High Performance Computing and Which Big Data?

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Overview of Presentation

- **Background**
  - What we benchmark ➔ Which big data
- **Current Initiatives in Big Data Benchmarking**
- **Making Progress**

Some Benchmarking History

- **1994-95: TPC-D**
  - Transaction Processing Council (est. 1988)
  - TPC-C: Transaction processing benchmark
    - Measured transaction performance and checked ACID properties
    - tpmC and $/tpmC
    - Jim Gray's role. *A Measure of Transaction Processing Power,* 1985. Defined the Debit-Credit benchmark, which became TPC-A
  - TPC-D was the first attempt at a *decision-support* benchmark
    - Measured effectiveness of SQL optimizers
  - TPC-H: Follow-on to TPC-D. Currently popular (regularly "misused")
    - Uses same schema as originally defined by TPC-D

(My) Background

- **TPC-D**
  - I was involved in helping define the TPC-D benchmark and metric (geometric mean of response times of queries in the workload)
  - December 1995: Led the team at IBM that published industry's first official TPC-D benchmark
    - Using IBM DB2 Parallel Edition (shared nothing)
    - On a **100GB** database, **100-node** IBM SP-1, **10TB** total disk

Background..fast forward

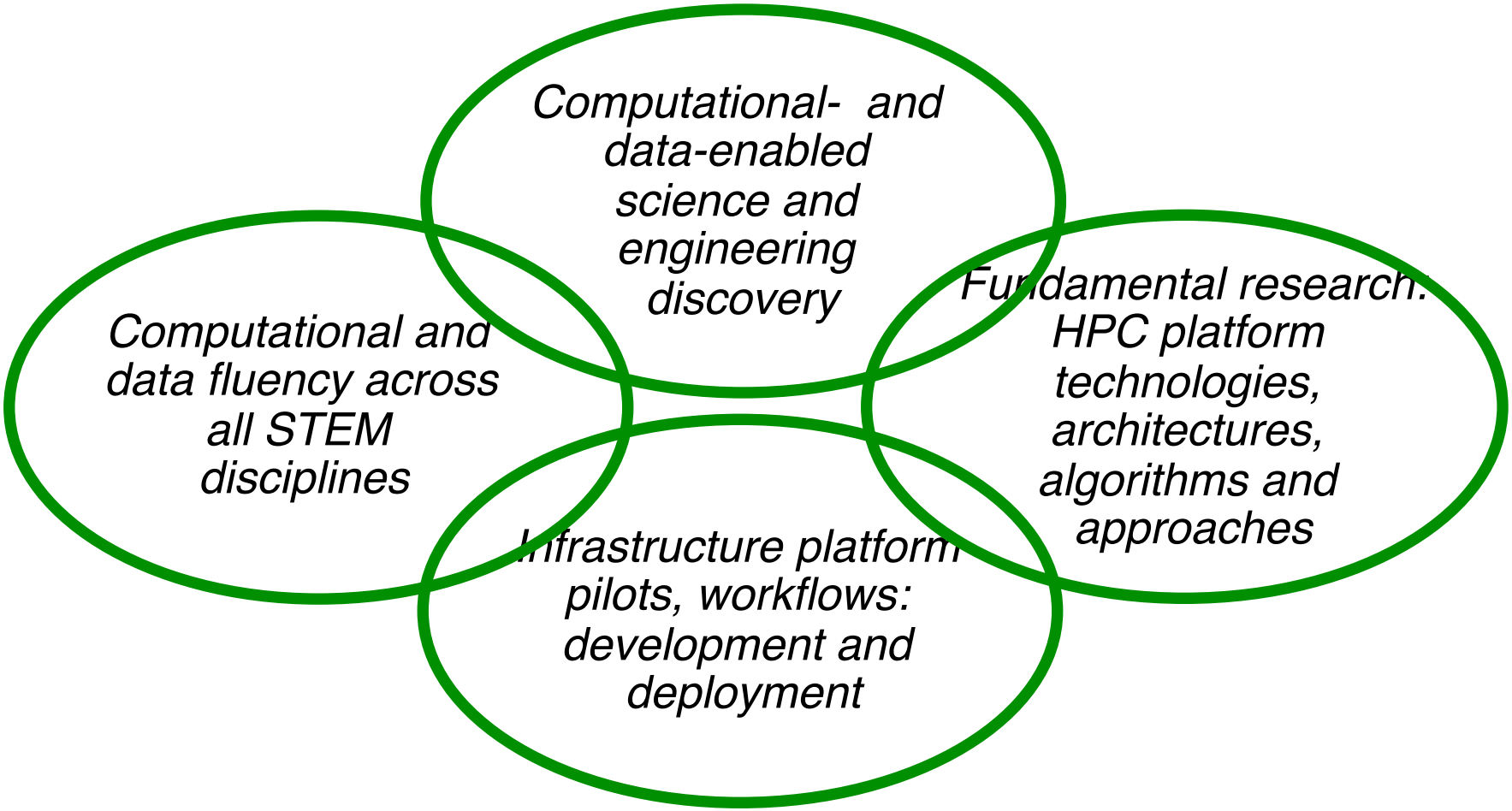
- **2009: NSF CluE grant, IIS-0844530**
  - NSF Cluster Exploratory program
  - Compared DB2 vs Hadoop ("Hadoop 2"…0.2) performance on LiDAR point cloud dataset
- **2012: WBDB, NSF IIS-1241838, OCI-1338373**
  - Workshops on Big Data Benchmarking (Big Data Top 100 List)
  - Worked with the TPC Steering Committee and other industry participants to organize first WBDB workshop, May 2012, San Jose, CA.
  - 7th WBDB was held in December 2015, New Delhi, India

