VI-HPS Tuning Workshop 2020

Arm MAP and Performance Reports

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30th July 2020

Agenda

- 14:00 – Introduction
- 14:15 – MAP & Performance Reports
- 14:45 – Examples
- 15:30 – (break)
- 16:00 – Hands-On
- 17:00 – (end of workshop)

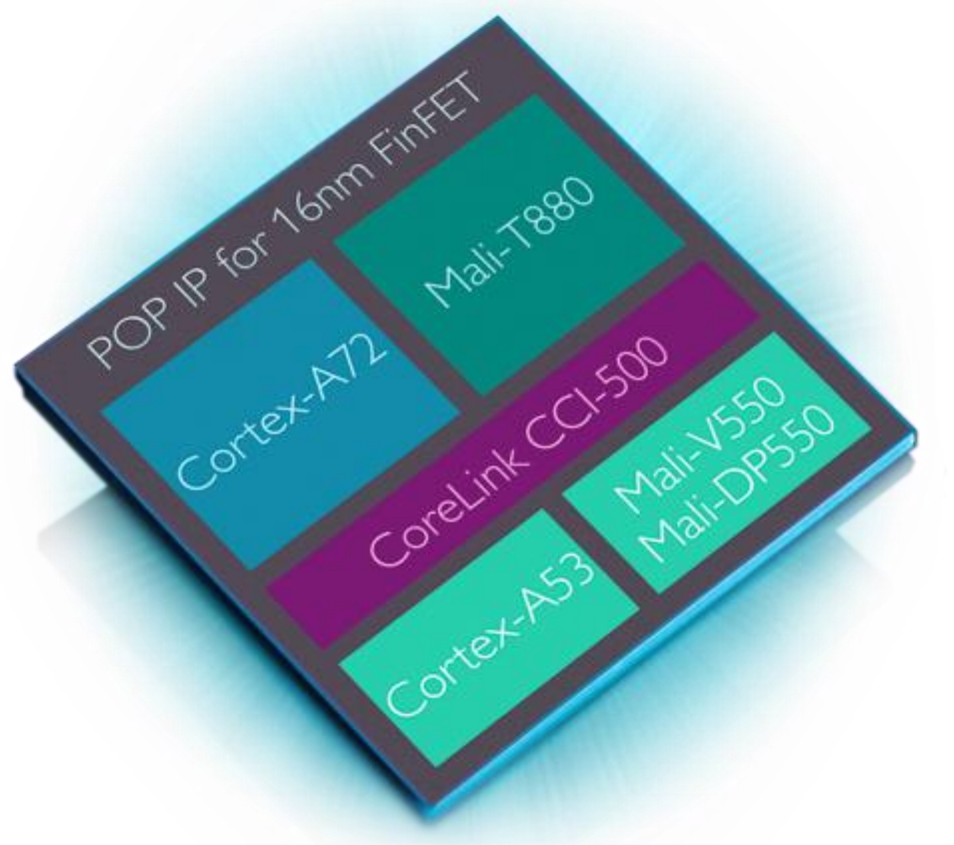
An Introduction to Arm

Arm is the world's leading semiconductor intellectual property supplier

We license to over 350 partners: present in 95% of smart phones, 80% of digital cameras, 35% of all electronic devices. Total of 60 billion Arm cores have been shipped since 1990*

Our partners license:

- Architectures and Technical Standards, e.g. Armv8-A or GIC-300
- Hardware Designs, e.g. Cortex-A72
- Software Development Tools, e.g. Arm Forge



...and our IP extends beyond the CPU

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Allinea history

Arm's solution for HPC application development and porting

Commercial tools for aarch64, x86_64, ppc64 and accelerators

Cross-platform Tools

arm FORGE

DDT | MAP

arm PERFORMANCE REPORTS

Arm Architecture Tools

arm C/C++ & FORTRAN COMPILER

arm PERFORMANCE LIBRARIES

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Performance Reports

Hardware utilization

Arm Performance Reports

Characterize and understand the performance of HPC application runs

Commercially supported by Arm

Accurate and astute insight

Relevant advice to avoid pitfalls

Gathers a rich set of data

- Analyses metrics around CPU, memory, IO, hardware counters, etc.
- Possibility for users to add their own metrics

