Announcements

- Teaching Evaluations
  - Monday, May 26 at 12:01 am and closing
  - Sunday, June 8 at 11:59 pm.
- Final Business Papers Due 6/5
- Final Exam
  - Wednesday June 11, 8am – 11am

Cloud Computing

- Cloud Computing: refers to both
  - applications delivered as services over internet
    - aka Software as a Service (SaaS)
  - hardware / software in data centers providing those services -- a cloud

- 2 flavors:
  - Public Cloud, available to public
    - provides utility computing
  - Private Cloud
    - internal to company

Advantages

- SaaS
  - Control of Versioning
  - Users access anywhere
  - Ease of data sharing
  - Pay as you go
- Additional +’s of Cloud Computing
  - Deploy new services without building and provisioning data centers
    - E.g. Zynga Farmville
  - Scale up/down resources as needed

Context

- 2000’s
  - Large investments by web giants (e.g. Google, Amazon) in infrastructure
    - Giant data centers
    - Software Infrastructure for such data centers
      - MapReduce -- allows computations to be distributed to multiple machines "map", and then results collected for further processing "reduce."
      - Hadoop - open source version of above
  - Above pieces prerequisites to become a cloud provider
Reasons to be a cloud provider

- A big player enjoys economy of scale advantage
- Leverage existing investments for new revenue stream (e.g. Amazon)
- Defend existing markets (e.g. MS enterprise apps with Azure)
- Become a platform (facebook)
- Leverage relationships (IBM)

Why is the Cloud becoming big only now?

- shift from large commitment models to contactless short term model
- Mobile interactive applications that need huge data sets
- Parallel batch processing - software like Hadoop makes it easier to do this
- Analytics - less growth in plain transaction processing, more growth in analyzing trends / predictions from large data sets

Types of Utility Computing

- Amazon EC2 - to programmer, each instance looks like physical hardware
  - Can control whole layer stack
  - Other managed services provided (e.g. SimpleDB)
- Application Domain specific platforms
  - Google AppEngine (software dev. platform for web applications)
  - Force.com (Salesforce.com) - platform for business apps that use salesforce.com DB
- MS Azure -
  - Provides developers a general purpose software framework .NET
  - Compiled to a managed environment (rather than to specific hardware)

Economics

- "pay as you go" model
- add and remove resources at a fine time scale
  - proprietary data centers have to provision for peak
  - hard to predict demand of new services
  - poor service quality can alienate customer
  - large data centers have significant econ. of scale advantage

Challenges

- Availability
  - Can actually be better than in-house data centers
  - More robust to DDOS (Distributed denial of service) attacks by being so large
- Lock-in
  - Data lock-in - online storage services have gone bust
  - application programming interfaces not common

Challenges

- Confidentiality and Audits
  - Sarbanes Oxley, HIPPA
  - Can use encryption
  - Audibility can be added as layer
- Data Transfer bottlenecks
  - Slow transfer can offset faster processing
  - Ship hard drives
  - Upload once, use multiple times
Amazon Web Services

Genesis
- Associates Group
  - Business that advertised Amazon products on their websites
- Amazon releases product data to associates group
  - API
  - Associates determine how to present it
  - Successful

Amazon Technology
- Proprietary tech to run at their scale
- Services low in the stack
  - Computing, storage, messaging, database
  - Experience in running large data centers
- Leverage in acquiring software/hardware at low prices

AWS Start
- Feedback from
  - Internal teams
  - Company leaders
  - External developers
- Feedback:
  - Requirements: Scalable, reliable, low-latency, simple to use

AWS First services
- Focus on Infrastructure
  - Simple Storage Service (S3)
  - Elastic Compute Cloud (EC2)
  - Simple Database (SimpleDB)
  - Simple Queue Service (SQS)

S3
- Launched March 2006
- Redundant copies
- .12 - .15 per GB per month
- .10 per GB uploaded, .17 per GB downloaded
- Usage
  - Small companies (SmuMug photo sharing)
  - Microsoft (Vista distribution)
**EC2**

- Launched August 2006
- $0.10 – 0.80 per instance hour
- 10 per GB uploaded, .17 per GB downloaded
- Users:
  - Powerset natural language search
  - AideRSS news story filtering

