Patterns for Cloud Computing

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Patterns for Cloud Computing
Patterns for Cloud Computing

This is Jim
Jim has many questions about cloud computing
The more he reads, the more confused he gets
Are SaaS & Cloud Computing Interchangeable Terms?

Feb 16th, 2009, 10:24 am

A couple of weeks ago Alfresco CTO John Newton posted the following tweet on Twitter:

"Does Cloud = SaaS [Software as a Service]? I don't think so. Cloud is computing, more like electricity."

My gut reaction was that they were equal, and up until that moment I had used the terms interchangeably, but Newton's post got me thinking that perhaps they were different. SaaS applications use cloud platforms, but are not exactly cloud computing. The more I thought about it, however, the less clear it got, so I decided to do some research and also take my questions directly to some cloud computing experts and ask if the two terms were indeed synonymous or if they were as Newton opined, completely different.

“What is cloud computing?”
August 19th, 2008

Piecing together Microsoft's cloud-computing vision

Posted by Mary Jo Foley @ 6:37 am

Categories: .Net Framework, Code names, Corporate strategy, Database, Development tools...

Tags: Zurich, Operating System, Vision, Microsoft Corp., Service...

The term “cloud computing” has become almost meaningless — being used synonymously for everything from software-as-a-service (SaaS), to platform-as-a-service (PaaS).

But a new white paper, sponsored by Microsoft and written by the always entertaining consultant David Chappell, provides more clues about what the Softies are planning to unveil at this October’s Professional Developers Conference. For anyone looking to understand how and where Red Dog, Zurich, BizTalk Services and SQL Server Data Services (SSDS) all fit together, the 13-pager is worth a read.

Chappell, who provided an insightful talk at TechEd in June on Microsoft’s “Oslo” initiative (while managing to tread safely through a minefield of non-
“What applications make sense in the cloud?”
Session Objectives
Session Objectives

Build on Stefan’s introduction of cloud computing

Provide you with 5 patterns for cloud-based applications

Show implementations of these patterns
Defining Cloud Computing
Defining Cloud Computing

Application runs on-premises

- Bring my own machines, connectivity, software, etc.
- Complete control and responsibility
- Upfront capital costs for the infrastructure
### Defining Cloud Computing

#### Application runs **on-premises**
- Bring my own machines, connectivity, software, etc.
- Complete control and responsibility
- Upfront capital costs for the infrastructure

#### Application runs at a **hoster**
- Rent machines, connectivity, software
- Less control, but fewer responsibilities
- Lower capital costs, but pay for fixed capacity, even if idle
Defining Cloud Computing

### Application runs on-premises
- Bring my own machines, connectivity, software, etc.
- Complete control and responsibility
- Upfront capital costs for the infrastructure

### Application runs at a hoster
- Rent machines, connectivity, software
- Less control, but fewer responsibilities
- Lower capital costs, but pay for fixed capacity, even if idle

### Application runs using cloud platform
- Shared, multi-tenant environment
- Offers pool of computing resources, abstracted from infrastructure
- Pay as you go
Defining Cloud Computing

Cloud “Variants”
Defining Cloud Computing

Public Cloud
Pool of computing resources offered by a vendor, typically using a “pay as you go” model.
Defining Cloud Computing

Private Cloud
Defining Cloud Computing

Pool of computing resources that lives within a **self managed datacenter**
Defining Cloud Computing

Pool of computing resources that lives within a **datacenter with no sharing**
Defining Cloud Computing

**Compute:** Virtualized compute based on Windows Server

**Storage:** Durable, scalable, & available storage

**Management:** Automated, management of the service

**Database:** Relational processing for structured/unstructured data

**Service Bus:** General purpose application bus

**Access Control:** Rules-driven, claims-based access control
Different Models

*Infrastructure as a Service (IaaS)*

*Platform as a Service (PaaS)*
Defining Cloud Computing

- Deployment
  - Provided by Windows Azure
  - Virtualized Instance
  - Operating System
  - OS Services
  - Web Server
  - Frameworks
  - Your Application
Defining Cloud Computing

Deployment

- Your Application
- Frameworks
- Web Server
- OS Services
- Operating System
- Virtualized Instance
- Hardware

Provided by

Google AppEngine

Windows Azure

Deployment
Patterns for Cloud Computing

#1 - Using the Cloud for Scale
“Isn’t the cloud good for applications that need to scale dynamically?”
For example, applications that have spikes or peak loads
Patterns for Cloud Computing