Build a culture of application performance & efficiency awareness

- Analyses data and reports the information that matters to users
- Provides simple guidance to help improve workloads' efficiency

Adds value to typical users' workflows

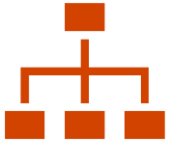
- Define application behaviour and performance expectations
- Integrate outputs to various systems for validation (e.g. continuous integration)
- Can be automated completely (no user intervention)

MAP

Arm MAP

A cross-platform toolkit for profiling

Commercially supported by Arm



Fully Scalable

Very user-friendly

The de-facto standard for HPC development

- Available on the vast majority of the Top500 machines in the world
- Fully supported by Arm on x86, IBM Power, Nvidia GPUs, etc.

State-of-the art profiling capabilities

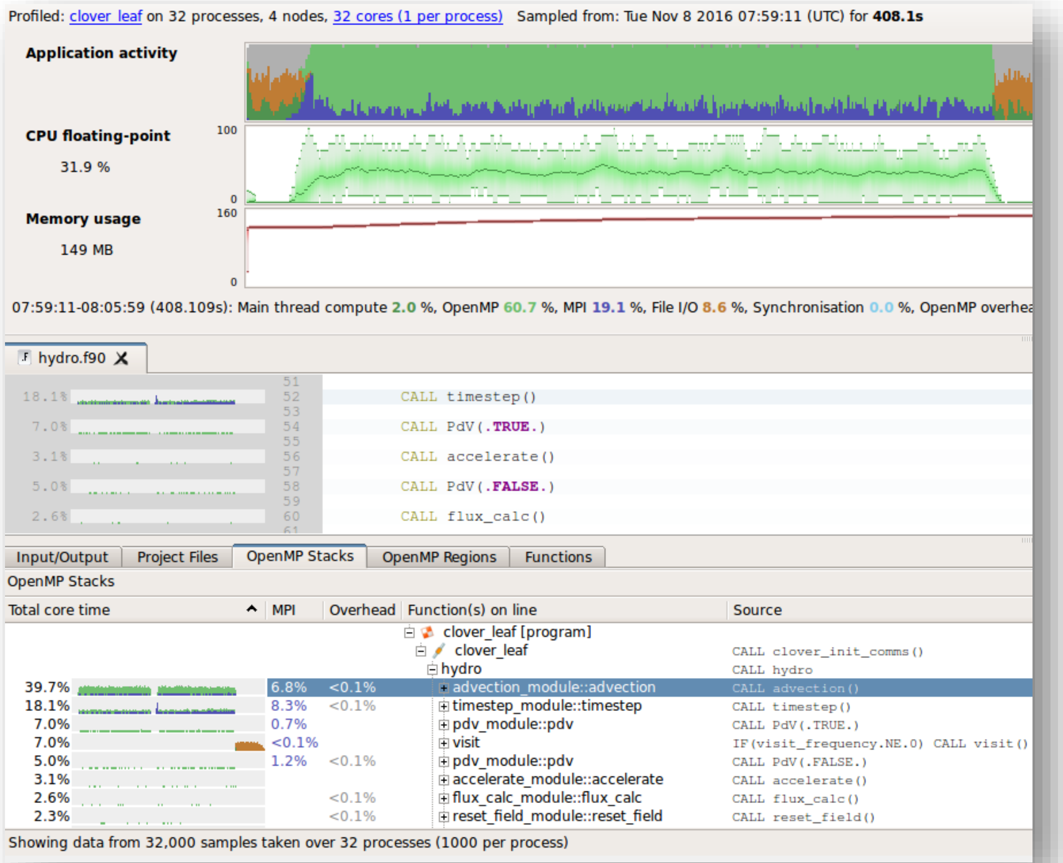
- Sampling-based profiler to identify and understand bottlenecks
- Available at any scale (from serial to petaflopic applications)