Where We Are

- **Many applications where Big Data and High Performance Computing are becoming essential**
  - Volume, velocity, complexity (deep learning)

- **National Strategic Computing Initiative**
  - Objective 2: “Increasing coherence between the technology base used for modeling and simulation and that used for data analytic computing.”

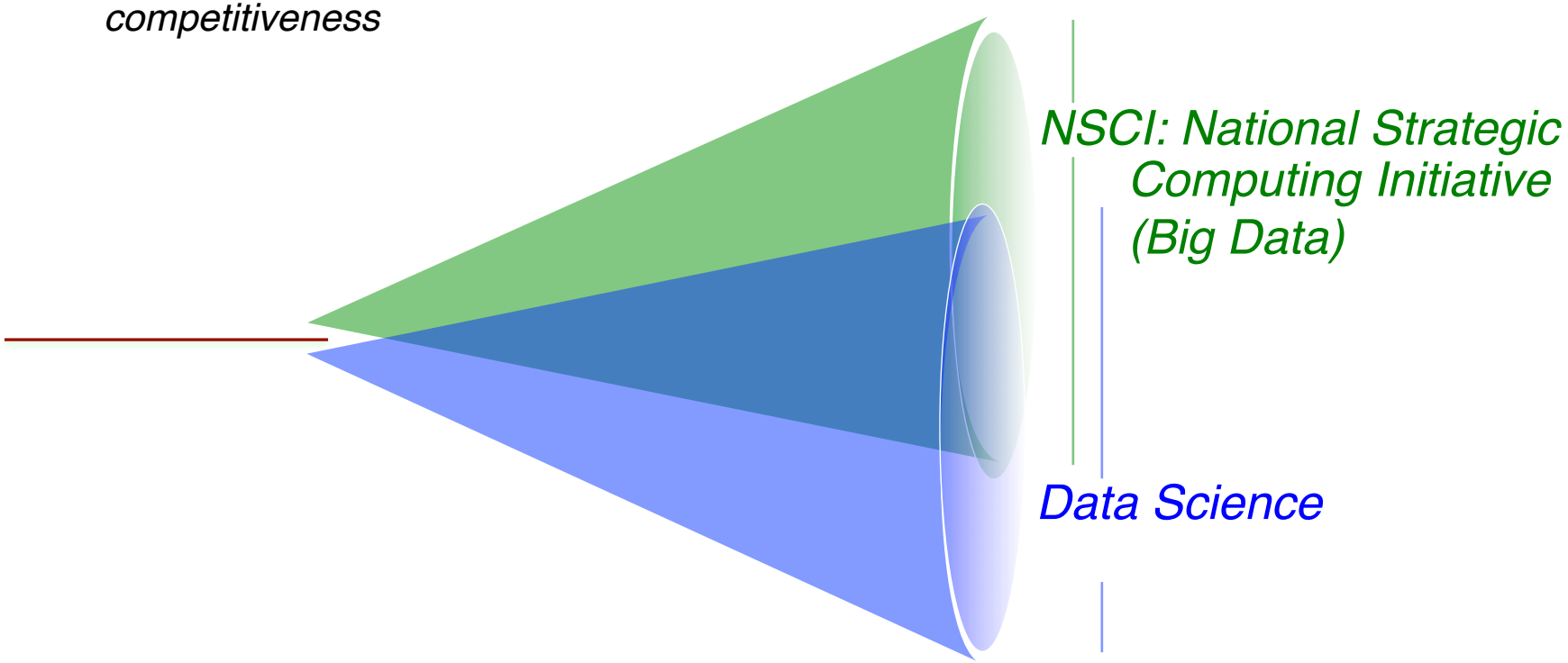
NSCI: Presidential National Strategic Computing Initiative



