

Infrastructure Innovation Opportunities

First Round Capital CTO Summit

James Hamilton, 2012/10/3

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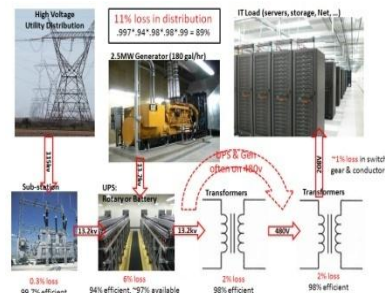
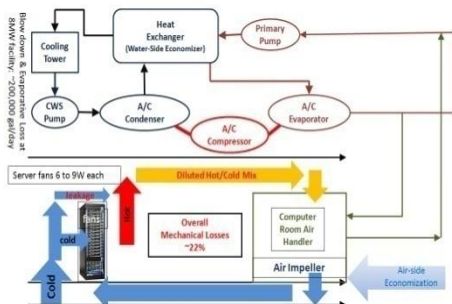
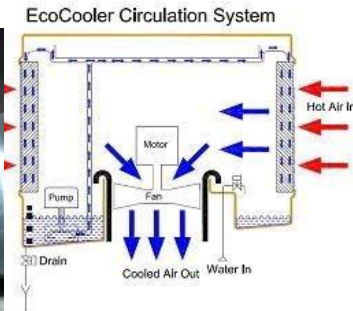
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blog: perspectives.mvdirona.com



Agenda

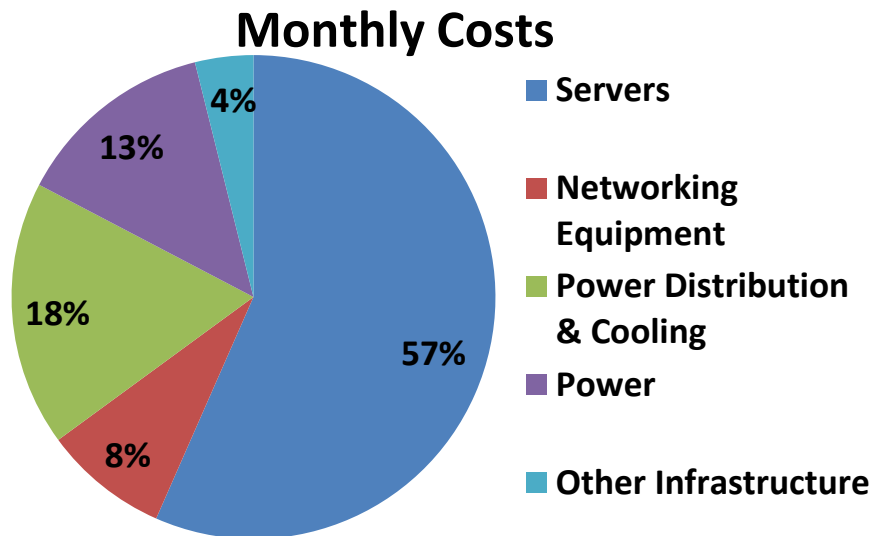
- Costs Drive Startup Opportunity
- Networking
- Storage
- Cloud Computing
 - Cloud Economics
 - 2nd Tier Effects



Costs Drive Startup Opportunity

- **Assumptions:**

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



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)

