Microsoft Research

Microsoft Research Asia Faculty Summit 2012

The MSR Cloud For Science Project

Dennis Gannon

Director Cloud Research Strategy

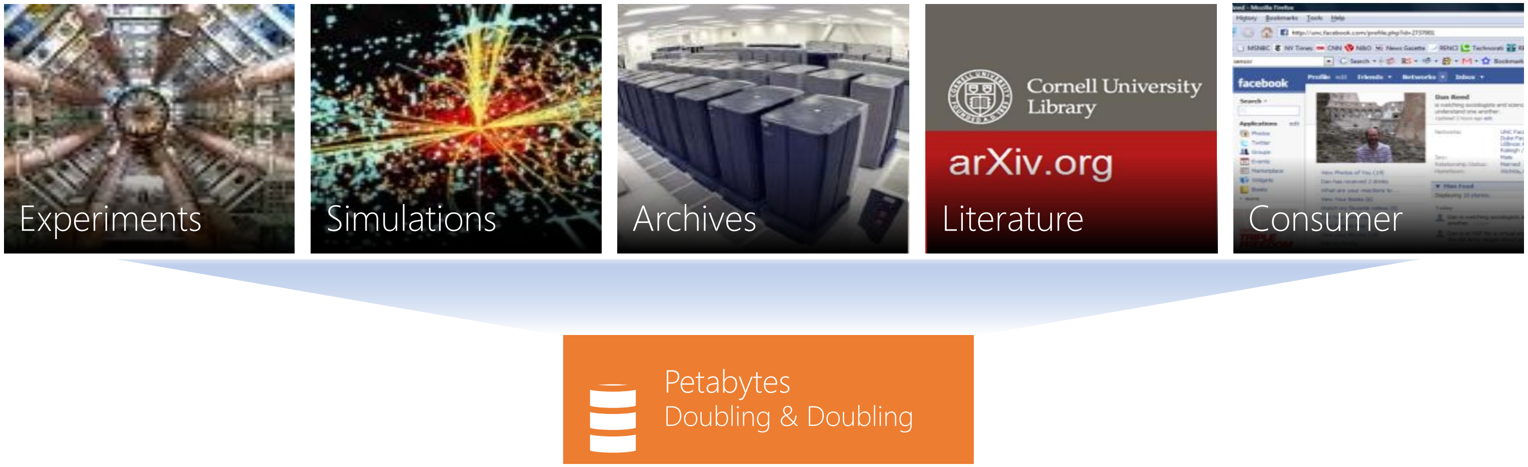
Microsoft Research Connections

Outline

- The Challenge of the “long tail” of science
- Is there a sustainable financial model for scientific data?
- Data Centers powering commercial clouds
    - The Azure cloud in research
- Managing parallel data analysis from your desktop
- Opportunities now in China

