



Goals

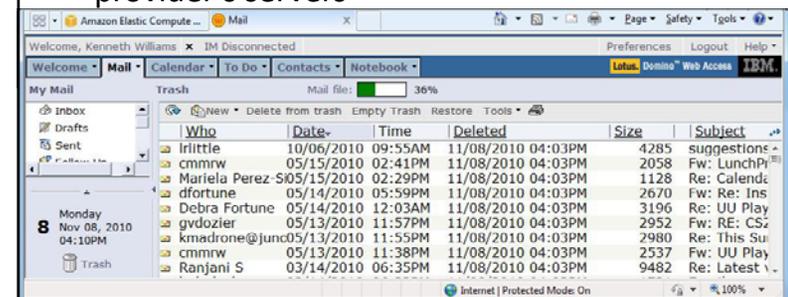
- Understand what cloud computing is and how it functions
- Understand the challenges and advantages of cloud computing
- Many slides were created by Peter Mell, Tim Grance of NIST

What is Cloud Computing?

- Cloud Computing is the idea of putting your applications and data on remote servers
- The cloud servers may be owned and managed by someone else
- Data is stored on the servers
- Applications are run from the servers instead of locally

Simple Example

- The easiest example of cloud computing is a web based email system
- You read your email through your browser
- The data (email) is stored on the email provider's servers



A Working Definition of Cloud Computing

- Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
- This cloud model promotes availability and is composed of five essential **characteristics**, three **service models**, and four **deployment models**.

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5 Essential Cloud Characteristics

- On-demand self-service
- Broad network access
- Resource pooling
 - Location independence
- Rapid elasticity
- Measured service

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3 Cloud Service Models

- Cloud Software as a Service (SaaS)
 - Use provider's applications over a network
- Cloud Platform as a Service (PaaS)
 - Deploy customer-created applications to a cloud
- Cloud Infrastructure as a Service (IaaS)
 - Rent processing, storage, network capacity, and other fundamental computing resources
- To be considered "cloud" they must be deployed on top of cloud infrastructure that has the key characteristics

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4 Cloud Deployment Models

- Private cloud
 - enterprise owned or leased
- Community cloud
 - shared infrastructure for specific community
- Public cloud
 - Sold to the public, mega-scale infrastructure
- Hybrid cloud
 - composition of two or more clouds

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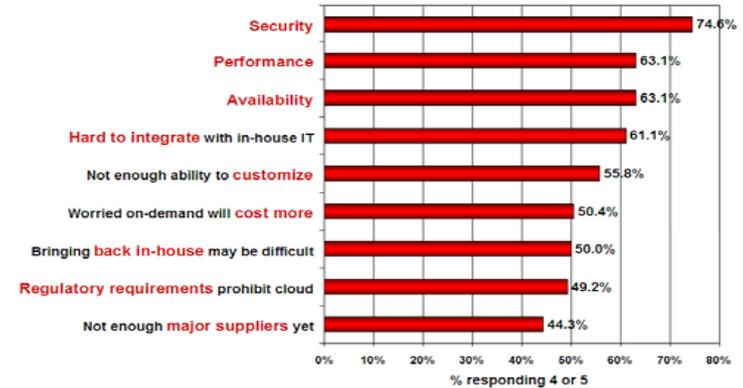
Common Cloud Characteristics

- Cloud computing often leverages:
 - Massive scale
 - Homogeneity
 - Virtualization
 - Resilient computing
 - Low cost software
 - Geographic distribution
 - Service orientation
 - Advanced security technologies

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Security is the Major Issue

Q: Rate the **challenges/issues** ascribed to the 'cloud'/on-demand model
(1=not significant, 5=very significant)



Source: IDC Enterprise Panel, August 2008 n=244

Analyzing Cloud Security

- Some key issues:
 - trust, multi-tenancy, encryption, compliance
- Clouds are massively **complex systems** can be reduced to **simple primitives** that are replicated thousands of times and **common functional units**
- Cloud security is a tractable problem
 - There are both advantages and challenges

Former Intel CEO, Andy Grove: "only the paranoid survive"

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General Security Advantages

- Shifting public data to a external cloud reduces the exposure of the internal sensitive data
- Cloud homogeneity makes security auditing/testing simpler
- Clouds enable automated security management
- Redundancy / Disaster Recovery

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General Security Challenges

- Trusting vendor's security model
- Customer inability to respond to audit findings
- Obtaining support for investigations
- Indirect administrator accountability
- Proprietary implementations can't be examined
- Loss of physical control

