Benchmarking Working Group

Status Report

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Benchmarking Working Group

Mandate:

- ➔ **Fast benchmark**
  to estimate the performance of the provided job slot (in traditional batch farms) or VM instance (in cloud environments)
  - Job matching / masonry
    (e.g. “can a pilot run another payload with the resources left?”)
  - Accounting if HS06 score is not available
  - ...
- ➔ **Next generation of long-running benchmark**
  for installed capacities, accounting, procurements aso. in WLCG (successor of HS06)

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Organization:

- **Mailing list (hepix-cpu-benchmark@hepix.org):**
  - 49 subscribers
- **Meetings:**
  - Kick-off at HEPiX Zeuthen
  - 5 Vidyo meetings so far (biweekly)
  - 6 … 16 attendees per meeting

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Fast benchmarks

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Fast benchmarks:

➔ **Started with 5 candidates:**

- 3 benchmarks relevant to HEP workload:
  - DIRAC Benchmark 2012 (Python script) [1]
    (DB12 – as yet named 'fastBmk', 'LHCbMarks', …)
  - Atlas Kit Validation (KV) [2]
    (default workload: Geant4 single muon event generation)
  - ROOT stress test [3]
- 2 benchmarks widely used in common workload management tools (HTCondor, Boinc, ...):
  - Whetstone, Dhrystone [4]

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Fast benchmarks:

➔ **Tools:**

- New release of the CERN Cloud Benchmarking Suite (Domenico Giordano, Cristovao Cordeiro) supports not only cloud but also batch environments [5]
- Now it provides a "hyper-benchmark" which reports:
  - 1-min load of the system under test
  - HS06 score from MJF store (if available)
  - DB12
  - Whetstone
- Can run KV as well (if available in CVMFS)
- Tool can send results to ES at CERN for later analysis

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Fast benchmarks:

- ➔ Indepentent investigations by Domenico Giordano (CERN) [5] and Manfred Alef (KIT) [6] have demonstrated good correlation between DB12 and KV when executed in batch jobs as well as in clouds
  - Work done by Domenico Giordano shows an outlier when running in VM with many cores – caused by much shorter runtime?
- ➔ User experiences:
  - LHCb and Alice have demonstrated good scaling of their applications with DB12 [7,8]
    (see talks at GDB 2016-09-14 *)
  - Latest investigations by Costin Grigoras (Alice) have demonstrated better scaling of Alice software with DB12 than ROOT stress [8]

* https://indico.cern.ch/event/394786/

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Fast benchmarks:

➔ Differences:

- Runtime:
  - DB12 (< 1 minute) is much faster than KV (~ 5 minutes)
- Licensing:
  - DB12 is open source
  - Geant4 (default workload of KV) is open source
  - Athena (wrapper used by KV) is closed source

➔ **DB12 seems to be the most suitable candidate in the first group of fast benchmarks (related to WLCG workloads)**

