Overview: Cloud Datacenters II

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Background: The Internet

• How do we get bits into and out of datacenters?
Background: The Internet

Internet Protocol / Internet Protocol Protocol Stack

- **application**: supporting network applications
  - FTP, SMTP, HTTP
- **transport**: process-process data transfer
  - TCP, UDP
- **network**: routing of datagrams from source to destination
  - IP, routing protocols
- **link**: data transfer between neighboring network elements
  - Ethernet, 802.111 (WiFi), PPP
- **physical**: bits “on the wire”
Background: The Internet

message
segment
datagram
frame

source

application
transport
network
link
physical

destination

application
transport
network
link
physical

link
physical

switch

router

H_t M
H_n H_t M
H_l H_n H_t M

H_t M
H_n H_t M
H_l H_n H_t M

H_n H_t M
H_l H_n H_t M

H_n H_t M
Network Protocol “Layers”

<table>
<thead>
<tr>
<th>Departure (airport)</th>
<th>Intermediate air-traffic control centers</th>
<th>Arrival (airport)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ticket (purchase)</td>
<td>ticket (complain)</td>
<td>ticket</td>
</tr>
<tr>
<td>baggage (check)</td>
<td>baggage (claim)</td>
<td>baggage</td>
</tr>
<tr>
<td>gates (load)</td>
<td>gates (unload)</td>
<td>gate</td>
</tr>
<tr>
<td>runway (takeoff)</td>
<td>runway (land)</td>
<td>takeoff/landing</td>
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<tr>
<td>airplane routing</td>
<td>airplane routing</td>
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**layers:** each layer implements a service

– via its own internal-layer actions

– relying on services provided by layer below
• What does it take to build a million server datacenter?
Tech Titans Building Boom

• What does it take to build a million server datacenter?

• Challenges
  – Readily available (fiber-optic) networking
  – Abundant water
  – Inexpensive electricity
    • How much electricity?
    • 200W per server * 1M servers = 200MW!
      • Equivalent to 200k houses!
  – Management (e.g. installation, failures)
  – Environmental impact

Titan tech boom, randy katz, 2008
Tech Titans Building Boom

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• Prior state of the art, dot-com era of 1990’s to 2000’s
  – 1k to 2k servers -> 1MW to 2MW
  – Setup and management was fairly manual
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• What does it take to build a million server datacenter?
• Locations (power/cooling/water)
  – Washington, N.C., S.C., Iowa, Oklahoma,..., Siberia!

Titan tech boom, randy katz, 2008
Tech Titans Building Boom

• What does it take to build a million server datacenter?

• Server Utilization
  – 40x 200W pizza boxes
  – CPUs are 60% of power
  – 8 to 16kW per rack
  – 0.5kW/m²
  – Air cooling

• Google/Microsoft
  - Better power mgmt.
    . Avg instead of peak
  - Better power supplies
    voltage regulators, fans
  - Remove GPU
  - Water cooling
Tech Titans Building Boom

• What does it take to build a million server datacenter?
• Containers (server, power, cooling efficiency)
  – 2500 to 3000 servers, instead of 40 to 80
  – Power and cooling efficiency
  – Power density, 16kW/m² instead of 0.5 kW/m²
Tech Titans Building Boom

- What does it take to build a million server datacenter?

Titan tech boom, randy katz, 2008
Tech Titans Building Boom

• What does it take to build a million server datacenter?
  – Power efficiency
  – Cooling efficiency
  – Server efficiency
    • Power proportionality
    • utilization
  – Power density
    • 0.5 kW/m² – raised floor datacenter
    • 16 kW/m² – containerized datacenter
  – Management/failure
    • Software masked failures
    • containerization

Titan tech boom, randy katz, 2008
Tech Titans Building Boom

• Power efficiency
  – Tune power supply for average, not peak
  – Voltage regulators
  – Remove unnecessary components

• Cooling efficiency
  – HP “smart cooling”
  – Air-side economization
  – Containers
Tech Titans Building Boom

• PUE
  – Total power consumption / total power used by consumers

• Results
  – Typical enterprise DC
    • 2007 – 2
    • 2011 – 1.7 (with optimizations may reach 1.3)
  – Google DCs
    • Avg – 1.21
    • Best – 1.15
  – Microsoft
    • Chicago – 1.22
• Virtualization
  – DCs run at 15% of their capacity without virtualization
  – DCs run at 80% with virtualization

• Other SW tools
  – Power usage control
  – Shared distributed data
  – Handle software failures
Perspective

• To build large and efficient datacenters
  – Better power efficiency
  – Better cooling efficiency
  – Specialized systems for datacenters
Before Next time

• Finish Lab0 by Tuesday

• Fill out survey to help form groups

• Create a project group
  – Start asking questions about possible projects

• Check website for updated schedule