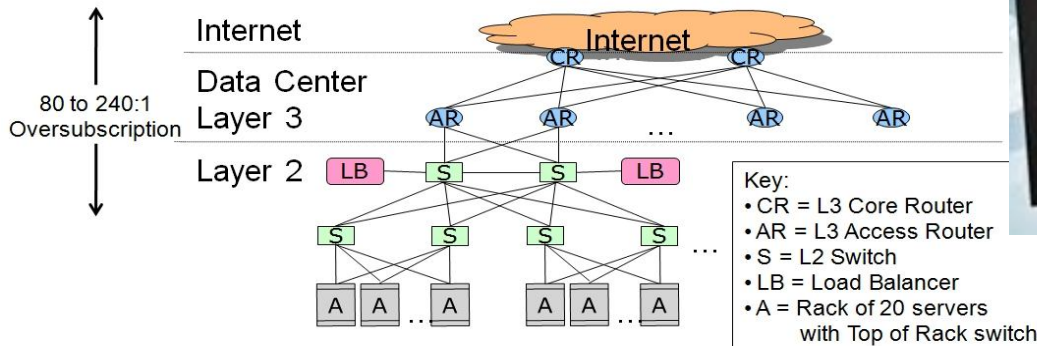
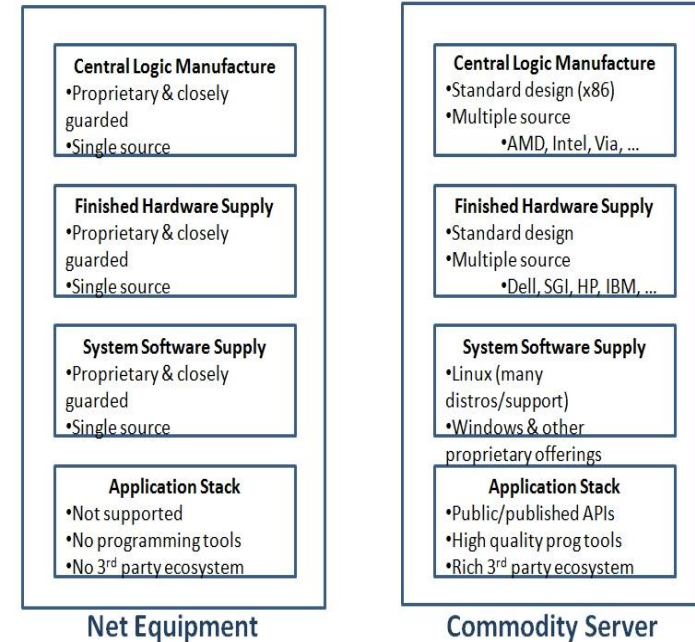
From: <http://perspectives.mvdirona.com/2010/09/18/OverallDataCenterCosts.aspx>

