HPC for the 99%

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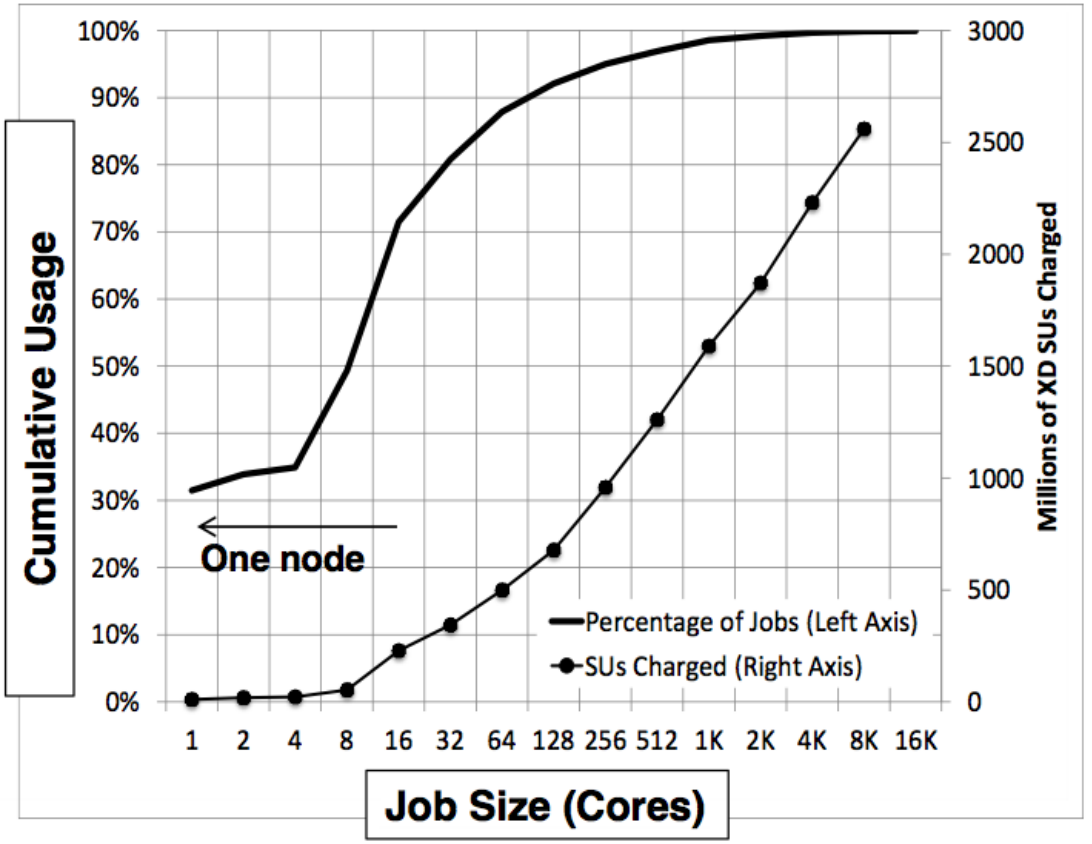
High-performance computing for the long tail of science

- **Comet goals (from NSF 13-528 solicitation)**
  - "… expand the use of high end resources to a much larger and more diverse community
  - … support the entire spectrum of NSF communities
  - ... promote a more comprehensive and balanced portfolio
  - … include research communities that are not users of traditional HPC systems."

HPC for the 99%

- 99% of jobs run on NSF's HPC resources in 2012 used <2,048 cores
- And consumed >50% of the total core-hours across NSF resources



