



Above the Clouds

A Berkeley View of Cloud Computing

Michael Armbrust et al.

Google Microsoft ORACLE

CISCO FUJITSU hp facebook amazon web services SIEMENS NetApp vmware

Outline

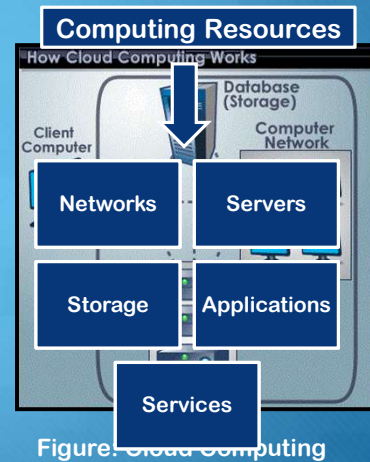
Topic	Navigate To
Cloud Computing	Cloud Computing
Cloud Computing Layers	Layers
Deployment Models	Deployment Models
Summary of Cloud	Summary
New Beginning	Cloud Off The Ground
Categories	Classes of Cloud
User Economics	Cloud Economics
Provider Economics	Economics of Providers
Challenges & Opportunities	Challenges
Conclusion	Conclusion

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Cloud Computing

- Shared utilization of Computing Resources
- With the abstraction of being utilized as a service rather than as a product
- Service model similar to utility services



