Data Centers, Cloud and HPC Optimization

Daniel A. Reed
Vice President for Research and Economic Development
University Computational Science and Bioinformatics Chair
Computer Science, Electrical Engineering & Computer Engineering, and Medicine

www.hpcdan.org
Everything I am about to say is public information ...

The opinions are mine (and I may disavow them later ...)

Energy efficiency is a multivariate challenge
• Historical practice and conventional wisdom
• Culture and normative behavior
• Economics and social constraints
• *Science and technology (this is the easy part)*

*Big change requires custom design and culture change*

*The data center energy efficiency problem is already (mostly) solved*
• *Stop sweating PUE and focus on other things*
Orders of magnitude change outcomes

An insight from the late Jim Gray ...

These are systemic problems

A computation task has four characteristic demands

- **Networking**: Delivering questions and answers
- **Computation**: Transforming information to produce new information
- **Data access**: Access to information needed by the computation
- **Data storage**: Long term storage of information

The ratios among these *and their* costs change the possible, technically, economically and politically.
What’s a cloud data center?

Many optimization axes
• Power (availability/cost)
• Bandwidth
• Regulatory and tax structure
• User base
• Stability (geo and political)
• Time value of money

Microsoft Dublin: Gen2/Gen3 data center
Commoditizing infrastructure
• Servers, storage and networks
• Data centers and facilities
• Management services

From OEMs to ODMs
• Lower margins and flexibility
• Focusing on differential value
Microserver futures

Two competing ecosystems
- ARM and x86
- Different cultures and business models

SoCs and mass specialization
- Integrated networks
  - Electrical, then silicon photonics
- Accelerators
- Stacked DRAM (with capacity implications)
- 3-D memory stacks
- PCM and beyond

Driving trends
- Data movement energy costs
- Thermal dissipation and dark silicon
- Memory bandwidth constraints
Rethinking computing energy

Multiple energy sources
- Electrical grid, solar, wind, fuel cell, ...

Multiple cost functions
- Energy pricing, carbon taxes, varying availability
- Hardware, data transfer bandwidth/latency ...

Multivariate optimization and prediction
- Workload demand
  - Diurnal and seasonal
- Weather and seasonal models
- Auction-based energy pricing
- Infrastructure
  - UPS, optical fiber and computing

Scheduling subject to energy and reliability
- Cost, availability, resilience ...

Microsoft Wyoming biogas prototype
Big lessons

Supply chain optimization
- The advantage of scale

Specialized server design
- Workload specific optimization
- ODM, not OEM partnerships
- Functional accelerators

Network optimization
- Flatter networks
- Software virtualization and flow

Energy optimization
- Substations and generation
- Switchgear control

Systemic resilience
- Failure management, not avoidance
Looking forward: services appliances

National sovereignty will persist ...
• ... and a globalization privacy backlash is building with deep implications

Transnational data flows
• Rising concerns around the world
• Business, sovereignty, protectionism and social issues

Implications
• “Zero touch” data appliances, operated by locals for locals
• Mega data centers for certain business and other social networks
• Local and regional policy frameworks
Culture and economics

Industry
• Capital is cheap (look at interest rates)
• Labor is expensive
• ROI drives behavior

Academia and government
• Capital is expensive
• Labor is cheap
• Other metrics drive success

To change the game, change the metrics ...
• Infrastructure, personnel, social and political

Put another way, where you draw the bounding box shapes the answer
Discussion