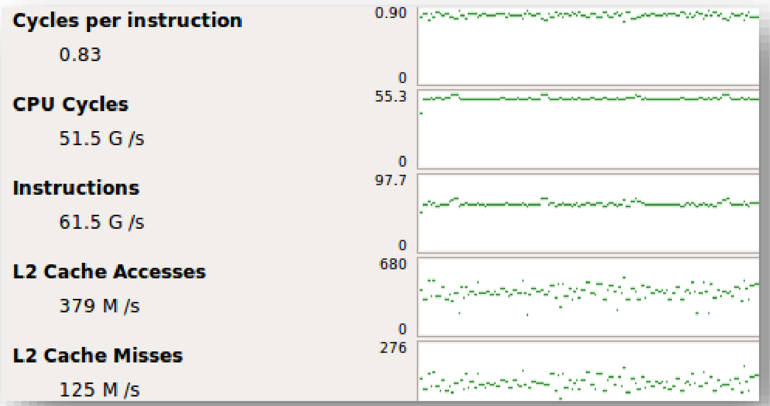
Easy to use by everyone

- Unique capabilities to simplify remote interactive sessions
- Innovative approach to present quintessential information to users

MAP Capabilities

- MAP is a sampling based scalable profiler
  - Built on same framework as DDT
  - Parallel support for MPI, OpenMP
  - Designed for C/C++/Fortran
- Designed for 'hot-spot' analysis
  - Stack traces
  - Augmented with performance metrics
- Adaptive sampling rate
  - Throws data away – 1,000 samples per process
  - Low overhead, scalable and small file size



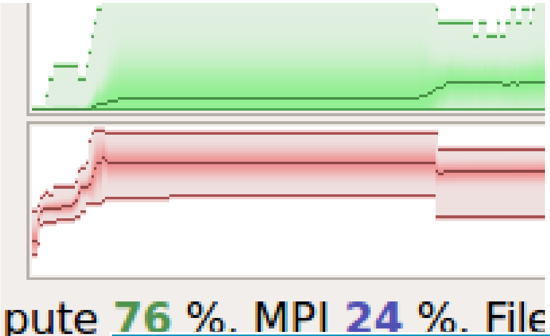


Quick Comparison

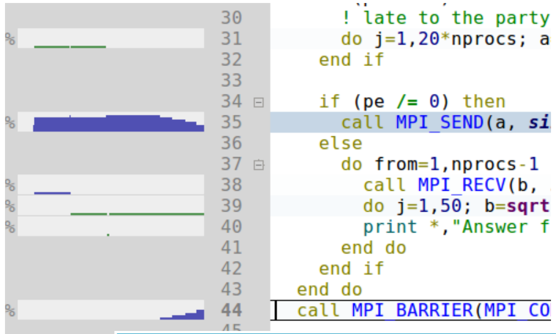
Using the right tool for the job…

- Easy to configure / use
  - No compiler wrappers / instrumentation / tracing
  - Minimal configuration (almost-all features enabled all the time)
  - Adaptive sampling to automatically keep overhead down
  - Aggregated data across processes/threads
  - Low overhead
  - One size fits all - tradeoffs…
- Potential workflow: MAP first and then dig deeper with other tools
  - Understand overall performance characteristics
  - Find hotspots
  - If more data is required:
    - Within Forge: Profile subset of program, Custom metrics, DDT
    - Other tools mentioned this week
    - Specialist tools - e.g. NVIDIA tools for GPUs, IO profilers, etc

