# Cloud Computing

CSC 375, Fall 2016

"When you move to the cloud, companies don't expect a multi-hundred-million-dollar project to make their CRM from Salesforce work with ERP from Oracle. We have to make that implementation work out of the box."

-Larry Ellison, CEO, Oracle

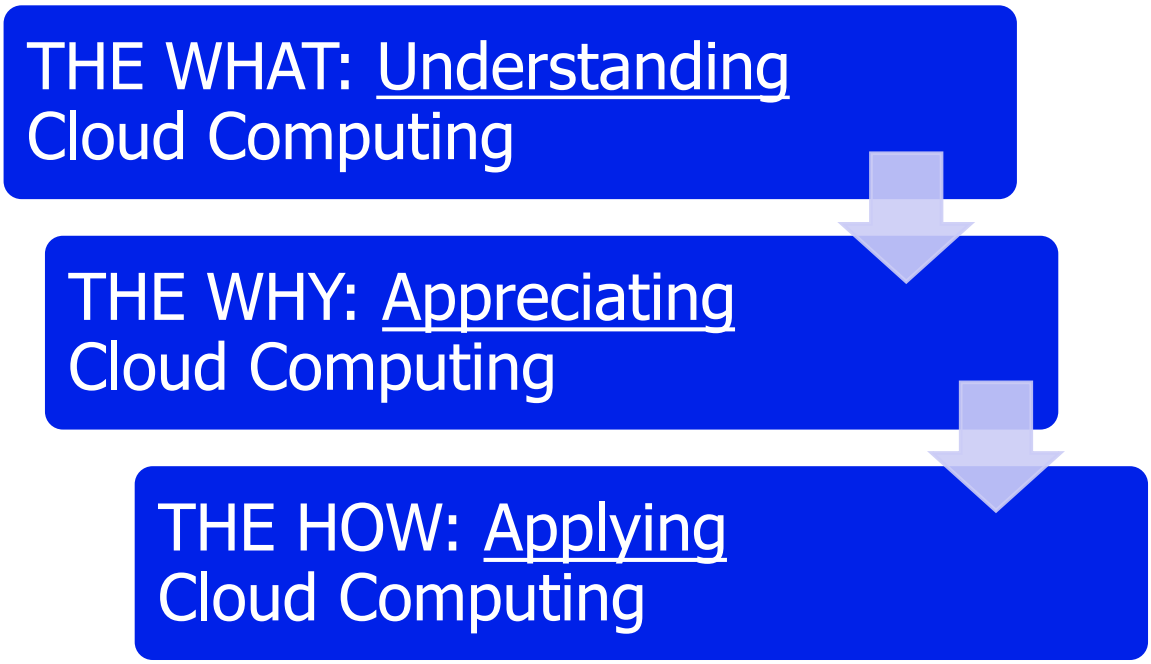
## Why Cloud Computing?

- In a recent survey, just 22% of Americans understood the concept of "the cloud"
- There is still a wide gap between the perceptions and realities of cloud computing



http://mashable.com/2012/08/29/clueless-cloud/

## Outline





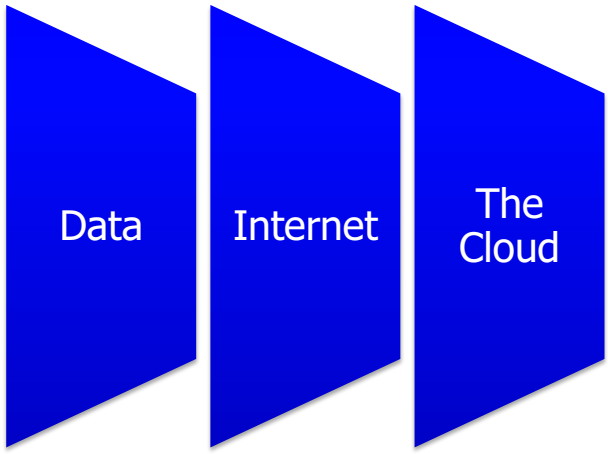

## Cloud Computing: Definition

- "The practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer"


http://www.us-cert.gov/reading_room/USCERT-CloudComputingHuthCebula.pdf
http://www.blippitt.com/2010-new-oxford-american-dictionary-new-words/

## Data, Internet, and the Cloud

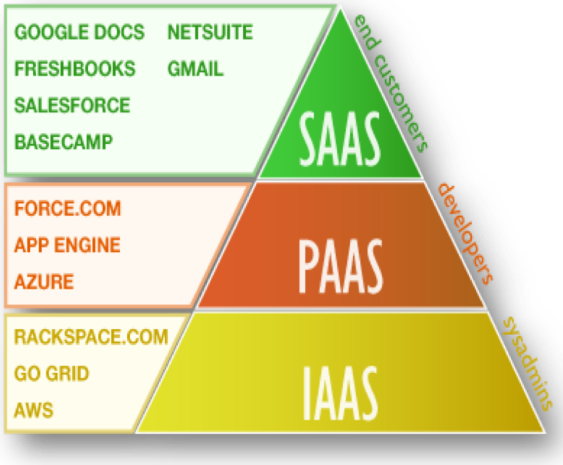
- Instead of storing data on individual physical machines, data is stored on the Internet
- Cloud can be Public, Private, Community, or Hybrid