“How does this work?”
Let’s do some white boarding for Jim...
...and when I say white boarding, I really mean it
#1 - Using the Cloud for Scale

“Wow! What a great site!”
#1 - Using the Cloud for Scale

Browser → Web Tier → B/L Tier → Database

“Server Busy”
#1 - Using the Cloud for Scale

![Diagram showing cloud architecture with browser requests to web tier, followed by timing out in B/L tier](image-url)
How would Jim do this today on premises?
#1 - Using the Cloud for Scale

How would Jim do this today on premises?
#1 - Using the Cloud for Scale

How would Jim do this today on premises?
#1 - Using the Cloud for Scale

How would Jim do this today on premises?
#1 - Using the Cloud for Scale

How would Jim do this today on premises?
Not without consequences...
#1 - Using the Cloud for Scale

How would Jim do this today on premises?

"That took a lot of work - and money!"
#1 - Using the Cloud for Scale

How would Jim do this today on premises?

“Not so great now...”

“Hmmm... Most of this stuff is sitting idle...”
#1 - Using the Cloud for Scale

![Graph showing datacenter peak load and idle time over months with April and July highlighted in red showing peak load and idle time respectively.](image)
How can cloud computing help?
“Wow! What a great site!”

#1 - Using the Cloud for Scale

Browser → Web Role → Worker Role → Azure Storage

Request
Response
#1 - Using the Cloud for Scale

- Browser
- Browser
- Browser
- Browser

```
Web Role
```

```
Worker Role
```

```
Azure Storage
```

“Server Busy”
Service Tuning

Event Logs
Copy the event logs for this deployment to a storage account:
- Storage Account: pilotappdata
- Container Name: pilotapp-staging

Configuration Settings
Edit the configuration:

```xml
<?xml version="1.0" encoding="utf-16"?>
  <Role name="WebRole1">
    <ConfigurationSettings />
    <Instances count="1" />
  </Role>
  <Role name="WorkerRole1">
    <ConfigurationSettings />
    <Instances count="1" />
  </Role>
</ServiceConfiguration>
```

Upload a new configuration file:
Hosted Service

Production v1.8

WebRole: Ready

Web Site URL: http://primephp.cloudapp.net/

Deployment ID: 52d2a2a9133d4b2ea5d72ae8b563683a

Affinity Group

Affinity Group Name: Unaffinitized
Geographic Location: Anywhere US
#1 - Using the Cloud for Scale

Browser
Browser
Browser
Browser

Browser

Web Role
Web Role
Web Role

Worker Role

Azure Storage

You don't see this bit
Using the Cloud for Scale
OK, so changing config is easy...

...but what else do I need to know?
#1 - Using the Cloud for Scale

Diagram showing the flow of requests from browsers to web roles and worker roles, ultimately connecting to Azure storage.
# Using the Cloud for Scale

Tight coupling between web and worker role is an anti-pattern.
#1 - Using the Cloud for Scale

1. Place on queue
2. Respond to UI
3. Pickup from queue
4. Process

Web Role

Worker Role

Queue
#1 - Using the Cloud for Scale

1. Using the Cloud for Scale

- Web Role
- Worker Role
- Queue
- Table

4. Process
5. Add result to table
6. Query table on refresh
Demo: Prime Solver
How many web and worker roles do you need?
How many web and worker roles do you need?
#1 - Using the Cloud for Scale

![Diagram showing the use of the Cloud for Scale]

- **Browser**
  - Web Role
  - Web Role
  - Web Role
  - Web Role

- **Web Role**
  - WMI_Win32_PerfFormattedData_ASPNET_ASPNETApplications/RequestsPerSecond
  - Management API or Email

- **Log**
  - Worker Role

- **Azure Storage**
How many web and worker roles do you need?
#1 - Using the Cloud for Scale

- Web Role
- Web Role
- Web Role
- Web Role
- Worker Role

Monitor queue length against user's expectations
Using the Cloud for Scale

Web Role → Web Role → Web Role → Queue → Monitor queue length against user's expectations → Worker Role → Worker Role → Worker Role → Web Role → Web Role → Web Role
Patterns for Cloud Computing

