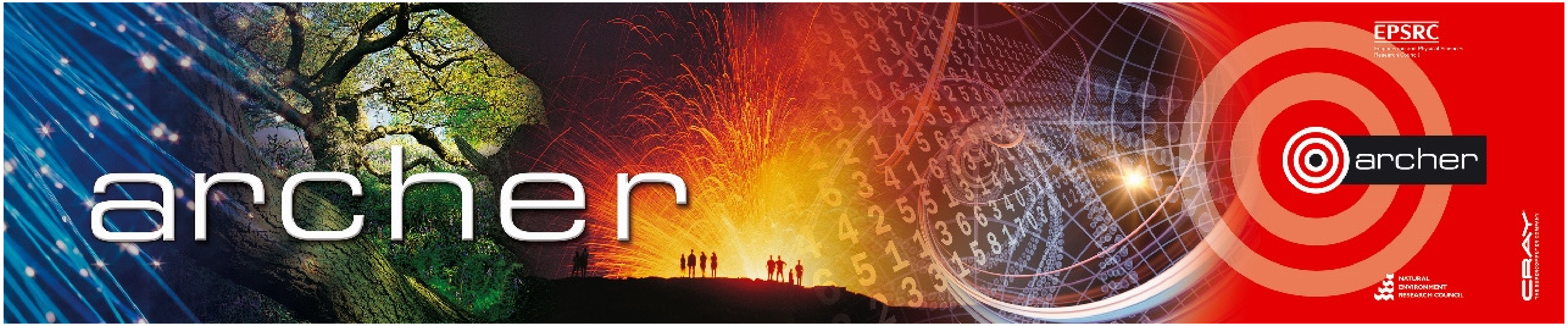

Welcome!

Virtual tutorial starts at 15:00 BST

eCSE: Supporting Data

ARCHER Virtual Tutorial, Wed 3rd September 2014

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EPCC

Reusing this material

Introduction

- Programme provides funding to ARCHER user community to develop software in a sustainable manner for ARCHER
- Objectives
  - To sustain key codes for the UK computational science community
  - To facilitate efficient use of ARCHER resources through enhanced code performance/functionality
  - To offer a not-for-profit service that provides value for money to the HPC user community and beyond
- Also
  - Develop and sustain codes and communities from new areas
  - Support and encourage early career researchers

Submission Format

- After calls opens, proposals should be submitted via SAFE:
  - https://www.archer.ac.uk/safe/
  - Please register first if you are not a registered user in SAFE

- Two components to the submission
  - Project Information
  - Project Proposal
- Project Information
  - Mandatory information such as names, proposed start date, travel requested
  - Required resources
    - Primarily for the eCSE team to determine if any additional support required
    - Additional AU's must however be justified

Submission: Project Proposal Template

- *Project Objectives*
- Project Overview
- Applicants' Track Record
- *Technical Information*
- Computational Benefits
- Scientific Benefits
- Benefits for the ARCHER Community
- Sustainability / Pathways to Impact
- Embedded CSE Support Requested / Work Plan

Project Objectives

- Form part of the proposal assessment criteria
- And if accepted will be asked to report against these objectives
  - Used to assess the final success of your project
  - Should therefore be specific and measurable
- Examples include but are not limited to:
  - The enablement of the scientific community to perform novel and previously untenable simulations
  - A quantifiable improvement in performance or scaling of a code
  - The integration of new algorithms/functionality into a code
  - Measurable outcomes leading to wider accessibility in the user community
  - Project outcomes of specific importance to the ARCHER community

Technical Background

- Demonstrate a good knowledge and understanding of previous and current work in the related area

- May include but is not limited to:
  - A brief summary of the previous / current use of the code
    - HPC platforms used, the software environments for the code running, the number of cores and problem size used, etc
  - The previous / current code performance, scaling and profiling
  - The major algorithms and functional updates related to the code to be used in the proposed project
  - The important prerequisites for the proposed project, e.g. the key algorithms, libraries, software to be installed, etc

Previous code performance, scaling and profiling

- Should allow the panel to understand the current performance of the code on ARCHER

- Ideally results will be on ARCHER, but if not, should address architecture differences
  - Provide confidence results are transferrable
- Need not be your “own” results, but must provide confidence in their accuracy
- Must give confidence that the results are representative of the problems you wish to consider in your proposal
  - i.e. scientific beneficiary systems
  - Need not be same systems but should be representative

Previous code performance, scaling and profiling

- Should demonstrate the codes appropriateness / ability to utilise ARCHER
  - Some codes are more suited to other forms of funding

- Should address current code limitations and motivate developments proposed
  - Profiling evidence
  - e.g. why does scaling tail-off?
  - e.g. how can this be addressed?
  - e.g. can you quantify the expected performance improvements?
- Can be used to provide confidence that the project objectives are realistic and achievable

Previous code performance, scaling and profiling

- The major algorithms and functional updates related to the code to be used in the proposed project
  - Motivated by your performance data

- The important prerequisites for the proposed project, e.g. the key algorithms, libraries, software to be installed, etc
  - Provide confidence that the work can actually be done on ARCHER
    - Particularly important if code has not been run on ARCHER before
  - Helps the eCSE team understand project and support requirements

How do I generate this data?

