

Cloud Computing Is Driving Infrastructure Innovation

Amazon Technology Open House

James Hamilton, 2011/6/7

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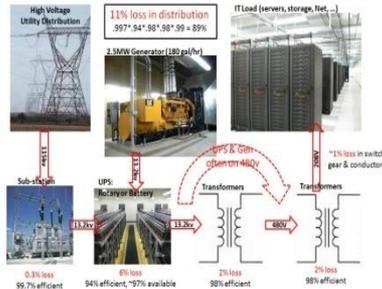
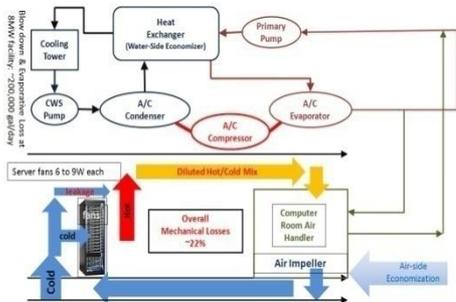
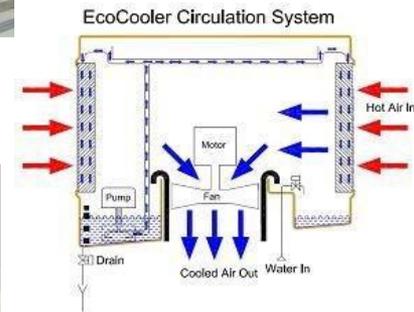
web: mvdirona.com/jrh/work

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Agenda

- Quickening pace of infrastructure innovation
- Where does the money go?
- Power distribution infrastructure
- Mechanical systems
- Modular & Advanced Building Designs
- Sea Change in Networking



Pace of Innovation

- Datacenter pace of innovation increasing
 - More innovation in last 5 years than previous 15
 - Driven by cloud service providers and very high-scale internet applications like search
 - Cost of infrastructure dominates service cost
 - Not just a cost center
- High focus on infrastructure innovation
 - Driving down cost
 - Increasing aggregate reliability
 - Reducing resource consumption footprint



Perspective on Scaling



Every day, Amazon Web Services adds enough new capacity to support all of Amazon.com's global infrastructure through the company's first 5 years, when it was a \$2.76B annual revenue enterprise

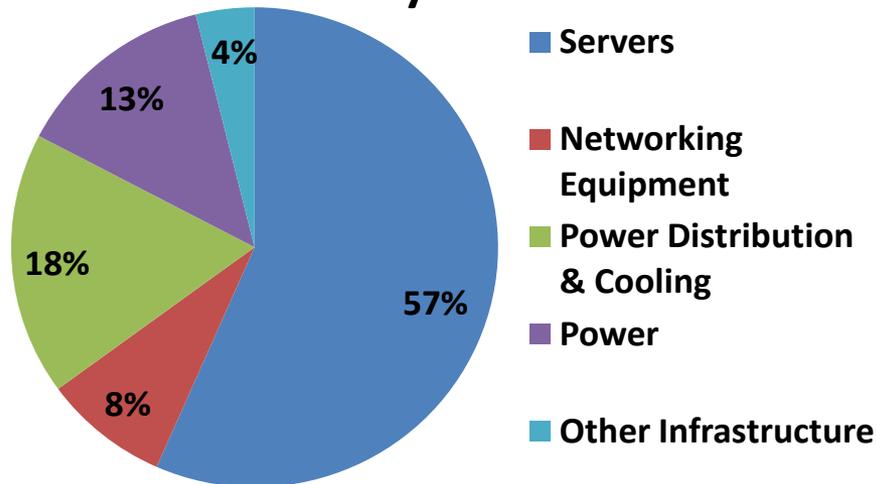
Where Does the Money Go?

- **Assumptions:**

- Facility: ~\$88M for 8MW critical power
- Servers: 46,000 @ \$1.45k each
- Commercial Power: ~\$0.07/kWhr
- Power Usage Effectiveness: 1.45



Monthly Costs



3yr server & 10 yr infrastructure amortization

- **Observations:**

- 31% costs functionally related to power (trending up while server costs down)
- Networking high at 8% of overall costs & 19% of total server cost (many pay more)

From: <http://perspectives.mvdirona.com/2010/09/18/OverallDataCenterCosts.aspx>

Power Distribution

High Voltage
Utility Distribution



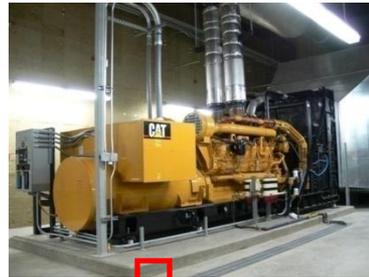
115kv

11% lost in distribution
 $.997 * .94 * .98 * .98 * .99 = 89\%$

IT Load (servers, storage, Net, ...)



