

Industry Standards for Benchmarking Big Data Systems

Invited Talk
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International Workshop on High-Performance Big Data Computing

About me

- Cisco Distinguished Engineer, Chief Architect of Big Data Solution Engineering
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Agenda

- 25+ years of industry standard benchmarks
- Emergence of big data
- Developing standards for big data systems
- Outlook

Benchmarks

- Micro Benchmarks
 - Synthetic workloads to stress test subsystems
- Application Benchmarks
 - Developed and administered by application vendors
- Industry Standard Benchmarks
 - Developed by a consortia through a democratic process

Industry Standard Benchmarks

- 25+ years of history
- Industry standard benchmarks have played, and continue to play, a crucial role in the advancement of the computing industry
- Demands for them have existed since buyers were first confronted with the choice between purchasing one system over another
- Historically we have seen that industry standard benchmarks enable **healthy** competition that results in product **improvements** and the evolution of brand new technologies
- **Critical** to vendors, customers and researchers

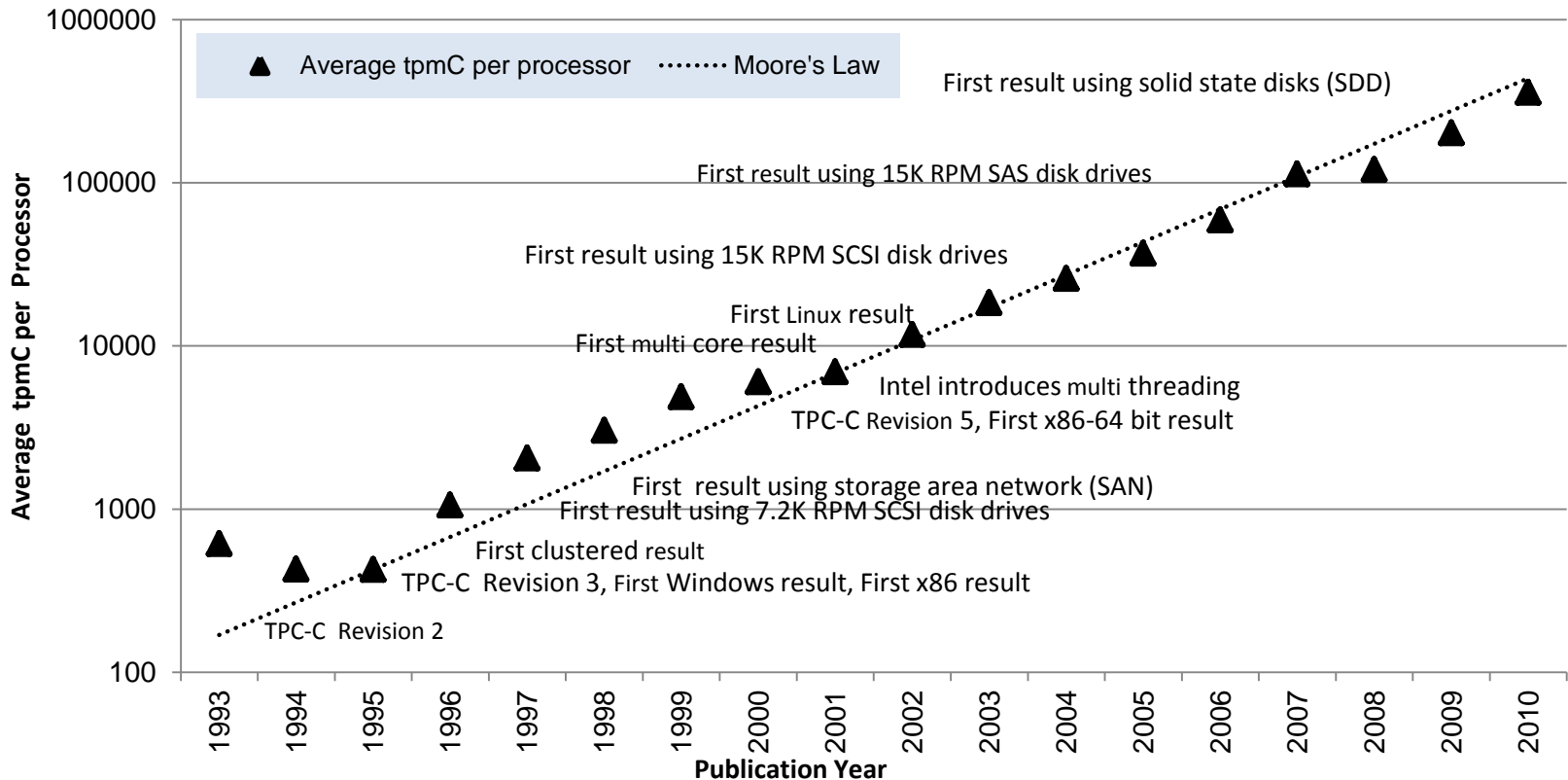
Relevance

- To Vendors
 - Define the level playing field for competitive analysis (marketing)
 - Monitor release to release progress, Qualify assurance (engineering)
 - Accelerate product developments and enhancements
- To Customers
 - Cross-vendor product comparisons (performance, cost, power)
 - Evaluate new technologies
- To Researcher