NSCI and Data Science: Two related national imperatives

- *High Performance Computing and Big Data Analytics*

  in support of science and engineering discovery and competitiveness

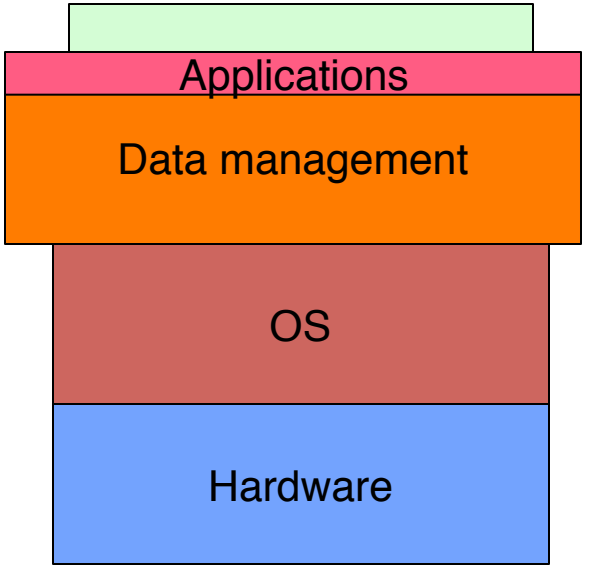


Industry Initiatives in Benchmarking

- **About TPC**
  - Developing data-centric benchmark standards; disseminating objective, verifiable performance data
  - Since 1988
- **TPC vs SPEC**
  - Specification-based vs Kit-based
  - “End-to-end” vs Server-centric
  - Independent review vs Peer review
  - Full disclosure vs Summary disclosure

Initiatives in Benchmarking: Industry

- **What TPC measures**
  - Performance of the data Management, layer (and, implicitly, the hardware and other software layers)
  - Based on applications requirements
- **Metrics**
  - Performance (tpmC, QppH)
  - Price/performance (TCA+TCO)
    - TCA: Available within 6 months; within 2% of benchmark pricing
    - TCO: 24x7 support for hardware and software over 3 years
  - TPC-Energy metric



Industry Benchmarks

- **TPCx-HS**
  - An outcome of the 1st WBDB
  - TPC Express – a quick way to develop, publish benchmark standards
  - Formalization of Terasort
  - HS – A benchmark for Hadoop Systems
  - Results published for 1, 3, 10, 30, 100TB
  - Metric: sort throughput

100 TB Results

Rank	Company	System	HSph	Price/HSph	Watts/KHSph	System Availability	Apache Hadoop Compatible Software	Operating System	Date Submitted	Nodes
1	CISCO	Cisco UCS Integrated Infrastructure for Big Data	21.99	39,193.64 USD	NR	10/26/15	Cloudera Distribution for Apache Hadoop (CDH) 5.3.2	Red Hat Enterprise Linux Server 6.5	10/23/15	32

Industry Benchmarks…

- **TPCx-BigBench (BB)**
  - Outcome from discussions at the 1st WBDB, 2012
    - *BigBench: towards an industry standard benchmark for big data analytics,* Ghazal, Rabl, Hu, Raab, Poess, Crolotte, and Jacobsen, ACM SIGMOD 2013
  - Analysis of workload on 500-node hadoop cluster
    - *An Analysis of the BigBench Workload*, Baru, Bhandarkar, Curino, Danisch, Frank, Gowda, Huang, Jacobsen, Kumar, Nambiar, Poess, Raab, Rabl, Ravi, Sachs, Yi and Youn, TPC-TC, VLDB 2014

