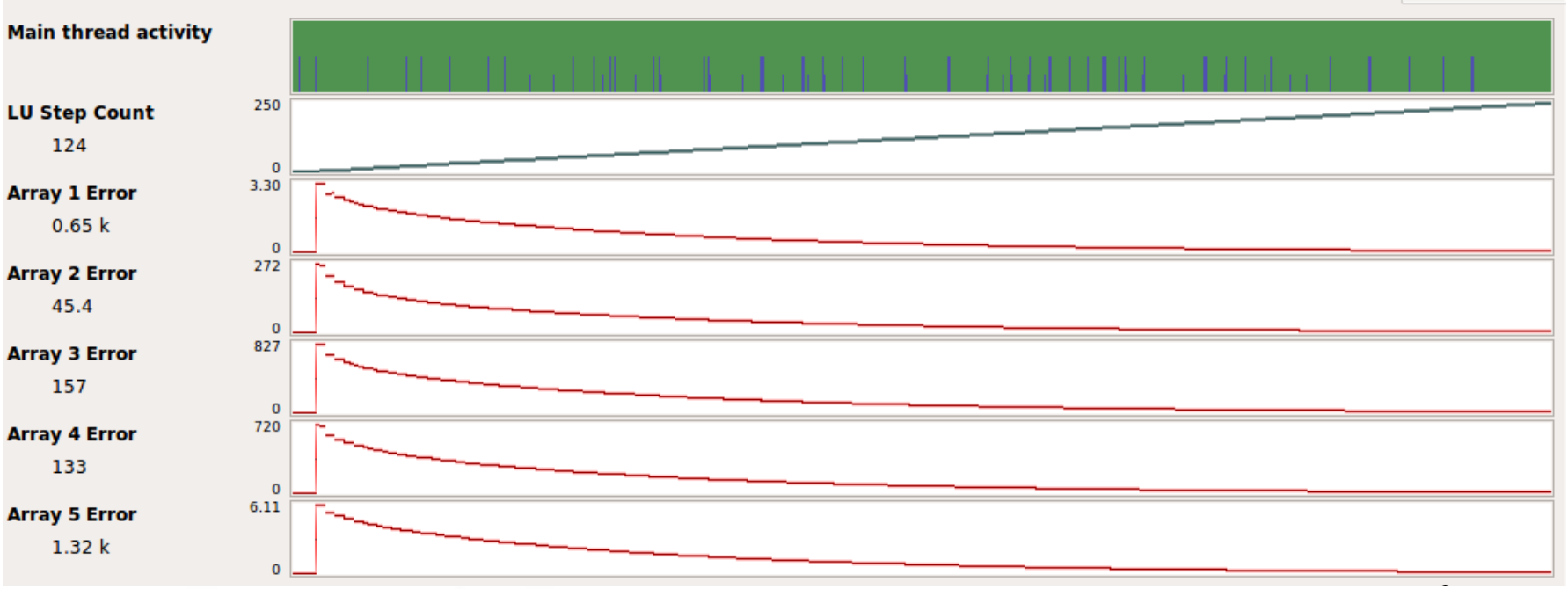
- Write your own metrics
- Must be async signal safe – quite limiting

Types of metric:

- System introspection – Specific counters / files
- Application introspection – Tracking application characteristics

Application Specific Custom Metric

- NPB-LU
  - Track the iteration number
  - Track the error term over time (for all 5 arrays)



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Writing a Custom Metric

XML Description

- Define multiple variables
- Function to call to get variables
- Library where functions exist

Functions Library

- Async signal safe functions
- Limit flexibility
- Return data to MAP

Makefile

- To build against MAP
- Install to metrics directory
- $ALLINEA_CONFIG_DIR/map/metrics

