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The Impact of Cloud Computing to Technology-Based Companies: Two Case Studies
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Topics of Discussion

- The Evolution of Computer Systems and Applications
- Cloud Computing 101
  - Cloud Enabling Technologies
  - Types of Cloud Services
  - Cloud Deployment Models
- Challenges of Cloud Computing
- NIST Definition of Cloud Computing
- Cost Models and Benefits of Cloud Computing
- Cloud Strategy for Tech-based Companies
Topics of Discussion (continue)

- Case Study 1: “Microsoft 365 for Enhancing Engineering Design Collaboration and Service Productivity – a SaaS Example,” Luis Morale and Stephen Obioma

- Case Study 2: “Implementing Remote Desktop Computing Services using Amazon EC2 – an IaaS Example,” Hemchand Lallad, MengWei Li and Greg Scalet

The Evolution of Computer Systems and Applications

- Mainframe Computers
- Minicomputers
- Personal Computers
- Client-Server Computing
- Distributed Computing
- Virtualization and data centers
- Utility Computing
- Grid Computing
- Internet computing
- Web services
- Service-Oriented Computing (SOA)
- Mobile Computing
- Cloud Computing

Source: http://www.computerhistory.org/
Berkeley NOS (Network of Workstations) Project

- Clustered machines connected via high-speed switched networks, 1995, [http://now.cs.berkeley.edu/](http://now.cs.berkeley.edu/)
- NOW-2 (1997) 105 Ultra-1 workstations
- Each with a 167 MHz UltraSPARC Microprocessor, 128 MB of memory, and 2 Seagate Hawk 2 GB 5400 RPM 3.5 inch disks
- Myrinet switch system area network with each link operating at 160 Mbytes/second

A Computational Grid

![Diagram of a computational grid](Figure 1.16)

A Typical Computational Grid

![Diagram of a computational grid](image)


X86 Virtualization Layer (source: VMWare [2])

![Diagram of X86 virtualization layer](image)
Scalable Internet-based Computing

- General Computing Trend
  - Leverage shared web resources
  - Massive amount of data over the Internet

- High Performance Computing (HPC)
  - Supercomputers (massively parallel processors, MPP)
  - Clusters of cooperative computers; share computing resources
  - Physically connected in close range to one another

- High Throughput Computing (HTC)

Scalable Internet-based Computing (cont.)

- High Throughput Computing (HTC) & Applications
  - Peer-to-peer (P2P) networks – distributed file sharing and content delivery applications
  - Web service platforms
  - Cloud computing

- HTC Technologies
  - Improved batch processing speed
  - Address acute problems at many data and enterprise computing centers
    - Cost, Energy saving, Security, Reliability
Cloud and Internet of Things (IOT)


Scalable Internet-based Computing

- HPC for Science and HTC for Business Applications

(Courtesy of Raj Buyya, University of Melbourne, 2011)
Cloud Computing 101: Enabling Technologies

- Cloud Computing - Convergence of Technologies
  1) Hardware virtualization and multi-core chips
  2) Utility and grid computing
  3) SOA (Service-Oriented Architecture), Web 2.0, and WS mashups (Web services)
  4) Atomics computing and data center automation

Cloud Computing: 101
Basic Concept of Internet Clouds

Cloud Computing 101:
Low Cost Datacenter

- IDC 2009 Datacenter Report
- Low-Cost Design Philosophy
  - About 60 percent of the cost is allocated to Management & Maintenance
  - The server purchase cost did not increase much with time
  - Use commodity switches and networks
  - Use commodity x86 servers
  - The software layer handles
    - Network traffic balancing
    - Fault tolerance
    - Expandability

Cloud Computing 101:
Datacenter Growth and Cost Breakdown

- 2009 IDC Report: data center cost
  - 30% - purchasing IT equipment; 33% - Chillers
  - 18% - Uninterruptable power supply; 9% - computer room HVAC; 7% - power distribution, lighting, transformer costs

- 2012 U.S. Datacenter Growing in Size but Declining in Numbers, Oct. 9, 2012,
  http://www.idc.com/getdoc.jsp?containerId=prUS23724512

- U.S. Datacenter 2012-2016 Forecast (Doc # 237070)
  - From 2.94 million in 2012 to 2.89 million in 2016
  - From 611.4 million square feet in 2012 to more than 700 million square feet in 2016
### Cloud Computing Challenges: too Many Issues

- Virtualization
- Programming Env. & App Development
- Software Engineering Complexity
- Provisioning on Demand
- Utility & Risk Management
- Legal & Regulatory
- Security
- Privacy
- Trust
- Energy Efficiency
- Resource Metering
- Pricing
- Billing
- Service Level Agreements
- QoS
- Scalability
- Reliability

### The NIST Definition of Cloud Computing

- **Five Essential Characteristics**
  - On-demand self-service, Broad network access,
  - Resource pooling, Rapid elasticity, Measured service
- **Three Service Models**
  - Software as a Service (SaaS)
  - Platform as a Service (Paas)
  - Infrastructure as a Service (IaaS)
- **Four Deployment Models**
  - Private cloud
  - Community cloud
  - Public cloud
  - Hybrid cloud
The NIST Definition of Cloud Computing

Three Service Models

- **Software as a Service (SaaS)**
  - The capability provided to the consumer is to use the provider’s applications running on a cloud infrastructure.
  - The applications are accessed from various client devices through either a thin client interface, such as web browser (e.g., web-based email), or program interface.
  - The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited specific application configuration settings.