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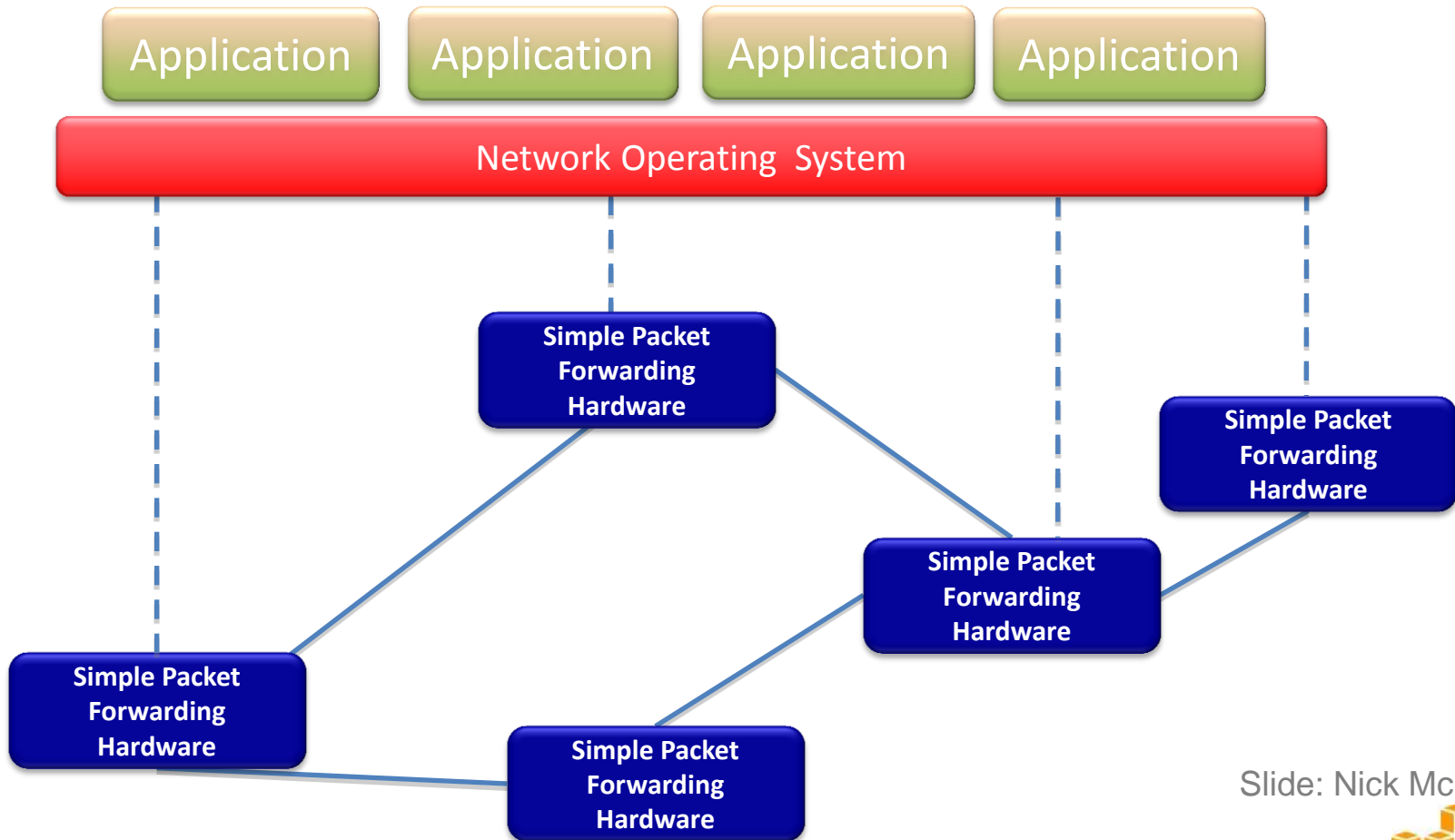
<http://perspectives.mvdirona.com>

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,...



