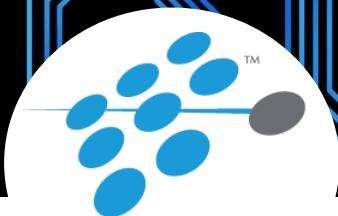


# 2016 HPCC Systems Engineering Summit – Community Day

Powering Forward with Machine Learning  
and Deep Learning



HPCC SYSTEMS®

Sreekanth Mopuru  
Principal Software Engineer  
Research Management / Elsevier

OCTOBER 12, 2016



# Leveraging the AWS Cloud to Create Scalable Research Performance Analytics

# Introduction

- Principal software engineer with Reed Elsevier
- Worked on development of Elsevier products on HPCC for 7 years
- Worked on SciVal for past 3 years.

# SciVal

- Research performance analyzer
- Used by research administrators, department heads, researchers at academic institutions to evaluate research performance.
- Based on Scopus Abstracts and Citation Database
- Scopus database contains over 60 million articles from 20,000 peer reviewed journals and over 550 million citations
- Other Data sources
  - Scopus Usage data
  - Patent Data
- SciVal Metrics
  - Metrics measuring amount of output
  - Metrics measuring quality of output
  - Metrics measuring Collaboration between institutions

# SciVal Modules

The figure is a screenshot of the SciVal dashboard for Stanford University. The top navigation bar includes links for Home, Overview, Benchmarking, Collaboration, Trends, and My SciVal. The main content area is titled 'Stanford University' and shows the university's ranking: 3rd (QS), 3rd (THE), 2nd (ARWU). It also indicates the United States and provides a link for more details on the institution.

On the left, a sidebar lists 'Institutions and Groups' with Stanford University selected. Other listed institutions include Aarhus University, ABB Group, Arizona State University, Asia University Taiwan, Banha University, Beirut Arab University, California, Chiang Mai University, Chinese Academy of Medical Sciences, Chulalongkorn University, City University of Hong Kong, CNRS, Dalarna University, Duke University, Eastern Mediterranean University, Edith Cowan University, Emory University, German Institute of Human Nutrition, and Graduate University for Advanced Studies. There are also options to add or remove entities from the section.

The main dashboard features a summary of overall research performance with the following data:

Metric	Value	Change
Publications	59,087	▲
Citations	864,602	
Authors	31,270	▲
Field-Weighted Citation Impact	2.49	
Citations per Publication	14.6	

Below this, a link 'View list of publications' is provided. The dashboard also includes a pie chart showing the distribution of publications across various fields of study:

Field	Percentage
Medicine	25.1%
Biochemistry, Genetics and Molecular Biology	10.3%
Engineering	6.7%
Immunology and Microbiology	2.2%
Other	12.2%
Neuroscience	2.9%
Arts and Humanities	2.2%
Social Sciences	4.2%
Psychology	2.2%
Physics and Astronomy	9.5%
Chemistry	3.3%
Materials Science	4.2%
Mathematics	3.2%
Computer Science	5.8%
Agricultural and Biological Sciences	3.0%
Earth and Planetary Sciences	3.1%

At the bottom, a link 'Analyze in more detail' is available.

# SciVal Module - Overview

2011 to 2015no subject area filter selected

### Performance indicators

#### Outputs in Top Citation Percentiles

Publications in top 10% most cited worldwide

Stanford University:  
**31.2%**

United States:  
17.9%

[Analyze in more detail](#)

Stanford University:  
**42.3%**

United States:  
27.1%

[Analyze in more detail](#)

Stanford University:  
**37.6%**

United States:  
30.0%

[Analyze in more detail](#)

Stanford University:  
**5.6%**

United States:  
3.1%

[Analyze in more detail](#)

<

### Quick links

Use the links below for more information on Stanford University:

[View the top authors](#)

[View the top collaborating Institutions](#)

[View the top Scopus Sources](#)

[View an analysis of research strengths](#)

# SciVal Module - Overview

Hide tags

**Institutions and Groups**

-  Stanford University
-  Aarhus University
-  ABB Group
-  Arizona State University
-  Asia University Taiwan
-  Banha University
-  Beirut Arab University
-  California
-  Chiang Mai University
-  Chinese Academy of Medical Sciences
-  Chulalongkorn University
-  City University of Hong Kong
-  CNRS
-  Dalarna University
-  Duke University
-  Eastern Mediterranean University
-  Edith Cowan University
-  Emory University
-  German Institute of Human Nutrition
-  Graduate University for Advanced Studies

[+ Add Institutions and Groups](#)

[✖ Remove all entities from this section](#)

**Researchers and Groups**

**Publication Sets**

**Countries and Groups**

**Research Areas**

Stanford University

3rd (QS) · 3rd (THE) · 2nd (ARWU) |  United States | More details on this Institution

View data sources | 2011 to 2015 | Computer Science | ASJC

Summary | Collaboration | Published | Viewed | Cited | Economic Impact | **Authors** | Competencies

## Authors

Export ▾

Top 100 authors, by number of publications at Stanford University over the period 2011 to 2015.  
Note that some authors may no longer be affiliated with Stanford University.