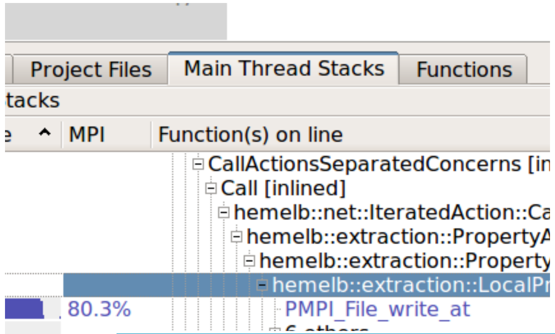
Six Great Things to Try with Allinea MAP



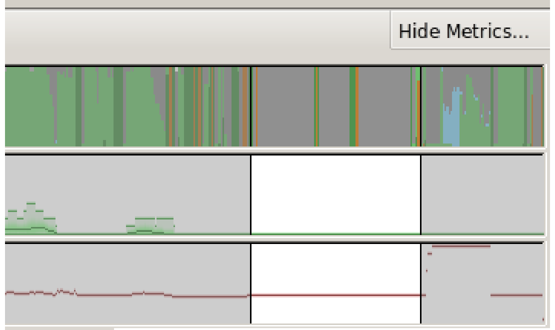
Find the peak memory use



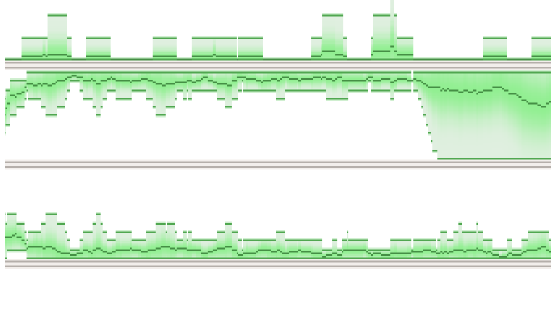
Fix an MPI imbalance



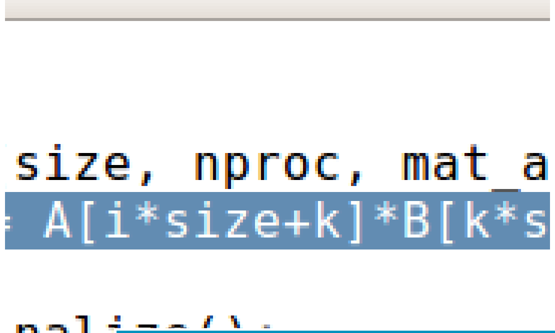
Remove I/O bottleneck



Make sure OpenMP regions make sense



Improve memory access



Restructure for vectorization

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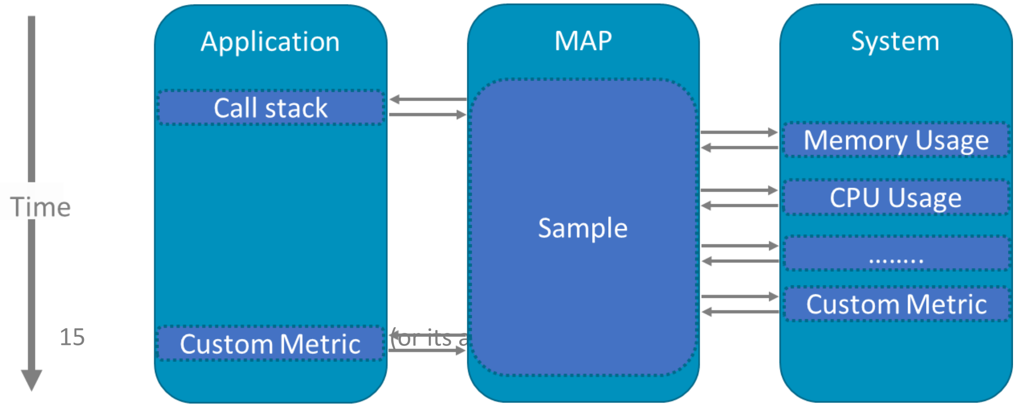
Core Principles of Profiling with MAP