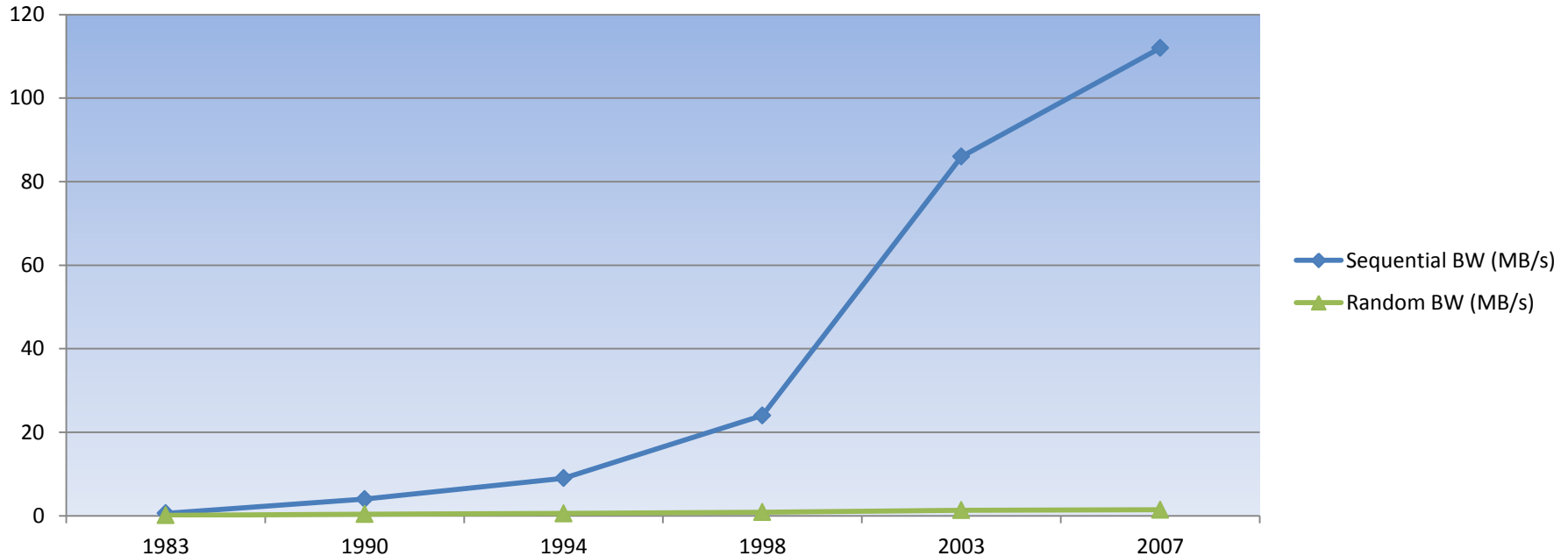
Software-Defined Networks



Slide: Nick McKeown



HDD Random BW vs Sequential BW



- Disk sequential BW growth slow
- Disk random access BW growth roughly 10% of sequential
- Storage chasm widening
 - BW a long term problem & IOPS growth very slow

Source: Dave Patterson with James Hamilton updates

Disk Becomes Tape

- Random disk latency increasingly impractical
- Sequential full read is over 11 hours
- Random full read 4TB disk:
 - 41.3 days @ 140 IOPS with 8kb page
 - Disk increasingly impractical for random workloads
- Cold storage biggest storage market
- Trending below tape price point
 - Tape only cost effective at very high scale
 - Disk wins at top and scales down better



Tape is Dead
Disk is Tape
Flash is Disk
RAM Locality is King

Jim Gray
Microsoft
December 2006



Flash Becomes Disk

- All random IOPS workloads to Flash
- Flash 4 to 6x more expensive capacity
- Log structured block store
 - Compress
 - De-dupe
 - Sparse provision
- Approaches HDD capacity price point



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Client Storage Migration

- Client device disk replaced by semiconductor caches
 - Much higher performance, Lower power dissipation, smaller form factor, greater shock resistance, scale down below HDD cost floor, greater humidity range, wider temp range, lower service costs, ...
- Clients storage drives cloud storage
 - Value added services, many data copies, shared access, indexed, classified, analyzed, monetized, reported, ...
 - Overall client storage continuing to expand rapidly but primarily off device in the cloud