**Takeaways**

A core tenet of cloud computing is the ability to scale up/down

Understand how to communicate between roles and nodes

Strategy on when to scale up/down roles in production
Patterns for Moving to the Cloud

#2 - Using the Cloud for Multi Tenancy
“I like the idea of scaling Web roles...”
“...but need to serve multiple customers”
Patterns for Cloud Computing

“Without creating separate codebases!”
How would Jim do this today on premises?
#2 - Using the Cloud for Multi Tenancy

How would Jim do this today on premises?
Gets expensive pretty quickly
#2 - Using the Cloud for Multi Tenancy

Browser
Customer #1

Browser
Customer #2

Browser
Customer #3

Web Tier

B/L Tier

Database
Schema Customizations

UI Customizations
Schema Customizations

UI Customizations
3 options for data in multi tenant environment
#2 - Using the Cloud for Multi Tenancy

Option 1: Everyone Uses the Same Database/Schema

Pros: Simplest approach, easy to maintain/upgrade.
Cons: No customizations. Restoring of tenant data.
#2 - Using the Cloud for Multi Tenancy

Option 2: Give Each Customer Their Own Database/Schema

Pros: Flexible. Tenant restore is easier. High Isolation.
Cons: Can be costly. Difficult to upgrade db schemas.
#2 - Using the Cloud for Multi Tenancy

### Option 3: Fixed Database/Schema, with customizations

**Pros:** Customers can add their own custom fields

**Cons:** Non standard way of customizing the schema, Tenant restore is difficult.
#2 - Using the Cloud for MultiTenancy

**Tenant**

<table>
<thead>
<tr>
<th>TenantID</th>
<th>int</th>
</tr>
</thead>
<tbody>
<tr>
<td>TenantName</td>
<td>nvarchar</td>
</tr>
</tbody>
</table>

**Employee**

<table>
<thead>
<tr>
<th>EmployeeID</th>
<th>int</th>
</tr>
</thead>
<tbody>
<tr>
<td>FirstName</td>
<td>nvarchar</td>
</tr>
<tr>
<td>LastName</td>
<td>nvarchar</td>
</tr>
</tbody>
</table>

**Type**

<table>
<thead>
<tr>
<th>TypeID</th>
<th>int</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>nvarchar</td>
</tr>
<tr>
<td>CLRType</td>
<td>nvarchar</td>
</tr>
</tbody>
</table>

**Customization**

<table>
<thead>
<tr>
<th>CustomizationID</th>
<th>int</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>nvarchar</td>
</tr>
</tbody>
</table>
#2 - Using the Cloud for Multi Tenancy

**Tenant**
- TenantID: 1
- TenantName: UK Branch

**Employee**
- EmployeeId: 1
- FirstName: Gordon
- LastName: Brown

**Type**
- TypeID: 1
- Name: PostalCode
  - CLRType: string

**Customization**
- CustomizationID: 1
- Value: SW1 A2AA
#2 - Using the Cloud for Multi Tenancy

**Tenant**
- TenantID: 2
- TenantName: US Branch

**Employee**
- EmployeeId: 2
- FirstName: Barack
- LastName: Obama

**Type**
- TypeID: 2
- Name: ZipCode
- CLRType: string

**Customization**
- CustomizationID: 2
- Value: 20500
#2 - Using the Cloud for Multi Tenancy

**Tenant**
- TenantID: 2
- TenantName: US Branch

**Employee**
- EmployeeID: 2
- FirstName: Barack
- LastName: Obama

**Type**
- TypeID: 2
- Name: ZipCode
- CLRType: string

**Customization**
- CustomizationID: 2
- Value: 20500

**Fixed Schema**
- Applies to All Tenants

**Customizable**
- Tenant by Tenant Basis

**Could be both**
Schema Customizations

UI Customizations
#2 - Using the Cloud for Multi Tenancy

- Browser
  - Customer #1

- Browser
  - Customer #2

- Browser
  - Customer #3

Web Tier

B/L Tier

Database
URL Handling
Routing using MVC approach
#2 - Using the Cloud for Multi Tenancy

http://hr.contoso.co.uk

Browser
Customer #1

Browser
Customer #2

Browser
Customer #3

http://hr.fabrikam.com

http://employeedata.cloudapp.net

Web Tier

B/L Tier

Database
#2 - Using the Cloud for Multi Tenancy

- **Browser** (Customer #1)
- **Browser** (Customer #2)
- **Browser** (Customer #3)

