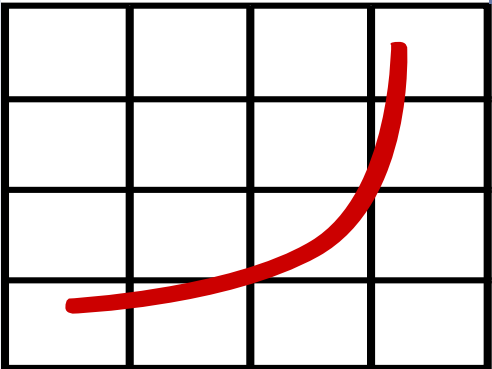




# Overview of SPEC and the SPEC High Performance Group

Kalyan Kumaran, Argonne Leadership Computing Facility

Robert Henschel, Indiana University



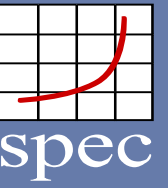
spec



<http://go.iu.edu/lp9>

- Tutorial Overview
- Intro to SPEC and SPEC HPG
- The SPEC Benchmark Philosophy
- SPEC HPG Benchmarks
- Users and Use Cases

# Tutorial Overview

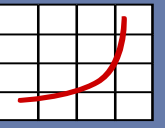


- Overview of SPEC and SPEC HPG
- SPEC Benchmarks
- Hands-On how to run SPEC Benchmarks
- Interpreting and Publishing Results
- Advances SPEC Benchmark Usage
- Wrap-Up

<http://go.iu.edu/lp9>



- **Intro to SPEC and SPEC HPG**
- The SPEC Benchmark Philosophy
- SPEC HPG Benchmarks
- Users and Use Cases



# Standards Performance Evaluation Corporation (SPEC)<sub>spec</sub>

- SPEC is a non-profit corporation formed to "establish, maintain and endorse a standardized set of relevant benchmarks that can be applied to the newest generation of high-performance computers"
- Composed of four groups
  - Graphics and Workstation Performance Group (GWPG)
  - High Performance Group (HPG)
  - Open Systems Group (OSG)
  - Research Group (RG)
- <https://www.spec.org>

## The SPEC Consortium: Members and Associates

### SPEC Members:

*Acer Inc. \* Action S.A. \* Advanced Micro Devices \* Amazon Web Services, Inc. \* Apple Inc. \* ARM \* ASUSTeK Computer Inc. \* Avere Systems \* Bull S.A. \* Cavium Inc. \* Cisco Systems, Inc. \* Dell, Inc. \* E4 Computer Engineering SPA \* EMC \* Fujitsu \* Gartner, Inc. \* Hitachi Data Systems \* Hitachi Ltd. \* HP \* Huawei Technologies Co. Ltd. \* IBM \* Inspur Corporation \* Intel \* Lenovo \* Micron Technology, Inc. \* Microsoft \* NEC - Japan \* NetApp \* NVIDIA \* Oracle \* Panasas \* Primary Data \* Principled Technologies \* Qualcomm Technologies Inc. \* Quanta Computer Inc. \* Red Hat \* Samsung \* SAP AG \* Seagate \* SGI \* Sugon \* Super Micro Computer, Inc. \* SUSE \* Symantec Corporation \* Twitter, Inc. \* Unisys \* Via Technologies \* VMware \* Wipro Ltd. \* ZTE Corporation \**

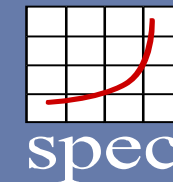
### SPEC Associates:

*Academia Sinica, Institute of Information Science \* Argonne National Laboratory \* Charles University \* China Academy of Telecommunication Research \* Department of Veterans Affairs - Corporate Data Center Operations \* Dresden University of Technology ZIH \* fortiss GmbH \* Indiana University \* Institute for Information Industry Taiwan \* JAIST \* Karlsruhe Institute of Technology \* Leibniz Rechenzentrum - Germany \* National University of Singapore \* Oak Ridge National Laboratory \* Ohio State University \* Pennsylvania State University \* Purdue University \* RWTH Aachen University \* Technische Universität Darmstadt \* Technische Universität Dresden \* Tsinghua University \* University of Aizu - Japan \* University of California - Berkeley \* University of Cologne \* University of Houston \* University of Illinois at Urbana-Champaign \* University of Maryland \* University of Miami \* University of Pavia \* University of Texas at Austin \* University of Tsukuba \* University of Wuerzburg \* Virginia Polytechnic Institute and State University \**