A quick start

Sampling in MAP

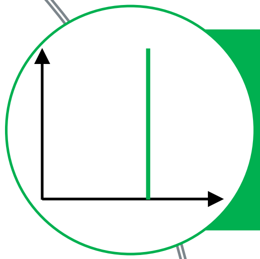
- Sampling driven profiler
  - Dynamic interval to scale
- On sample collect data
  - Current call stack
  - Performance metrics
  - Custom metric events
- Additional metrics added in
  - Such as MPI events



GUI

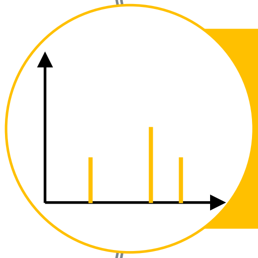
- Activity timeline
  - Percentage of active threads in activity
  - Colour coded
- Activity classified such as:
  - Compute, MPI, I/O, Synchronisation
  - Based on call stack analysis
- Top down source code tree
  - Drill down into ‘Hotspots’
  - Time regions selectable

Some types of profiles



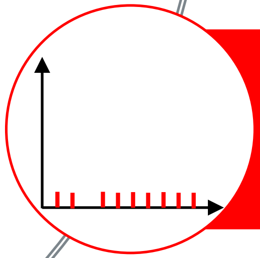
Hotspot

- One function corresponds to more 80% of the runtime
- Large speed-up potential
- Best optimisation scenario



Spike

- The application spends most of the time in a few functions
- Speed-up potential depends on the aggregated time
- Variable optimisation time



Flat

- Runtime split evenly between numerous functions, each one with a very small runtime
- Little speed-up potential without algorithmic changes
- Worst optimisation scenario

Preparing Code for Use with MAP

- To see the source code, the application should be compiled with the debug flag typically –g

- It is recommended to *always* keep optimization flags on when profiling

Collecting a profile / performance report

- MAP
  - Prepare application by compiling with "`-g`" (leave optimization enabled)
  - In general
    - `map --profile mpirun …`
- Performance Reports
  - No preparation required
  - Collect directly
    - `perf-report –mpiexec …`
  - Convert from a MAP file
    - `perf-report myfile.map`