http://hr.contoso.co.uk -> CNAME (employeedata.cloudapp.net)

http://hr.fabrikam.com -> CNAME (employeedata.cloudapp.net)

http://employeedata.cloudapp.net

Diagram:
- Web Tier
- B/L Tier
- Database

Connections:
- Browser (Customer #1) to Web Tier
- Browser (Customer #2) to Web Tier
- Browser (Customer #3) to Web Tier
- Web Tier to B/L Tier
- B/L Tier to Database
- Database to Web Tier
- Web Tier to Database
#2 - Using the Cloud for Multi Tenancy

http://hr.contoso.co.uk -> CNAME (employeedata.cloudapp.net)

http://hr.fabrikam.com -> CNAME (employeedata.cloudapp.net)

Use custom route to controller mapping

Browser
Customer #1

http://employeedata.cloudapp.net

Browser
Customer #2

Browser
Customer #3

Database
Demo: Multi Tenant Schema and UI
Patterns for Cloud Computing

**Takeaways**

Always consider Multi Tenancy first, even if only one customer

Design considerations must include both data and UI

Many other considerations, such as identity – p&p guidance
#3 - Using the Cloud for Compute
Patterns for Cloud Computing

Jim sees how cloud computing supports scaling up/down nodes
“Can I use all of these nodes in parallel?”
“I’ve got this complex calculation I would like to share across these multiple nodes...”
#3 - Using the Cloud for Compute

Diagram:

- Client
- Master
- Worker
- Worker
- Worker
- Data
- Data
- Data
#3 - Using the Cloud for Compute

Client → Master → Workers → Results
Popularized by the term "MapReduce"*  

* 2004 OSDI paper by Jeff Dean and Sanjay Ghemawat (Google)
#3 - Using the Cloud for Compute

How many "e"s in "The quick brown fox jumps over the lazy dog"?

Map:

MK("the quick brown", "e")
MK("fox jumps over", "e")
MK("the lazy dog", "e")
#3 - Using the Cloud for Compute

![Diagram showing a Client, a Master, and multiple Workers. The Master is connected to the Workers with arrows labeled `<k,v>`. The diagram includes text indicating that 3 x "e"s found are reduced by the Master.](image)

3 x "e"s found

"Reduce"
And it's definitely popular...
#3 - Using the Cloud for Compute

Google
20pb of data analyzed every day using MapReduce

Yahoo!
10k+ cores, 4pb of data using MapReduce

Facebook
2500+ cores, 1pb of data using MapReduce
Frameworks
#3 - Using the Cloud for Compute

Apache Hadoop
Open Source Java “Inspired by MapReduce”
(Core, HDFS, many more)

Cloudera
Consulting, training, distribution of Hadoop

Amazon Elastic MapReduce
Hadoop implementation on EC2
How would Jim do this today on premises?
#3 - Using the Cloud for Compute

How would Jim do this today on premises?
How about implementing this on Windows Azure?
#3 - Using the Cloud for Compute

![Diagram]

Client Application ➔ Web Role ➔ Queue ➔ Table ➔ Remote Service

Client ➔ Job/Task Scheduler ➔ Worker

Data ➔ Table

Req ➔ Queue ➔ Worker

Data ➔ Worker

Data ➔ Worker

Data ➔ Worker
Demo: Windows Azure Demo

“Inspired by MapReduce”
Patterns for Cloud Computing

**Takeaways**

MapReduce very visible, although can be difficult to initially grasp

Learn about existing frameworks, especially Apache Hadoop

Read up on Dryad (DryadLINQ) for future direction
#4 - Using the Cloud for Storage
“The cloud lets me store infinite data, right?”
Patterns for Cloud Computing

Lots of headaches with data management today
“It sounds too good to be true...”
How does Jim do this today on premises?
#4 - Using the Cloud for Storage

How would Jim do this today on premises?
#4 - Using the Cloud for Storage
How would Jim do this today on premises?
#4 - Using the Cloud for Storage

How would Jim do this today on premises?
#4 - Using the Cloud for Storage

Affinity between your data and physical hardware that serves it

I love you!