### SPEC Research Group:

*Advanced Strategic Technology LLC \* bankmark UG \* Barcelona Supercomputing Center \* Charles University \* Cisco Systems \* Cloudera, Inc \* Compilaflores \* Delft University of Technology \* Dell \* fortiss GmbH \* Friedrich-Alexander-University Erlangen-Nuremberg \* Goethe University Frankfurt, Big Data Lab \* Hewlett-Packard \* Huawei \* IBM \* Imperial College London \* Indian Institute of Technology, Bombay \* Institute for Information Industry, Taiwan \* Institute of Communication and Computer Systems/NTUA \* Intel \* Karlsruhe Institute of Technology \* Kiel University \* MIOsoft Corporation \* Mitre Corporation \* NICTA \* Nova-Tec Consulting GmbH \* Oracle \* Purdue University \* Red Hat \* RWTH Aachen University \* Salesforce.com \* San Diego Supercomputing Center \* San Francisco State University \* SAP AG \* Siemens Corporation \* Technische Universität Darmstadt \* Technische Universität Dresden \* The MITRE Corporation \* Umea University \* University of Alberta \* University of Coimbra \* University of Florence \* University of Lugano \* University of Minnesota \* University of North Florida \* University of Paderborn \* University of Pavia \* University of Stuttgart \* University of Texas at Austin \* University of Wuerzburg \* VMware \**

# SPEC High Performance Group (HPG)



- Develops benchmarks to represent high-performance computing applications for standardized, cross-platform performance evaluation.
- Benchmarks
  - SPEC OMP2012
  - SPEC MPI2007
  - SPEC ACCEL



INDIANA UNIVERSITY



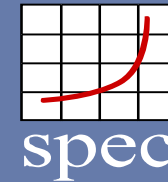
UNIVERSITY OF HOUSTON



NVIDIA



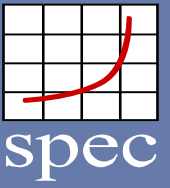
# Contents



- Intro to SPEC and SPEC HPG
- **The SPEC Benchmark Philosophy**
- SPEC HPG Benchmarks
- Users and Use Cases



# SPEC Benchmark Philosophy



- The result of a SPEC benchmark is always a SPEC score.
  - Higher is better
- This score is always in relation to a reference machine.
  - Each benchmark has its own reference machine

# SPEC Benchmark Philosophy cont'd

- SPEC (HPG) benchmarks are full applications.
  - Including all the overhead of a real application
- SPEC harness ensures correctness of results.
  - To detect “overly aggressive optimization”
  - To guard against tampering
- Each benchmark suite has a set of run rules.