Name	Publications	Most recent publication	Citations	<i>h</i> -index
1. Goldsmith, Andréa J.	100	2015	422	57
2. Weissman, Tsachy	86	2015	307	19
3. Guibas, Leonidas J.	70	2015	881	47
4. Aghajan, Hamid K.	63	2015	47	12
5. Aiken, Alex S.	59	2015	287	29
6. Girod, Bernd	58	2015	483	49
7. Leskovec, Jure	55	2015	1,905	37
8. Manning, Christopher D.	55	2015	1,128	31
9. Bilkstein, Paulo	54	2015	96	7
10. Enge, Per K.	53	2015	106	18
11. Okamura, Allison	53	2015	211	36

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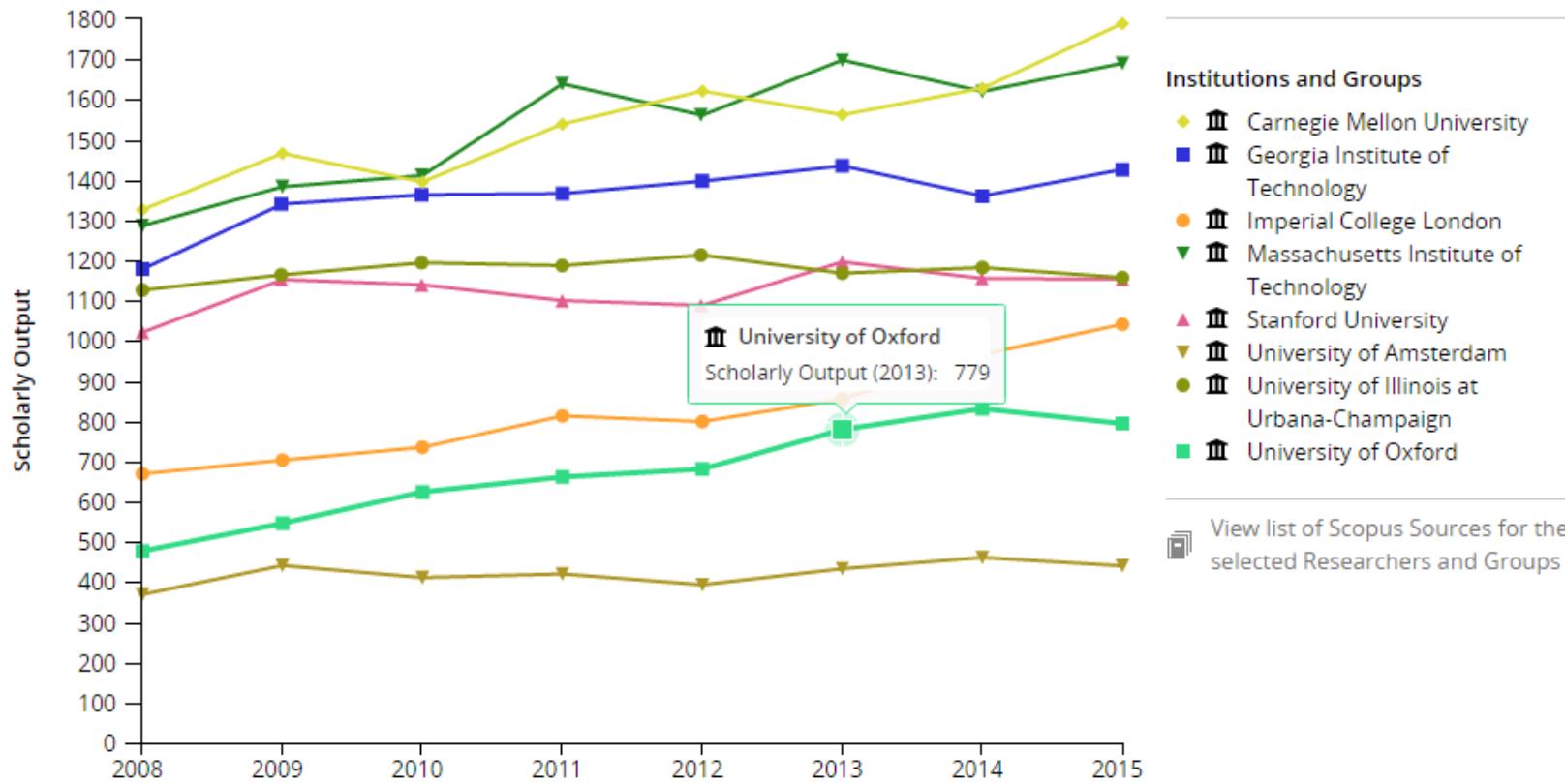
Leveraging the AWS Cloud to Create Scalable Research Performance Analytics