NIST 13

Data Storage Services

- Advantages
 - Data fragmentation and dispersal
 - Automated replication
 - Provision of data zones (e.g., by country)
 - Encryption at rest and in transit
 - Automated data retention
- Challenges
 - Isolation management / data multi-tenancy
 - Storage controller
 - Single point of failure / compromise?
 - Exposure of data to foreign governments

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Cloud Processing Infrastructure

- Advantages
 - Ability to secure masters and push out secure images
- Challenges
 - Application multi-tenancy
 - Reliance on hypervisors
 - Process isolation / Application sandboxes

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Cloud Support Services

- Advantages
 - On demand security controls (e.g., authentication, logging, firewalls...)
- Challenges
 - Additional risk when integrated with customer applications
 - Needs certification and accreditation as a separate application
 - Code updates

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Cloud Network and Perimeter Security

- Advantages
 - Distributed denial of service protection
 - VLAN capabilities
 - Perimeter security (IDS, firewall, authentication)
- Challenges
 - Virtual zoning with application mobility

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Cloud Security Advantages Part 1

- Data Fragmentation and Dispersal
- Dedicated Security Team
- Greater Investment in Security Infrastructure
- Fault Tolerance and Reliability
- Greater Resiliency
- Hypervisor Protection Against Network Attacks
- Possible Reduction of C&A Activities (Access to Pre-Accredited Clouds)

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Cloud Security Advantages Part 2

- Simplification of Compliance Analysis
- Data Held by Unbiased Party (cloud vendor assertion)
- Low-Cost Disaster Recovery and Data Storage Solutions
- On-Demand Security Controls
- Real-Time Detection of System Tampering
- Rapid Re-Constitution of Services
- Advanced Honeynet Capabilities

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Cloud Security Challenges Part 1

- Data dispersal and international privacy laws
 - EU Data Protection Directive and U.S. Safe Harbor program
 - Exposure of data to foreign government and data subpoenas
 - Data retention issues
- Need for isolation management
- Multi-tenancy
- Logging challenges
- Data ownership issues
- Quality of service guarantees

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Cloud Security Challenges Part 2

- Dependence on secure hypervisors
- Attraction to hackers (high value target)
- Security of virtual OSs in the cloud
- Possibility for massive outages
- Encryption needs for cloud computing
 - Encrypting access to the cloud resource control interface
 - Encrypting administrative access to OS instances
 - Encrypting access to applications
 - Encrypting application data at rest
- Public cloud vs internal cloud security
- Lack of public SaaS version control

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Cost of Traditional Data Centers

- 11.8 million servers in data centers
- Servers are used at only 15% of their capacity
- 800 billion dollars spent yearly on purchasing and maintaining enterprise software
- 80% of enterprise software expenditure is on installation and maintenance of software
- Data centers typically consume up to 100 times more per square foot than a typical office building
- Average power consumption per server quadrupled from 2001 to 2006.
- Number of servers doubled from 2001 to 2006

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Energy Conservation and Data Centers

- Standard 9000 square foot costs \$21.3 million to build with \$1 million in electricity costs/year
- Data centers consume 1.5% of our Nation's electricity (EPA)
 - .6% worldwide in 2000 and 1% in 2005
- Green technologies can reduce energy costs by 50%
- IT produces 2% of global carbon dioxide emissions

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Cloud Economics

- Estimates vary widely on possible cost savings
- "If you move your data centre to a cloud provider, it will cost a tenth of the cost." – Brian Gammage, Gartner Fellow
- Use of cloud applications can reduce costs from 50% to 90% - CTO of Washington D.C.
- IT resource subscription pilot saw 28% cost savings - Alchemy Plus cloud (backing from Microsoft)
- Preferred Hotel
 - Traditional: \$210k server refresh and \$10k/month
 - Cloud: \$10k implementation and \$16k/month

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Cloud Economics

- George Reese, founder Valtira and enStratus
 - Using cloud infrastructures saves 18% to 29% before considering that you no longer need to buy for peak capacity

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Microsoft Azure Services

Windows Live Office Live Exchange Online SharePoint Online Microsoft Dynamics CRM Online

Azure Services Platform



Windows Azure

Source: Microsoft Presentation, A Lap Around Windows Azure, Manuvir Das

Amazon Elastic Compute Cloud

- Why is a book vender selling computing resources?
- Amazon found it had to maintain a large computing system to handle its book business at peak times
- Most of the time, much of the system was idle
- Amazon sells their available idle resources