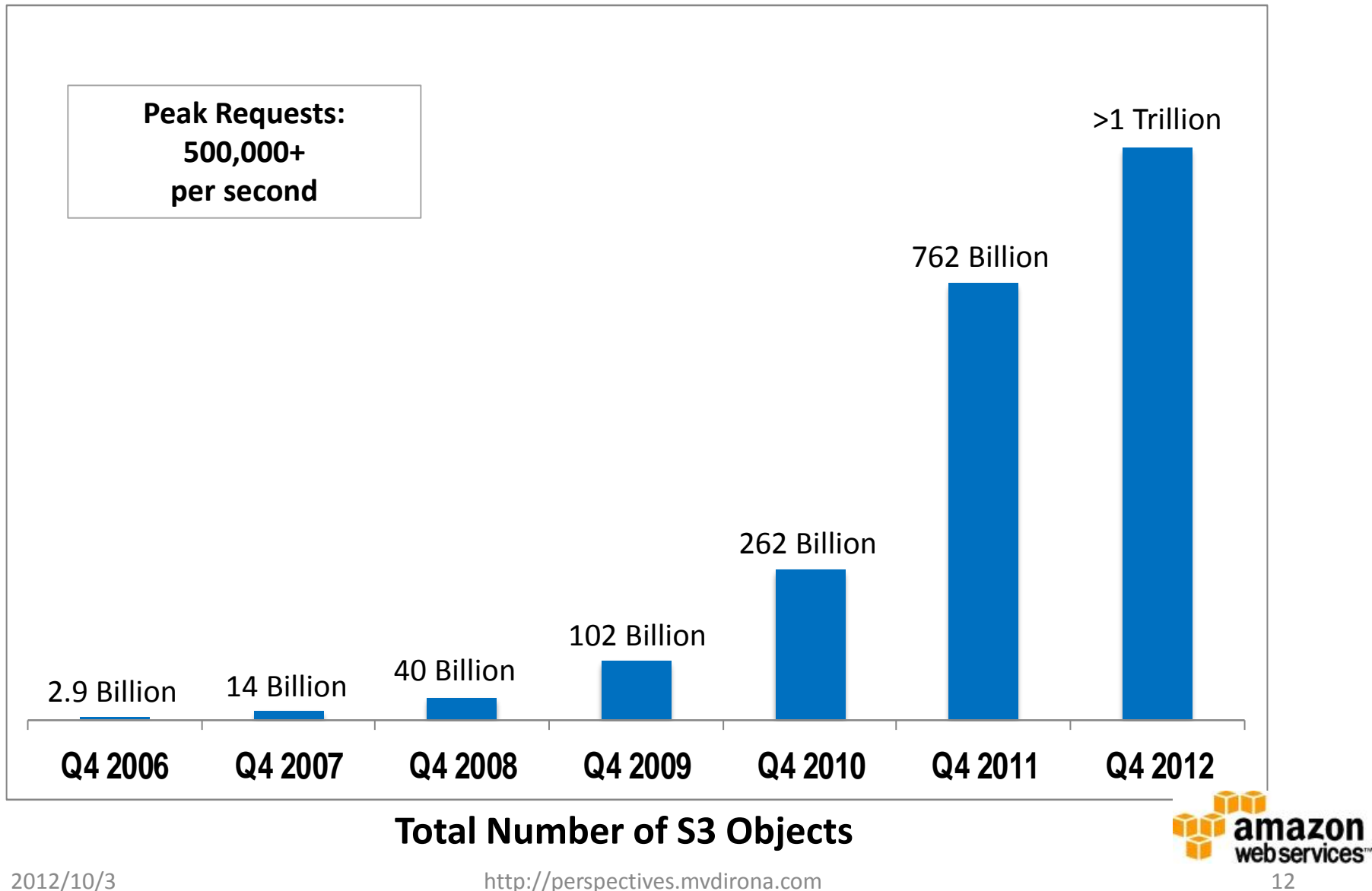
The Cloud Changes Everything

- Scale economics up several orders of magnitude
- Infrastructure utilization key lever
- Data center Innovation & efficiency
- Custom, service-specific hardware
- Cloud low-cost, very high-volume business
 - Not on enterprise uplift model
- Opportunities:
 - Infrastructure-free startups (and very large businesses)
 - 2nd tier effect

Perspective on Scaling



The Cloud Scales: Amazon S3 Growth



AWS Datacenters in 8 Regions

US GovCloud
(US ITAR Region
-- Oregon)

US West x 2
(N. California and
Oregon)

US East
(Northern Virginia)

**Europe
West**
(Dublin)

**Asia Pacific
Region**
(Singapore)

**Asia Pacific
Region**
(Tokyo)

**>10 datacenters
In US East alone**

LATAM
(Sao Paulo)