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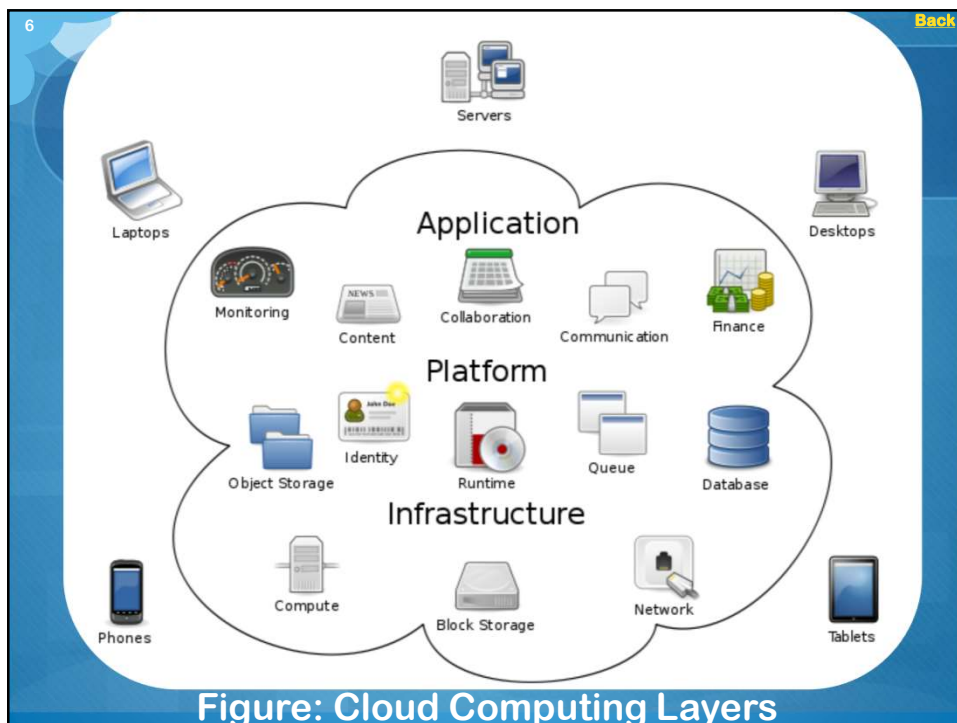
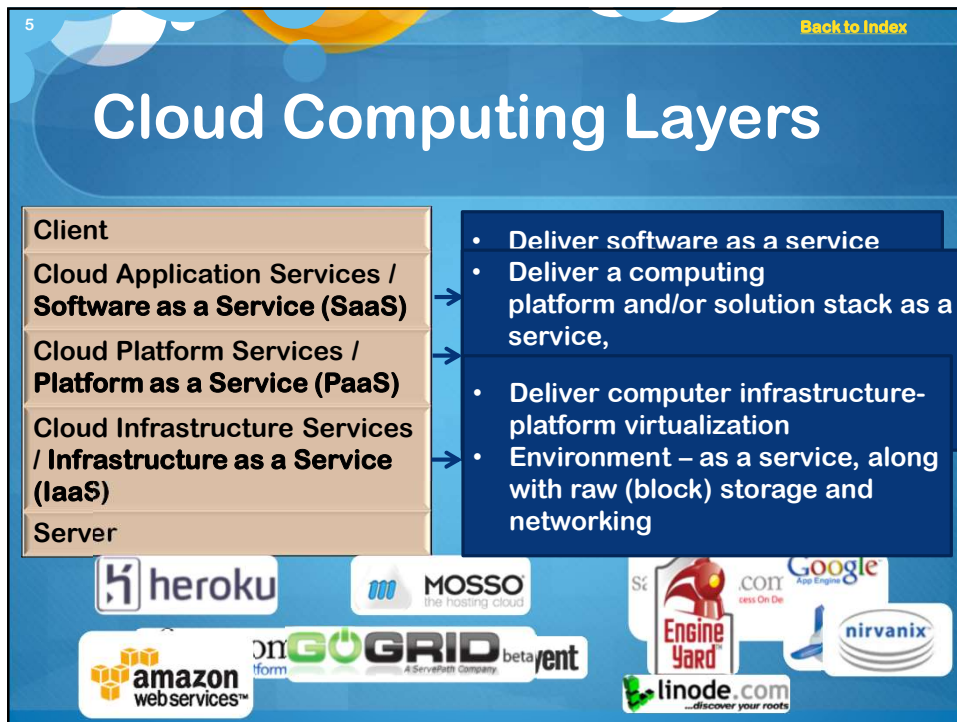
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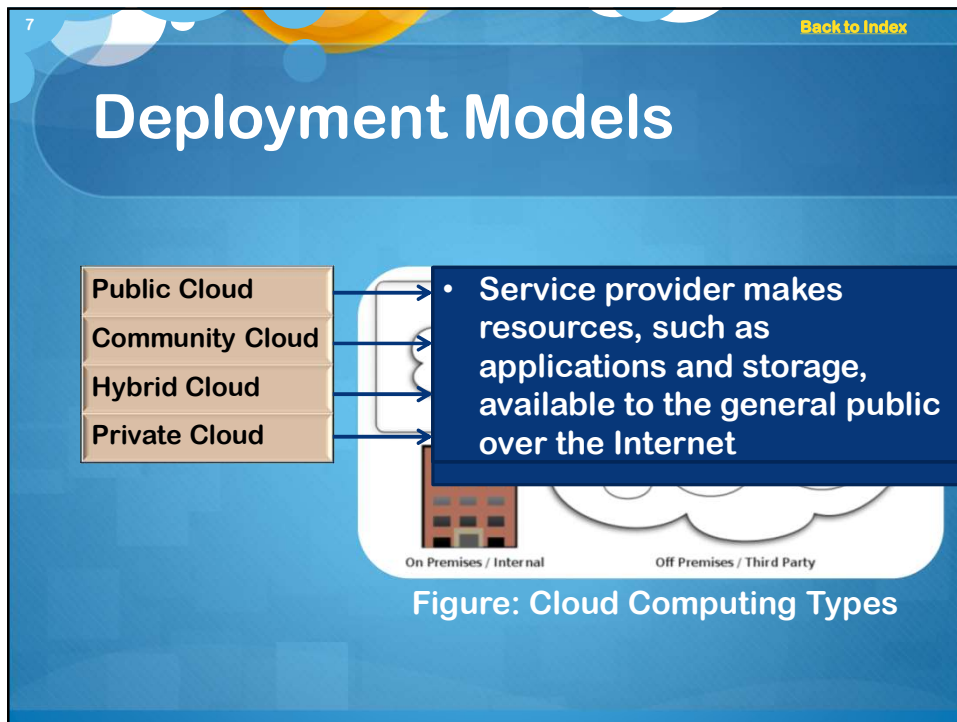
Cloud Computing (Contd.)

NIST's Final (16th) definition:

- Ubiquitous, convenient, on-demand network access
- Shared pool of configurable Computing Resources
- Resources can be rapidly provisioned and released
- Minimal management effort or service provider interaction