The 4th Paradigm and the Revolution in Science

The data explosion is transforming science



Experiments

Simulations

Archives

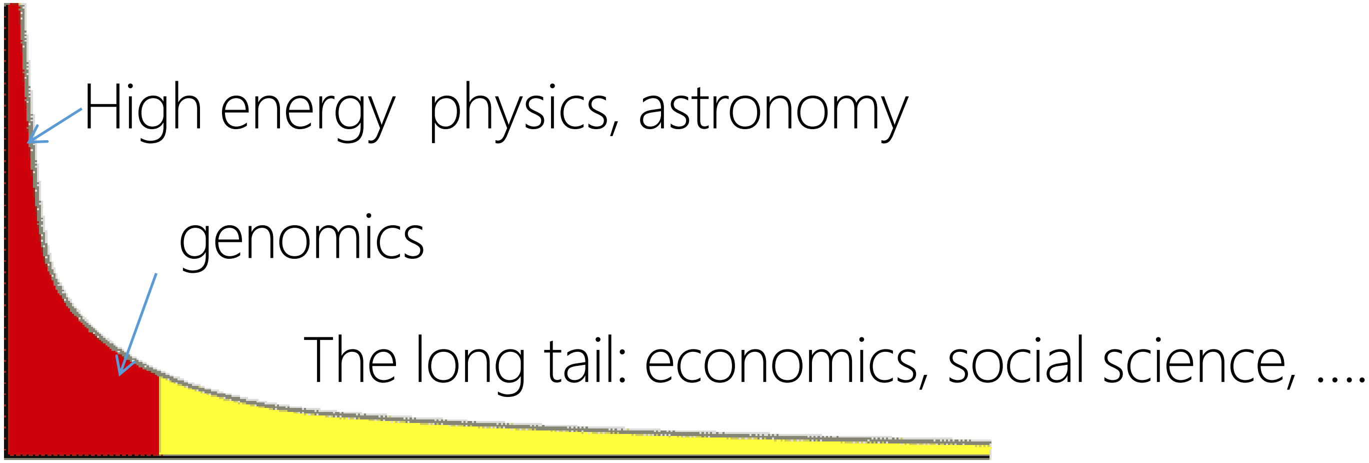
Literature

Consumer

Petabytes
Doubling & Doubling

- Every area of science is now engaged in data-intensive research
- Researchers need
  - Technology to publish and share data in the cloud
  - Data analytics tools to explore massive data collections
  - A sustainable economic model for scientific analysis, collaboration and data curation

The Long Tail of Science



Collectively "long tail" science is generating a lot of data

Estimated at over 1PB per year and it is growing fast.

Many research funding agencies now require all data be made public

US Universities are struggling with this new load

Data must be preserved

Data must be sharable, searchable, and analyzable

The Data for Science Sustainability Challenge

- Can we create a sustainable *economic* model for the long tail of science?
  - The government will not **directly** support an exponentially growing data collection.
- Our hypothesis
  - We can create an ecosystem that supports a **marketplace** of research tools and domain expertise
    - Allowing researchers to outsource special tasks to expert service providers
    - Funding will come from subscriptions from individual researchers, academic institutions and private sectors
    - Michigan’s Inter-university Consortium for Political and Social Research (ICPSR) is a great model.

Data Centers and the Microsoft Cloud

The Microsoft Cloud is Built on Data Centers

~100 Globally Distributed Data Centers

Range in size from “edge” facilities to megascale (100K to 1M servers)

