Cloud Computing

COMP755

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.

5 Essential Cloud Characteristics

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

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

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
Common Cloud Characteristics

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

Security is the Major Issue

![Graph showing various challenges and issues associated with cloud computing]

- Security is the most significant challenge.
- Performance and availability are also major concerns.
- Other issues include integration with on-premise IT, trust, multi-tenancy, encryption, and compliance.

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

General Security Advantages

- Shifting public data to an 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

Former Intel CEO, Andy Grove: “only the paranoid survive”
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

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

Cloud Processing Infrastructure

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

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
Cloud Network and Perimeter Security

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

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)

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

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
### 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

### 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

### 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

### 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
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

Amazon Elastic Compute Cloud

- Why is a book vendor 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