3,000 TB Results

Rank	Company	System	BBQpm	Price/BBQpm	Watts/BBQpm	System Availability	DBMS Software (Big Data Software Framework)	Operating System	Date Submitted	Cluster
1	Hewlett Packard Enterprise	Hewlett Packard Enterprise ProLiant DL for Big Dat	337.26	1,102.94 USD	NR	05/19/16	Cloudera for Apache Hadoop (CDH) 5.6	Red Hat Enterprise Linux Server 6.7	03/31/16	Y
2	Hewlett Packard Enterprise	Hewlett Packard Enterprise ProLiant DL for Big Dat	265.93	1,212.46 USD	NR	05/19/16	Cloudera for Apache Hadoop (CDH) 5.6	Red Hat Enterprise Linux Server 6.7	03/24/16	Y

Other Benchmarking Efforts

- **Industry and academia**
  - HiBench, Yan Li, Intel
  - Yahoo Cloud Serving Benchmark, Brian Cooper, Yahoo!
  - Berkeley Big Data Benchmark, Pavlo et al., AMPLab
  - BigDataBench, Jianfeng Zhan, Chinese Academy of Sciences

NIST

- **NIST Public Working Group on Big Data**
  - Use Cases and Requirements. 2013. http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1500-3.pdf

  - Big Data Use Cases and Requirements, Fox and Chang, 1st Big Data Interoperability Framework Workshop: Building Robust Big Data Ecosystem ISO/IEC JTC 1 Study Group on Big Data March 18 -21, 2014. San Diego Supercomputer Center, San Diego. http://grids.ucs.indiana.edu/ptliupages/publications/NISTUseCase.pdf

Characterizing Applications

- ***Based on analysis of the 51 different use cases from the NIST study***
  - *Towards a Comprehensive Set of Big Data Benchmarks*, Fox, Jha, Qiu, Ekanayake, Luckow

