Internet Scale Infrastructure Innovation

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Agenda

- Quickening Pace Infrastructure Innovation
  - Influence of Cloud computing
- Power Distribution
- Cooling & Shell Designs

Talk does not necessarily represent positions of current or past employers
Quickening 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

Each day Amazon Web Services adds enough capacity to support all of Amazon.com’s global infrastructure through the company’s first 5 years, when it was a $2.76B enterprise 2011/10/
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

- **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)

Power Distribution

~11% lost in distribution - \(0.997 \times 0.94 \times 0.98 \times 0.98 \times 0.99 = 89\%\)

High Voltage Utility Distribution
- 115kv

Sub-station
- 13.2kv
- 0.3% loss
- 99.7% efficient

Generators
- 13.2kv

UPS: Rotary or Battery
- 13.2kv
- 6% loss
- 94% efficient, ~97% available

Transformers
- 13.2kv
- 2% loss
- 98% efficient

UPS & Gen often on 480V

IT Load (servers, storage, Net, ...)
- 480V
- 2% loss
- 98% efficient

Note: Two more levels of power conversion at server

~1% loss in switch gear & conductors

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Power Distribution Efficiency Summary

- 2 more power conversions at servers
  5. Power Supply: often under 80% at typical load
  6. On board voltage regulators (VRMs or VRDs)

- Rules to minimize power distribution losses:
  - Oversell power (more load than provisioned power)
  - Avoid conversions (fewer & better)
  - Increase efficiency of conversions
  - High voltage as close to load as possible
  - Size voltage regulators to load & use efficient parts
  - High voltage direct current a small potential gain
Mechanical Systems

- Cooling Tower
- CWS Pump
- A/C Condenser
- A/C Compressor
- A/C Evaporator
- Primary Pump
- Heat Exchanger (Water-Side Economizer)

20% of total power

Overall Mechanical Losses ~22%

Blow down & Evaporative Loss at 8MW facility: ~200,000 gal/day

Server fans 6 to 9W each

Diluted Hot/Cold Mix

Computer Room Air Handler

Air Impeller

Cold fans

Hot fans

leakage

cold

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Hot Aisle Containment

Facebook Open Compute

WriteLine

Intel

Intel
ASHRAE Recommendations

NEBS Telco Standard (~1970)
ASHRAE 2011 Allowable Class 1
ASHRAE 2011 Recommended Class 1
ASHRAE 2008 Allowable Class 1
ASHRAE 2008 Recommended Class 1
Most Datacenters Still Run Cold

ASHRAE 2008 Recommended Class 1

Most datacenters run down in this range
Avoiding Air Conditioning

- Component temps specs higher than historically hottest place on earth
  - Al Aziziyah, Libya: 136F/58C (1922)
- Just a mechanical engineering problem
  - More air or better mechanical designs
- Tradeoff: semi-conductor leakage & power to move more air vs cooling savings
- Currently available equipment temp limits:
  - 40C/104F: CloudRack C2 & most net gear
  - 35C/95F: Most of the server industry

Thanks to Ty Schmitt & Giovanni Coglitore

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Innovative Shell Designs

- Evaporative cooling only
  - High pressure misting on right
  - Damp media design below
- Full building ductless cooling

Facebook Prineville above & below
Modular and Pre-fab DC Designs

- Fast & economic deployments
- Sub-1.2 PUE designs
- Air-side economized
  - In some cases no mechanical cooling
- ISO standard shipping containers offered by Dell, HP, SGI, IBM, ...

Microsoft ITPAC

Amazon Perdix
Questions?

- Slides will be posted to:
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- Perspectives Blog:
  - http://perspectives.mvdirona.com/
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