I love you too!
#4 - Using the Cloud for Storage

Symptoms:
- Which RAID number was that again?
- Tedious to backup exponentially growing data
- Crap! I’m at 95% capacity - got to move to a bigger disk
How does the cloud help?
Breaks the affinity between your data and hardware
Blobs, Tables, Relational
Blobs, Tables, Relational
#4 - Using the Cloud for Storage

**PutBlob**
PUT http://account.blob.core.windows.net/containername/blobname

**REST API**

http://account.blob.core.windows.net/containername/blobname

*PutBlob = 64Mb MAX*
*MetaData = 8Kb per Blob*
#4 - Using the Cloud for Storage

Client

REST API

Blob Container

GET Blob
GET http://account.blob.core.windows.net/containername/blobname

http://account.blob.core.windows.net/containername/blobname
#4 - Using the Cloud for Storage

GetBlob
GET http://account.blob.core.windows.net/containername/blobname
Range: bytes=329300 - 730000

http://account.blob.core.windows.net/containername/blobname
#4 - Using the Cloud for Storage

PutBlock(blobname, blockid, data)
PutBlockList(blobname, blockid1, ..., blockidN)

Blob Container

http://account.blob.core.windows.net/containername/blobname

PutBlock = 4Mb MAX to a maximum of 50Gb
BlockId = 64 bytes
Blobs, Tables, Relational
#4 - Using the Cloud for Storage

REST:
GET http://account.table.core.windows.net/Customer?$filter=PartitionKey eq value

LINQ:
var customers = from o in context.CreateQuery("Customer") where o.PartitionKey == value select o;

Each Table:
PartitionKey (e.g. DocumentName) to ensure scalability
RowKey (e.g. version number) [fields] for data

http://account.table.core.windows.net
Blobs, Tables, Relational
Codename Sitka (early 2008)
SQL Server Data Services (MIX08)
#4 - Using the Cloud for Storage

This is what I'm doing on premises...

Client → TDS → DB Server → RDBMS
#4 - Using the Cloud for Storage

So, this is what I would like to do in the cloud...
SQL Data Services (MIX09)
SQL Azure (July 2009)
So, this is what I would like to do...
#4 - Using the Cloud for Storage

![Diagram showing a cloud service architecture with Browser, Web Role, SQL Azure, and RDBMS connected through HTTP and TDS protocols.](image-url)
#4 - Using the Cloud for Storage
Migration!
#4 - Using the Cloud for Storage

Browser → Web Tier → Bus. Logic → SQL Server → RDBMS

“The Data Center”

HTTP → TDS
#4 - Using the Cloud for Storage

Diagram:
- Browser
- Web Role
- Worker Role
- SQL Azure
- RDBMS
- "The Cloud"
- HTTP
- Queue
- TDS
Demo: SQL Azure CTP
Takeaways

Storage in the cloud may look the same, but breaks the affinity issue.

Understand the pricing model for storage on-premises vs. cloud.

SQL Azure as a factor for migration/move from on premises.
Patterns for Moving to the Cloud

#5 - Using the Cloud for Communications
Jim's organization needs to communicate with other organizations.
“This has always been a very tricky and expensive process to get working”
“Does the cloud offer anything to help?”
How would Jim have done this before?
#5 – Using the Cloud for Communications

![Diagram of cloud communications](image)
#5 - Using the Cloud for Communications

Company 1

Client

FTP Client

Internet

Telco provided WAN

Company 2

Server

FTP Server
#5 - Using the Cloud for Communications

Company 1

Client

Browser

Internet
Telco provided WAN

Company 2

Server

PMZ
Extranet Site
What does the cloud provide?
#5 - Using the Cloud for Communications

![Diagram showing a client connecting to an Azure Queue using REST](http://app.queue.core.windows.net/)
Using the Cloud for Communications

Company 1

Client

http://app.queue.core.windows.net/

Company 2

Client

Azure Queue
#5 - Using the Cloud for Communications

Company 1

Client

http://app.queue.core.windows.net/

Azure Queue

REST

Company 2

Client
#5 - Using the Cloud for Communications

Client

Company 1

Primary Access Key

Client

Company 2

Primary Access Key

http://app.queue.core.windows.net/

REST

Azure Queue
#5 - Using the Cloud for Communications

Company 1

Client

Company 2

Client

http://app.queue.core.windows.net/

Web Role

REST

Azure Queue
#5 - Using the Cloud for Communications

http://app.queue.core.windows.net/

Company 1
- Client
- Firewall
- Proxy?