## Types of Cloud Computing

- Software as a Service (SaaS)
  - Access to resources and applications
- Platform as a Service (PaaS)
  - Access to development and operational components
- Infrastructure as a Service (IaaS)
  - Completely outsources needed storage and resources



# The WHY: Why are so many companies moving to the cloud?

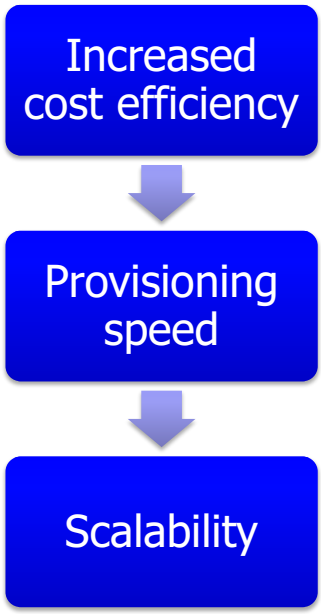


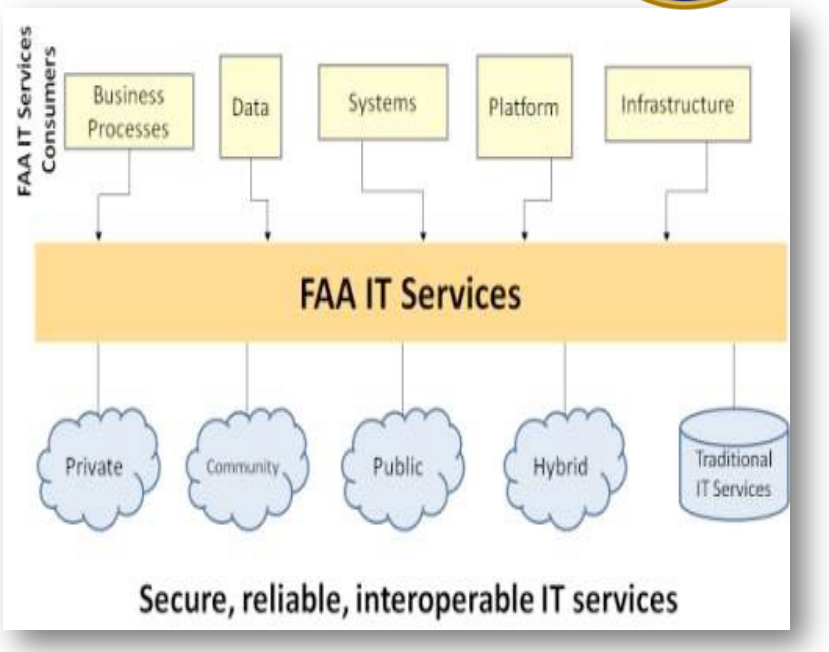

# Benefits of Cloud Computing

| | |
|---|---|
| Availability | • Access data anywhere, anytime through standard internet connection |
| Cost reductions | • Pay as you go model<br>• Savings on maintenance, repairs, and upgrades |
| Mobility | • Can access data and application from various devices<br>• Connecting employees, partners, and suppliers globally |
| Scalability | • Users have access to resources that scale quickly based on their demand |

http://www.businessweek.com/magazine/toc/09_24/B4135cloud_computing.htm
http://www.sei.cmu.edu/library/assets/whitepapers/Cloudcomputingbasics.pdf

# Putting the Cloud to Work: FAA




http://www.fastcompany.com/1843699/air-traffic-cloud



# Putting the Cloud to Work:

InterContinental Hotels Group

- IHG: 9 hotel brands, 660,000 rooms, 153 Million guests a year
- Believer in major cloud vendors:
  - Amazon Web Services
  - Salesforce CRM
- Operating their own private cloud:
  - "Camelot" supported by cloud services from HP & Verizon
  - Runs IHG's: Revenue Mgmt System, Loyalty program, promotions
- Continuing to Reach for the Cloud

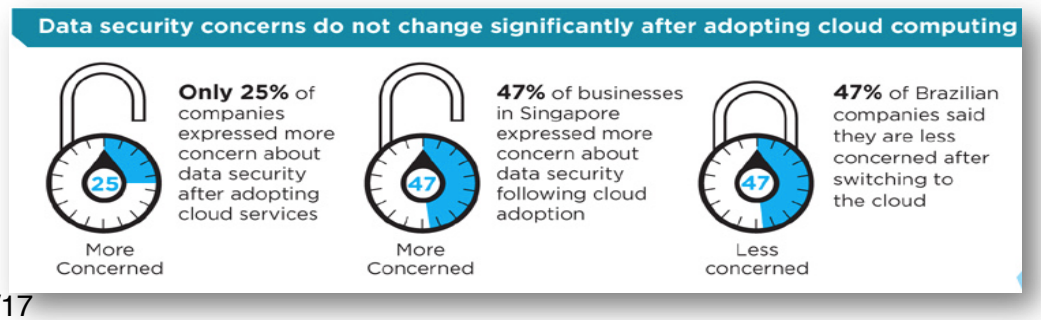
http://www.informationweek.com/hardware/data-centers/4-companies-getting-real-results-from-cl/229000706