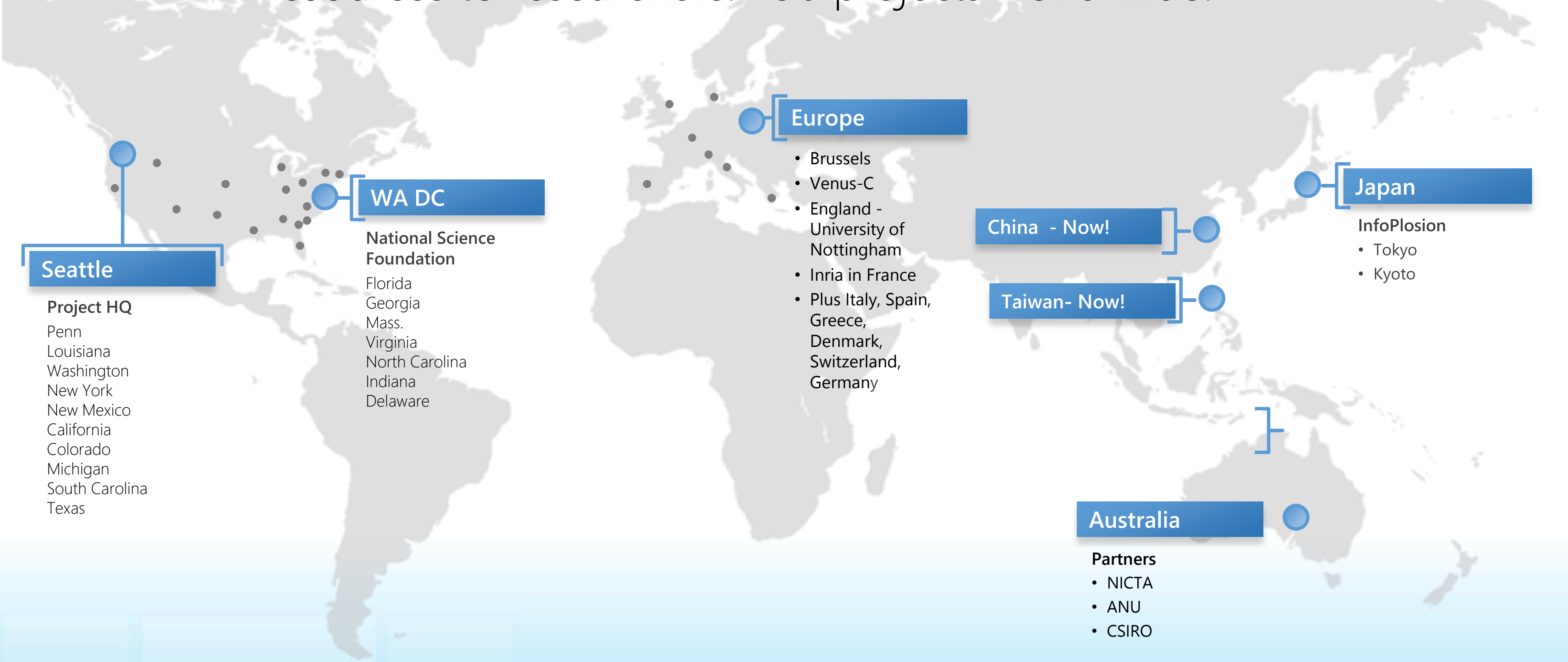
Cloud Properties

- Designed to Provide Information and Computation to Many Users
- Automatic Deployment and Management of Virtual Machine Instances
    - tens to thousands & dynamic scalability
- Dynamic Fault Recovery of Failed Resources
    - Cloud Services must run 24x7
- Automatic Data Replication
    - Geo-replication if needed
- Two levels of parallelism
    - Thousands of concurrent users
    - Thousands of servers for a single task.

Our Experience (so far) with Science in the Cloud

Microsoft Cloud Research Engagement Project

Work with international funding agencies to grant access to cloud resources to researchers. 90 projects world wide.



Seattle

Project HQ

Penn
Louisiana
Washington
New York
New Mexico
California
Colorado
Michigan
South Carolina
Texas

WA DC

National Science Foundation

Florida
Georgia
Mass.
Virginia
North Carolina
Indiana
Delaware

Europe

- Brussels
- Venus-C
- England - University of Nottingham
- Inria in France
- Plus Italy, Spain, Greece, Denmark, Switzerland, Germany

China - Now!

Taiwan- Now!

Japan

InfoPlosion

- Tokyo
- Kyoto

Australia

Partners

- NICTA
- ANU
- CSIRO

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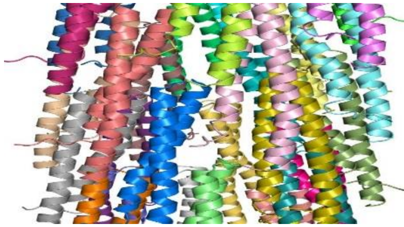
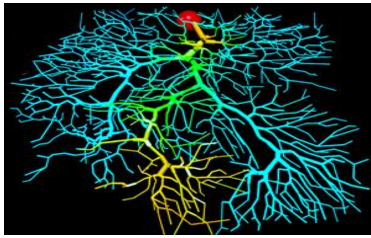
Sample Projects on Windows Azure

- Protein Folding
  - The University of Washington is studying the ways proteins from salmonella virus inject DNA into cells. Used 2000 concurrent cores. PI: Nikolas Sgourakis, Baker Lab.



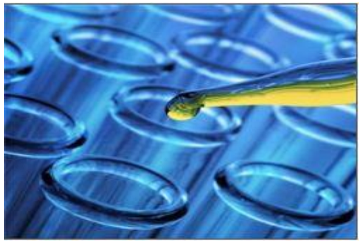
- Joint Genetic and Neuroimaging Analysis
  - France's premier research institute INRIA is using 1000 cores of Azure to study large cohorts of subjects to understand links between genetic patterns and brain anomalies. Pis: Radu Marius Tudoran, Gabriel Antoniu IRISA INRIA France.