 - Known, measurable and repeatable workloads
 - Accelerate developments

Industry Standard Committees

- **Transaction Processing Performance Council (TPC)**
 - A non-profit corporation founded in 1988 to define transaction processing and database benchmarks
 - Now focusing on data centric benchmarks
 - Complete application system level performance and price-performance
 - Flagship benchmark TPC-C (inline with Moore's law)
 - Represented by major server and software vendors
- **Standard Performance Evaluation Corporation (SPEC)**
 - Established in 1988 to provide the industry with a realistic yardstick to measure the performance of advanced computer systems and to educate consumers about the performance of vendors' products
 - Creates, maintains, distributes, and endorses a standardized set of relevant benchmarks that can be applied to the newest generation of high-performance computers
 - Flagship benchmark SPEC CPU with 30,000 publications
 - Represented by major industry and research organizations

TPC-C Performance vs. Moore's Law



25 Years ! Contributions of the TPC

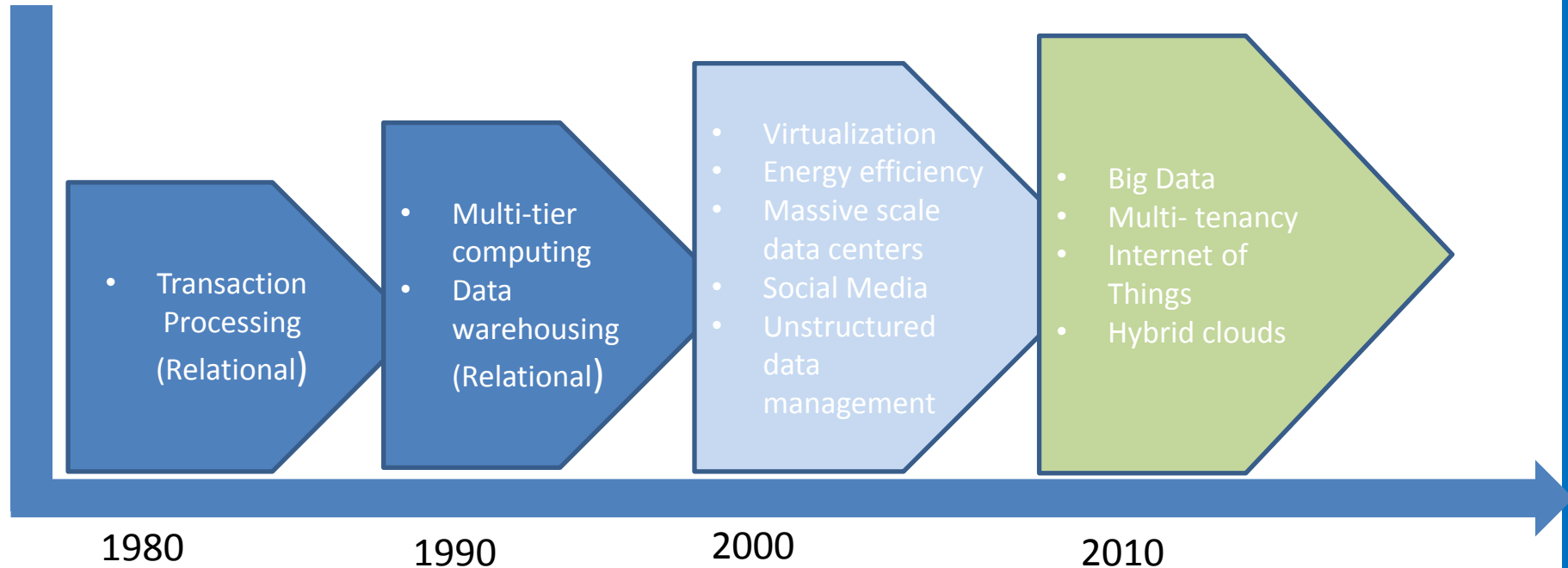
- Reputation of providing the most credible transaction processing and database benchmark standards and performance results to the industry.
- Role of “consumer reports” for the computing industry
- Solid foundation for complete system-level performance
- Methodology for calculating total-system-price and price-performance
- Methodology for measuring energy efficiency

Technology and industry changed rapidly

Traditional organizations (and standards committees) struggled ...