Generators



13.2kv

UPS & Gen
often on 480v

~1% loss in switch gear & conductors

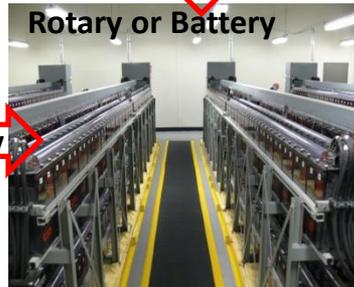
208V

Sub-station

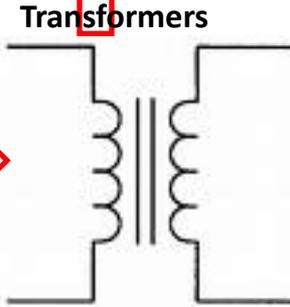
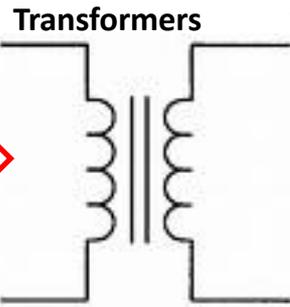


13.2kv

UPS:
Rotary or Battery



13.2kv



480V

0.3% loss
99.7% efficient

6% loss
94% efficient, ~97% available

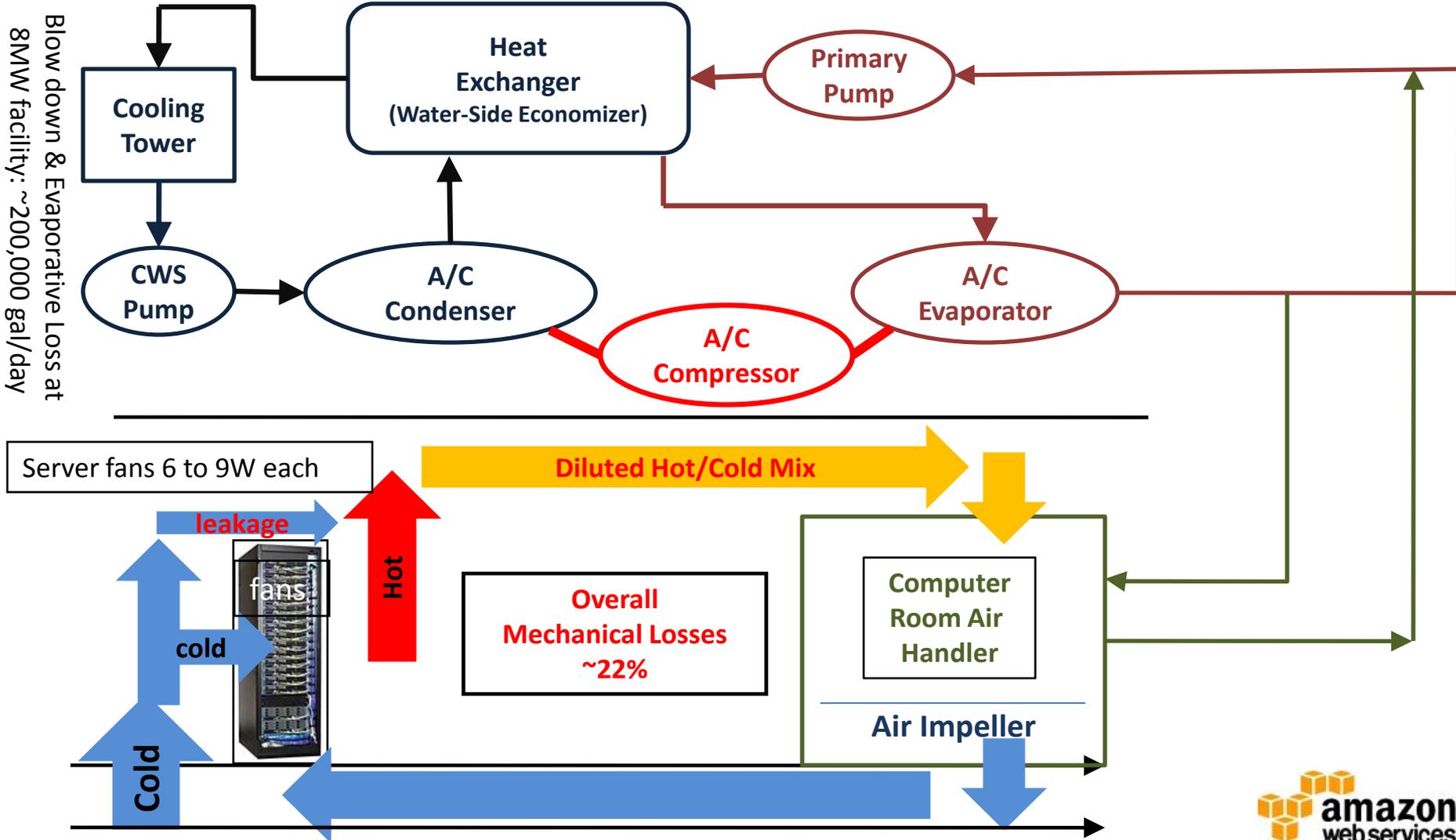
2% loss
98% efficient

2% loss
98% efficient

Note: Two more levels of power conversion at server



Mechanical Systems



Modular and Pre-fab Designs



Microsoft ITPAC



Amazon Perdix

- Fast & economic deployments
- Built in a factory setting
- Air-side economized
- ISO standard shipping containers also offered by Dell, HP, SGI, IBM, ...



Sea Change in Networking

- Current networks over-subscribed
 - Forces workload placement restrictions
 - Goal: all points in datacenter equidistant
- Mainframe model goes commodity
 - Competition at each layer over vertical integ.
- Get onto networking on Moores Law path