- The centralised eCSE team can help
  - Either through advise or carrying out some initial benchmarking/profiling
- You can apply for “EPSRC Instant Access”
  - Provides pump priming time for new users
  - Limited number of AUs available over 6 months for testing
- Various tools available on ARCHER to obtain this information
  - Next part of the tutorial discusses this in more detail

Performance data

- **Total wall clock time**
  - System commands (e.g. time) or batch system statistics
  - Built-in timers in the program (e.g. MPI_Wtime)
- **Built-in timers** can be used to get fine-grained timings, e.g., excluding initialization time, or I/O time.
  - No information about hardware related issues e.g. cache utilization
  - Information about load imbalance and communication statistics is difficult to obtain

Performance analysis tools

- On Archer
  - Cray performance tools
    - Works with all compilers
    - For Cray systems only
  - Scalasca
    - Currently works with the Cray compiler only
    - Used on many other systems

Cray Performance Tools

- **Instrument** the code
  - Adds special measurement code to binary
- **Collect** data from a run of the instrumented binary
  - Sampling (statistical averages, low overhead) vs. tracing (data from every traced call, high overhead, lots of data)
  - Guided tracing: trace functions that are not too small and contribute a lot to application's run time. Cray Automatic Profiling Analysis does this.
- **Analyze**
  - Text based analysis reports
  - Visualization

Steps to Collecting Performance Data

- Access performance tools software

```
% module load perftools
```

- Build application keeping .o files

```
% make clean
% make
```

- Instrument application for automatic profiling analysis
  - You will get an instrumented program `<name>+pat`

```
% pat_build -O apa a.out
```

- Run application (in a qsub script)
  - You will get a performance file ("`<sdatafile>.xf`") or multiple files in a directory `<sdatadir>`

```
% aprun … a.out+pat
```

Steps to Collecting Performance Data (2)

- Generate text report and an `.apa` instrumentation file

```
% pat_report -o my_sampling_report [<sdatafile>.xf |
   <sdatadir>]
```

- Inspect `.apa` file
- View sampling report as text or with Cray Apprentice

```
% app2 <sdatafile>.ap2
```

- Verify if additional instrumentation is needed

APA File Example

```
#  You can edit this file, if desired, and use it
#  to reinstrument the program for tracing like this:
#
#           pat_build -O cfd+pat+780378-3005s.apa
#
#  These suggested trace options are based on data from:
#
#    cfd+pat+780378-3005s.ap2
# ----------------------------------------------------------------------
#       Collect the default HWPC group.
  -Drtenv=PAT_RT_PERFCTR=default
# ----------------------------------------------------------------------
#       Libraries to trace.
  -g mpi
# ----------------------------------------------------------------------
# ----------------------------------------------------------------------
#       User-defined functions to trace, sorted by % of samples.

#       The way these functions are filtered can be controlled with
#       pat_report options (values used for this file are shown):
#
#       -s apa_max_count=200    No more than 200 functions are listed.
#       -s apa_min_size=800     Commented out if text size < 800 bytes.
#       -s apa_min_pct=1        Commented out if it had < 1% of samples.
#       -s apa_max_cum_pct=90   Commented out after cumulative 90%.
#       Local functions are listed for completeness, but cannot be traced.
  -w  # Enable tracing of user-defined functions.
      # Note: -u should NOT be specified as an additional option.

# 67.53% 6633  bytes
    -T cfd_

# ----------------------------------------------------------------------
-o cfd+apa # New instrumented program.
/fs3/y02/y02/ted/training/201312-CSE-EPCC/reggrid/cfd # Original program.
```

Effectively a series of command line arguments to pat_build

Generating Event Traced Profile from APA

- Instrument application for further analysis (a.out+apa)

```
% pat_build -O <apafile>.apa
```

- Run application (in a qsub script)

```
% aprun … a.out+apa
```

- Generate text report and visualization file (.ap2)

```
% pat_report -o my_text_report.txt [<datafile>.xf | <datadir>]
```

- View report as text or with Cray Apprentice

```
% app2 <datafile>.ap2
```

Using pat_report

- Always need to run `pat_report` at least once to perform data conversion
  - Combines information from the raw performance data in the `xf` file (optimized for writing to disk) and the binary to produce an `ap2` file (optimized for visualization analysis)
- Generates a text report of performance results
  - Data laid out in tables
  - **Many** options for sorting, slicing or dicing data in the tables.
    - `pat_report -O <table option> *.ap2`
    - `pat_report -O help` (list of available profiles)
  - Volume and type of information depends upon sampling vs. tracing.