Enterprise Applications Landscape



Emergence of Big Data ...

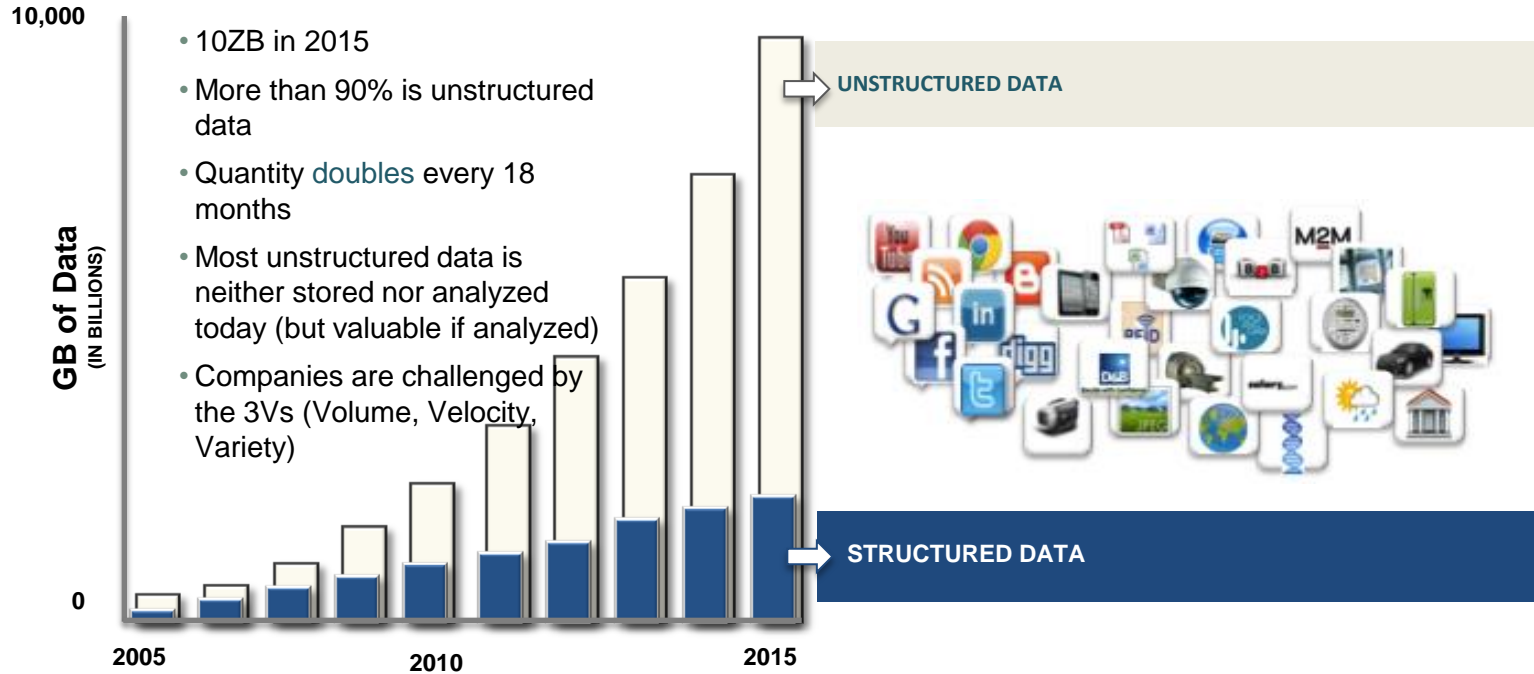
Emergence of Big Data

- Big Data is one of the most talked about topics in industry, research and government
- It is becoming an integral part of enterprise IT ecosystem across major verticals including agriculture, education, energy, entertainment, healthcare, insurance, manufacturing and finance
- Challenges represented by the 5V's
- Becoming center of 3I's – Investments, Innovation, Improvization