Python Profiling

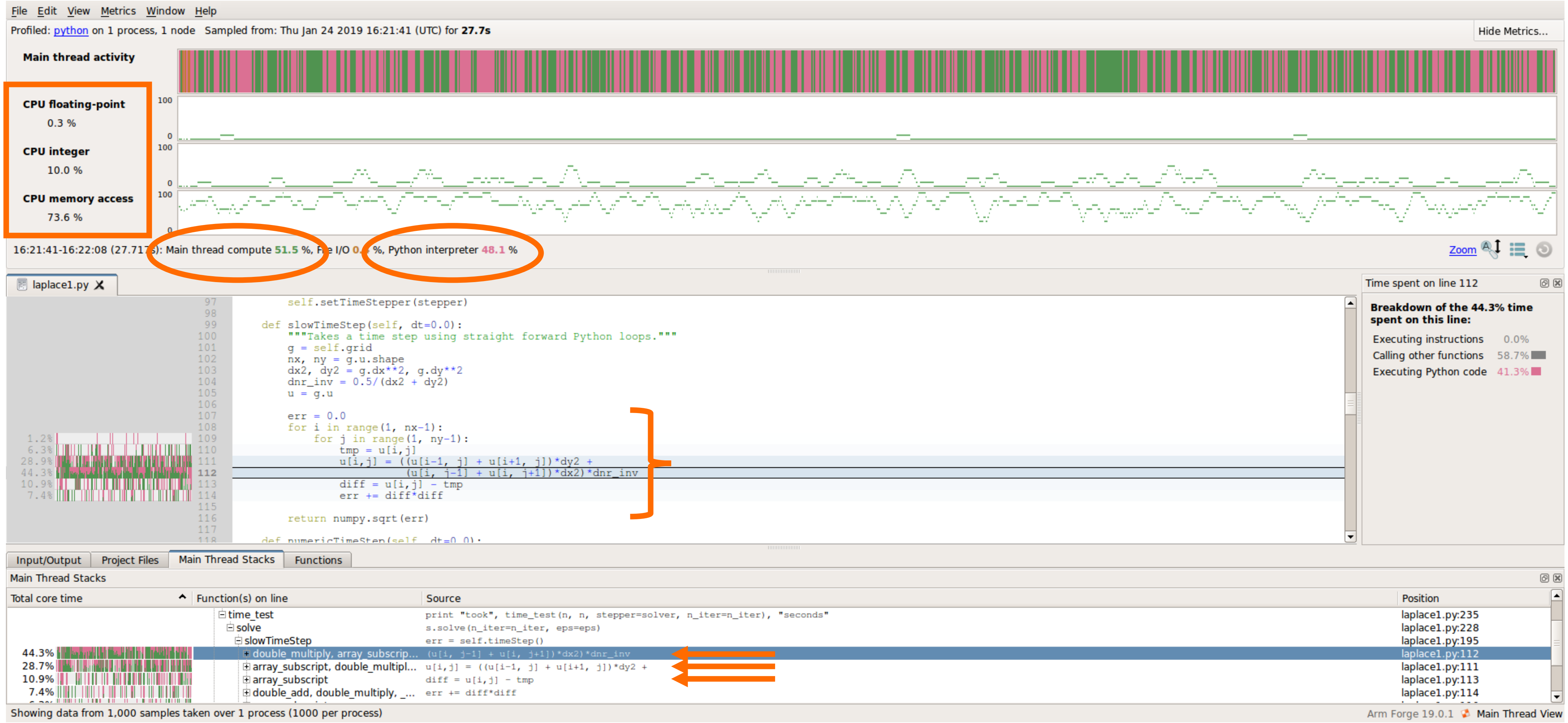
Arm MAP: Python profiling

- Launch command
  - $ **python** ./laplace1.py slow 100 100
- Profiling command
  - $ **map --profile python** ./laplace1.py slow 100 100
  - --profile: non-interactive mode
  - --output: name of output file
- Display profiling results
  - $ **map** laplace1.map

Laplace1.py

```
[…]
err = 0.0
for i in range(1, nx-1):
  for j in range(1, ny-1):
    tmp = u[i,j]
    u[i,j] = ((u[i-1, j] + u[i+1, j])*dy2 +
      (u[i, j-1] + u[i, j+1])*dx2)*dnr_inv
    diff = u[i,j] - tmp
    err += diff*diff
return numpy.sqrt(err)
[…]
```

Naïve Python loop (laplace1.py slow 100 100)



Optimizing computation on NumPy arrays

Naïve Python loop

```
err = 0.0
for i in range(1, nx-1):
  for j in range(1, ny-1):
    tmp = u[i,j]
    u[i,j] = ((u[i-1, j] + u[i+1, j])*dy2 +
    (u[i, j-1] + u[i, j+1])*dx2)*dnr_inv
    diff = u[i,j] - tmp
    err += diff*diff
return numpy.sqrt(err)
```