NIST: National Institute of Standards and Technology





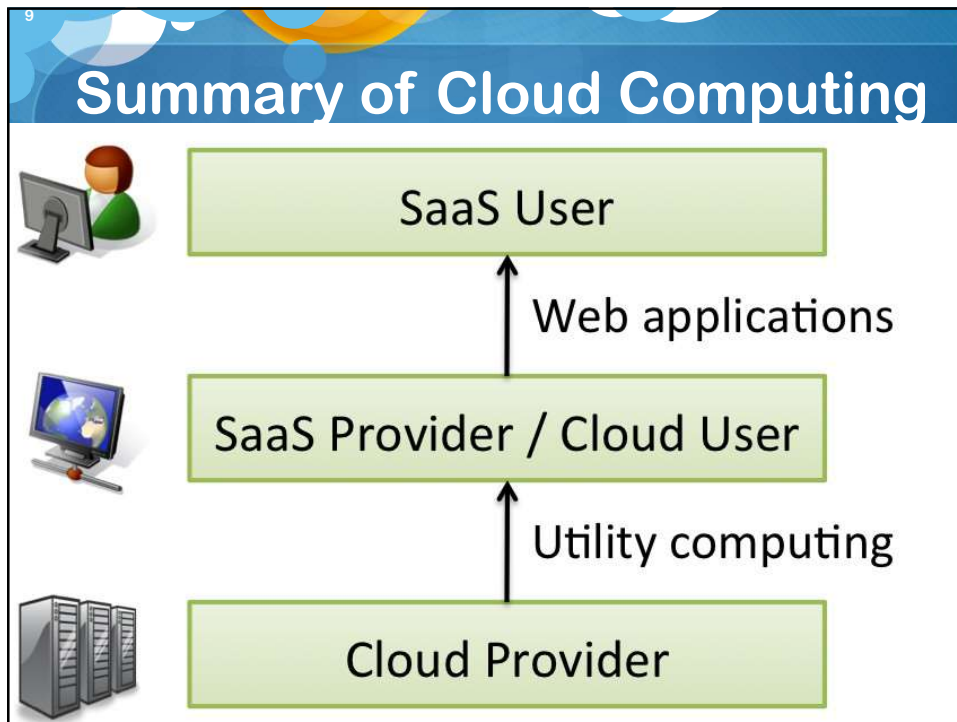
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Summary of Cloud Computing

Utility Computing:

- Illusion of on-demand infinite resources
- Elimination of up-front cost
- Pay for usage

**Cloud Computing =
SaaS + Utility Computing**



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Cloud Off The Ground

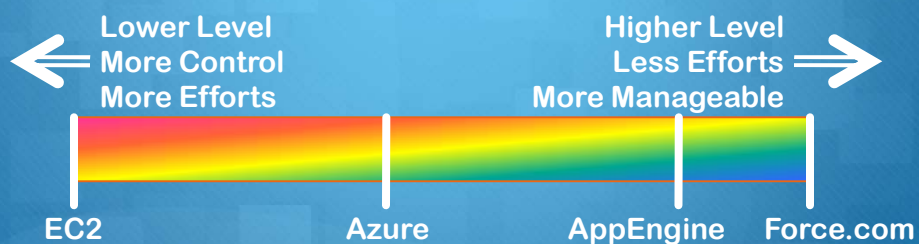
- Experience with
 - Economies of Scale, 1:5 → 1:7
 - Very Large Data Centers
- New Technology Trends, Apps Business Model
 - Standardized of Software Stack
 - Pervasive Internet
 - Usage based Billing Model
 - Advanced x86 Virtualization