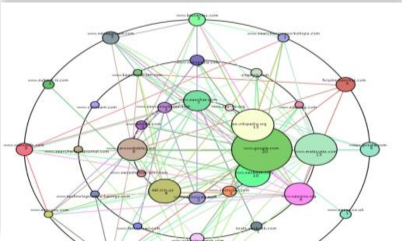
- Fire Risk
  - This app from the University of Aegean estimates the fire risk probability using meteo and geo-data sources and calculates the so-called fire risk index. A client application for the fire and forest services as well as cloud services that allow access to real-time data from sensors and on-the-ground reporting. This service has been tested and validated with fire-fighting crews in both Mytilene and Thessaloniki, Greece PI: Kostas Kalabokidis

More Samples

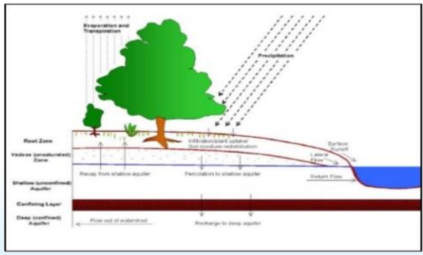
- Drug Discovery
  - Researchers at Newcastle University in the U.K. are using Azure to model the properties (toxicity, solubility, biological activity) of molecules for potential use as drugs. This cloud solution is primarily aimed at domain scientists who do not have advanced IT skills. PI: Paul Watson



- **Predicate-Argument Structure Analysis**
  - University of Kyoto team applied a predicate-argument structure analysis to a huge Japanese corpora consisting of about 20 billion web sentences, to improve the open-search engine infrastructure TSUBAKI, which is based on deep natural language processing. To achieve this goal 10,000 core on Windows Azure were used in a massively parallel computation that took about a week.

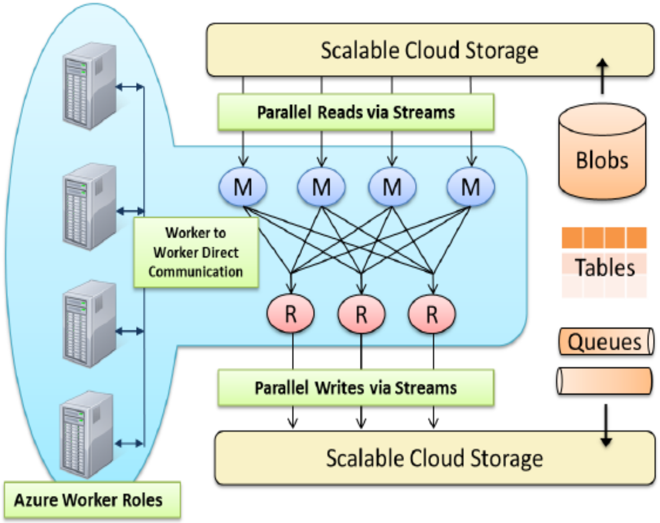


- Model and Manage Large Watershed Systems
  - Predict the impact of land use change and climate change on water resources.   Going beyond modeling to include entire workflow from data collection to decision making.   University of Virginia and South Carolina. Using HPC Scheduler on Azure to launch thousands of analysis jobs.


Evaporation and Transpiration
Precipitation
Root Zone
Vadose (unsaturated) Zone
Infiltration/plant uptake/ Soil moisture redistribution
Surface Runoff
Lateral Flow
Revap from shallow aquifer
Percolation to shallow aquifer
Return Flow
Shallow (unconfined) Aquifer
Confining Layer
Deep (confined) Aquifer
Flow out of watershed
Recharge to deep aquifer

What have we learned?

1. Traditional communication-intensive MPI apps belong on supercomputers.
2. The cloud advantage
   - Applications that require sharing & web access
   - Massive "Map Reduce" data analytics on cloud resident data
   - Massive ensemble computations
3. The "scale-out as needed" model works.
   - Users prefer spending on pay-as-you-go cloud to buying and cluster hardware. (use 500 cores 2 days a week vs. 120 cores purchased)
   - Most researcher prefer to avoid maintaining cluster and data storage facilities.
   - Most users do not have access to supercomputers


Scalable Cloud Storage
Parallel Reads via Streams
M
M
M
M
Worker to Worker Direct Communication
R
R
R
Parallel Writes via Streams
Scalable Cloud Storage
Azure Worker Roles
Blobs
Tables
Queues

Bringing Large scale data analytics to more people.
Let Scientists Be Scientists…

Most scientists do not want to be system administrators

They don’t want to learn to use supercomputers

They want to focus on their science

They use standard tools: spreadsheets, statistical packages, desktop visualization

Programming = modifying a few parameters in a trusted scripting language

They want to share experiments with their collaborators

Cloud Science Stack

- **The challenge**: Design a platform for scientific data management and analysis that is
  - Open and extensible
  - Provides an economic sustainability model for data preservation and use
  - Is easily accessed by simple desktop/web analysis apps.
  - Encourages scientific collaboration
  - Leverages the capabilities of public clouds and on-campus resources
- Can we build a demonstration project to test the feasibility of this?
- Build it using the tools the community wants and uses.