7

# SciVal Module - Benchmarking

Scholarly Output 

Publication Year



# SciVal Module - Collaboration

## Institutions collaborating with Stanford University

Worldwide ▾

All sectors ▾

← Filter for more (regional) detail or filter by field at the top of the page

3,688 collaborating Institutions

25,366 co-authored publications

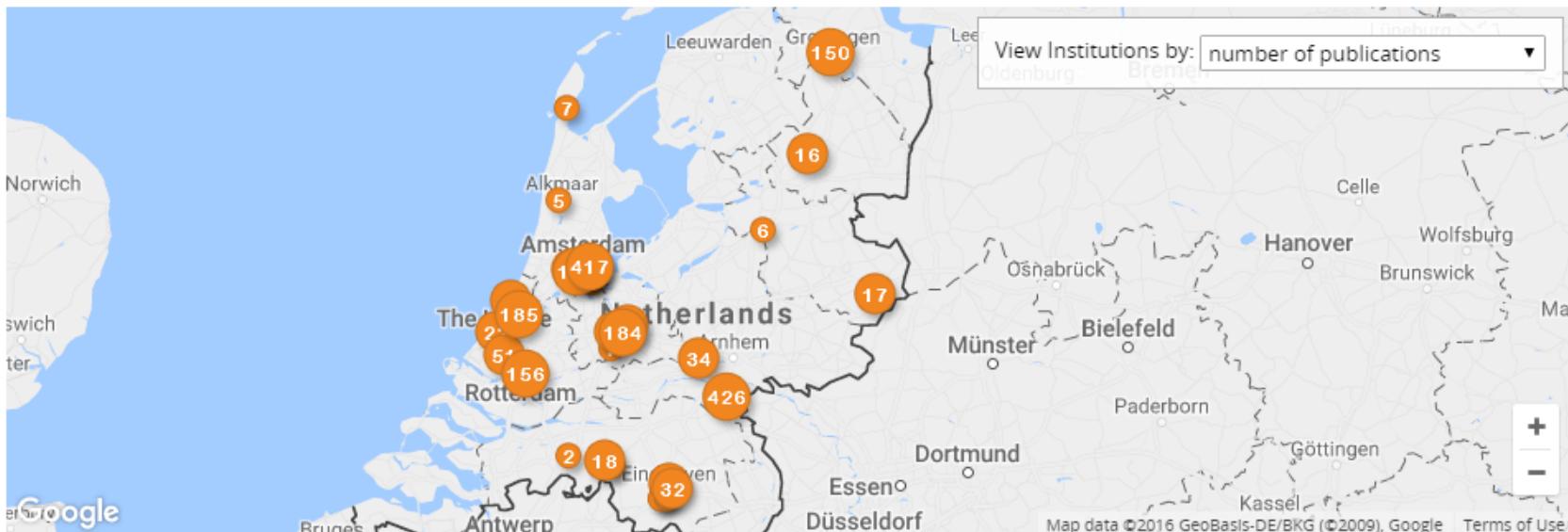


# SciVal Module - Collaboration

## Institutions collaborating with Stanford University

Europe ▾   Netherlands ▾   All sectors ▾   [reset filter](#)

 49 collaborating Institutions    1,395 co-authored publications



# SciVal Module - Trends

## Machine Learning and Data Science

[View data sources](#)

2011 to 2015

no subject area filter selected

ASJC

Summary

Institutions

Countries

Authors

Scopus Sources

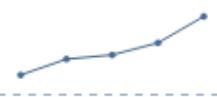
Keyphrases

### Overall research performance

Export ▾

Scholarly Output 

693



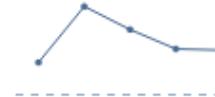
Views Count

12,958



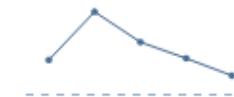
Field-Weighted Citation Impact 

1.12



Citation Count 

2,314



[View list of publications](#)

