

# **WLCG HEP-SCORE Deployment Task Force**

Helge Meinhard / CERN-IT  
HEPiX Online Autumn 2021  
26 October 2021

# Why a CPU Benchmark?

- From WLCG perspective, most importantly
  - Experiment requests and site pledges
  - Accounting of CPU usage
- Many sites also use them for procurements



# CPU Benchmarks in WLCG

- Pre-2009: WLCG used a benchmark based on SPECint 2000 (part of SPEC-CPU 2000)
- At EOL, WLCG started looking into SPEC CPU 2006
  - C++ applications of both SPECint 2006 and SPECfp 2006 matched applications well
- Defined benchmark in January 2009 as **HEP-SPEC06**
- At EOL, WLCG started looking into SPEC CPU 2017
  - Found to be a sub-optimal match



# HEP-SPEC06

- Defining workload is not enough
  - Also need to describe the conditions of running
  - Chose conditions in 2009 that were as realistic as possible in view of CPU farms in use for WLCG
    - gcc version and flags, 32bit app, as many concurrent processes as cores, ...
  - Scaling behaviour of real workload initially well within about 10% of benchmark
  - Conditions have changed much since then
    - 64bit, new compilers/versions, flags, SMP processors, multi-threaded applications or pilots launching identical binaries multiple times, VMs and containers, ...
  - Still maintained the initial choices
    - Scaling behaviour matching real workload still surprisingly well (often ~ 20% or better with some exceptions)



# HEP-SPEC06: A Success Story

- Used successfully for more than ten years
- Initially designed as a tool for WLCG, found widespread use in other communities (not limited to HEP)
- Key reasons IMO:
  - Benchmark defined as one single number
  - Definition did not change during the HEP-SPEC06 lifetime



# HEP-SPEC06 Criticism

- Individual reports of scaling deviations of 40% and more
  - Some suggested replacements turned out to be worse for typical workload mixes
- Benchmark workload not typical of HEP applications
  - Would the reasonable scaling persist with non-x86 CPUs, for example? Well, we didn't have that issue (yet)...
- Running HEP-SPEC06 requires a software licence from SPEC
  - Strong desire to consider licence-free benchmarks as successor
- Not representative of full machine potential, not representative of improved experiment workload
  - These are “features” rather than “bugs”
- Time to move on...



# Future HEP Benchmarking (1)

- Pretty much like in 2007/2008, benchmark experts got together and worked on a new benchmark: HEPiX Benchmarking Working Group co-chaired by Manfred Alef (KIT), Domenico Giordano (CERN) and Michele Michelotto (INFN Padua)
  - Several reports to GDB, HEPiX, WLCG MB
    - Domenico's report to HEPiX 26-Oct-2021 (a few minutes ago):  
<https://indico.cern.ch/event/1078853/contributions/4576275/>
  - Without fixing the details of how to use it for a given purpose
- With respect to 2008...2009, landscape has changed completely, which implies new challenges and new opportunities



# Future HEP Benchmarking (2)

- Result of the HEPiX benchmarking working group:
  - “HEP Benchmark Suite”: Framework for running containerised benchmarking workloads
    - Automatises benchmark runs
    - Ensures structured delivery and storage of results
  - “HEP Workloads”: Collection of (mostly) HEP workloads for which it is desirable to obtain performance information
    - Rather dynamic – add improved workloads, new compilers/flags/OS, ...
    - Sometimes called “the matrix” or “the basket”
  - “HEP Score”: Single number based on a defined, stable combination of defined, stable reference workloads; sample implementation (“HEP-SCORE20”) using various LHC experiment workloads (from Run 2)
    - Good consistency with HEP-SPEC06





# HEP-SCORE Deployment Task Force

- WLCG Management board discussed and decided to launch a task force
- Started in November 2020, bi-weekly meetings since then
- Membership:
  - Experts on pledge etc. process / procurements
  - Experiment experts
    - Four LHC experiments
    - Belle 2, DUNE, LIGO/Advanced VIRGO(/KAGRA), JUNO/BES III etc.
  - Site experts
  - Some MB members



# Task Force Members

Name	Function	Name	Function
Tommaso Boccali	CMS	Jeff Templon	Nikhef
Simone Campana	WLCG	Andrea Valassi	LHCb
Domenico Giordano	Benchmarking WG	Ian Collier	STFC-RAL; APEL team
Michel Jouvin	Tier-2s	Gonzalo Merino	PIC
Walter Lampl	ATLAS	Fazhi Qi	JUNO, BES etc.
Andrew McNab	DUNE	Oxana Smirnova	NDGF
Helge Meinhard	WLCG and Convener	Tony Wong	US Tier-1s
Bernd Panzer	CERN	Josh Willis	LIGO/Adv. VIRGO
Stefano Piano	ALICE	Manfred Alef	KIT and Benchmarking WG
Randy Sobie	Belle 2	Alastair Dewhurst	STFC-RAL
Andrew Melo	Vanderbilt U; US CMS T2		



# Topics to Cover

- Compute facilities at WLCG sites
  - Still very much x86 dominated (mostly Intel, some AMD)
- Compute facilities used (quasi-)opportunistically
  - Various processors (x86, POWER, ARM), e.g. at HPC sites
  - Various GPUs in various relations with CPUs, e.g. at HPC sites
  - May see some of this soon at WLCG sites, too – even as part of the pledges
  - More may be coming, e.g. FPGAs



# Strategy

- Start with CPU benchmarking on x86-based systems; look at other CPUs and/or GPUs later
  - Aim: single benchmark with a stable definition for at least (a typical CPU server lifetime cycle | a complete LHC machine cycle)
- Framework by benchmarking WG is very attractive
  - Use it to record behaviour of (wide) selection of workloads (not limited to HEP) across machines
- Study behaviour of large range of workloads over large range of benchmarking platforms
  - Aim: Select a sample of workloads (possibly with weights)
    - Sufficiently representative of real workloads on installations we (WLCG or HEP) use
    - Sufficiently small to be practical as a benchmark
    - Sufficiently precise and reproducible
- Propose a transition scenario from HEP-SPEC 06 to HEP-SCORE 2x for WLCG



# Progress since Spring (1)

- Workloads: detailed reports on candidates
  - LHC experiments: event generation, detector simulation and digitisation, reconstruction; (analysis)
  - Other (mostly HEP) experiments: Belle II, JUNO, GW experiments, DUNE
  - Non-HEP workloads: HS06, SPEC-CPU 2017, DB12
- Good fraction of workloads packaged already, rest on-going
- Benchmarking platforms: plethora from
  - BNL
  - CERN
  - IHEP
  - IJCLab
  - KIT
  - LIGO
  - NDGF-T1
  - Nikhef
  - PIC
  - RAL



# Progress since Spring (2)

- Tools and infrastructure: see Domenico's WG report
- Person-power
  - One additional person at CERN
  - Support ensured at sites with benchmarking platforms



# Interested? How Can You Help?

- Help integrate proposed workloads as containers into HEP Benchmark Suite
- Provide sample machines of typical worker node configurations (“benchmarking platforms”)
  - The more variety we have, the better
- Once ready, run HEP Workloads on your sample machines



# (Personal) Conclusions

- Defining a HEP-SPEC 06 successor is a complex, ambitious task
  - Will take many months rather than weeks
  - ... and then we will have to tackle non-x86 CPUs and GPUs
- Quite a number of different views on how exactly this should be done
  - Good representation in the task force
- Nonetheless, discussions in a constructive and collaborative spirit
- Steady progress
  
- Thanks to all task force members!





# Questions? Comments?