# The How: Addressing Risks and Implementing a Strategy



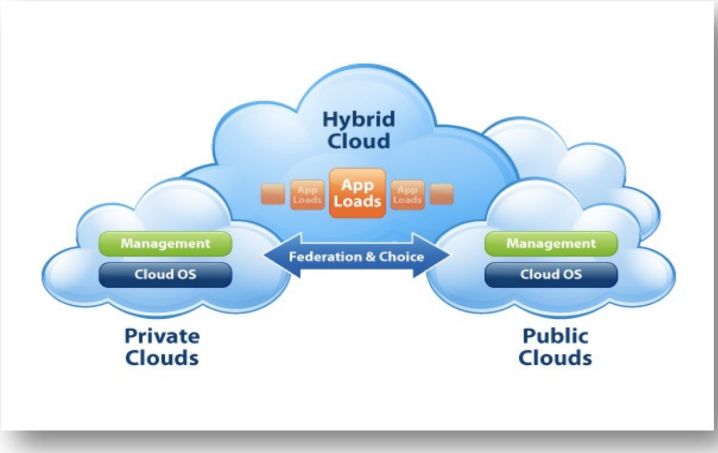

# Issues with Cloud Computing: Security and Privacy

- Does the cloud back up your data?
- Is your data always safe?
- Can you conduct business abroad?
- Who is given access to your data?
- Who else is on your server?



## Issues with Cloud Computing: Security and Privacy Solutions

- Triage, Secure, and Back Up
- Authentication & Authorization
- "Private Cloud" vs. "Public Cloud"
- Hybrid Approach





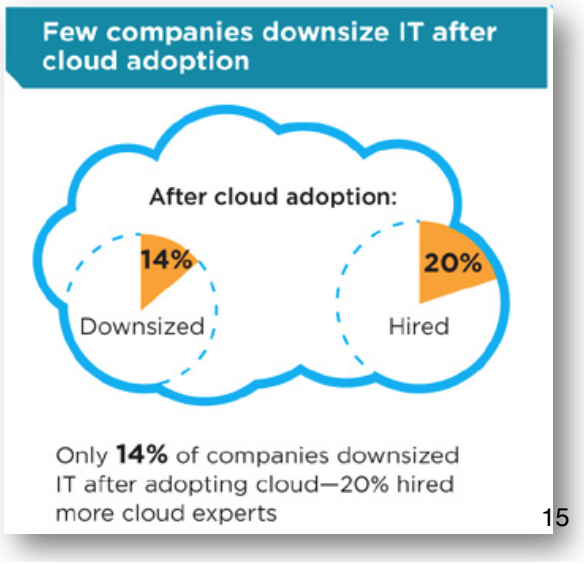

## Issues with Cloud Computing: Reliability

- Past Outages
  - Amazon's "Simple Storage Ser
    "Elastic Computing Cloud"
  - Microsoft & Google
- Prevention & Strategic
  - Choice of server
  - Think ahead
  - Hybrid Approach



## Issues with Cloud Computing: Downsizing Workforces?

- Increasing need for cloud experts and third-party companies
- Increase in workforce leads to increase in efficiency






## Appendix

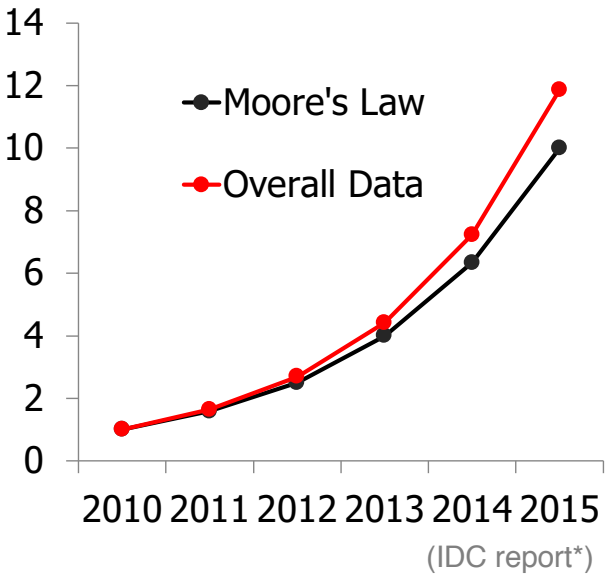
Data Centers

# Datacenter evolution

Facebook's daily logs: 60 TB

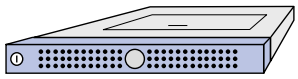
1000 genomes project: 200 TB

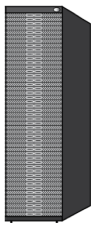
Google web index: 10+ PB

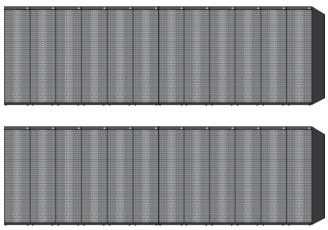



Slide from Ion Stoica

# Datacenter Organization







Single server:

- 8-24 cores
- DRAM: 16-64GB @ 100ns
- Disk: 2 TB @10ms

Rack:

- 50 machines
- DRAM: 800-3200GB @ 300 µs
- Disk: 100TB @ 10ms

**Row/cluster:**

- **30+ racks**
- **DRAM: 24-96TB @ 500 µs**
- **Disk: 3 PB @ 10ms**

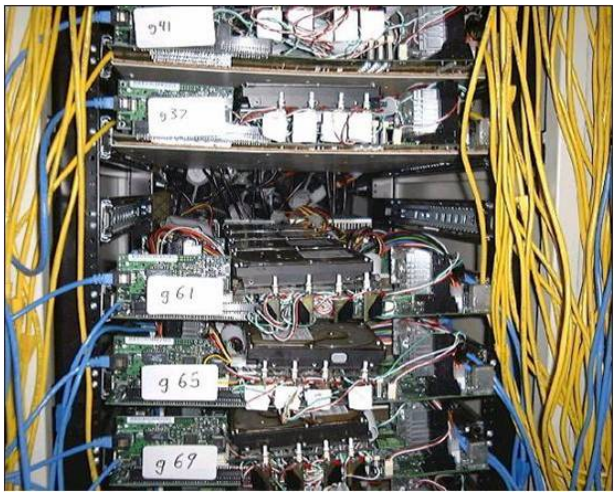
# Sun Containers




# Sun Containers, cont'd

## Google 1997

## Google 2001



Commodity CPUs

Lots of disks

Low bandwidth network

Cheap !

## Google Data Center 2015



## Google Modular Data Center

- In 2009, Google revealed the hardware at the core of its operation
  - each server has its own 12-volt battery
  - Data centers are composed of standard shipping containers--each with 1,160 servers and a power consumption that can reach 250 kilowatts.

# Google Modular Data Center

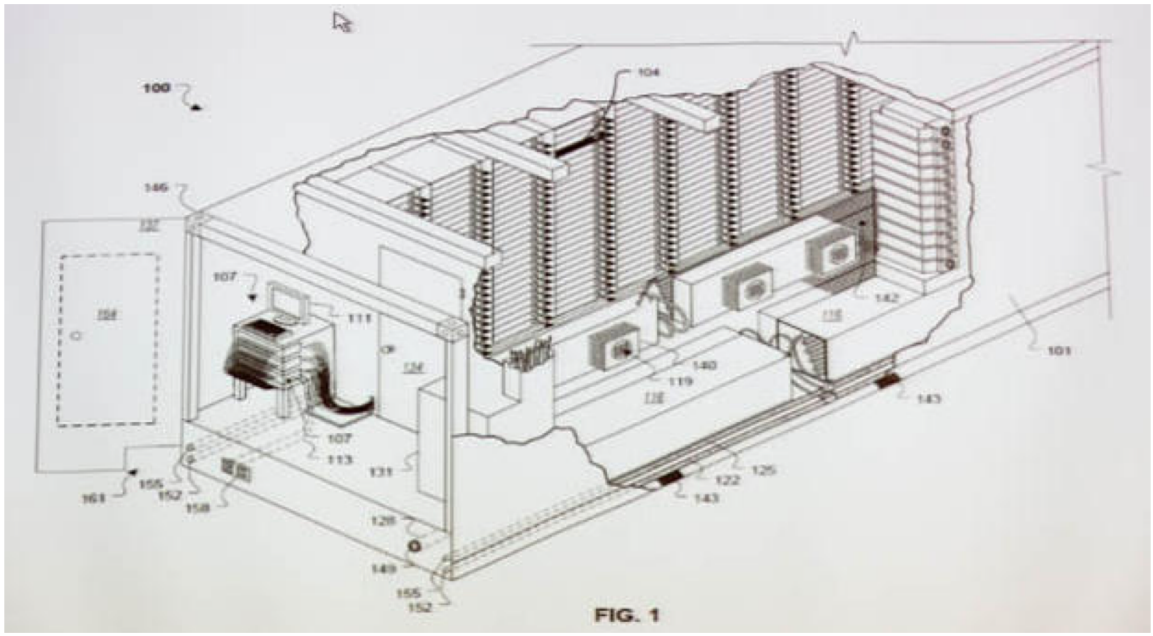
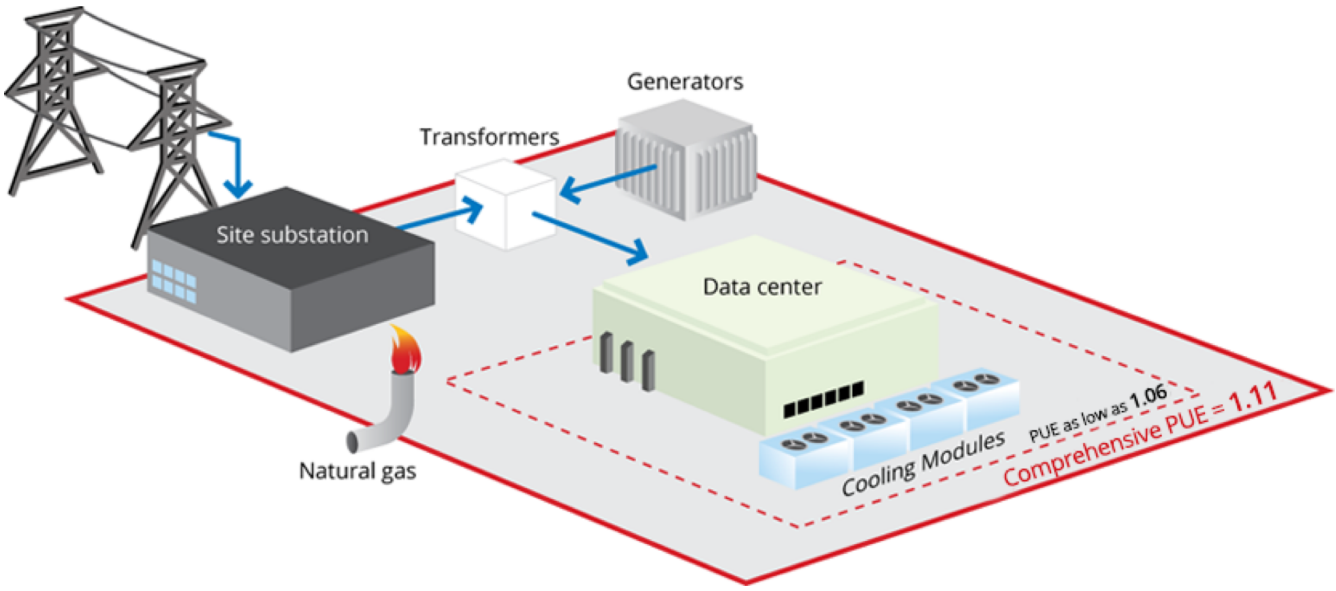