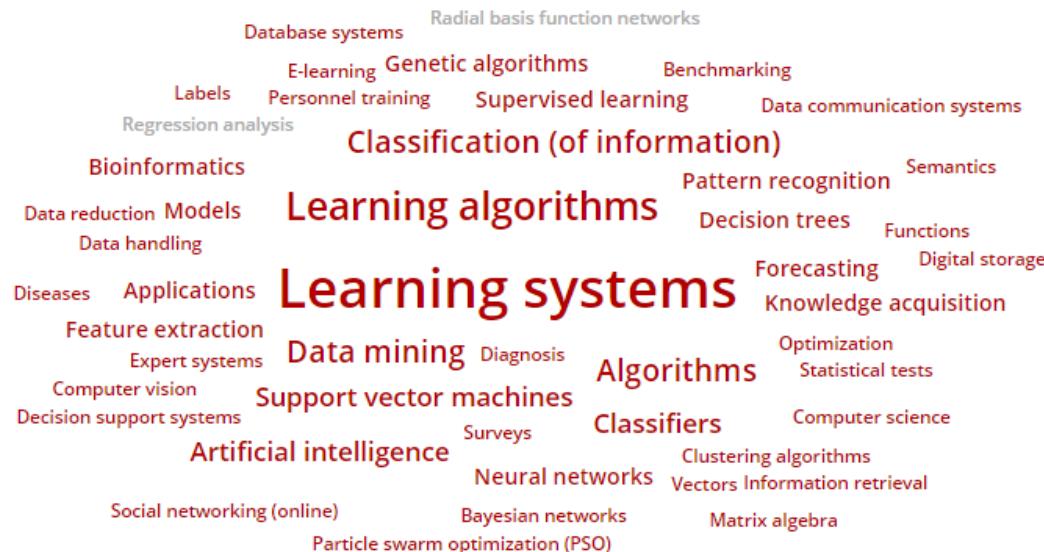
Source: Scopus | [Change](#)



# SciVal Module - Trends

## Keyphrase analysis

Top 50 keyphrases by relevance, based on 693 publications | Learn about keyphrase calculations ↗



AAA relevance of keyphrase | declining  growing (2011-2015)

