Data Centers and Cloud Computing

Data Centers

- Large server and storage farms
  - 1000s of servers
  - Many TBs or PBs of data

- Used by
  - Enterprises for server applications
  - Internet companies
    - Some of the biggest DCs are owned by Google, Facebook, etc

- Used for
  - Data processing
  - Web sites
  - Business apps
Traditional vs “Modern”

- Data Center architecture and uses have been changing

- Traditional - static
  - Applications run on physical servers
  - System administrators monitor and manually manage servers
  - Use Storage Array Networks (SAN) or Network Attached Storage (NAS) to hold data

- Modern - dynamic, larger scale
  - Run applications inside virtual machines
  - Flexible mapping from virtual to physical resources
  - Increased automation allows larger scale

Inside a Data Center

- Giant warehouse filled with:
  - Racks of servers
  - Storage arrays
  - Cooling infrastructure
  - Power converters
  - Backup generators
Modular Data Center

• ...or use shipping containers

• Each container filled with thousands of servers

• Can easily add new containers
  • “Plug and play”
  • Just add electricity

• Allows data center to be easily expanded
• Pre-assembled, cheaper

Server Virtualization

• Allows a server to be “sliced” into Virtual Machines

• VM has own OS/applications

• Rapidly adjust resource allocations

• VM migration within a LAN
Virtualization in Data Centers

• Virtual Servers
  • Consolidate servers
  • Faster deployment
  • Easier maintenance

• Virtual Desktops
  • Host employee desktops in VMs
  • Remote access with thin clients
  • Desktop is available anywhere
  • Easier to manage and maintain

Data Center Challenges

• Resource management
  • How to efficiently use server and storage resources?
  • Many apps have variable, unpredictable workloads
  • Want high performance and low cost
  • Automated resource management
  • Performance profiling and prediction

• Energy Efficiency
  • Servers consume huge amounts of energy
  • Want to be “green”
  • Want to save money
Reliability Challenges

• Typical failures in first year of a Google data center:
  • 0.5% overheat (power down most machines in under five minutes, expect 1-2 days to recover)
  • 1 PDU (Power Distribution Unit) failure (about 500-1000 machines suddenly disappear, budget 6 hours to come back)
  • 1 rack-move (You have plenty of warning: 500-1000 machines powered down, about 6 hours)
  • 1 network rewiring (rolling 5% of machines down over 2-day span)
  • 20 rack failures (40-80 machines instantly disappear, 1-6 hours to get back) 5 racks go wonky (40-80 machines see 50% packet loss)
  • 8 network maintenances (4 might cause ~30-minute random connectivity losses)
  • 12 router reloads (takes out DNS and external virtual IP address (VIPS) for a couple minutes)
  • 3 router failures (have to immediately pull traffic for an hour)
  • dozens of minor 30-second blips for DNS
  • 1000 individual machine failures
  • thousands of hard drive failures


Data Center Costs

• Running a data center is expensive

Economy of Scale

• Larger data centers can be cheaper to buy and run than smaller ones
  • Lower prices for buying equipment in bulk
  • Cheaper energy rates

• Automation allows small number of sys admins to manage thousands of servers

• General trend is towards larger mega data centers
  • 100,000s of servers

• Has helped grow the popularity of cloud computing

What is the cloud?

Remotely available
Pay-as-you-go
High scalability
Shared infrastructure
The Cloud Stack

**Software as a Service**

- Hosted applications
- Managed by provider

**Platform as a Service**

- Platform to let you run your own apps
- Provider handles scalability

**Infrastructure as a Service**

- Raw infrastructure
- Can do whatever you want with it

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**PaaS: Google App Engine**

- Provides highly scalable execution platform
  - Must write application to meet App Engine API
  - App Engine will autoscale your application
  - Strict requirements on application state
    - “Stateless” applications much easier to scale

- Not based on virtualization
  - Multiple users’ threads running in same OS
  - Allows google to quickly increase number of “worker threads” running each client’s application

- Simple scalability, but limited control
  - Only supports Java and Python
IaaS: Amazon EC2

• Rents servers and storage to customers
  • Uses virtualization to share each server for multiple customers
  • Economy of scale lowers prices
  • Can create VM with push of a button

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Public or Private

• Not all enterprises are comfortable with using public cloud services
  • Don’t want to share CPU cycles or disks with competitors
  • Privacy and regulatory concerns

• Private Cloud
  • Use cloud computing concepts in a private data center
    • Automate VM management and deployment
    • Provides same convenience as public cloud
    • May have higher cost

• Hybrid Model
  • Move resources between private and public depending on load
    • Cloud Bursting
Programming Models

• Client/Server
  • Web servers, databases, CDNs, etc

• Batch processing
  • Business processing apps, payroll, etc

• Map Reduce
  • Data intensive computing
  • Scalability concepts built into programming model

Cloud Challenges

• Privacy / Security
  • How to guarantee isolation between client resources?

• Extreme Scalability
  • How to efficiently manage 1,000,000 servers?

• Programming models
  • How to effectively use 1,000,000 servers?
Further Resources

• “Above the Clouds” - cloud computing survey paper from Berkeley

• Workshops & Conferences
  • Hot Topics in Cloud Computing (HotCloud)
  • Symposium on Cloud Computing (SOCC)
  • lots of other small workshops
  • most recent systems conferences (NSDI, USENIX ATC, OSDI, SOSP)

• Other
  • Google App Engine / Amazon EC2 blogs
  • James Hamilton’s Perspectives: http://perspectives.mvdirona.com/