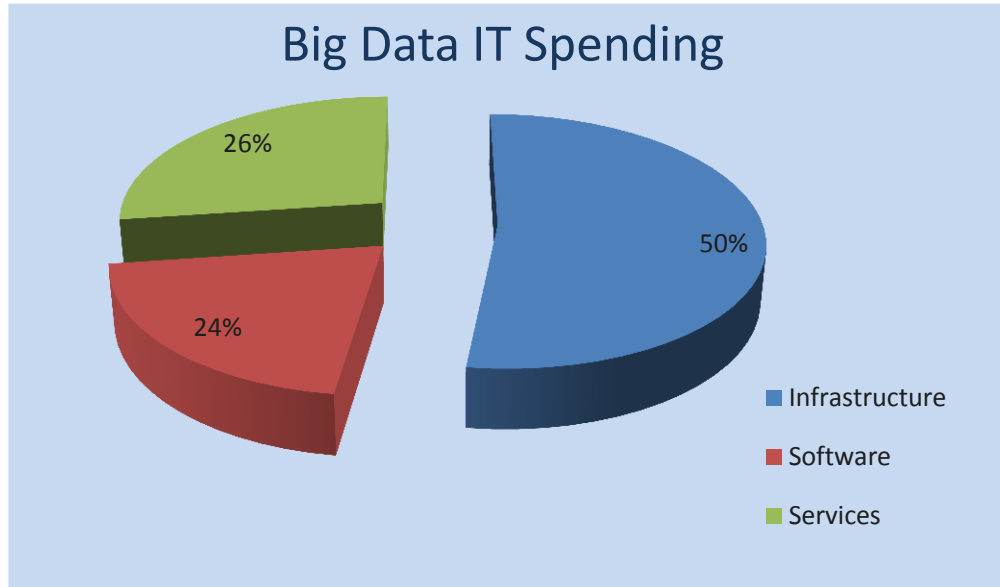
Big Data Market

- The Big Data technology and services market represents a **fast-growing multibillion-dollar** worldwide opportunity (Source: IDC)
- Big Data technology and services market will grow at a 27% compound annual growth rate (CAGR) to \$34 billion through 2017 - or **about six times the growth** rate of the overall Information and Communication Technology (ICT) market (Source: IDC)
- Big Data will drive \$240 billion of worldwide IT spending in 2016 directly or indirectly (Source: IDC)
- **73%** of organizations have invested in or plan to Invest in Big Data in two years. (Source: Gartner)

IT Transition: The Information Explosion



Top Challenge for Enterprise Customers



What platform
(hardware and
software) to pick in
terms of performance,
price-performance,
and energy efficiency ?

Not Easily Verifiable Claims and Chaos

Performance benchmark for Hadoop

an industry-standard Apache Hadoop Terasort benchmark

to demonstrate real world big data workloads, the HP Apache Hadoop solution is 1
deliver industry-leading performance for a 10-terabyte (TB) dataset processed in
(approximately 1.5 hours). Built on HP Conv

ProLiant Generation 8 (Gen8) DL380 cluster

Comment: 63 visits

IBM... Platform Computing today announced results of Platform Syred
BigDights Hadoop benchmarking. The result:

Benchmark 1 - 10x faster than Hadoop 1.0.1

Benchmark 2 - 5x faster than Hadoop 1.0.1

Benchmark 3 - 10x fewer CPU cores

This is breakthrough performance.

Benchmark 1.

This is a simple sleep test. It sends a job to the cluster, job sleeps
purpose is to m

There are Claims (not discrediting them) but not easily verifiable or comparable due to lack of standards

- (1) As the first vendor to submit performance results for the 10TB Terasort benchmark, an 18-node ProLiant Gen8 sorted the 10C HP ProLiant Gr 100GB 2011 r 2.9GHz processors; 64 GB memory; 16 x 1 TB s Red Hat Enterprise Linux 6.2; Java Platform, Standard Edition, JDK 6 Update 29-b11.
- (2) Based on internal testing, deployed 800 nodes in 30 minutes.
- (3) HP ProLiant Gen8 DL380P with 768GB memory versus Oracle Sun Fire X4270 M2 with 144GB memory.
- (4) The HP Reference Architecture for Hortonworks Data Platform is expected in Q4 2012.

Remember the 1980's ?

State of the Nature - early 1980's

the industry began a race that has accelerated over time: automation of daily end-user business transactions. The first application that received wide-spread focus was automated teller transactions (ATM), but we've seen this automation trend ripple through almost every area of business, from grocery stores to gas stations. As opposed to the batch-computing model that dominated the industry in the 1960's and 1970's, this new online model of computing had relatively unsophisticated clerks and consumers directly conducting simple update transactions against an on-line database system. Thus, the on-line transaction processing industry was born, an industry that now represents billions of dollars in annual sales.

