

Data Centers, Cloud and HPC Optimization

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Disclaimers

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)*

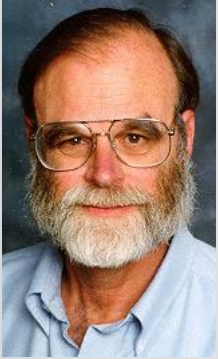
Big change requires custom design and culture change

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

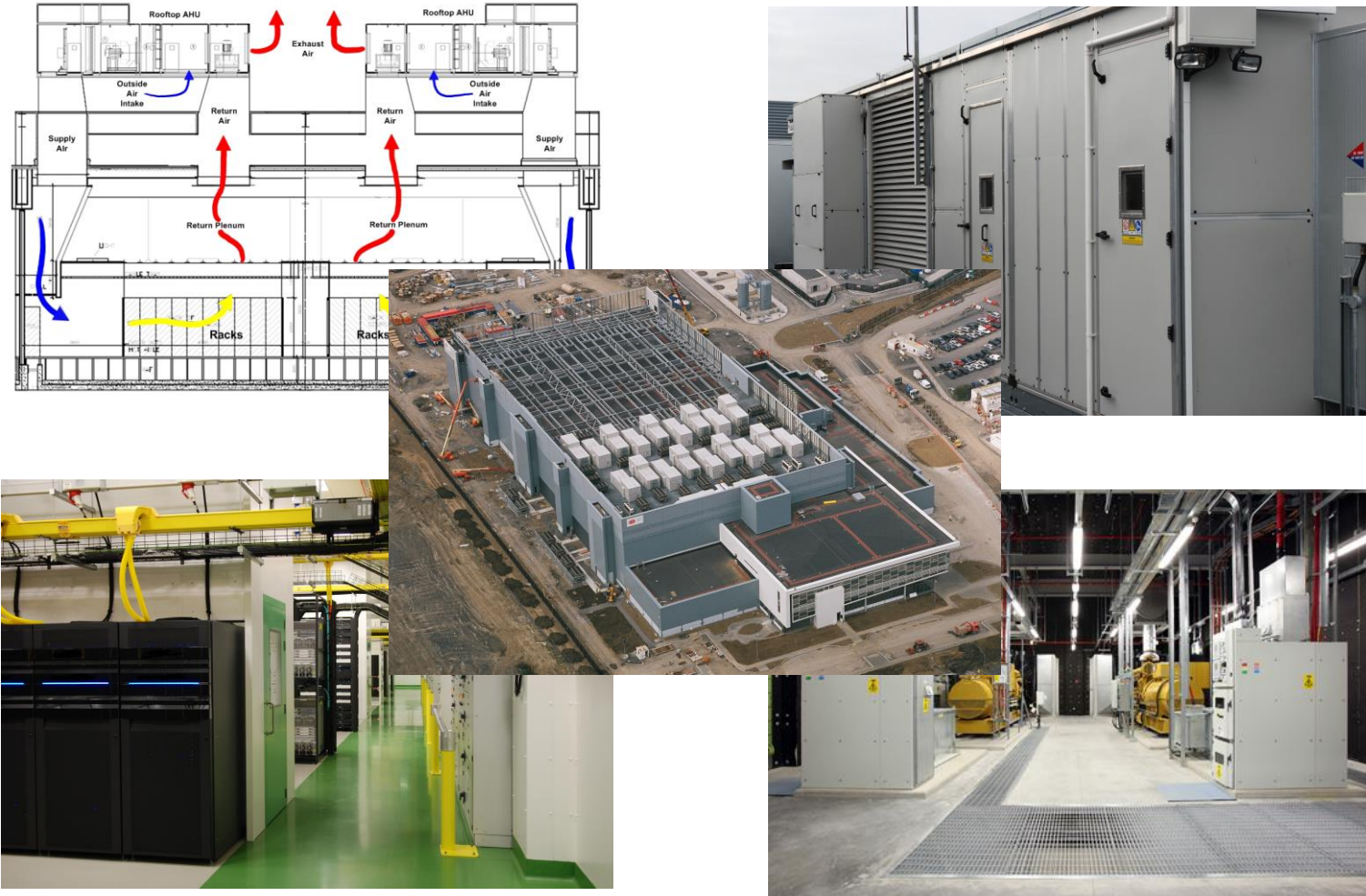
Access to information
needed by the
computation

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

Open Compute vs. Custom

Commoditizing infrastructure

- Servers, storage and networks
- Data centers and facilities
- Management services



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Hacking Conventional Computing Infrastructure

We started a project at Facebook almost two years ago with a pretty big goal: to build one of the most efficient computing infrastructures at the lowest possible cost. We decided to honor our hacker roots and challenge convention by custom designing and building our software, servers and data centers from the ground up – and then share these technologies as they evolve.

The result is a data center full of vanity free servers which is 38% more efficient and 24% less expensive to build and run than other state-of-the-art data centers.

Why Open Hardware?

By releasing Open Compute Project technologies as open hardware, our goal is to develop servers and data centers following the model traditionally associated with open source software projects. That's where you come in.



[Click here for talk and video archives from the May 2012 summit in San Antonio, TX](#)

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Amazon Bares Its Computers

By QUENTIN HARDY



Amazon Web Services

An Amazon Web Services data center. A company executive said its data storage system handles 1.5 million requests a second, and holds trillions of "objects," or individual stored items.