 - ASIC port count growth at near constant cost
 - Competition: Broadcom, Marvell, Fulcrum,...

Central Logic Manufacture

- Proprietary & closely guarded
- Single source

Finished Hardware Supply

- Proprietary & closely guarded
- Single source

System Software Supply

- Proprietary & closely guarded
- Single source

Application Stack

- Not supported
- No programming tools
- No 3rd party ecosystem

Net Equipment

Central Logic Manufacture

- Standard design (x86)
- Multiple source
 - AMD, Intel, Via, ...

Finished Hardware Supply

- Standard design
- Multiple source
 - Dell, SGI, HP, IBM, ...

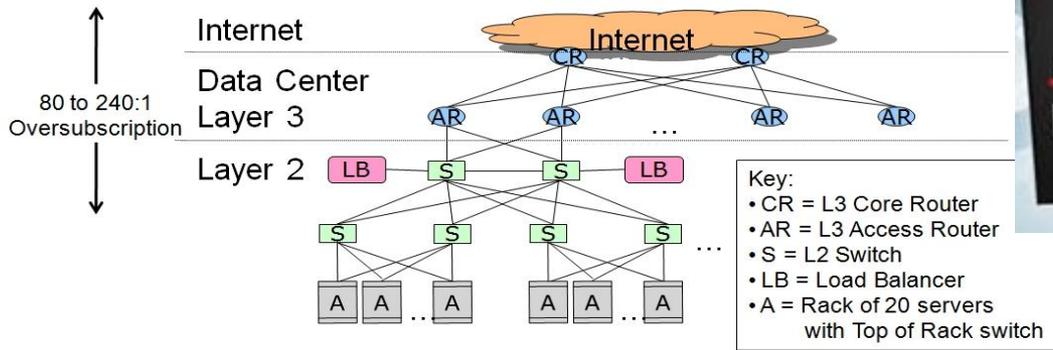
System Software Supply

- Linux (many distros/support)
- Windows & other proprietary offerings

Application Stack

- Public/published APIs
- High quality prog tools
- Rich 3rd party ecosystem

Commodity Server



Questions?

- **Slides will be posted to:**
 - <http://mvdirona.com/jrh/work>
- **Perspectives Blog:**
 - <http://perspectives.mvdirona.com/>
- **Email:**
 - James@amazon.com