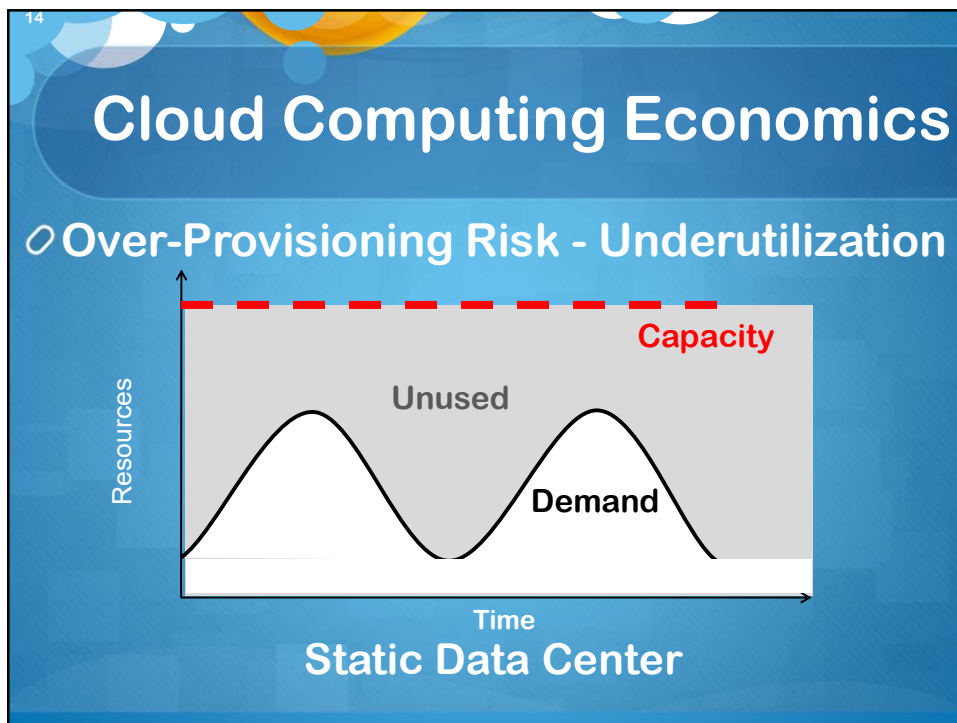
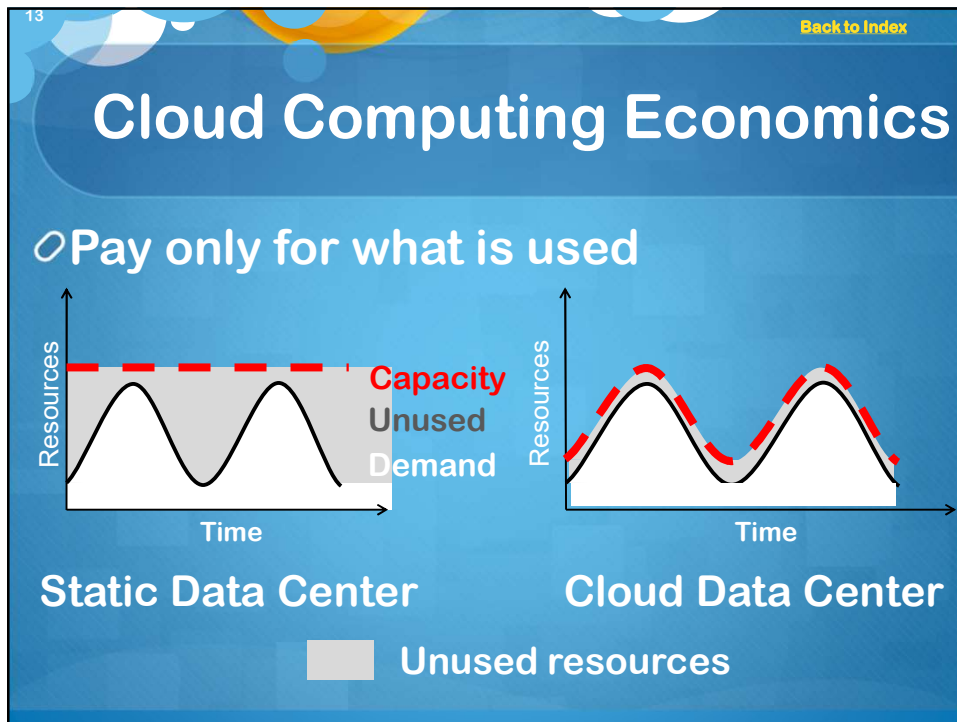
Cloud Application Opportunities

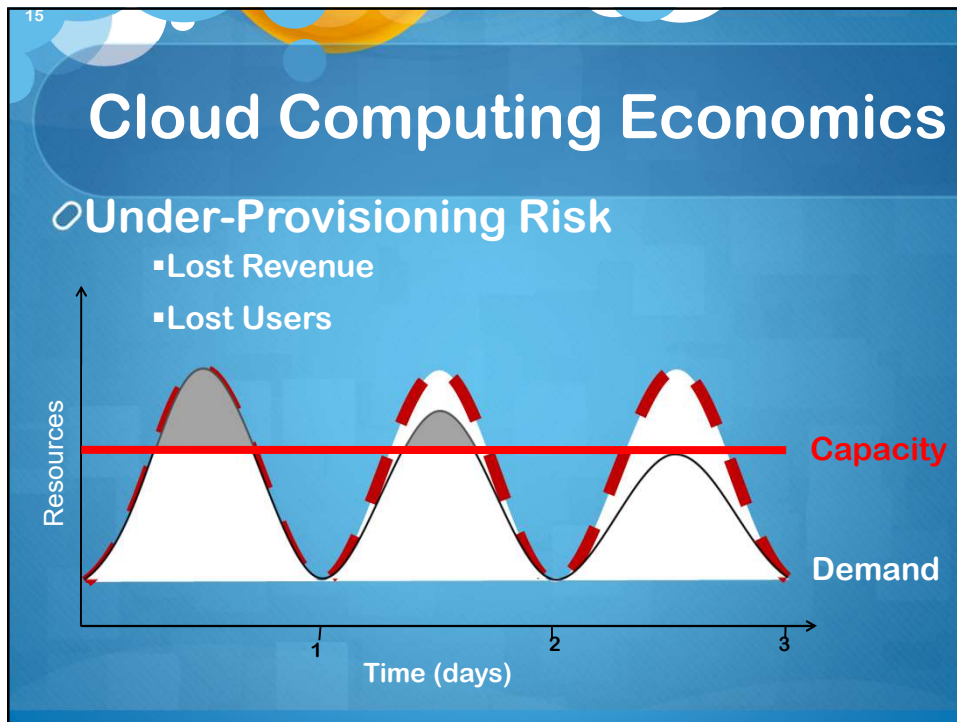
- Mobile and Web Apps
 - Mashups, Real-time apps
- Extensions of Compute-Intensive Desktop Software
 - Matlab, Mathematica
- Batch Processing / MapReduce
 - The Washington Post

