Why Scale Matters and how the Cloud Really is Different

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Agenda

- Redefining Scale at AWS
- AWS Designed Hardware & Infrastructure
  - AWS Specific Power Distribution and Optimizations
  - Custom Network Hardware & Protocol Stack
  - Workload targeted Server Designs
  - AWS Custom NIC & other H/W Components

- Relative cost of networking increasing quickly
  - Server & storage prices falling fast
  - Networking frozen in time
- Profit margins high
- Vertically integrated ecosystem
Perspective on Scaling

Every day, AWS adds enough new server capacity to support all of Amazon’s global infrastructure when it was a $7B annual revenue enterprise.
AWS Datacenters in 9 Regions

- US GovCloud (US ITAR Region -- Oregon)
- US West x 2 (N. California and Oregon)
- US East (Northern Virginia)
- LATAM (Sao Paola)
- Europe West (Dublin)
- Asia Pacific Region (Singapore)
- Asia Pacific Region (Tokyo)
- Australia Region (Australia)

>10 data centers in US East alone

9 AWS Regions with 25 Availability Zones and growing
42 world-wide edge locations
Amazon S3: Trillions of Total Objects

Over 1,500,000 peak requests/sec
DynamoDB Requests Served/Month

Single Region Only

Trillions

Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct
DynamoDB: Consistent Performance at Scale
“AWS is the overwhelming market share leader, with **more than five times the compute capacity** in use than the aggregate total of the other fourteen providers.”
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Pace of Innovation

• Infrastructure pace of innovation increasing
  – Driven by cloud service providers and high-scale internet applications such as search
  – Cost of datacenter & H/W infrastructure dominates
  – Infrastructure not just a cost center

• High focus on infrastructure innovation
  – Driving down cost
  – Increasing aggregate reliability
  – Reducing resource consumption footprint
AWS Custom Server Designs

• OEM server ecosystem:
  – Optimized for 10s to 100s of thousands of customers
    • Vast, expensive, world-wide distribution network
    • Rapidly aging inventory throughout network
  – Broadly applicable servers able to run a wide variety of workloads
    • e.g. 64 PCI lanes & 24 memory slots
    • Power supply & voltage regulators tuned to worst case usage

• Cloud server ecosystem:
  – Optimized only for AWS deployment
  – Highly specialized servers optimized for a specific workload
  – Large scale deployments allow hardware specialization
  – Move hot s/w kernels to hardware implementations
  – Datacenters, servers, networking, storage to designed to integrated specification
AWS Custom Storage Designs

- Commercial high-density storage:
  - Quanta M4600H 4U Disk Enclosure
  - Impressive best in class general purpose design
  - We use custom design with still higher density

- OEM storage & servers must target vast workload diversity

- High scale supports AWS-specific optimizations
  - Less power
  - Less space
  - More efficient
  - Less expensive
Networking Equipment

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Monthly Costs
- Servers: 57%
- Networking Equipment: 18%
- Power: 13%
- Power Distribution & Cooling: 8%
- Other Infrastructure: 4%

3yr server & 10 yr infrastructure amortization

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Get the Network Out of the Way

- **Mainframe cost model**
  - Amazon custom routers & protocol stacks
- **Networks typically over-subscribed**
  - Forces workload placement restrictions
  - Goal: all points in datacenter equidistant
Power Infrastructure

- Negotiated power purchasing agreements
- AWS custom high-voltage sub-stations in some regions
  - lower power cost
  - build more quickly
Super Bowl Power Outage

34 minute outage that very nearly changed the 2013 game

“A piece of equipment that was designed to monitor electrical load sensed an abnormality in the system. The equipment operated as designed and opened a breaker that partially cut power to the Superdome in order to isolate the issue. Backup generators kicked in immediately as designed.”

Lights without immediate backup power
- Restarting gas discharge lights takes 15+ min

Highly likely backup power wouldn’t have helped
- Switchgear lockout

- We design & deploy custom switch firmware
Carbon Neutral Power Choice

Most companies rarely build new datacenters so there are few new power procurement options.

The entire multi-datacenter US-WEST (Oregon) is 100% carbon neutral.

One of the largest AWS regions world-wide
  – Fastest growing
Supply Chain & Procurement Optimization

- Purchasing power at volume utilizing our global demand
- Direct component purchasing
  - Disk drive, processors, memory, NICs, …
  - Precise inventory control, better pricing, & optimized designs
- Supply chain optimization
  - Demand signals immediately feeding component buying, server & network builds, real estate purchasing, datacenter builds,…
  - Shorter cycle time drives much higher utilization
    - Predicting next week easier than 4 to 6 months out
  - Avoid overbuy & capacity risk
Utilization & Economics

• Server utilization problem
  – On premise 30% utilization VERY good &10% to 20% more common
    • Expensive & not good for environment
  – Solution: pool number of heterogeneous services
    • Single reserve capacity pool far more efficient
    • 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 spot market for low priority work
Amazon Cycle of Innovation

- Re-invest in Features
- Innovate
- Listen to Customers
- Lower Costs
- Improve Processes
- Reduce Prices

18+ years of operational excellence

38 AWS price reductions since 2006

700k trusted advisor recommendations saving customers $140m
New Research: Customers Improve Availability by Migrating Apps to AWS

32% reduction in total application downtime

2013 AWS Customer Survey

Research Note: Benchmarking availability and reliability in the cloud: Amazon Web Services Nucleus Research, November 2013, Document N168
Hosting on-premise less expensive?

• Utilization fundamentally higher in cloud
  – Aggregating non-correlated workloads, scale, spot market,…
• Amazon specific H/W designs
  – ODM acquisition of custom servers & net gear
  – Direct purchasing of disk, memory, & CPU
  – AWS controlled hypervisor & net protocol layers
• Deep R&D: Many new data centers built each year
• Immense scale
  – Volume purchasing, highly automated, specialists in all areas
• Amazon margins tiny compared with enterprise margins
Summary

• AWS Economics driven by scale & singular focus
  – Economies of scale
  – Increased availability through multiple-datacenter deployment
  – Steadily declining price
• Mega-scale advantages available to all customers regardless of size
  • Datacenter presence near all customers world-wide
  • Multiple datacenters in each region for high availability
  • Deeper R&D investment & operational focus in datacenter, server, storage, & networking than any IT organization in the world
  • Buying power that rivals the biggest in the world
• Cloud Model Fundamentally different from the last 30 years
  – Even if rebranded as “cloud enabled”, “private cloud”, “cloud-like”, …
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