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**SQS**

- 2004
- Messaging service
- .01 per 10000 requests
- .10 GB uploaded, .10 to .17 GB downloaded

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**Other services**

- Flexible Payment Service
  - August 2007
  - Usable by developers
  - More flexibility in when transactions take place than Paypal
- Premium Support
  - Silver: MAX[ $100 per month, 10Xservice bill]
  - Gold: MAX[ $300 per month, .10-.20 X service bill]

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**Market**

- Digital Infrastructure Market
  - Deutsche Bank
- AWS has potential for $200 million incremental revenue
  - Deutsche Bank
- AWS ~revenue: $800 million a year today
  - (vs. 61 billion for Amazon as a whole)

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**Competition**

- Traditional IT infrastructure
  - IBM, Sun, HP
  - Sun Grid – Compute power at $1 per hour
- Storage
  - Network Application, EMC, IBM, HP, Sun
  - Storage Service:
    - A few small players

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**Competition**

- Google Apps for your domain
  - Offload email systems
  - Office applications
- Google App Engine
  - Allow developers to build, host web apps on Google infrastructure
    - Web apps only
    - Python required
Competition

- Salesforce.com
  - CRM app service
  - Force.com
  - Platform for creating business apps

- Microsoft
  - Windows Live
    - Consumer software Services: email, news headlines, blog, audio feed
  - Microsoft Azure (Beta Release October 08)
    - SharePoint Services (doc management)
    - net services (app framework)
    - SQL services (data storage)
    - Live Services (data synchronization)
    - DynamicsCRM (CRM)

Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>Microsoft</th>
<th>Amazon</th>
<th>Google</th>
<th>VMware</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Early private CTP</td>
<td>Yes, commercially available</td>
<td>In public beta</td>
<td>Announced</td>
</tr>
<tr>
<td>Computing Architecture</td>
<td>You provide .NET code for front-end and back-end servers which Microsoft then run on Windows 2008 virtual machine.</td>
<td>Elastic Compute: You write your web or mobile apps with a specific framework and machine images to set of constraints.</td>
<td>You write your web applications in Python or Django with specific machine images and management services to manage them.</td>
<td>For Azure services: Business. For Windows Azure services: Business. For Windows storage: Business.</td>
</tr>
<tr>
<td>Storage</td>
<td>Yes: Simple Storage Service (S3) and SimpleDB</td>
<td>Yes: Simple Storage (S3) and SimpleDB</td>
<td>Yes: database Datastore APIs</td>
<td>Not announced</td>
</tr>
<tr>
<td>Message queuing for machine communication via other services</td>
<td>Yes, with existing services: authentication, search, storage, maps, presentations, schedule, live events.</td>
<td>Yes: Simple Queue Service (SQS)</td>
<td>No</td>
<td>Yes, with existing Google services: authentication, mail, base, calendar, contacts, documents, pictures, spreadsheets, YouTube.</td>
</tr>
<tr>
<td>Load balancing</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Development tools</td>
<td>Yes, integration into Visual Studio, support for Ruby, Python, PHP, JavaScript, etc.</td>
<td>Yes, with existing services: authentication, search, storage, maps, presentations, schedule, live events.</td>
<td>Yes, have basic editing, local simulation, and deployment tools.</td>
<td>Not applicable. VMware simply runs your virtual machines and does not care which development platform you are using on top of the base OS.</td>
</tr>
</tbody>
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AWS Pricing

- Low
- No upfront fee

AWS reaction

- 400K developers in 08
- Wall street reaction
  - "I have yet to see how these investments are producing any profit. They’re probably more of a distraction than anything else." - Safa Rashtchy, Piper Jaffray
  - "Amazon is years ahead of anyone else when it comes to ‘cloud computing. Tomorrow’s computing environment is being dictated by Amazon. - Trip Chowdhry, Global Equities Research"
Questions

- Imagine you are launching a new service and smartphone app to find green businesses in a user’s local area.
  - Would you host your new service on EC2 or build a traditional data center? Why?
- Imagine you are a large medical insurance company.
  - Would you host your enterprise application for processing medical claims on the cloud or in a private data center?