Early Automata: a Civilized Competition

In the April 1, 1985 issue of Datamation, Jim Gray in collaboration with 24 others from academy and industry published (anonymously) an article titled, "A Measure of Transaction Processing Power." This article outlined a test for on-line transaction processing which was given the title of "DebitCredit." Unlike the TP benchmark, Gray's DebitCredit benchmark specified a true system-level benchmark where the network and user interaction components of the workload were included. In addition, it outlined several other key features of the benchmarking process that were later incorporated into the TPC process:

The TPC Lays Down the Law

While Gray's DebitCredit ideas were widely praised by industry opinion makers, the DebitCredit benchmark had the same success in curbing bad benchmarking as the prohibition did in stopping excessive drinking. In fact, according to industry analysts like Omri Serlin, the situation only got worse. Without a standards body to supervise the testing and publishing, vendors began to publish extraordinary marketing claims on both TP1 and DebitCredit. They often deleted key requirements in DebitCredit to improve their performance results.

From 1985 through 1988, vendors used TP1 and DebitCredit--or their own interpretation of these benchmarks--to muddy the already murky performance waters. Omri Serlin had had enough. He spearheaded a campaign to see if this mess could be straightened out. On August 10, 1988, Serlin had successfully convinced eight companies to form the Transaction Processing Performance Council (TPC).



Early Attempts at Civilized Competition

History and Overview of the TPC

by Kim Shanley, Chief Operating Officer, Transaction Processing Performance Council <http://www.tpc.org/information/about/history.asp>

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- **Total system cost published with the performance rating.** Total system cost included all hardware and software used to successfully run the benchmark, including 5 years maintenance costs. Until this concept became law in the TPC process, vendors often quote only part of the overall system cost that generated a given performance rating.
- **Test specified in terms of high-level functional requirements** rather than specifying any given hardware or software platform or code-level requirements. This allowed any company to run this benchmark if they could meet the functional requirements of the benchmark.
- **The benchmark workload scaleup rules** -- the number of users and size of the database tables -- increased proportionally with the increasing power of the system to produce higher transaction rates. The scaling prevented the workload from being overwhelmed by the rapidly increasing power of OLTP systems.
- **The overall transaction rate would be constrained by a response time requirement.** In DebitCredit, 95 percent of all transactions had to be completed in less than 1 second.

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Staying Relevant ...

Industry Initiatives

- TPC
 - Technology Conference Series on Performance Evaluation and Benchmarking (2009)
 - TPC Express Benchmark Standard (2013)
 - Big Data Benchmark Standards Committee (2013)
- Big Data Benchmark Community (BDBC)
 - Workshop Series on Big Data Benchmarking (WBDB) (2012)
 - 7 workshops since 2012. Next workshop will be in New Delhi 12/2015
 - BDBC merged with **SPEC Research** (2014)
 - BigData Top 100 (2102, work in progress)

Technology Conference Series: TPCTC

- **Mission**
 - Keep pace with technological changes
 - Foster collaboration between industry experts and research community
 - Explore new areas, ideas and methodologies for performance evaluating an benchmarking and enhancements to existing TPC benchmarks
- **Impact**
 - New members joining the TPC
 - New collaborations with universities
 - Influenced the development of a TPC-VMS, TPC-DI
 - Several extensions to TPC benchmarks
 - Lessons learned in practice
- **Established as a known forum**
 - Co-located with VLDB since 2009

TPC Express Benchmark Standard

- Easy to implement, run, audit, publish, and less expensive for vendors
- Kit is provided and test sponsor is required to use the TPC provided kit (TPC Enterprise benchmarks provided a specification)
- The vendor may choose an independent audit or peer audit
- Simpler approval process. Approved by super majority of the TPC General Council
- All publications must follow the TPC Fair Use Policy

Developing a standard...

Industry Standards: What is Important ?

- Performance
- Cost of ownership
- Energy efficiency
- Floor space efficiency
- Manageability
- User experience

Successful Benchmark Requirements

- Relevant
- Repeatable
- Understandable
- Fair
- Verifiable
- Economical



Design Considerations for Big Data Benchmark

- Relevant (to Big Data Market), Repeatable (Reproducible), Understandable (Customers, Vendors: Engineering, Marketing), Fair (Hardware and Software technologies), Verifiable, Economical (Create, Run, Publish)
- There is an immediate need for a standard. Long development cycle is not acceptable. (Can a known workload be used ?)
- Must provide an objective measure of hardware and software (most common is Hadoop) with verifiable performance, price-performance and availability metrics
- Can be used to assess a broad range of system topologies and implementation methodologies in a technically rigorous and directly comparable, in a vendor-neutral manner.