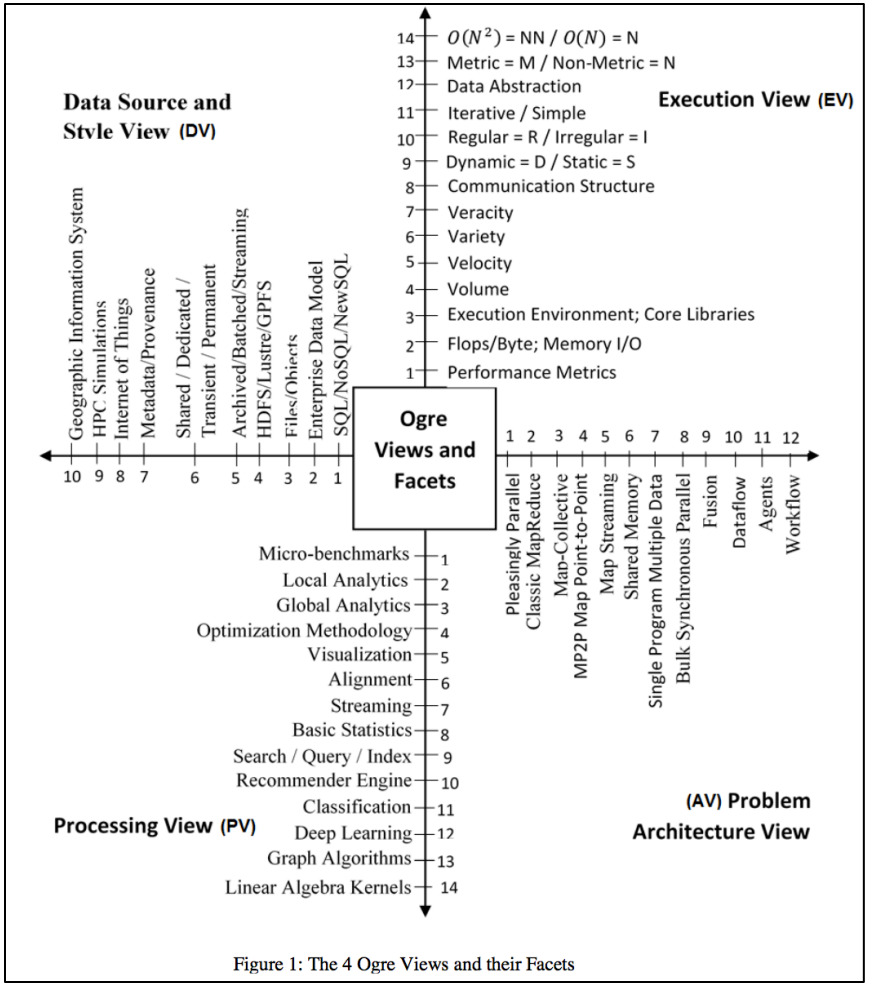


Figure 1: The 4 Ogre Views and their Facets

Other Related Activities

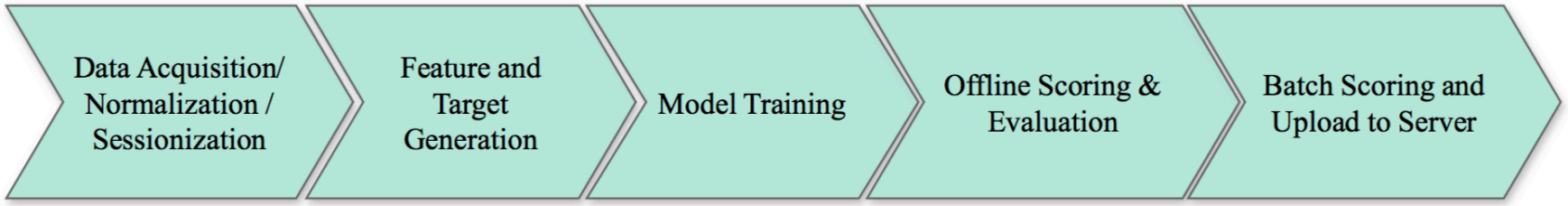
- **BPOE: Big data benchmarking, performance optimization, and emerging hardware**
  - BPOE-1 in Oct 2013; BPOE-7 in April 2016
- **Tutorial on Big Data Benchmarking**
  - Baru & Rabl, IEEE Big Data Conference, 2014
- **EMBRACE: Toward a New Community-Driven Workshop to Advance the Science of Benchmarking**
  - BoF at SC 2015
  - NSF project, “EMBRACE: Evolvable Methods for Benchmarking Realism through Application and Community Engagement” Bader, Riedy, Vuduc ACI-1535058

More Related Activities

- **Panels at SC, VLDB**
  - Organized by NITRD High-End Computing and Big Data Groups
- **At SC 2015**
  - *Supercomputing and Big Data: From Collision to Convergence*
  - Panelists: David Bader (GaTech), Ian Foster (Chicago), Bruce Hendrickson (Sandia), Randy Bryant (OSTP), George Biros (U.Texas), Andrew W. Moore (CMU)
- **At VLDB 2015**
  - *Exascale and Big Data*
  - Panelists: Peter Baumann (Jacobs University), Paul Brown (SciDB), Michael Carey (UC Irvine), Guy Lohman, (IBM Almaden), Arie Shoshani (LBL)

Things that TPC has difficulty with

- Benchmarking of processing pipelines



- Extrapolating, interpolating benchmark numbers

- Dealing with the range of Big Data data types and cases

From the NSF Big Data PI Meeting

- **Meeting held on April 20-21, 2016, Arlington, VA**
- **A part of the report out from the Big Data Systems breakout group**

http://workshops.cs.georgetown.edu/BDPI-2016/
http://workshops.cs.georgetown.edu/BDPI-2016/notes.htm

Strategic Priorities & Investments That Will Advance Innovation

- ***Making complex analytics fast***
  - Interactive analytics
  - Innovation in architectures
  - Across-the-stack innovations
  - Benchmarks: data sets, analytics, etc.
  - In-memory analytics
  - Complex analytics
  - Mobile devices or even IoT devices
  - Federated analytics
  - HPC + dataflow systems

Reporters:
Magda Balazinska (UW) &
Kunle Olukotun (Stanford)