FIG. 1



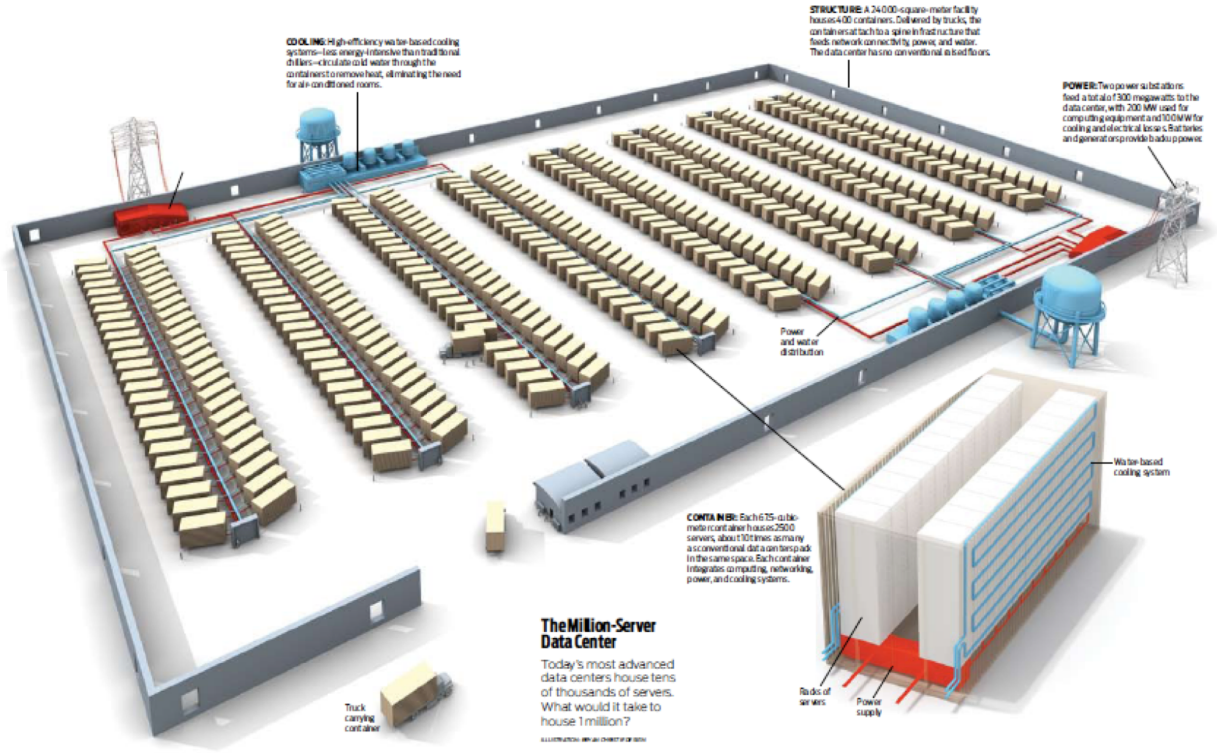
# Google Containers

# Google Server Room






# Microsoft Containers

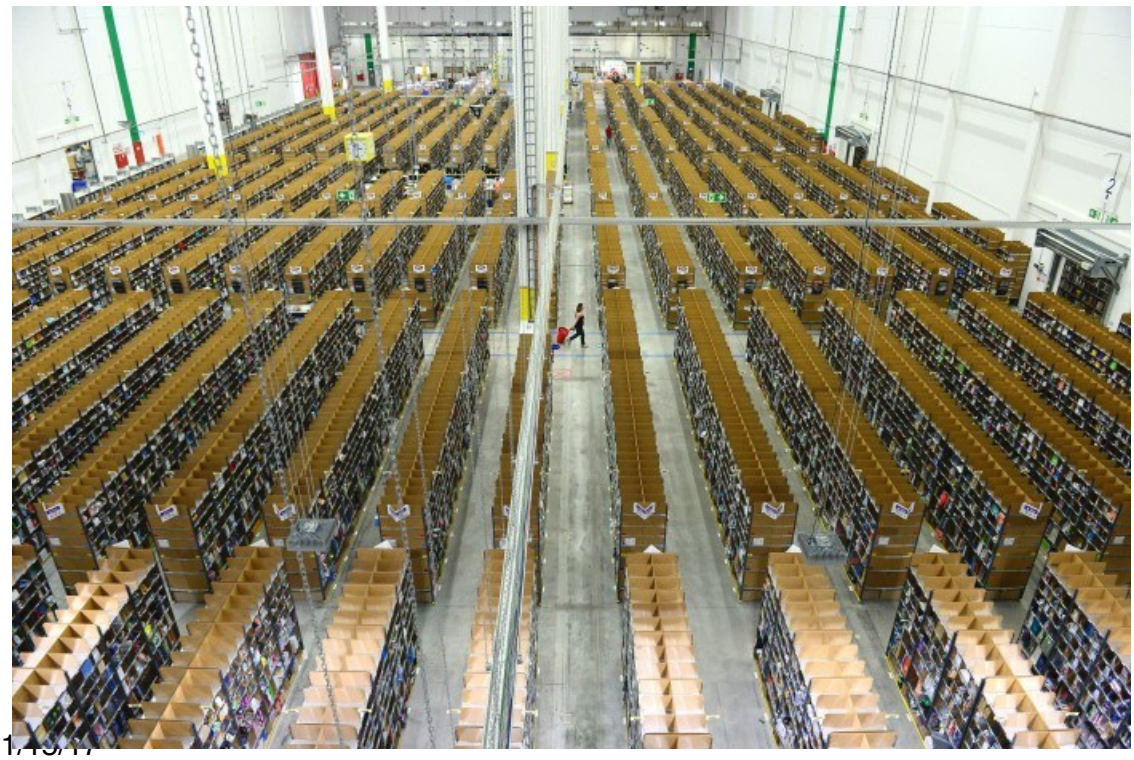


# Microsoft Containers, cont'd



# Apple Data Center

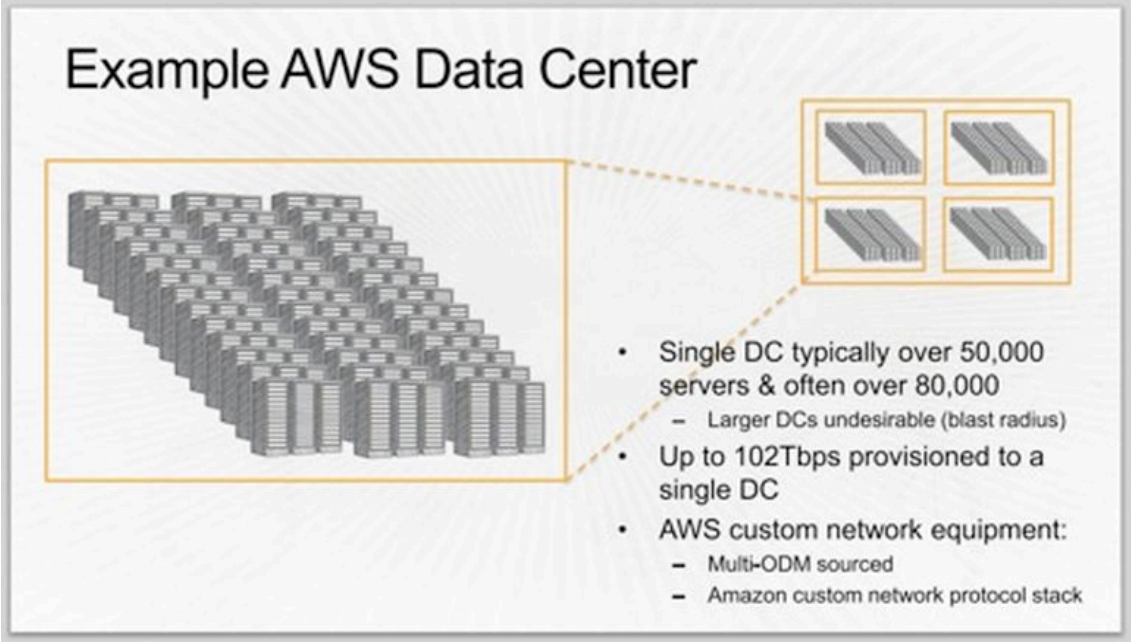
# Amazon Data Center





# Amazon Data Center [Dublin, 28335 m²]

# Amazon Data Center






# Amazon Data Centers

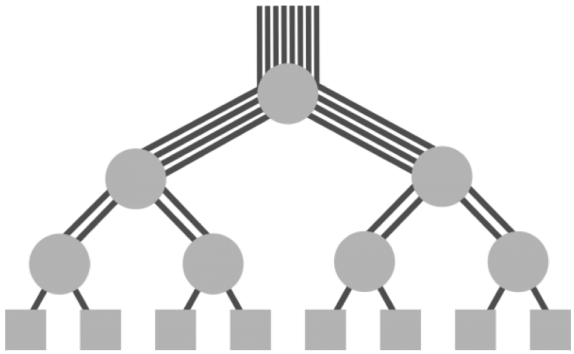
## Amazon EC2

| Machine | Memory (GB) | Compute Units (ECU) | Local Storage (GB) | Cost / hour |
|---|---|---|---|---|
| t1.micro | 0.615 | 2 | 0 | $0.02 |
| m1.xlarge | 15 | 8 | 1680 | $0.48 |
| cc2.8xlarge | 60.5 | 88 (Xeon 2670) | 3360 | $2.40 |

1 ECU = CPU capacity of a 1.0-1.2 GHz 2007 Opteron or 2007 Xeon processor

## Datacenter Networking

Initially tree topology
Over subscribed links



Fat tree, Bcube, VL2 etc.