TPC Big Data Benchmark Standards

- A Working Group was formed in October 2013 to evaluate big data workload(s) and make recommendations to the TPC general council
- A Development Subcommittee formed in February 2014 to develop an Express benchmark for Hadoop systems based on already popular TeraSort workload (time to market)
- In July 2014 TPCx-HS became industry's first standard for benchmarking Big Data Systems
- Positive response from industry and academia
- First benchmark publication on January 2015
- TPC continues to invest in new benchmarks: TPC-DS (Hadoop Friendly Version), Big Bench

TPCx-HS

- x: Express, H: Hadoop, S:Sort
- Primary audience is enterprise customers (not public clouds)
- Enable measurement of both hardware and software including Hadoop Runtime, Hadoop Filesystem API compatible systems and MapReduce layers
- Provides verifiable performance, price/performance, general availability, and optional energy consumption metrics of big data systems
- The TPCx-HS follows a stepped Scale factor model (like in TPC-H and TPC-DS). 1TB, 3TB, 10TB, 30TB, 100TB, 300TB, 1PB, 30PB, 100PB
 - TPC mandates 3-way replication for source data, temp and result. So, 7-8x capacity requirement
- The benchmark test consists of two runs. No configuration or tuning changes or reboot are allowed between the two runs. Run with lower metric is reported
- Complete kit is provided – lowering learning curve, development cost, and benchmark audit cost

TPCx-HS: Metrics

- Performance Metric (effective sort throughput of the SUT)
 - $\text{HSph@SF} = \text{SF} / (\text{T} / 3600)$. Where SF is the Scale Factor, T is the elapsed time for the performance run (data generation, pre data check, sort, post data check, data validate)
- Price-Performance
 - $\$/\text{HSph@SF} = \text{P} / (\text{HSph@SF})$. Where P is the total cost of ownership of the SUT
- Availability Date
 - The date when the all Components of the system under test are generally available
- Energy Metric (Optional)
 - $\text{Watts/HSph@SF} = \text{E} / (\text{T} * \text{HSph@SF})$. Where E is the energy consumption for the reported run, T is the elapsed time in seconds for the reported run, and HSph@SF is the performance metric

TPCx-HS Contributors

Developing an industry standard benchmark for a new environment like Big Data has taken the dedicated efforts of experts across many companies. Thanks to:

Andrew Bond (Red Hat), Andrew Masland (NEC), Avik Dey (Intel), Brian Caufield (IBM), Chaitanya Baru (SDSC), Da Qi Ren (Huawei), Dileep Kumar (Cloudera), Jamie Reding (Microsoft), John Fowler (Oracle), John Poelman (IBM), Karthik Kulkarni (Cisco), Meikel Poess (Oracle), Mike Brey (Oracle), Mike Crocker (SAP), Paul Cao (HP), Reza Taheri (VMware), Simon Harris (IBM), Tariq Magdon-Ismail (VMware), Wayne Smith (Intel), Yanpei Chen (Cloudera), Michael Majdalany (L&M), Forrest Carman (Owen Media) and Andreas Hotea (Hotea Solutions).

Lessons Learned

- Focus on what the industry is looking for
- Recruit relevant players
- Keep it simple ? (develop, understand, run, publish) for the vendors
- Start with known workloads. Too risky to develop standards from scratch
- Complete kit – lower learning curve, lower development cost, lower benchmark audit cost
- Evolve with industry and technology trends

Is that all ?

Industry landscape Continues to Changes

People

40% of the world population
has internet access
50% by 2020



Things

16 billion connected devices today, 50
billion by 2020
2.5 Billion Smart Connected Devices
will be shipped in 2016



New Applications and Services

The third generation of IT platform
Built on 4 pillars - cloud, mobile devices, social
technologies and big data

What Happens in an Internet Minute?



And Future Growth is Staggering



Top Areas for Benchmarking

- Internet of Things (Edge, Core)
- Complex Systems (Converged systems, Mixed workloads, Multi tenancy)
- Performance and TCO {Private, Public, Hybrid} Clouds
- How to measure Manageability, User Experience (?)