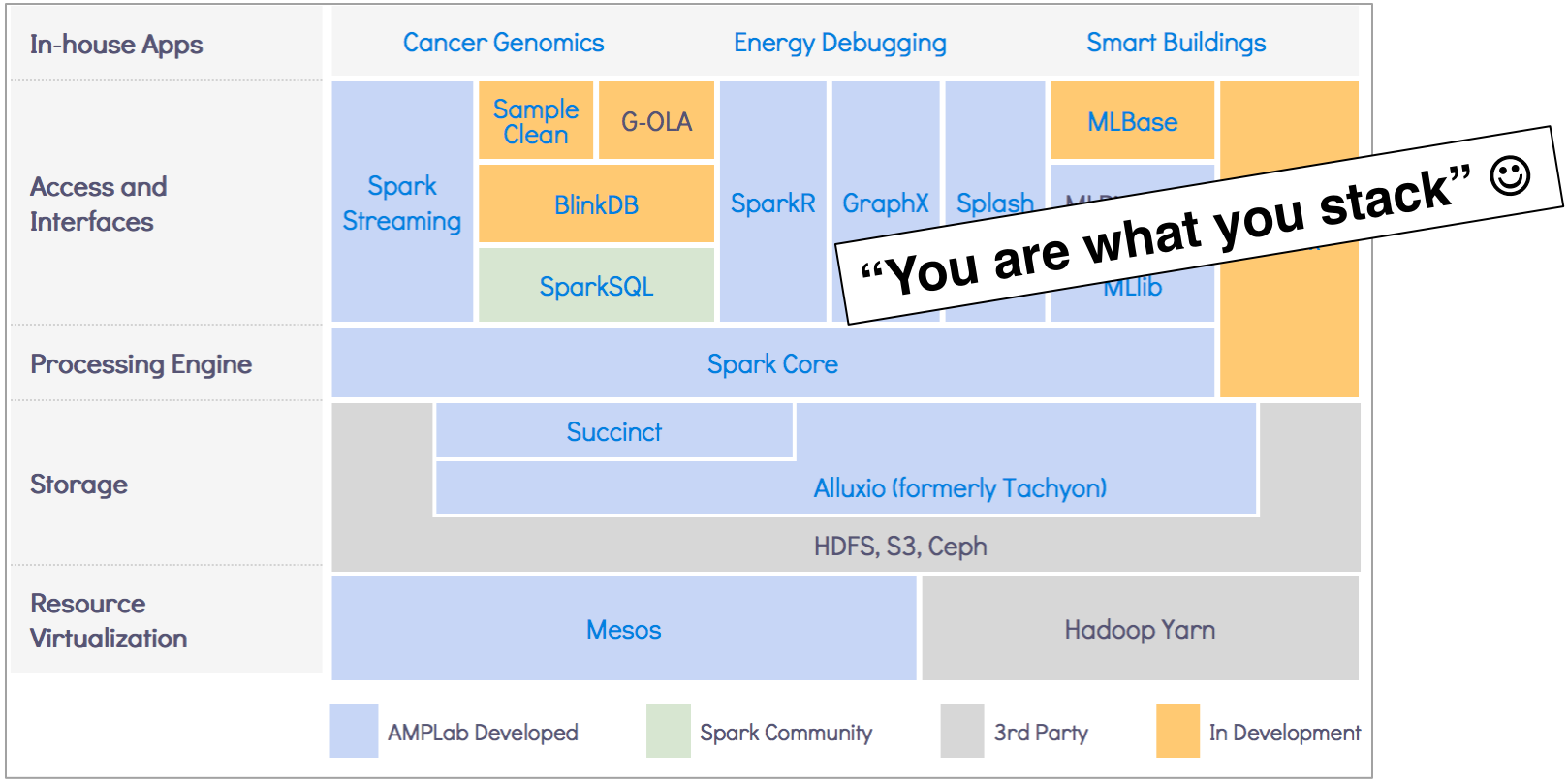
Making Progress

- **Adapting Big Data software stacks for HPC is probably more fruitful than other way around – viz., adapting HPC software to handle Big Data needs**
- **Because**
  - HPC: well-established software ecosystem, highly sensitive to performance, established codebases
  - Big Data: Rapidly evolving and emerging software ecosystem, evolving applications needs, price/ performance is more relevant

What to measure for HPCBD?

- **TPC**
  - Data management software (+ underlying sw/hw)
- **SPEC**
  - Server-level performance
- **Top500**
  - Compute performance
- **HPCBD: Focus on performance of the HPCBD software stack (+ implicitly the hardware)**
- **But there could be multiple stacks**
  - Not 100's, or 10's, but perhaps >5, <10 ?
  - E.g. stream processing; genomic processing; geospatial data processing; deep learning with image data; …

E.g., Berkeley BDAS



- https://amplab.cs.berkeley.edu/software/

Ideas for next steps

- **Can we enumerate a few stacks, based on functionality?**
  - Do we need reference datasets for each stack?
- **Could we run a workshop to identify stacks and how stack-based benchmarking would work**
  - Can we develop “reference stacks”…how should that be done?
  - Streaming data processing will be big…
- **Can we use performance with given datasets using reference stacks as basis for selecting future BDHPC systems**
  - And, the basis for which stacks should be well supported on such machines

Thanks!