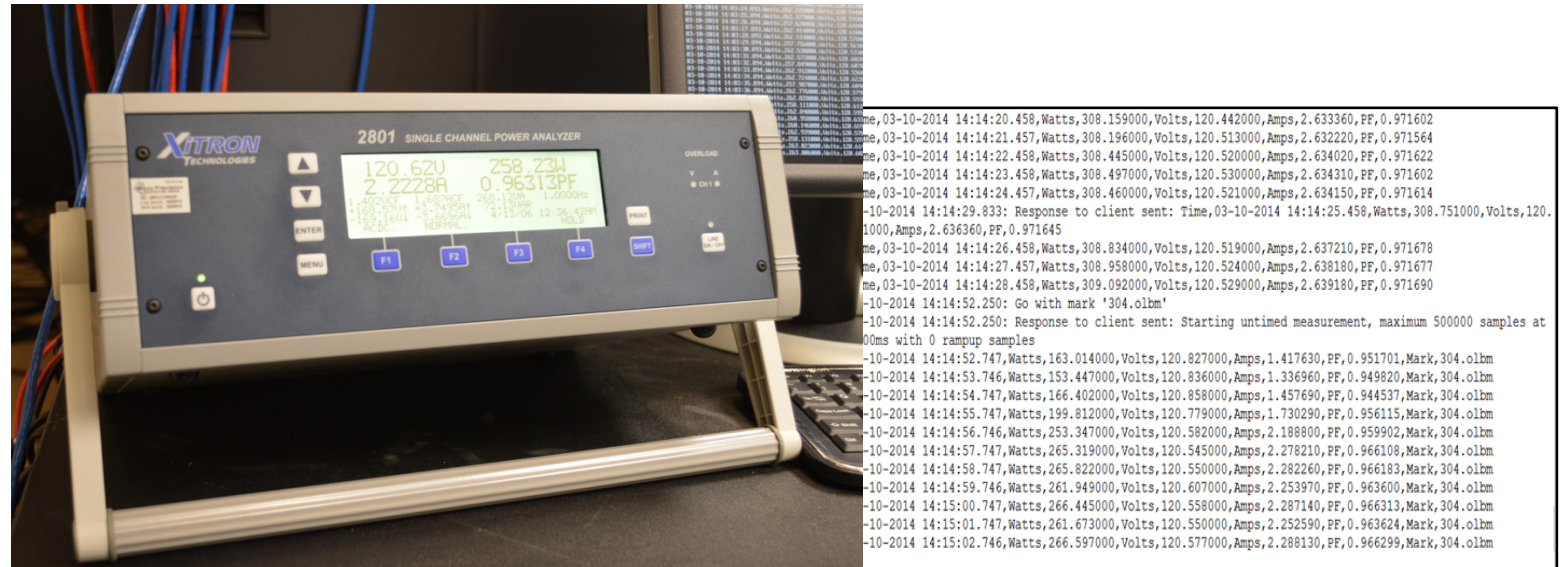
# SPEC Benchmark Philosophy cont'd

- Hierarchy within benchmark suits
  - Benchmark suite i.e. SPEC ACCEL
  - Benchmark i.e. OpenACC
  - Dataset size i.e. Medium
  - Component i.e. 350.md

# SPEC Benchmark Philosophy cont'd

- Benchmarks support “Base” and “Peak” configuration
  - These yield separate SPEC scores.
  - Peak” runs allow for more freedom.
- Base runs
  - The same compiler switches for all components
  - The same parallelism
  - Only portability switches allowed

- SPEC provides a standard methodology to measure and report power usage which can be incorporated into a SPEC benchmark.
- Normalizes the power usage across the full run of the suite



# Benchmark Development Process

- Group effort, with lots of discussions
- Final decisions are by vote, even though we strive for consensus
- Technical and managerial parts
  - Find benchmark components and define run rules
- Using SPEC provided tools
  - SVN, harness, “common rules”
  - Websites, mailing lists, meeting venues

# Result Submission Process

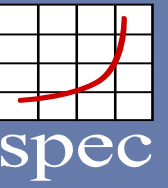
- Obtain and install the benchmark
- Perform a valid run
- Supply hardware and software description
- Submit result for review (and publication) to SPEC HPG
  - 2 week review process
  - (Define embargo period)
- Use the result as you would like (within fair use policy)

# The Value of a Curated Result Repository

- Given appropriate hardware.... a published result should be reproducible just with the information available in the submission.
- Peer reviewed results are so much better than “everyone can upload a result”!
- The value of a benchmark suite lies in public results, their correctness and the ability to compare them.



# Contents



- Intro to SPEC and SPEC HPG
- The SPEC Benchmark Philosophy
- **SPEC HPG Benchmarks**
- Users and Use Cases

- SPEC Accel provides a comparative performance measure of
  - Hardware accelerator devices (GPU, Co-processors, etc.)
  - Supporting software tool chains (Compilers, Drivers, etc.)
  - Host systems and accelerator interface (CPU, PCIe, etc.)
- Computationally-intensive parallel HPC applications and mini-apps
- Portable across multiple accelerators
- Two distinct benchmarks
  - OpenACC v1.0
  - OpenCL v1.1
- Support for power measurement

- Follow on to SPEC OMP2001
- 14 applications
- Scales up to 512 threads
- Support for power measurement

- Large and medium data set
- 13 applications
- Scales to 2048 MPI processes
- Power not supported

- SPEC MPI2007 XXL dataset
  - Scalability target 8K cores
- SPEC ACCEL version 1.1
  - Minor tweaks
- SPEC ACCEL OpenMP 4.0 benchmark
  - This is hard... given the state of OpenMP 4.0 compilers

- Intro to SPEC and SPEC HPG
- The SPEC Benchmark Philosophy
- SPEC HPG Benchmarks
- **Users and Use Cases**

- System vendors
- Accelerator vendors
- Software vendors
- Users looking for objective comparison
- Researchers

- Marketing
- Drive benchmark development
  - To utilize state of the art hardware/software features
- Internal validation suite
  - Compiler
  - OMP / MPI runtime libraries
- Prepare for RFPs