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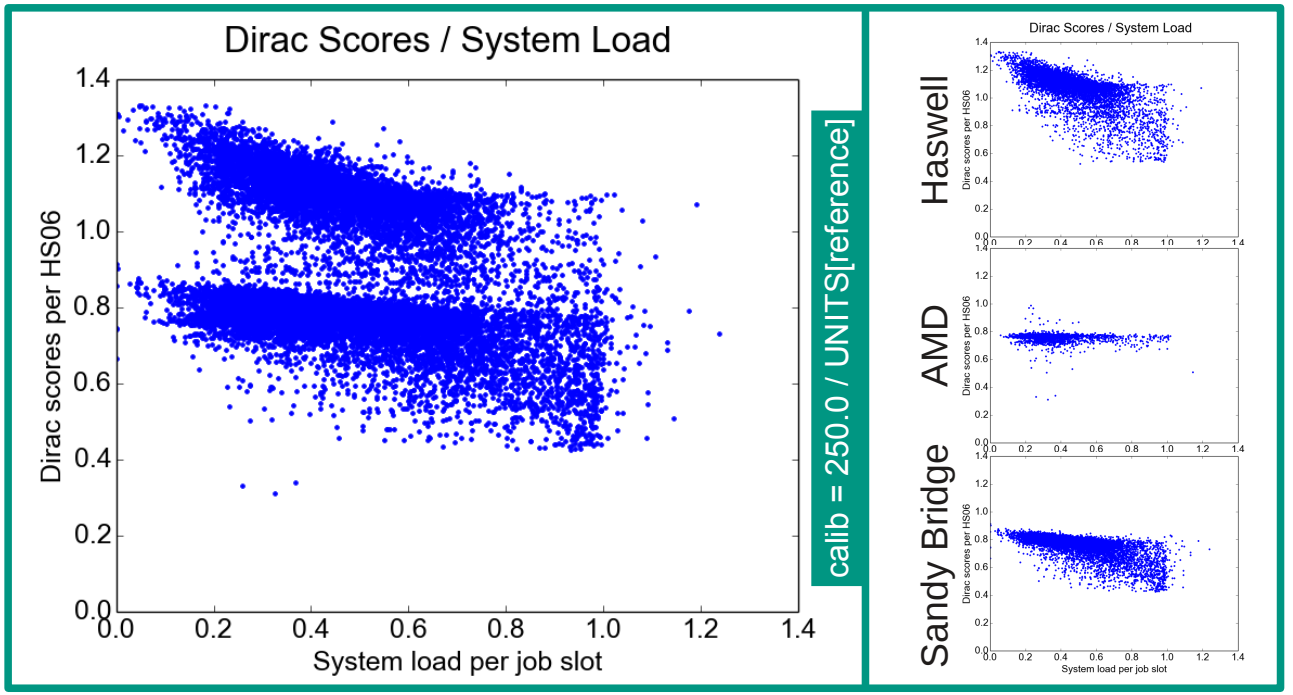
Fast benchmarks and HS06 score:

- ➔ At the present time HS06 is still the official metric for installed capacities (pledges, accounting, …)
- ➔ Unfortunately DB12, KV, and ROOT don't scale well with HS06 [6]



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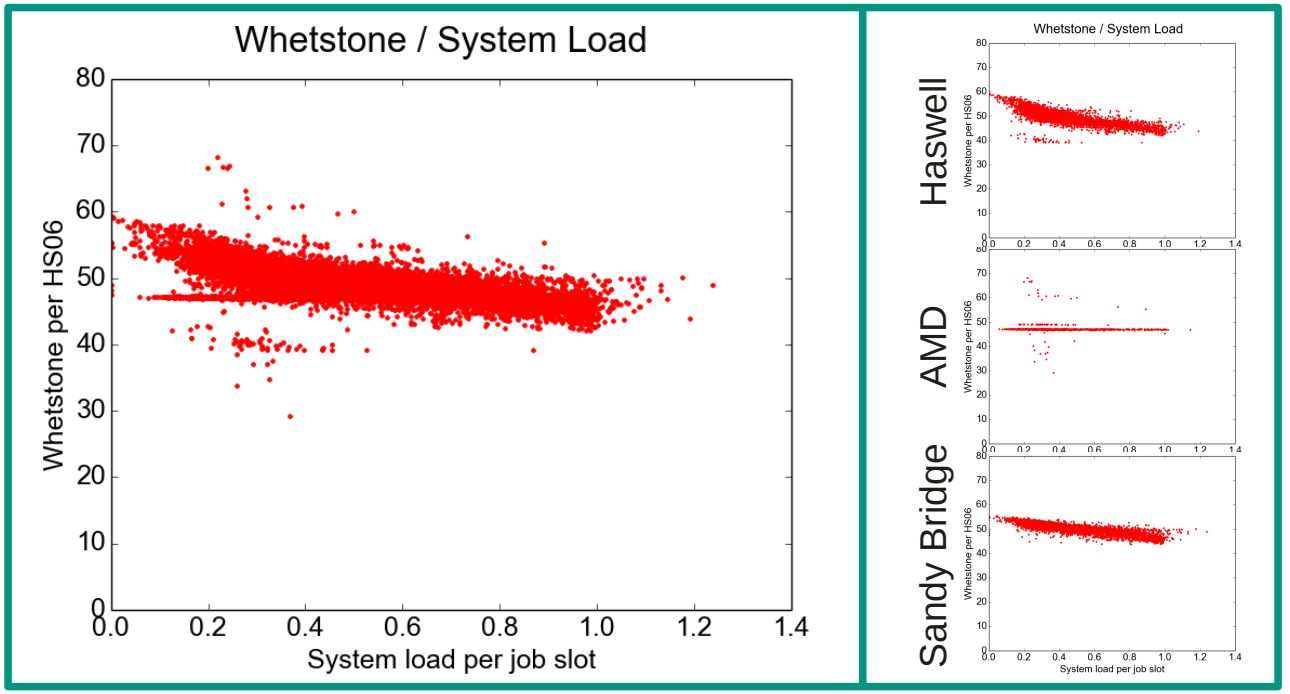
Fast benchmarks and HS06 score:

- ➔ Are we happy with DB12 also for predicting HS06 score (e.g. in anonymouns environments like clouds)?
- ➔ Whetstone might be a better choice to estimate HS06 [6]



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Fast benchmarks and HS06 score:

- ➔ Scaling of Whetstone with HS06 has been demonstrated so far only by Manfred Alef as the results of single-core batch jobs at GridKa [6]
  - There are currently no other results known, for instance from multi-core or cloud VMs

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Fast benchmarks and HS06 score:

- ➔ Dhrystone scales similar to ROOT stress and is therefore not of the first choice

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Fast benchmarks and HS06 score:

- ➔ An important open question is why DB12 and KV are scaling well with WLCG applications, contrary to HS06
  - Where is the magic boost of DB12, KV, and WLCG applications coming from when running on latest chip generations, e.g. Haswell?
- ➔ Investigations by Marco Guerri [9] have shown that the hot-spot in DB12 is a huge switch statement which benefits from the improved Branch Prediction Unit of modern processors
  - Pending work on default workload (Geant4 single muon event generation) used by KV

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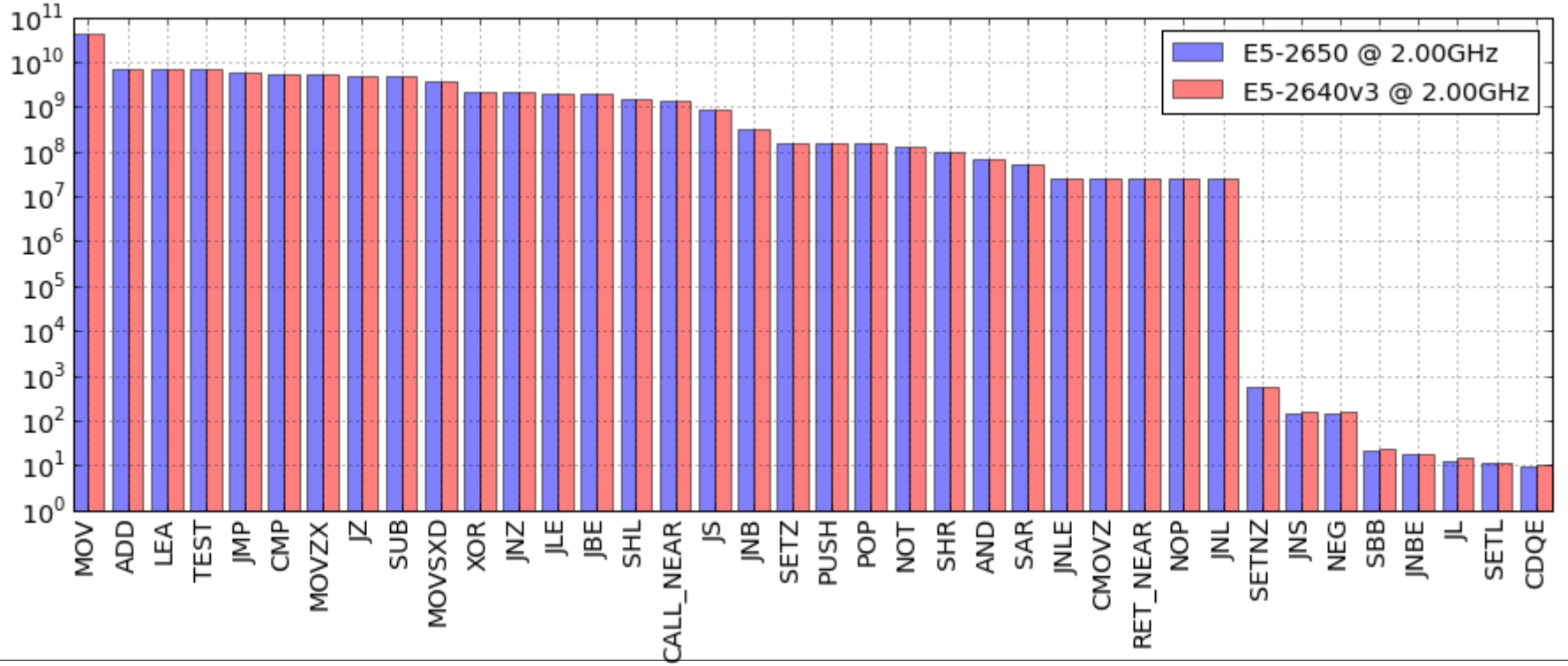
Evolution of processors:

➔ **No general speedup in typical instructions**
between Sandy Bridge (blue bars) and Haswell hosts (red bars) running at the same clock speed, e.g. PyEval_EvalFrameEx [9]



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Evolution of processors:

- Boost of up to 45% in DB12 is caused by **improvements in a single type of instructions** (Branch Prediction Unit) [9]

- Why is this important for the selection of a benchmark?

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Evolution of processors:

- ➔ Until ~10 years ago:
  Clock speed racing, small steps of enhancements
- ➔ Multiple cores
- ➔ Inflating cache size
- ➔ Peripheral, special purpose hardware extensions, for instance:
  - Vector engines
  - Graphics hardware
  - Video processing
  - Encryption
  - Random number generation
  - Branch prediction
  - ...

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Evolution of processors:

➔ The hot-spot in the CPU consumptions of the WLCG benchmarks should be the same as in the most relevant HEP applications

- **Else high risk that the new fast benchmarks will break as soon as one of the next chip generations will boost only the benchmark, or only the HEP applications**

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To-Do list, plans

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To-Do list:

- ➔ Continue running fast benchmarks in various operating environments (batch and clouds, single-core and multi-core)

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To-Do list:

➔ Repeatability of fast benchmark results

- Fluctuations of up to 20% in whole node scores (like HS06)
  - System under test:
    2x Intel Xeon E5-2660v3 (10-core, Haswell), HT enabled
    20 or 40 parallel benchmark copies started on idle host

	20 copies		40 copies	
KV	.63 … .74	**20%**	.64 …1.14	**75%**
DB12	15 … 17	**15%**	8 … 14	**75%**
Whetstone	728 … 763	**5%**	634 … 671	**5%**

  - (HS06: range of variation less than around 3%)
- Similar fluctuations in HTCondor internal benchmark scores

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To-Do list:

➔ Hotspot investigation of Atlas KV (Geant4 workload)

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Plans:

- ➔ Proposal of fast benchmark Q1/2017
- ➔ Development of long-running benchmark starting in Q2/2017

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Questions, comments?

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References:

[1] http://diracgrid.org
[2] http://iopscience.iop.org/article/10.1088/1742-6596/219/4/042037/pdf
[3] https://root.cern.ch
[4] https://github.com/cloudharmony/unixbench
[5] https://indico.cern.ch/event/535458/contributions/2176092/attachments/1284582/1909948/CERNCloudBenchmarkSuite_HEPiXBmkWG_giordano.pdf
[6] https://indico.cern.ch/event/394780/contributions/1832628/attachments/1238976/1820833/Fast-benchmarks-2016-03-07.pdf
[7] https://indico.cern.ch/event/394786/contributions/2298897/attachments/1335785/2011087/20160914-mcnab-lhcb-benchmark.pdf
[8] https://indico.cern.ch/event/394786/contributions/2298897/attachments/1335785/2010771/ALICE_update_on_fast_benchmarking.pdf
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