8 AWS Regions and growing

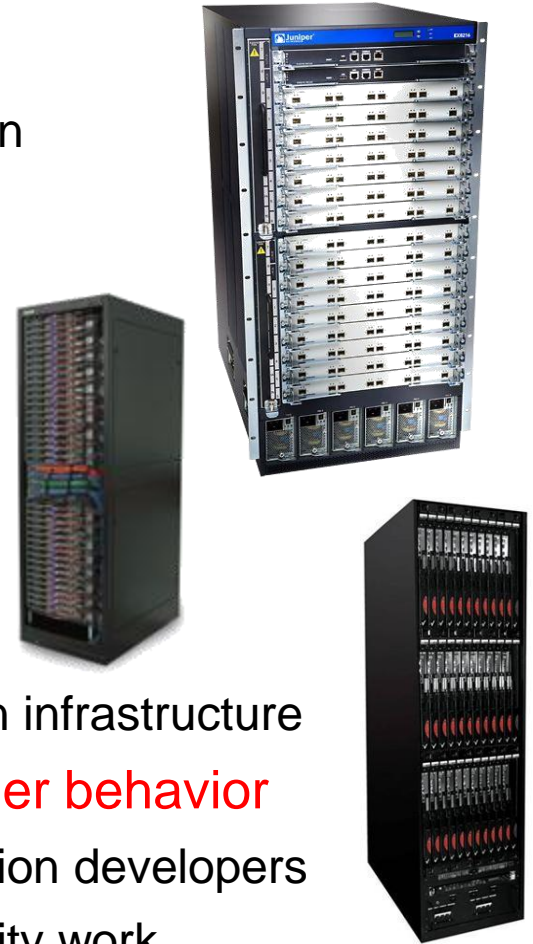


21 AWS Edge Locations for CloudFront (CDN) & Route 53 (DNS)



Utilization & Economics

- **Server utilization problem**
 - 30% utilization VERY good & 10% to 20% common
 - Expensive & not good for environment
 - Solution: pool number of heterogeneous services
 - Non-correlated peaks & law of large numbers
- **Pay as you go & pay as you grow model**
 - Don't block the business
 - Don't over buy
 - Transfers capital expense to variable expense
 - Apply capital for business investments rather than infrastructure
- **Charge back models drive good application owner behavior**
 - Cost encourages prioritization of work by application developers
 - High scale needed to make a market for low priority work



Data Center Efficiency

- Datacenter design efficiency
 - Average datacenter efficiency low with PUE over 2.0 (Source: EPA)
 - Many with PUE over 3.0
 - High-scale cloud services in 1.2 to 1.5 range
 - Lowers computing cost & better for environment
- Multiple datacenters
 - At scale multiple datacenters can be used
 - Close to customer
 - Cross datacenter data redundancy
 - Address international markets efficiently
- Avoid upfront datacenter cost with years to fully utilize
 - Scale supports pervasive automation investment

Hardware Scale Effects

- Custom service-optimized hardware
 - ODM sourced
- Purchasing power at volume
- Supply chain optimization
 - Shorter supply chain drives higher server utilization
 - Predicting next week easier than 4 to 6 months out
 - Less over buy & less capacity risk
- Networking transit costs strongly rewards volume
- Cloud services unblocks new business & growth
 - Remove dependence on precise capacity plan



Amazon Cycle of Innovation

- 15+ years of operational excellence
 - Managing secure, highly available, multi-datacenter infrastructure
- Experienced at low margin cycle of innovation:
 - Innovate
 - Listen to customers
 - Drive down costs & improve processes
 - Pass on value to customers
- 19 AWS price reductions so far
 - Expected to continue



2nd Tier Provider Effect

- Amazon investments tend to be:
 - Early stage technology
 - Later stage companies with developed markets
 - Most AWS technology internally developed, but ...
- Internally developed AWS technology opens up startup sales & acquisition opportunities
 - Cloud market large with some companies not software focused
 - Leaders push innovation while 2nd tier players buy or acquire

Questions?

- **Perspectives Blog:**

- <http://perspectives.mvdirona.com/>

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