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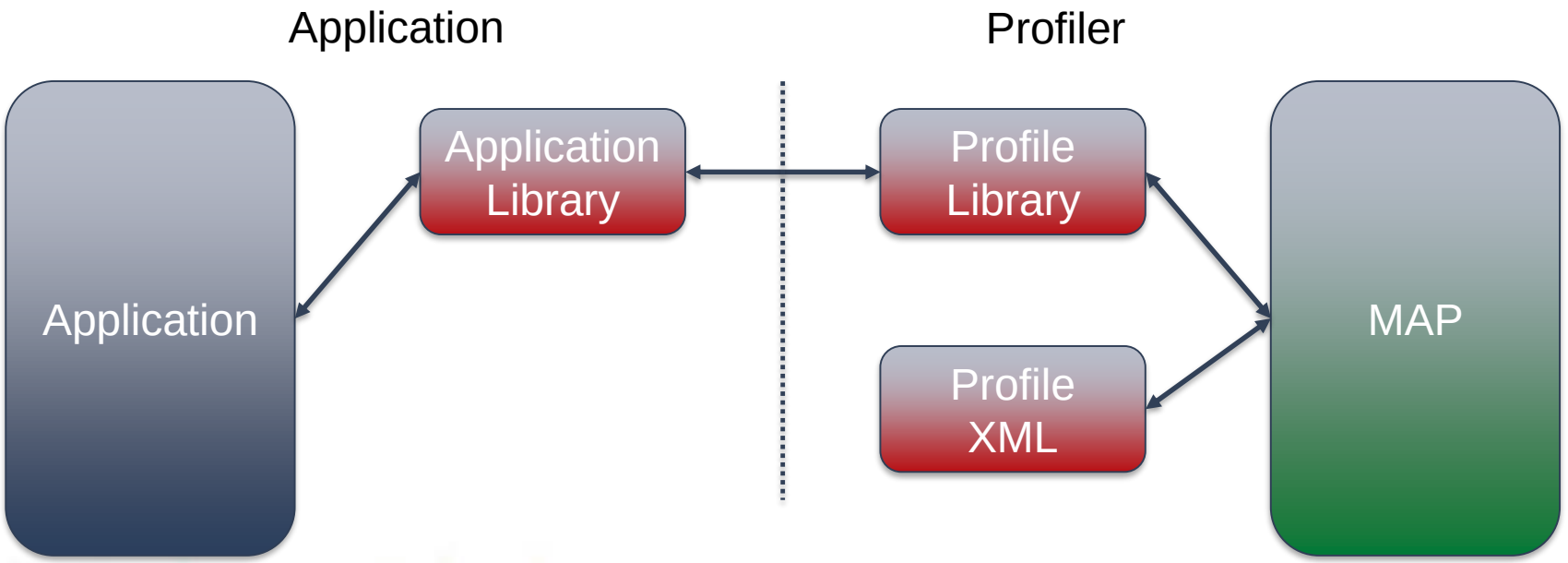
Writing a Custom Application Metric

Application Library

- Library with application variables
- Called from profiling library
- Should maintain own data – with application getters / setters



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Guide: LU Custom Metrics

- Install the LU Custom Metrics library

```
$ cp -r /fs4/y14/shared/allinea/custom_metric_lu .
$ cd custom_metric_lu
$ make install
```

  Will install the metric in /work/y14/y14/$USER/.allinea/map/metrics/

- Go to the NPB root directory and compile lu-mz

```
$ cd NPB3.3-MZ-MPI
$ make lu-mz CLASS=C NPROCS=24
```

- Submit the job to profile in bin/

```
map --profile aprun -n 24 ./lu-mz_C.24
```

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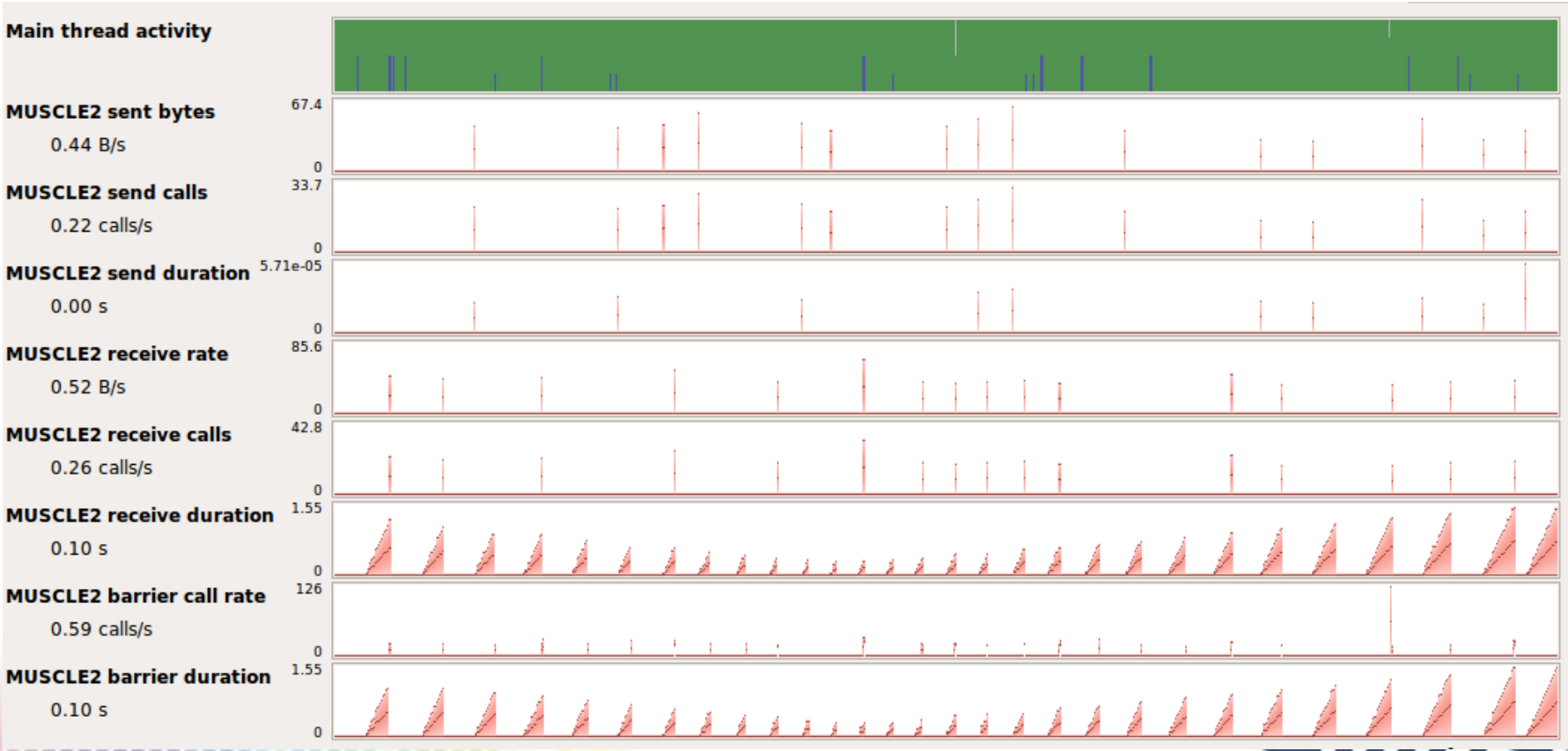
System Specific Custom Metric