Key Strategies for Comet Users

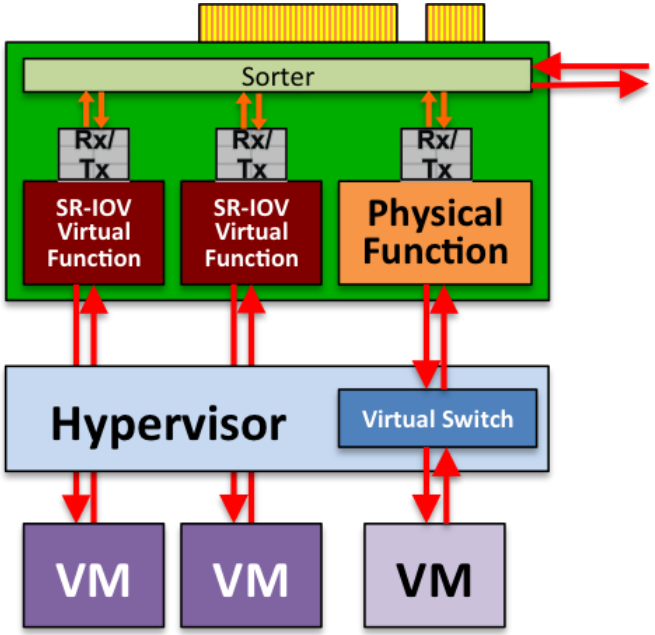
- **Target modest-scale users and new users/communities: goal of 10,000 users/year!**
- **Support capacity computing, with a system optimized for small/modest-scale jobs and quicker resource response using allocation/scheduling policies**
- **Build upon and expand efforts with Science Gateways, encouraging gateway usage and hosting via software and operating policies**
- **Provide a virtualized cluster environment (when requested) to support development of customized software stacks, and project control of workspaces**

Comet: System Characteristics

- **Total peak flops 2 PF**
- **Dell primary integrator**
  - Intel Haswell processors w/ AVX2
  - Mellanox FDR InfiniBand
- **1,944 standard compute nodes (47K cores)**
  - Dual CPUs, each 12-core, 2.5 GHz
  - 128 GB DDR4 2133 MHz DRAM
  - 2*160GB GB SSDs (local disk)
- **36 GPU nodes (Feb 2015)**
  - Same as standard nodes *plus*
  - Two NVIDIA K80 cards, each with dual Kepler3 GPUs
- **4 large-memory nodes (April 2015)**
  - 1.5 TB DDR4 1866 MHz DRAM
  - Four Haswell processors/node
- **Hybrid fat-tree topology**
  - FDR (56 Gbps) InfiniBand
  - Rack-level (72 nodes, 1,728 cores) full bisection bandwidth
  - 4:1 oversubscription cross-rack
- **Performance Storage (Aeon)**
  - 7.6 PB, 200 GB/s; Lustre
  - Scratch & Persistent Storage segments
- **Durable Storage (Aeon)**
  - 6 PB, 100 GB/s; Lustre
  - Automatic backups of critical data
- **Gateway hosting nodes**
- **Virtual image repository**
- **Home directory storage**
- **100 Gbps external connectivity to Internet2 & ESNet**

Single Root I/O Virtualization in HPC

- **Problem**: Virtualization generally has resulted in significant I/O performance degradation (e.g., excessive DMA interrupts)
- **Solution**: SR-IOV and Mellanox ConnectX-3 InfiniBand host channel adapters
  - One physical function → multiple virtual functions, each light weight but with its own DMA streams, memory space, interrupts
  - Allows DMA to bypass hypervisor to VMs
- ***SRIOV enables virtual HPC cluster w/ near-native InfiniBand latency/bandwidth and minimal overhead***



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Latency Results: QDR IB & 10 GbE, native and SR-IOV

- SR-IOV with QDR InfiniBand
  - < 30% overhead for small messages (<128 bytes)
    - < 10% overhead for eager send/receive
  - Overhead → 0% for bandwidth-limited regime
- Amazon EC2 (10 GbE)
  - > 50X worse latency
  - Time dependent (noisy)