→

NumPy loop

```
u[1:-1, 1:-1] =
    ((u[0:-2, 1:-1] + u[2:, 1:-1])*dy2 +
     (u[1:-1,0:-2] + u[1:-1, 2:])*dx2)*dnr_inv

return g.computeError()
```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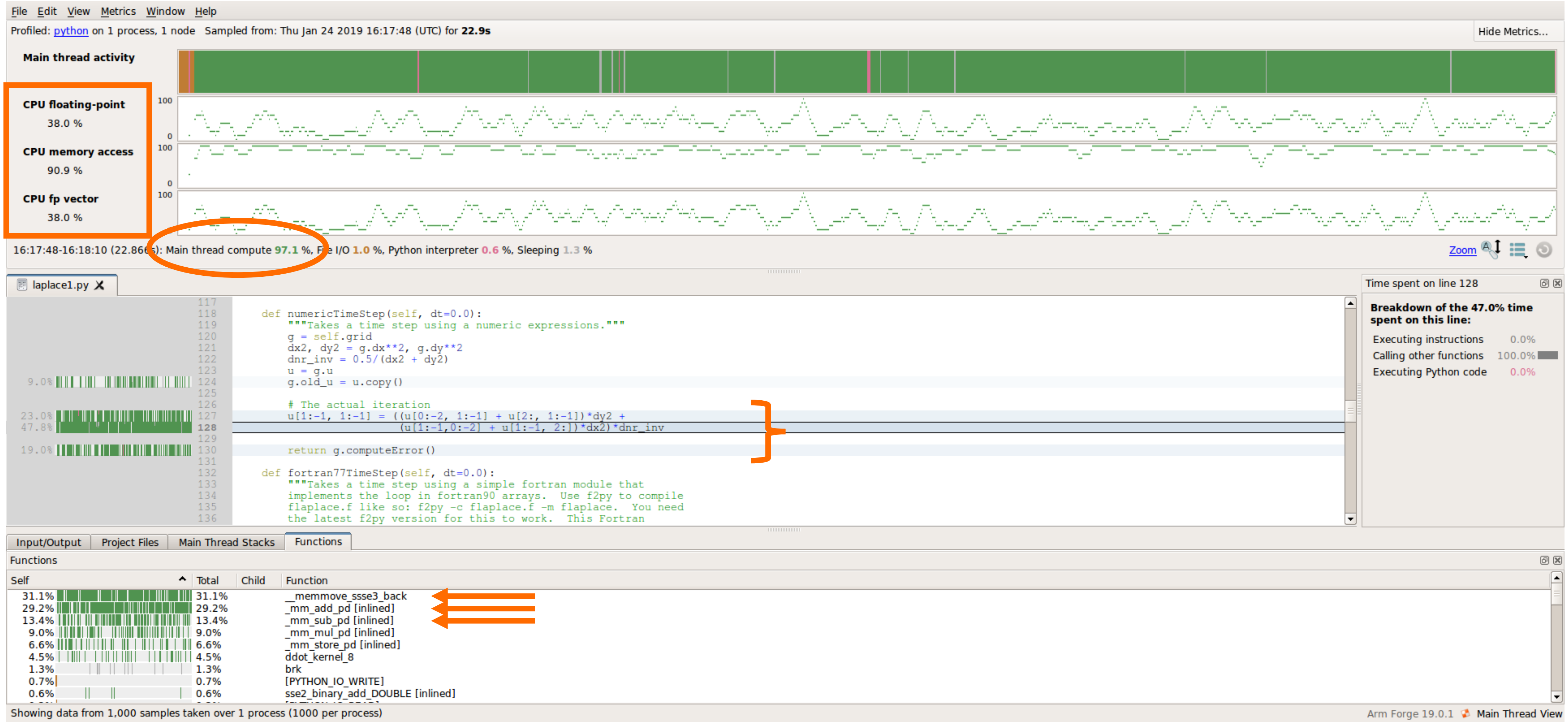
NumPy array notation (laplace1.py numeric 1000 1000)

This is 10 times more iterations than was computed in the previous profile



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Thank You
Danke
Merci
谢谢
ありがとう
Gracias
Kiitos
감사합니다
धन्यवाद
شكرًا
ধন্যবাদ
תודה

Extra documentation

Arm DDT User Guide : https://developer.arm.com/docs/101136/latest/ddt

Arm MAP User Guide : https://developer.arm.com/docs/101136/latest/map

Arm Performance Reports User Guide : https://developer.arm.com/docs/101137/latest/introduction

Arm Forge Webinars : https://developer.arm.com/products/software-development-tools/hpc/training/arm-hpc-tools-webinars