pat_report: Profile (sampling)

```
Table 1:  Profile by Function

 Samp%   |  Samp   |  Imb.   |  Imb.   |Group
         |         |  Samp   |  Samp%  | Function
         |         |         |         |  PE=HIDE

 100.0% | 7607.1 |     -- |     -- |Total
|-----------------------------------------------
|  67.6% | 5139.8 |     -- |     -- |USER
||----------------------------------------------
|  67.5% | 5136.8 | 1076.2 |  17.9% | cfd_
||==============================================
|  31.8% | 2421.7 |     -- |     -- |MPI
||----------------------------------------------
||  13.7% | 1038.5 |  315.5 |  24.1% |MPI_SSEND
||   7.2% |  547.1 | 3554.9 |  89.5% |mpi_recv
||   7.1% |  540.4 | 3559.6 |  89.6% |MPI_WAIT
||   3.8% |  290.8 |  319.2 |  54.0% |mpi_finalize
|===============================================
================  Observations and suggestions  ========================

MPI Grid Detection:

    A linear pattern was detected in MPI sent message traffic.
    For table of sent message counts, use -O mpi_dest_counts.
    For table of sent message bytes, use -O mpi_dest_bytes.
```

pat_report: Hardware Performance Counters

```
==================================================================
  Total
------------------------------------------------------------------
  PERF_COUNT_HW_CACHE_L1D:ACCESS                       99236829284
  PERF_COUNT_HW_CACHE_L1D:PREFETCH                      1395603690
  PERF_COUNT_HW_CACHE_L1D:MISS                          5235958322
  CPU_CLK_UNHALTED:THREAD_P                           229602167200
  CPU_CLK_UNHALTED:REF_P                                7533538184
  DTLB_LOAD_MISSES:MISS_CAUSES_A_WALK                     29102852
  DTLB_STORE_MISSES:MISS_CAUSES_A_WALK                     6702254
  L2_RQSTS:ALL_DEMAND_DATA_RD                           3448321934
  L2_RQSTS:DEMAND_DATA_RD_HIT                           3019403605
  User time (approx)               76.128 secs   205620987829 cycles
  CPU_CLK                           3.048GHz
  TLB utilization                 2956.80 refs/miss     5.775 avg uses
  D1 cache hit,miss ratios          95.1% hits           4.9% misses
  D1 cache utilization (misses)     20.22 refs/miss     2.527 avg hits
  D2 cache hit,miss ratio           91.8% hits           8.2% misses
  D1+D2 cache hit,miss ratio        99.6% hits           0.4% misses
  D1+D2 cache utilization          246.83 refs/miss    30.853 avg hits
  D2 to D1 bandwidth             2764.681MB/sec  22069260378 bytes
```

perftools documentation

```
% module load perftools
% man intro_craypat
% man pat_build
% man pat_report
```

Relevant Information

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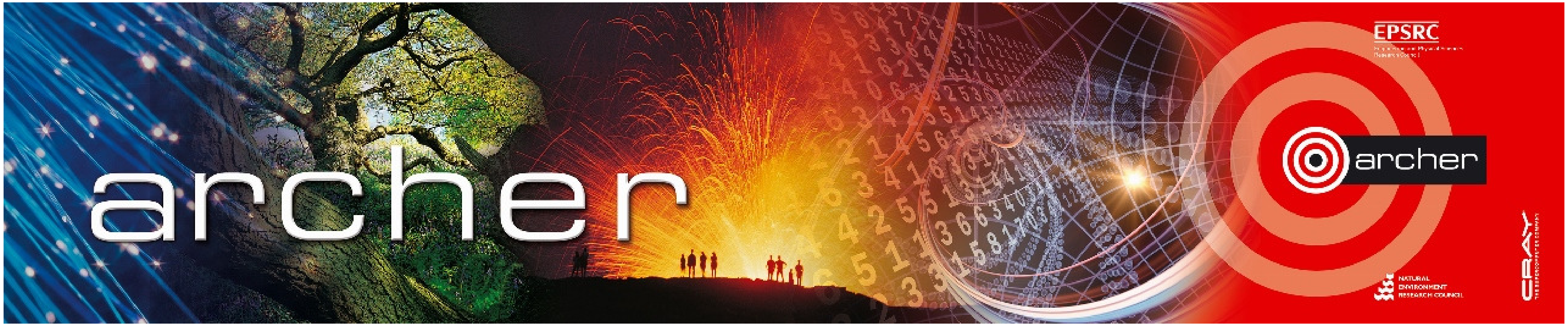
  - Please register first if you are not a registered user in SAFE
- Information and guidelines for applying can be found at:
  - https://www.archer.ac.uk/community/eCSE/eCSE_ApplicationGuidance.pdf
  - https://www.archer.ac.uk/community/eCSE/eCSE_ProposalTemplate.doc
- Applicants can request guidance from the centralised CSE team before submission:
  - Please contact ARCHER helpdesk: support@archer.ac.uk



Goodbye!

Virtual tutorial has finished