Classes of Utility Computing

- x86 Instruction Set Architecture (ISA) VM
- ByteCode based VM
- Application Framework VM







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Economics of Cloud Providers

Resource	Cost in Medium DC	Cost in Very Large DC	Ratio
Network	\$95 /Mbps/month	\$13 /Mbps/month	7.1x
Storage	\$2.20 /GB/month	\$0.40 /GB/month	5.7x
Administration	≈140 servers/admin	>1000 servers/admin	7.1x

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Economics of Cloud Providers

- Oracle
 - sell licenses
- Amazon
 - utilize off-peak capacity
- Microsoft
 - sell .NET tools
- Google
 - reuse existing infrastructure

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Cloud Adoption Challenges

- Challenge: Availability of Service
- Opportunity
 - Multiple Providers, Elasticity for DDoS




Windows Azure




amazon web services™


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Cloud Adoption Challenges

○Challenge: Data Lock-In


○Opportunity

- Standardization of API
- Surge Computing



How Much **Control** Do You Have Over Your **Critical Cloud-Based Business Data**?

The First Annual
Data Liberation Awards



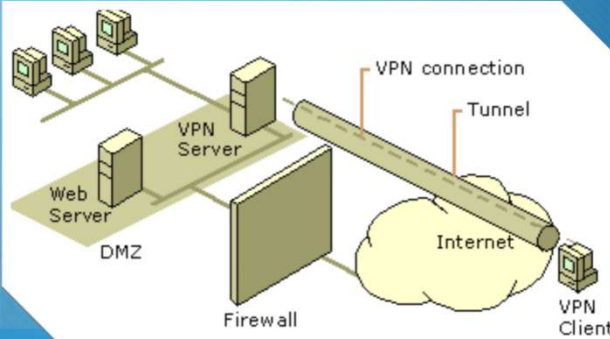
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Cloud Adoption Challenges

○Challenge: Data Confidentiality & Auditability

○Opportunity

- Geographical Data Storage
- Encryption
- VLANs
- Firewalls



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Cloud Growth Challenges

Challenge	Opportunity
Data Transfer Bottlenecks	FedEx-ing Disks, Data Backup/Archival
Performance Unpredictability	Improved VM support, Flash Memory, Scheduling VMs
Scalable Storage	Invent Scalable Store
Bugs in Large Distributed Systems	Invent Debugger on Distributed VMs
Scaling Quickly	Invent Machine Learning enabled Auto-Scaler;

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Policy and Business Challenges

Challenge	Opportunity
Reputation Fate Sharing	Offer Reputation-Guarding Services like those for email
Software Licensing	Pay-for-use Licenses; Bulk use sales

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Conclusion

Short Term Implications:

- Startups and Prototyping
- One-Off Task: Washington Post, NY Times
- Research at Scale
- Cost Associativity
 - 1 VM x 1000 hours = 1000 VMs x 1 hour

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Conclusion

Long Term Implications:

Area	Implication
Application Software	<input type="checkbox"/> Cloud & Client Parts <input type="checkbox"/> Disconnection Tolerance
Infrastructure Software	<input type="checkbox"/> Resource accounting <input type="checkbox"/> VM awareness
Hardware Systems	<input type="checkbox"/> Containers <input type="checkbox"/> Energy Proportionality

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Reference

- Above the Clouds: A Berkeley View of Cloud Computing
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Questions?

