Scientific computing using Windows Azure

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Introduction

- Space Situational Awareness
- How are we using the cloud?
  - Cloud computing scenarios
  - Clouds in Space architecture
- Data visualisation
- Atmospheric Science Through Robotic Aircraft (ASTRA)
- Q&A
Knowledge of space vehicle environment important
Space debris increasingly problematic, e.g. Cosmos 2251 & Iridium-33 collision in February 2009
Near-earth objects (Apophis 2029-miss, 2036-hit)
Observation, data management, modelling, and operational tools. Global problem requires global IT infrastructure
Southampton Space Situational Awareness Azure System
• Processing and visualisation of tracked space objects, conjunction/impact analysis
• Decision support system for space debris and NEO impacts
• Debris removal
Iridium 33 and Cosmos 2251

Collision of Iridium-33 with Cosmos-2251

Fragments ≥ 10 cm

Initial orbits

20 minutes after collision

50 minutes after collision (first pass over South pole)
Space debris

~20,000 objects (currently tracked)

~19,000 objects with a diameter over 10cm (not tracked)

~500,000 objects over 1cm (not tracked)

*Images from www.bbc.co.uk
What is Cloud computing?

- Pay-per-use
- Quick provisioning
- Unlimited resources ($)
- Compare with a datacentre or outsourcing
  - Bulk hardware purchase
  - Bulk admin
  - High utilisation
- No capital cost / lead time
- “Architect well and trade time for cost”
Hype curve

- Data centre maximum capability
- Resources
- Time
  - Idle resources
  - Under resourced demand
  - Application workload
  - Application workload
Burst capability (predictable and unpredictable)

- **Resources**
- **Time**
- **Application workload**
- **Idle resources**
- **Data centre maximum capability**
(Super) - scalability
Data and algorithms

- **Data dissemination**
  - Co-locate data and processing power
  - Easier costing model for shared datasets.
  - DataMarket section of the Windows Azure Marketplace

- **Algorithm development / validation**
  - In general a serial task
  - Many require a large test dataset (large computation)
  - ‘Rent’ an appropriate machine for development tasks
Cloud computing

• Infrastructure as a Service (IaaS)
  • Cloud IaaS sells/rents out infrastructure such as servers, virtual machines and networking and is an alternative to physically owning infrastructure.
  • For example renting a virtual machine on Amazon EC2

• Platform as a Service (PaaS)
  • Often build upon IaaS, cloud PaaS offerings include an Operating System and perhaps a software stack (.Net, Java).
  • For example Microsoft Windows Azure Workers

• Software as a Service (SaaS)
  • SaaS offers an end user application and can be built upon IaaS and PaaS.
  • For example SalesForce CRM
Windows Azure

- **Azure Compute**
  - Windows 2008 R2 (64 bit)
  - VM Role (build locally)
  - Scale out (more hardware)
  - Scale up (faster hardware)

- **Azure Storage**
  - Blob
  - Table
  - Queue
  - SQL Azure

Consider database sharding over scale-up.

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<table>
<thead>
<tr>
<th>Compute Instance Size</th>
<th>CPU</th>
<th>Memory</th>
<th>Instance Storage</th>
<th>I/O Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra Small</td>
<td>1.0 GHz</td>
<td>768 MB</td>
<td>20 GB</td>
<td>Low</td>
</tr>
<tr>
<td>Small</td>
<td>1.6 GHz</td>
<td>1.75 GB</td>
<td>225 GB</td>
<td>Moderate</td>
</tr>
<tr>
<td>Medium</td>
<td>2 x 1.6 GHz</td>
<td>3.5 GB</td>
<td>490 GB</td>
<td>High</td>
</tr>
<tr>
<td>Large</td>
<td>4 x 1.6 GHz</td>
<td>7 GB</td>
<td>1,000 GB</td>
<td>High</td>
</tr>
<tr>
<td>Extra Large</td>
<td>8 x 1.6 GHz</td>
<td>14 GB</td>
<td>2,040 GB</td>
<td>High</td>
</tr>
</tbody>
</table>

Images: www.microsoft.com/windowsazure
Clouds in space

- Import TLE
- Propagate (SGP4)
- Collision algorithm
- Convergence checker
- Timespan increment $T = n + 1$
- Full catalogue
- Collision probability list/mesh
- World Wide Telescope
- Removal catalogue
- Top N debris
- Energy Calculator
- Removal order calculator
- Lowest energy calculator
Windows Azure

- **Compute**
- **Storage**
- Virtual Network
- Content Delivery Network
- AppFabric
  - Service Bus
  - Access control
  - Caching
  - Workflow
- Marketplace
- Appliance
- ....and more!

Images: www.microsoft.com/windowsazure
General considerations for Cloud compute

- Data storage policy (data export / local storage laws)
- There is a public network in-between (security/availability)
- SLA compensation policy
- Clouds are multi-tenanted (Security, Security, Security)
- Pricing (PAYG, Spot pricing, CPU units, offers.....) beware of direct comparisons
- Vendor roadmap (Lock-in)
- Use a flexible architecture (Pricing models change)
- Licensing (for example per core application licenses)

(Many issues are answered by current outsourcing scenarios)
World Wide Telescope (WWT)
Atmospheric Science Through Robotic Aircraft

- Monitoring the atmosphere
  - Weather, pollution
  - Volcanic ash...
- Low cost metrological balloons
  - High altitude
- Instrument retrieval using WP7 + GPS
- Predicting the landing location with Azure
ASTRA architecture

Windows
Azure
University of Southampton
GSM
Followers
Internet
Windows Phone 7
Windows Phone 7 notifications
Flight prediction algorithms and trajectory updates
Tracker using Bing maps on WP7
Device registration and GPS logging notifications
Blob storage
Logging and data storage
Meteorological weather balloon

Internet

University of Southampton
ASTRA flights using WP7 and Windows Azure

• ASTRA 7
  • 18,237 meters (59,832 feet)
  • Top speed 145 km/h (90mph)
  • 1hr 16’

• ASTRA 8
  • 21,600 meters (71,000 feet)
  • Top speed 82 km/h (51mph)
  • 2hr 30’
Summary

- Cloud advantages
  - Burst capability (predictable and unpredictable)
  - Super-scalability
  - Algorithm development
  - Data dissemination
  - ‘Augmented processing’

Cloud computing is opening up new opportunities for science
Further information

- **Clouds in space**

- **Atmospheric Science Through Robotic Aircraft (ASTRA)**
  [http://www.soton.ac.uk/~astra/](http://www.soton.ac.uk/~astra/) (Main page)
  [http://segoz.co.uk/Stratosphericflight.aspx](http://segoz.co.uk/Stratosphericflight.aspx) (WP7 application)
  [http://www.soton.ac.uk/~astra/diary.html](http://www.soton.ac.uk/~astra/diary.html)
Further information

• Azure
  http://www.microsoft.com/windowsazure/ (Main page)
  http://www.microsoft.com/windowsazure/getstarted/ (Start here)
  http://www.microsoft.com/windowsazure/features/ (Features starting point)
  http://www.microsoft.com/windowsazure/whitepapers/ (Extra reading)

• Azure tools ($)
  http://www.cerebrata.com/products/cloudstoragesudio/ (Data access)
  http://www.red-gate.com/search?fi=1&s=azure (SQL Azure backup & admin)
Further information

- **WP7**

- **WWT**
Q & A

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