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LAS VEGAS — However big and ambitious you think Amazon's plan to run the world's computing may be, you should probably think bigger.

In a startling talk Thursday evening, a vice president who oversees the internal engineering of Amazon's global computing system described how Amazon is building its own specialized computers, data storage systems, networking systems, even power substations and optical transmissions systems. In every case, he said, Amazon Web Services had developed ways

From OEMs to ODMs

- Lower margins and flexibility
- Focusing on differential value

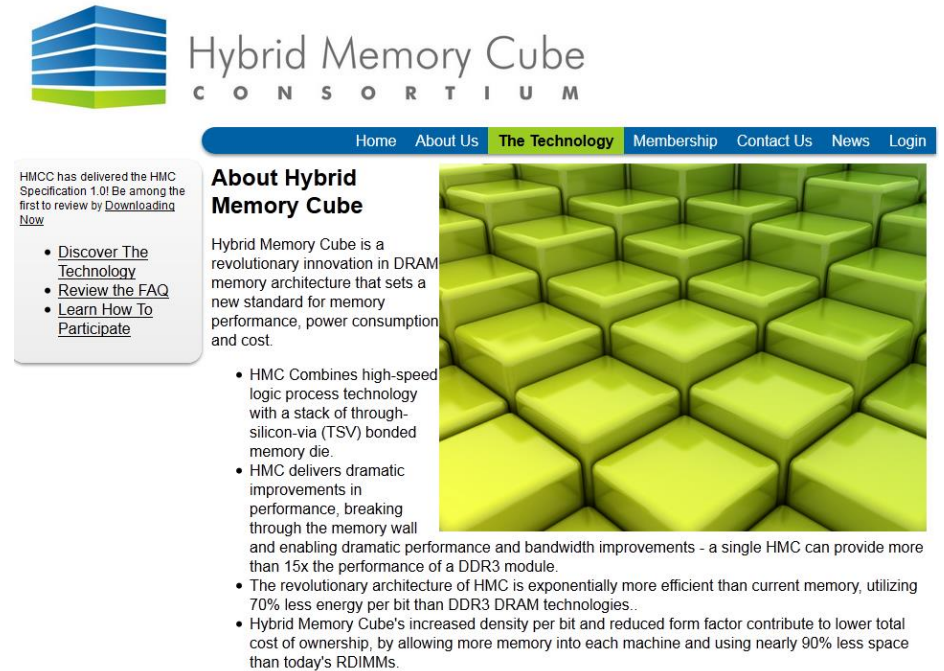
Microserver futures

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



The screenshot shows the Hybrid Memory Cube Consortium website. At the top is the logo, which consists of a 3D grid of blue and green cubes. To the right of the logo is the text "Hybrid Memory Cube" in a large serif font, with "CONSORTIUM" in a smaller sans-serif font below it. A navigation bar below the logo contains links: "Home", "About Us", "The Technology" (highlighted in green), "Membership", "Contact Us", "News", and "Login". On the left side of the page, there is a small box with the text: "HMCC has delivered the HMC Specification 1.01 Be among the first to review by [Downloading Now](#)". Below this are three bullet points: "• [Discover The Technology](#)", "• [Review the FAQ](#)", and "• [Learn How To Participate](#)". The main content area has the heading "About Hybrid Memory Cube". Below the heading is a paragraph: "Hybrid Memory Cube is a revolutionary innovation in DRAM memory architecture that sets a new standard for memory performance, power consumption and cost." To the right of this text is a large image of a 3D grid of green cubes. Below the image are four bullet points: "• HMC Combines high-speed logic process technology with a stack of through-silicon-via (TSV) bonded memory die.", "• HMC delivers dramatic improvements in performance, breaking through the memory wall and enabling dramatic performance and bandwidth improvements - a single HMC can provide more than 15x the performance of a DDR3 module.", "• The revolutionary architecture of HMC is exponentially more efficient than current memory, utilizing 70% less energy per bit than DDR3 DRAM technologies.", and "• Hybrid Memory Cube's increased density per bit and reduced form factor contribute to lower total cost of ownership, by allowing more memory into each machine and using nearly 90% less space than today's RDIMMs."

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

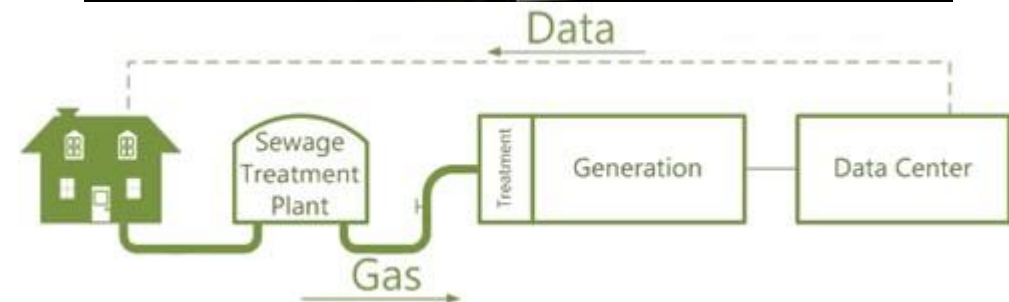
- Energy pricing, carbon taxes, varying availability
- Hardware, data transfer bandwidth/latency ...

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