- **Platform as a Service (PaaS)**

- **Infrastructure as a Service (IaaS)**
The NIST Definition of Cloud Computing

- Three Service Models: **Software as a Service (SaaS)**, **Platform as a Service (PaaS)**, and **Infrastructure as a Service (IaaS)**
  - **Infrastructure as a Service (IaaS)**
    - The capability provided to the consumer is to provision processing, storage, networks, and fundamental computing resources where the consumer is able to deploy and run arbitrary software which can include operating systems and applications.
    - The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deploying applications; and possibly limited control of select networking components (e.g. host firewalls).

The NIST Definition of Cloud Computing

- Four Deployment Models
  - **Private Cloud**
    - The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g. business units).
    - It may be owned, managed, and operated by the organization, or some combination of them. And it may exist on or off premises.
  - Public Cloud
  - Community Cloud
  - Hybrid Cloud
The NIST Definition of Cloud Computing

Four Deployment Models

- Private Cloud
- **Public Cloud**
  - The cloud infrastructure is provisioned for open use by the general public.
  - It may be owned, managed, and operated by a business, academic, government organization, or some combination of them.
  - It exists on the premises of the cloud provider.
- Community Cloud
- Hybrid Cloud

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The NIST Definition of Cloud Computing

Four Deployment Model

- Private Cloud, Public Cloud
- **Community Cloud**
  - The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security, requirements, policy, and compliance considerations.)
  - It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and
  - It may exist on or off premises.
- Hybrid Cloud
The NIST Definition of Cloud Computing

- Four Deployment Model
  - Private Cloud, Public Cloud, Community Cloud
  - Hybrid Cloud
    - The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enable data and application portability (e.g. cloud bursting for load balancing between clouds)

The NIST Cloud Conceptual Model

Figure 12 The Combined Conceptual Reference Diagram, NIST Cloud Computing Standards Roadmap
Cost Models Comparison:
Traditional IT and Cloud-Based IT

(a) Traditional IT cost model
(b) Cloud computing cost model


Cloud Role in the Future

Subscription-Oriented Cloud Services
X (compute, apps, data, ..) as a Service (.. aaS)


Public Cloud Computing & Service Models

- Public clouds – Some Examples
  - Google App Engines (GAE), https://developers.google.com/appengine/
  - Amazon Web Services (AWS), http://aws.amazon.com/
  - RackSpace
  - IBM SmartCloud
  - Force.com
Amazon VPC (Virtual Private Cloud) for Multiple Tenants


Google App Engine Cloud Computing Service

Software as a Services (SaaS)

- Google Gmail and docs
- Microsoft Office 365
- CRM from Salesforce.com
  - AppDirect
  - Concur
  - Ingram Micro
  - Jamcrakr
  - Ospero
  - NetSuite
  - Parallels
  - Salesforce.com
  - Standing Cloud
  - Workday

Cloud Strategy for Tech-Based Enterprises

- **SWOT Analysis (Strength-Weaknesses, Opportunities-Threat)**
  - IT-based Enterprise, Healthcare Industries, Service-Oriented Industry, Technology & Engineering Firms, Educational Institutional, etc
- **Learning & Trying Cloud Services & Technologies**
- **Put Cloud Technology into Corporate Planning**
  - Technology & Business Competitive Strategy
  - Product Technological Change
  - Business and/or Manufacturing Process Technological Change
Cloud Strategy for Tech-Based Enterprises  
(cont.)

- Integrating & Migrating to the Cloud
  - Resource Allocation for Innovative Activities
  - Your Enterprise Cloud: Private Cloud, Public Cloud, Hybrid Cloud
  - Establishing a Baseline and Metrics Tools
  - Finding the Right Vendors
  - Phase In and Get Ready

Cloud Strategy for Tech-Based Enterprises  
(cont.)

- Profiting from Cloud Strategy
  - Operational Benefits:
    - Reduced IT Cost, Increased Storage, Automation, Flexibility, Better Mobility, Better Use of IT Staff
  - Economic Benefits:
    - Staffing Benefits
      - No software installation or maintenance
      - Shorter Deployment Time
      - World Availability
    - SLA
    - Upgrades
    - Hardware (Leasing vs. Buying)
    - On Demand Pay as You Need,
    - Time to Market (Apps)
Two Case Studies

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