Lots of research to get full bisection bandwidth

## Datacenter Design

Goals

Power usage effectiveness (PUE)

Cost-efficiency

Custom machine design

Open Compute Project (Facebook)

## Failures are Frequent

Typical first year for a new cluster (Jeff Dean, Google):

- ~0.5 overheating (power down most machines in <5 mins, ~1-2 days to recover)
- ~1 PDU failure (~500-1000 machines suddenly disappear, ~6 hours to come back)
- ~1 rack-move (plenty of warning, ~500-1000 machines powered down, ~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 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
- Slow disks, bad memory, misconfigured machines, flaky machines, etc.

- Long distance links: wild dogs, sharks, dead horses, drunken hunters, etc.

## How Many Datacenters?

- 1-10 datacenter servers/human?
- 100,000 servers/datacenter

| | U.S. | World |
|---|---|---|
| **Servers** | **0.3-3B** | **7-70B** |
| **Datacenters** | **3000-30,000** | **70,000-700,000** |

- 80-90% of general-purpose computing will soon be in datacenters?



## Hopper vs. Datacenter

| | Hopper | Datacenter[2] |
|---|---|---|
| Nodes | 6384 | 1000s to 10000s |
| CPUs (per node) | 2x12 cores | ~2x6 cores |
| Memory (per node) | 32-64GB | ~48-128GB |
| Storage (overall) | ~4 PB | 120-480 PB |
| Interconnect | ~ 66.4 Gbps | ~10Gbps |

[2]http://blog.cloudera.com/blog/2013/08/how-to-select-the-right-hardware-for-your-new-hadoop-cluster/

## Part II: Virtualization

## What is virtualization?

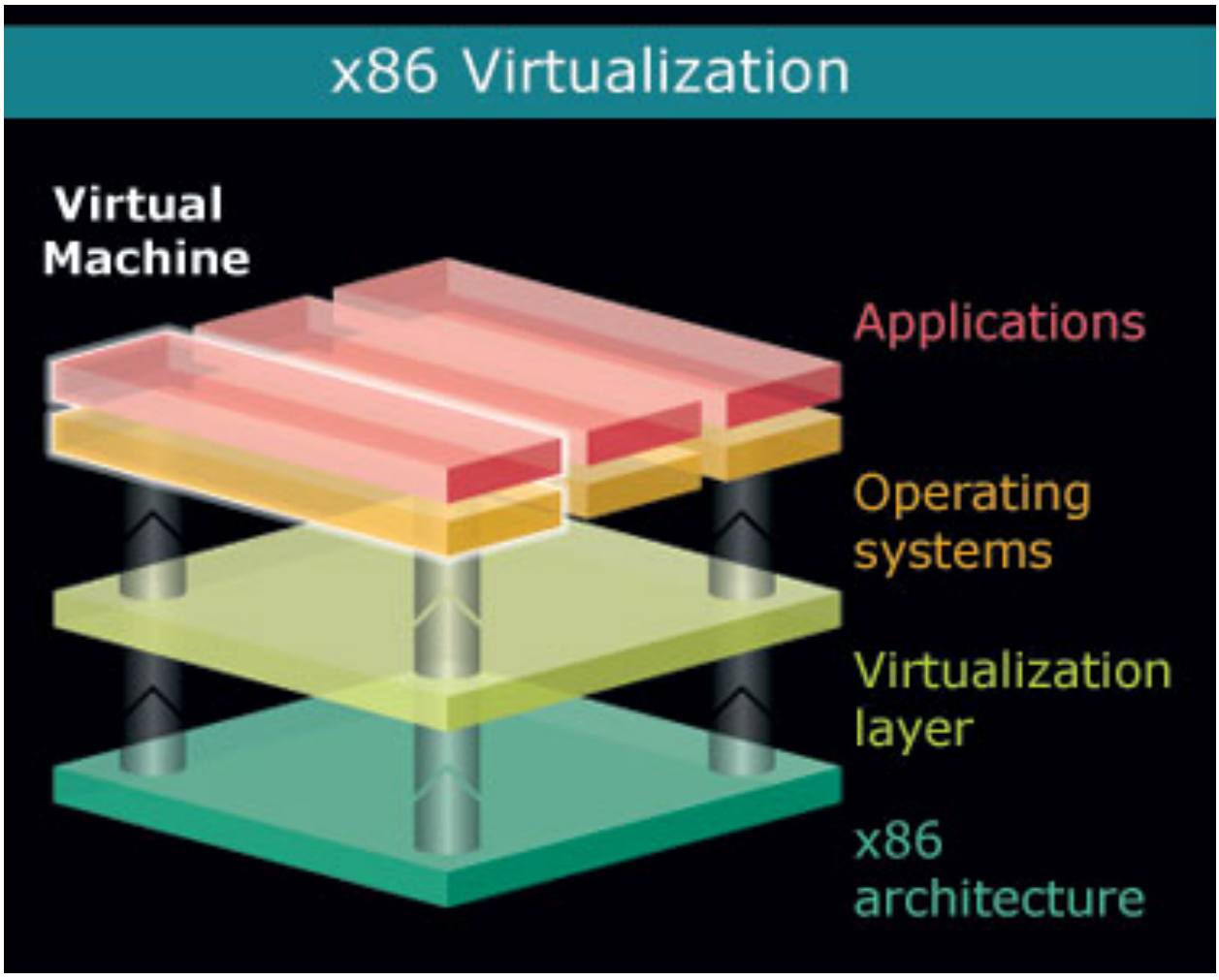
- Virtualization allows one computer to do the job of multiple computers.
- Virtual environments let one computer host multiple operating systems at the same time