- MUSCLE-2 Communication
  - Inter-MPI program communication library
  - Record communication performance data – Like MPI



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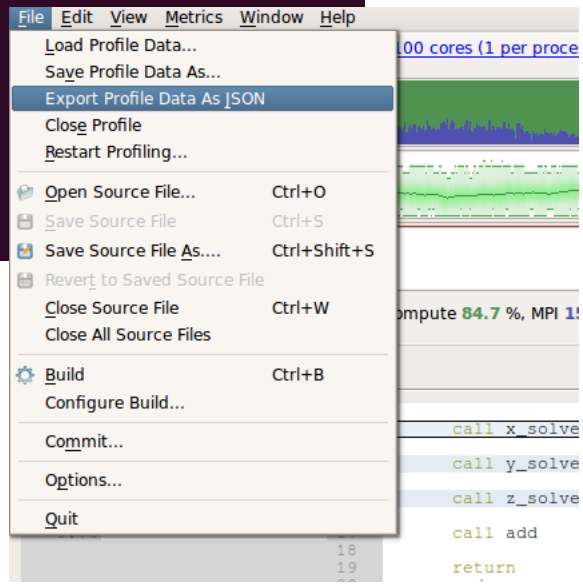
JSON Export

- Export map profile data to JSON file
  - Command line or GUI
  - Provides meta data + samples

```
operks@eslogin001:/work/y14/y14/operks/CloverLeaf_ref> map --export=clover.json clover_leaf_6p_1n_4t_2017-02-09_12-18.map
Loading MAP file clover_leaf_6p_1n_4t_2017-02-09_12-18.map...
...done
Collecting samples...
...done
Calculating...
...done
Collecting s
...done
Calculating.
...done
MAP generate
```


```
{
  "info": {
    "command_line": "aprun -n 6 -N 6 -S 3 -d 4 ./clover_leaf",
    "create_version": "7.0",
    "machine": "mom5",
    "metrics": {
      "memory_per_node": {
        "max": 67658141696,
        "mean": 67658141696,
        "min": 67658141696,
        "sum": 67658141696,
        "var": 0
      },
      "num_cores_per_node": {
        "max": 48,
        "mean": 48,
        "min": 48,
        "sum": 288,
        "var": 0
      },
      "num_omp_threads_per_process": {
        "max": 3,
        "mean": 3,
        "min": 3,
        "sum": 18,
        "var": 0
      },
```

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JSON Ideas

- JSON exposes the ~1000 sample data arrays
  - Min, Max, Mean, STD and sum
- Plot these with Python scripts
- Integrate with regression testing suite
  - Jenkins plugin developed
- Compatibility with Performance Reports JSON export
  - Multisource data visualisation / analytics

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Thank you!

Questions? Olly.Perks@arm.com

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Support: support@allinea.com