Building a Research Marketplace

- Built on top of a general purpose framework for deploying apps and data as services
- Tools available now to support data curation in the cloud
  - DataUp (From MRC), DataVerse (Harvard), Duraspace (MIT), SQL Share (Bill Howe UW)
- More sophisticated large scale data movement tools.
- Should support access to HPC on Azure and evolving Big Data tools (Hadoop, etc.) and MSR and community ML libraries
- Tools to integrate services into re-usable pipelines must be available
  - In Genomics - eScience Central, Galaxy, ETA, etc
- It should be easy to deploy standard community tools as services or as stored VM images.

IPython Notebook on Windows Azure

Browser/OS independent

Math rendering

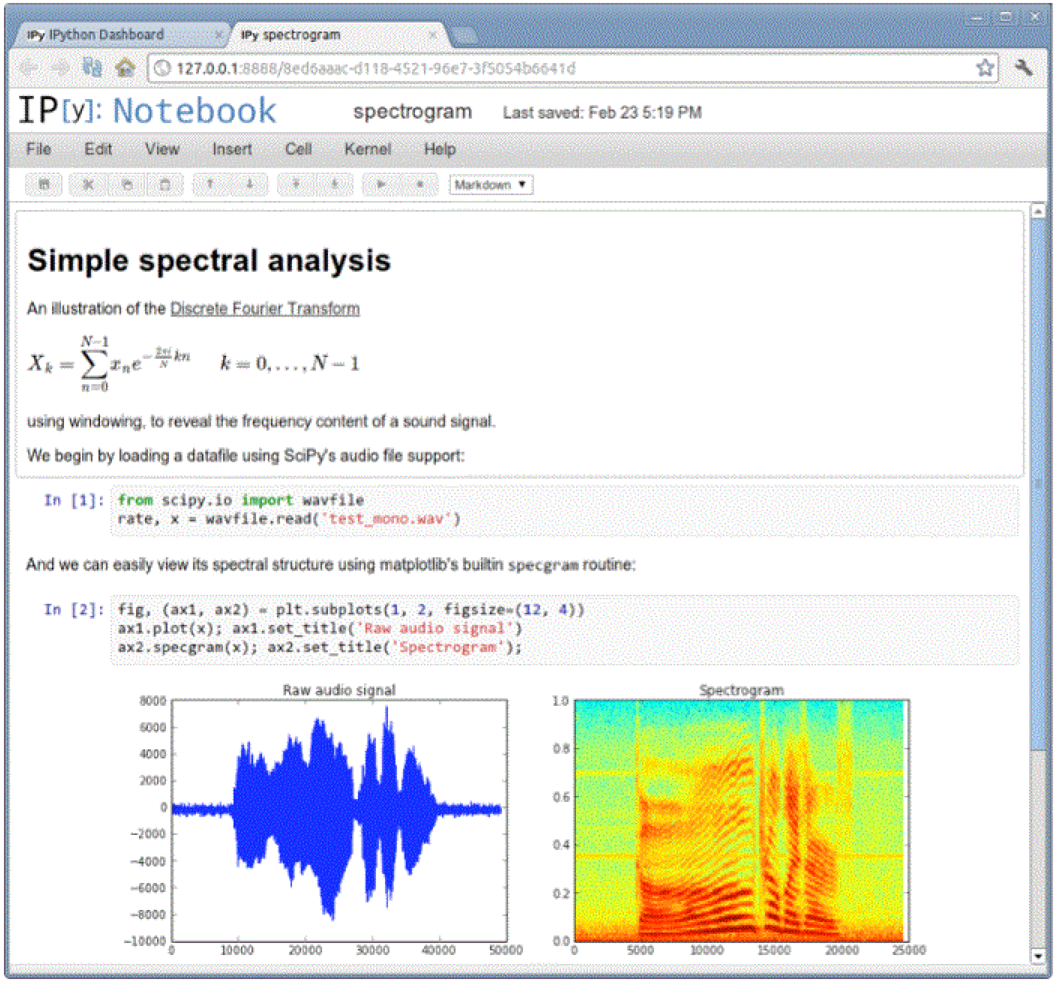
Notebooks stored in Azure Blobs

Interactive Parallel Computing & MPI Engine on Azure via Windows or Linux VM

Support for R, LaTeX, PHP, …

Inline graphics & Video

Collaborate with colleagues



Simple spectral analysis

An illustration of the Discrete Fourier Transform

$$X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i}{N} kn} \qquad k = 0, \ldots, N-1$$

using windowing, to reveal the frequency content of a sound signal.