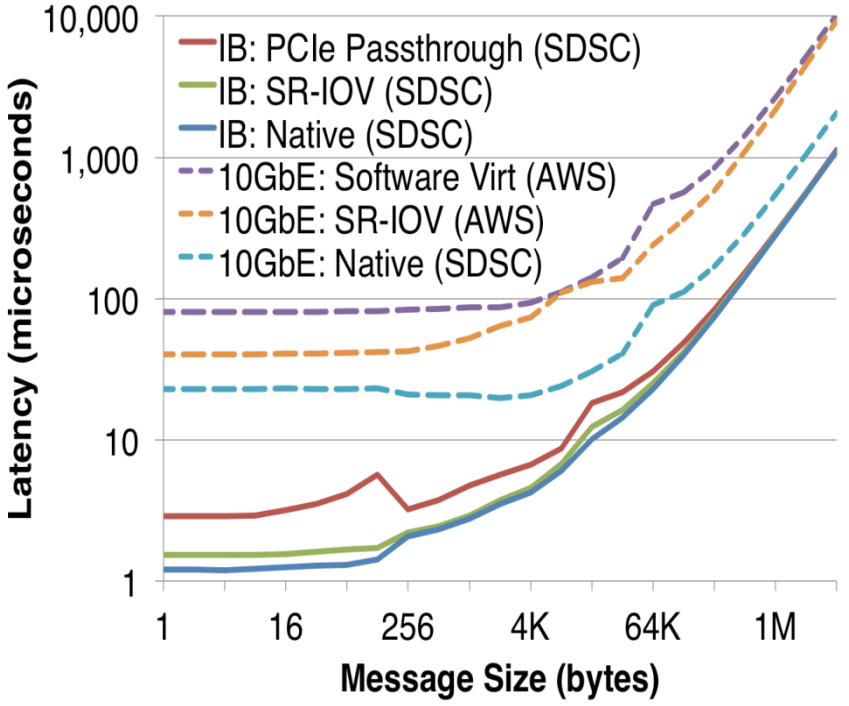

Figure 5. MPI point-to-point latency measured by osu_latency for QDR InfiniBand. Included for scale are the analogous 10GbE measurements from Amazon (AWS) and non-virtualized 10GbE.

50x less latency than Amazon EC2

Bandwidth Results: QDR IB & 10 GbE, native and SR-IOV

- Comparison of bandwidth relative to native InfiniBand
- SR-IOV w/ QDR InfiniBand
  - < 2% bandwidth loss over entire range
  - > 95% peak bandwidth
- Amazon EC2 (10 GbE)
  - < 35% peak bandwidth
  - While ratio of QDR/10GbE bandwidth is ~4X, EC2 bandwidth is 9-25X worse than SR-IOV IB

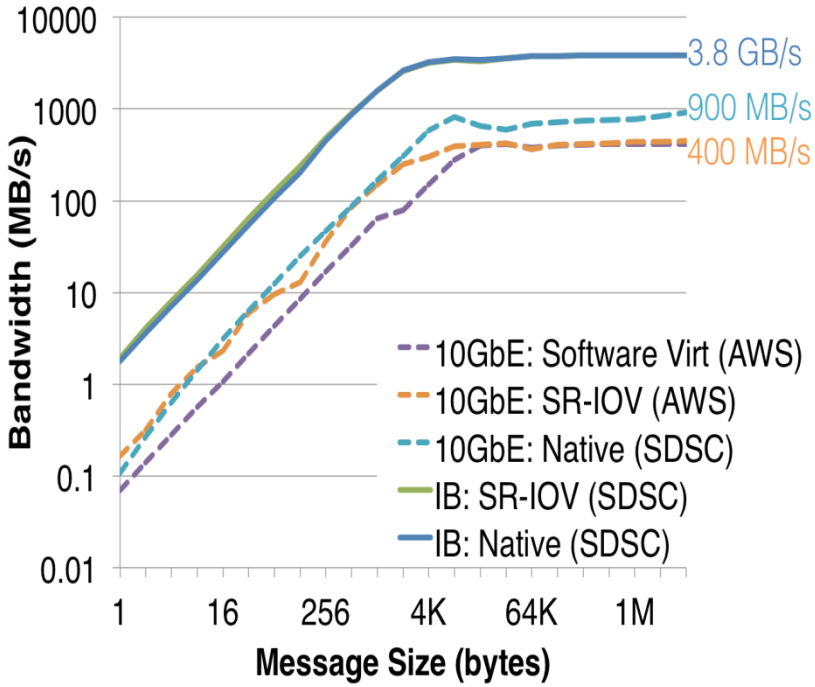

Figure 6. MPI point-to-point bandwidth measured by `osu_bw` for QDR InfiniBand. Included for scale are the analogous 10GbE measurements from Amazon (AWS) and non-virtualized 10GbE.

10x more bandwidth than Amazon EC2

High Level Schedule

- **Jan 2015**
  - Build hardware and component test
- **Feb 2015**
  - Software environment
  - Integrated acceptance tests
  - Reliability tests
- **March 2015**
  - Friendly users
  - NSF review panel
- **April 2015**
  - Production

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