Company 2
- Client
- Firewall

REST

Web Role

Azure Queue
#5 - Using the Cloud for Communications

Client

Company 1

Client

Company 2

192.168.14.100

Firewall

http://app.queue.core.windows.net/

Web Role

REST

65.55.33.204

Azure Queue

NAT?
#5 - Using the Cloud for Communications

Client

Company 1

Firewall

Client

65.55.33.204

Web Role

http://app.queue.core.windows.net/

REST

Azure Queue

Company 2

192.168.14.100

Firewall

OK, so I'll do a HTTP poll every minute
#5 - Using the Cloud for Communications

Client

Company 1

Firewall

65.55.33.204

Web Role

REST

http://app.queue.core.windows.net/

Company 2

Client

Firewall

192.168.14.100

... and how about other protocols other than HTTP?
How does the .NET Service Bus help?
#5 - Using the Cloud for Communications

Company 1

Client

Company 2

Client

sb://.../myqueue

.NET Service Bus
Two modes: TCP Relay and Message Buffer
Two modes: TCP Relay and Message Buffer
#5 - Using the Cloud for Communications

Company 1
- Client

Company 2
- Client

Firewall

Outbound bi-directional socket
Kept alive in background

sb://.../myqueue

.NET Service Bus
#5 - Using the Cloud for Communications

Company 1

Client

Firewall

Outbound one-way socket

sb://.../myqueue

.NET Service Bus

Message routed accordingly

Outbound bi-directional socket

Kept alive in background

Company 2

Client

Firewall
#5 - Using the Cloud for Communications

**This Conference**

- **Application**
  - **My Laptop**
    - Localhost:1000

**My Home**

- **Home PC**
  - 192.168.14.193

**Firewall**

- Outbound one-way socket
- Outbound bi-directional socket
  - Kept alive in background

**Message routed accordingly**

- **sb://.../myqueue**
- **.NET Service Bus**
Two modes: TCP Relay and Message Buffer
#5 - Using the Cloud for Communications

**Company 1**

Client

**Company 2**

Client

Firewall

Consumer defines and creates a Message Buffer

.NET Service Bus

sb://.../myqueue

ATOMPub via REST
#5 - Using the Cloud for Communications

Client

Producer sends messages to the Message Buffer

sb://.../myqueue

Company 1

Company 2

Firewall

ATOMPub via REST

.Net Service Bus
#5 - Using the Cloud for Communications

Client

Company 1

Client

Firewall

ATOMPub via REST

Company 2

Client

Firewall

Consumer picks up these messages (retrieve, peek, lock)

sb://.../myqueue

.NET Service Bus
Patterns for Cloud Computing

Takeaways

Be careful consuming REST based queues using shared secret

Firewalls/NATs can add additional trouble (especially non-HTTP)

Learn how .NET Service Bus traverses in these scenarios
Patterns for Moving to the Cloud

Putting the Patterns Together
We’ve covered 5 patterns, but Jim has one last question...
Are there cases where these patterns work together?
Putting the Patterns Together

Let's build an application in PHP that scales to many nodes...
Use the principles of multi-tenancy to create a version of the application across multiple vendors.
Putting the Patterns Together

Compute results with a MapReduce-like way of distributing work across all of these applications.
Putting the Patterns Together

Store the results in a SQL Azure database
Putting the Patterns Together

Client

.NET Service Bus

Windows Azure

PHP

Google AppEngine

Java Servlet

SQL Azure Database

Amazon EC2

ASP.NET

Coordinate communication through the .NET Service Bus
Putting the Patterns Together

.NET Service Bus

Windows Azure

PHP

Google AppEngine

Java Servlet

SQL Azure Database

Amazon EC2

ASP.NET

Client

Job

Job

Job
Putting the Patterns Together

How many prime numbers between 1 and 10,000,000?

40 jobs of 250,000 numbers

.NET Service Bus

Windows Azure
- PHP
- Compute

Google AppEngine
- Java Servlet
- Compute

Amazon EC2
- ASP.NET
- Compute

SQL Azure Database

Store results in SQL Azure
Demo: Prime Solver v2.0
Next Steps
Obviously, our friend Jim, is fake...
Next Steps

Make sure you have a clear definition of Cloud Computing

Explore the 5 usage patterns for your scenarios today

Think about the next steps for implementation and migration