We begin by loading a datafile using SciPy's audio file support:

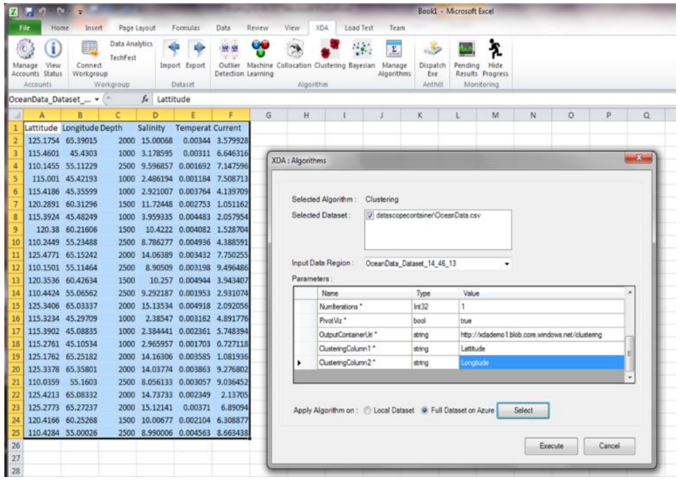
```
In [1]: from scipy.io import wavfile
        rate, x = wavfile.read('test_mono.wav')
```

And we can easily view its spectral structure using matplotlib's builtin `specgram` routine:

```
In [2]: fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
        ax1.plot(x); ax1.set_title('Raw audio signal')
        ax2.specgram(x); ax2.set_title('Spectrogram');
```

Excel DataScope

Cloud Scale Data Analytics from Excel



	A	B	C	D	E	F
1	Lattitude	Longitude	Depth	Salinity	Temperat	Current
2	125.1754	65.39015	2000	15.00068	0.00344	3.579928
3	115.4601	45.4303	1000	3.178595	0.00311	6.646316
4	110.1455	55.11229	2500	9.596857	0.001692	7.147596
5	115.001	45.42193	1000	2.486194	0.001184	7.508713
6	115.4186	45.35599	1000	2.921007	0.003764	4.139709
7	120.2891	60.31296	1500	11.72448	0.002753	1.051162
8	115.3924	45.48249	1000	3.959335	0.004483	2.057954
9	120.38	60.21606	1500	10.4222	0.004082	1.528704
10	110.2449	55.23488	2500	8.786277	0.004936	4.388591
11	125.4771	65.15242	2000	14.06389	0.003432	7.750255
12	110.1501	55.11464	2500	8.90509	0.003198	9.496486
13	120.3536	60.42634	1500	10.257	0.004944	3.943407
14	110.4424	55.06562	2500	9.292187	0.001953	2.931074
15	125.3406	65.03337	2000	15.13534	0.004918	2.092056
16	115.3234	45.29709	1000	2.38547	0.003162	4.891776
17	115.3902	45.08835	1000	2.384441	0.002361	5.748394
18	115.2761	45.10534	1000	2.965957	0.001703	0.727118
19	125.1762	65.25182	2000	14.16306	0.003585	1.081936
20	125.3378	65.35801	2000	14.03774	0.003863	9.276802
21	110.0359	55.1603	2500	8.056133	0.003057	9.036452
22	125.4213	65.08332	2000	14.73733	0.002349	2.13705
23	125.2773	65.27237	2000	15.12141	0.00371	6.89094
24	120.4166	60.25268	1500	10.00677	0.002104	6.308877
25	110.4284	55.00026	2500	8.990006	0.004563	8.663438

XDA : Algorithms

Selected Algorithm : Clustering

Selected Dataset : ☑ datascopecontainer\OceanData.csv

Input Data Region : OceanData_Dataset_14_46_13

Parameters :