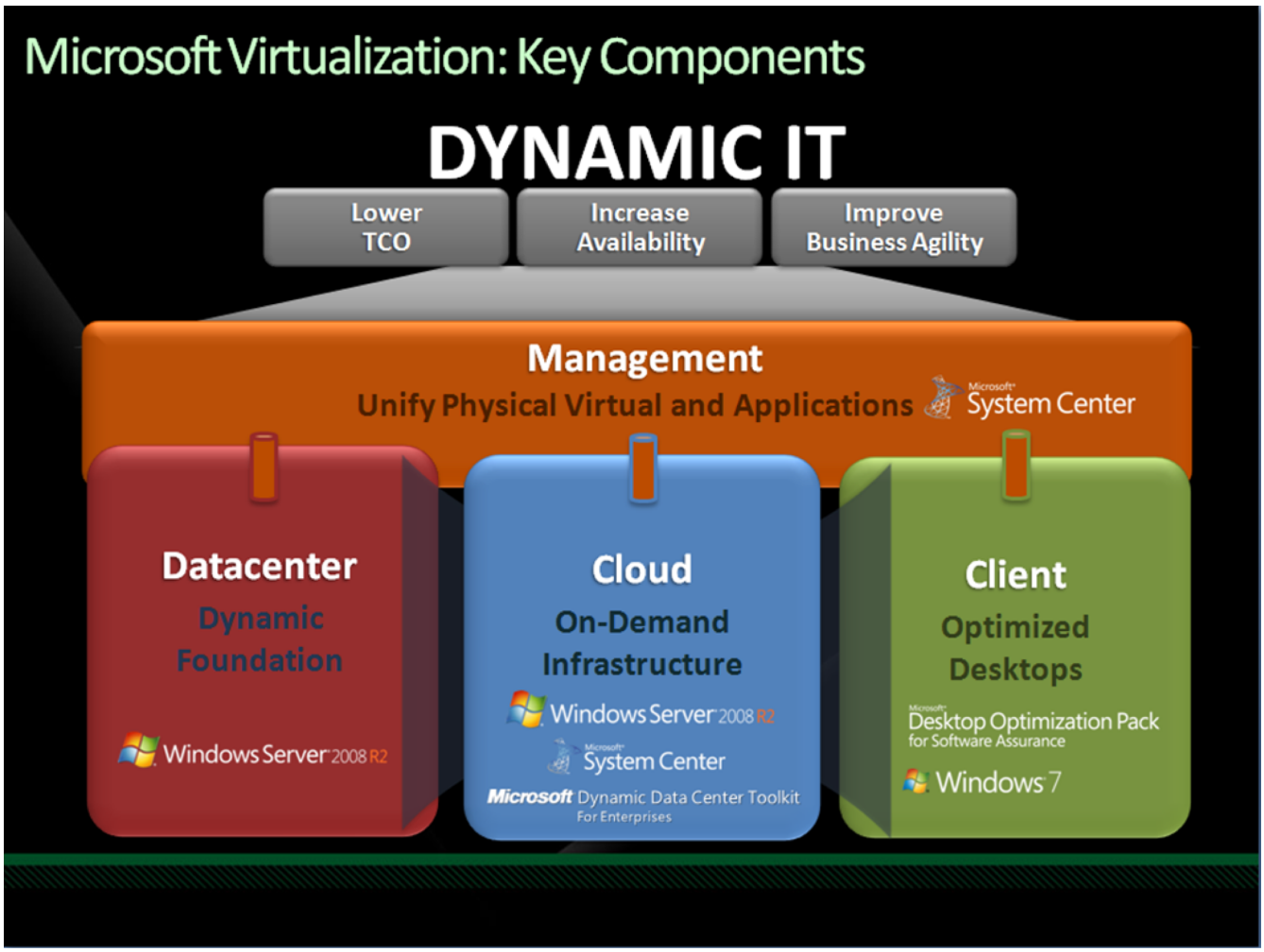

## How does it work?

- Virtualization transforms hardware into software.
- It is the creation of a fully functional virtual computer that can run its own applications and operating system.
- Creates virtual elements of the CPU, RAM, and hard disk.

## Background and Evolution

- Virtualization arose from a need in the 1960's to partition large mainframe hardware.
- Improved in the 1990s to allow mainframes to multitask.
- First implemented by IBM more than 30 years ago.






## Pros

- Benefits include freedom in choice of operating system.
- It saves time and money.
- Consolidates server and infrastructure.
- Makes it easier to manage and secure desktop environments.

## Cons

- Only powerful computers can successfully create virtual environment.
- Requires training to operate.

## Conclusion

- "Companies that don't understand the risk just shouldn't use cloud computing, the potential for a security breach or a compliance violation can be high" –IDC Analyst Phil Hochmuth
- Understanding cloud computing will allow you to understand both the risks and the rewards
- Virtualization is a cost-effective way to run multiple operating systems and software.
- It allows for greater access to basic system resources.
- It is safer and easier to manage than physical hardware.