Infrastructure Innovation Opportunities

First Round Capital CTO Summit

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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

• **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)

2012/10/3
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

Network Operating System

Application

Simple Packet Forwarding Hardware

Simple Packet Forwarding Hardware

Simple Packet Forwarding Hardware

Simple Packet Forwarding Hardware

Application

Application

Application

Slide: Nick McKeown

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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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December 2006
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

Each 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.
The Cloud Scales: Amazon S3 Growth

Peak Requests:
500,000+ per second

Total Number of S3 Objects

- Q4 2006: 2.9 Billion
- Q4 2007: 14 Billion
- Q4 2008: 40 Billion
- Q4 2009: 102 Billion
- Q4 2010: 262 Billion
- Q4 2011: 762 Billion
- Q4 2012: >1 Trillion

2012/10/3
http://perspectives.mvdirona.com
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

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
2\textsuperscript{nd} 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 2\textsuperscript{nd} tier players buy or acquire
Questions?

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