Name	Type	Value
NumIterations *	Int32	1
PivotViz *	bool	true
OutputContainerUri *	string	http://xdademo1.blob.core.windows.net/clustering
ClusteringColumn1 *	string	Lattitude
ClusteringColumn2 *	string	Longitude

Apply Algorithm on : ○ Local Dataset ● Full Dataset on Azure

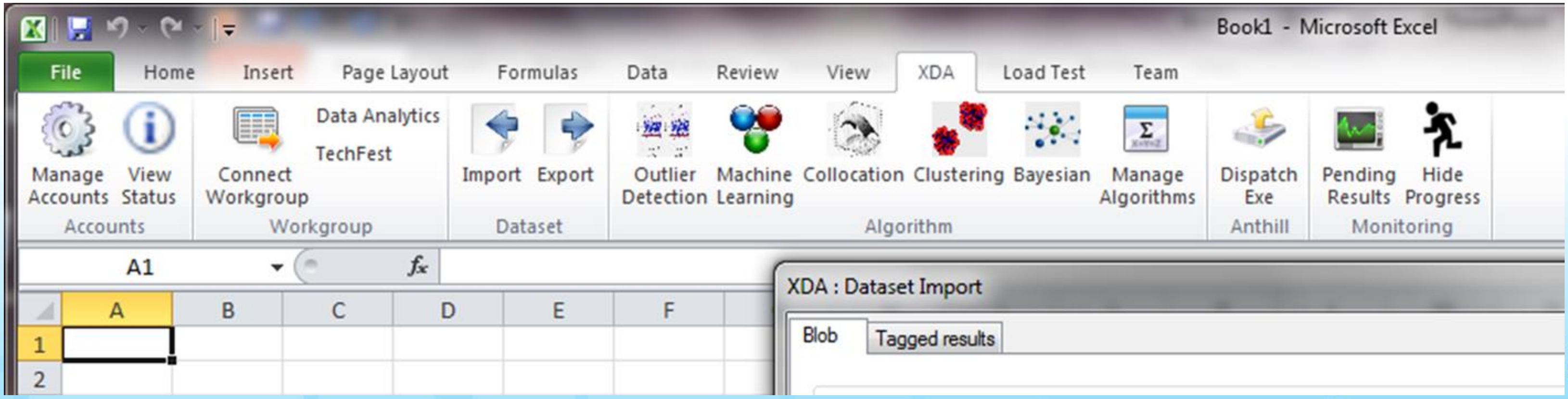
Bringing the power of the cloud to the laptop

- **Data sharing in the cloud**, with annotations to facilitate discovery and reuse;
- **Sample and manipulate** extremely large data collections in the cloud;
- **Top 25 data analytics algorithms**, through Excel ribbon running on Azure;
- **Invoke models**, perform analytics and visualization to gain insight from data;
- **Machine learning** over large data sets to discover correlations;
- **Publish** data collections and visualizations to the cloud to share insights;

Researchers use familiar tools, **familiar but differentiated**.

Data Analytics Algorithms for Datascope

- Parallel algorithms for massively distribute data
  - ❑ Clustering: K-means, fuzzy clustering, canopy clustering;
  - ❑ Recommendation Mining: Log-Likelihood;
  - ❑ Prediction: SVM; trend prediction
  - ❑ Frequent Item Set Mining: Collocation, Outlier Detection;
  - ❑ Bayesian/Regression Toolkit (linear, non-linear, logistic);
  - ❑ Bayesian Net, Neural Nets, other Machine learning
- These algorithms are being built on top of the Daytona mapreduce engine



Opportunities for Cloud Research in China

Computer Network Information Center
Chinese Academy of Sciences

Microsoft®

- In 2012 CNIC and Microsoft announced an agreement to provide researchers with free access to cloud computing resources
  - A total of 5 million core hours of Windows Azure
  - 40 Terabytes of cloud storage and SQL Azure
- The Windows Azure Cloud is a powerful tool for
  - Hosting Web access to scientific data collections and tools
  - Large scale data analytics with MapReduce
  - Massive parameter sweep or ensemble computations
  - Hosting large distributed scientific collaborations
- Interested academic researchers please contact: dennis.gannon@microsoft.com or Dr. Jianhui Li, Director of Scientific Data Center of CNIC at

  lijh@cnic.cn

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Questions

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