# Application Developers

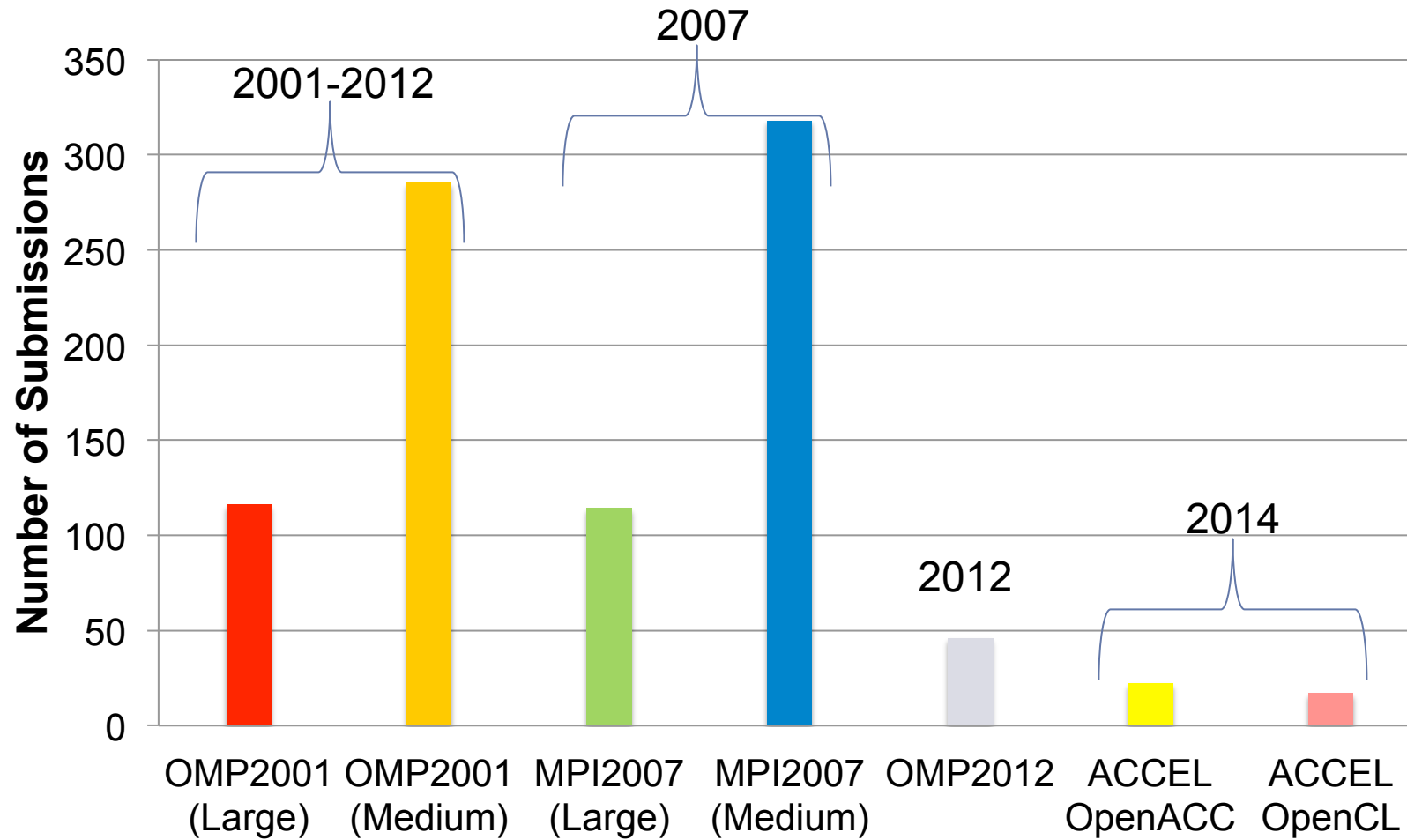
- Include their application in the benchmark suite
- Compare hardware and software stack
  - Compilers
  - Parallel runtimes
  - Different versions of processors
  - Different interconnects

- Include the benchmarks in the RFP process
- Use them for performance regression testing
  - Hardware
  - Software
- System configuration and tuning
- Power consumption

- Scalability studies
- Novel implementations of parallel runtime libraries
- Detailed power consumption studies
- Comparison of parallel programming paradigms

- Submit results
- Full members vs. associate members
- Contribute benchmark components
- Help with benchmark suite development
- Test release candidates

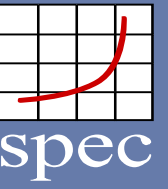
# Result Submissions by Benchmark



# Sample Use Cases

- Comparing performance and energy
- Comparing performance of hypervisors
- Comparing HPC systems at a specific center
- Compare compiler performance over time
- Compare performance of different compilers
- Scalability study for different interconnects
- System setup questions like to use HT or not, which OS to use
- Compare accelerator performance

# Thank you!



## Questions?