→ Analyze in more detail

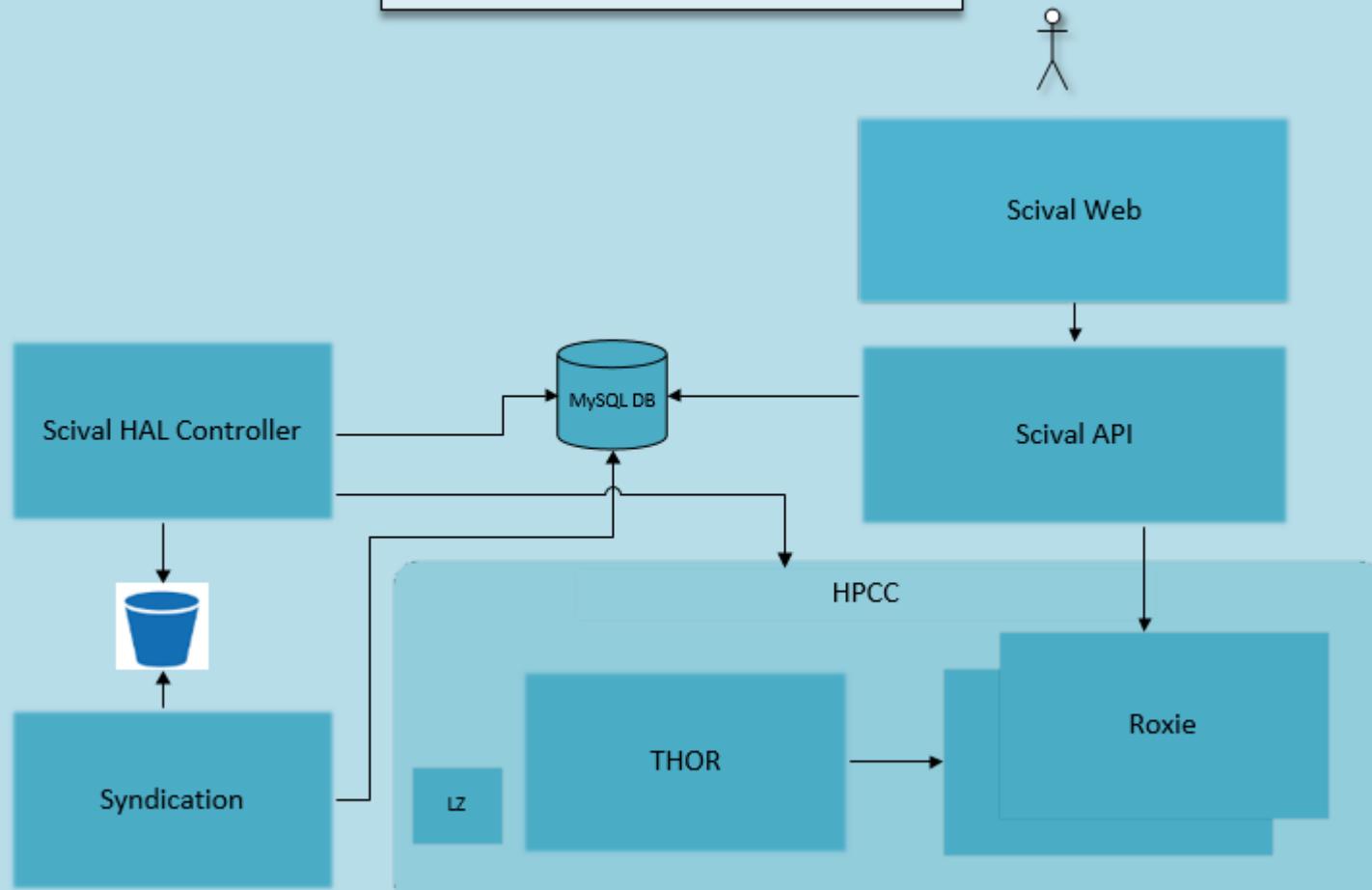


## Leveraging the AWS Cloud to Create Scalable Research Performance Analytics

# SciVal Entities And Metric Computation

- Precomputed entities
  - Entities with over 5000 documents
  - Metrics precomputed on Thor
- Dynamic entities
  - Entities containing  $\leq$  5000 documents
  - Metrics are computed on the fly on Roxie
- Computations
  - Total number of Precomputed Entities is about 600,000
  - # Years : 21 , # Subject Areas : 1050
  - Number of Metrics : 30
  - Number of Top-N lists : 15

## Scival Architecture



# SciVal Growing Computation And Storage Needs

- Growth in user entities - research areas, research groups, institutional and country groups.
- Scopus publication and citation data growth.
- Usage data growth
- New features and more metrics
- New data sources - Patents data, News flow data
  
- Because of this, we were looking for options to migrate SciVal cluster out of traditional data center hosting environment to Cloud platform.
- Amazon Cloud Platform (AWS) was the obvious choice because HPCC was already supported on that.

# AWS HPCC Installation/Configuration

- HPCC installation and configuration scripts available from LexisNexis Risk Solutions at
  - <https://github.com/tlhumphrey2/EasyFastHPCCoAWS>
- Made enhancements to scripts to productionize.
- AWS has many instance types available with varying memory, disk space and CPU capacity.
- Used smaller EC2 instances to prototype installation and configuration
  - c3.2xlarge – 8 vCPU, 16G Mem, 160 SSD Storage, High Network Performance (1G)

# Thor AWS EC2 Instances

- Large multi-core EC2 instances with very high network bandwidth (10G) used for Thor
- Thor master, HPCC middleware server processes (DALI, ECL Server, DFU , ECL Agent ...) share a single EC2 instance.

Model	vCPU	Mem (G)	Storage (G)	Cost per hour (reserved all upfront)
c3.8xlarge	32	64	2 x 320 SSD	\$0.99

- Thor Slave

Model	vCPU	Mem (G)	Storage (G)	Cost per hour(reserved all upfront)
d2.8xlarge	36	256	24 x 2000 HDD	\$2.69

- Run in multi-slave mode with 16 Thor slaves per EC2 instance.

# Roxie AWS EC2 Instances

- Picked Smallest EC2 instance with high bandwidth (1G) for Roxie

ModelvCPU	Mem (G)	Storage (G)	Cost per hour (reserved all upfront)
i2.2xlarge	8	64	2 x 800 SSD \$0.71

- 4 instances used to have enough disk capacity to fit in data/indexes
- Single EC2 to run all HPCC middleware admin processes

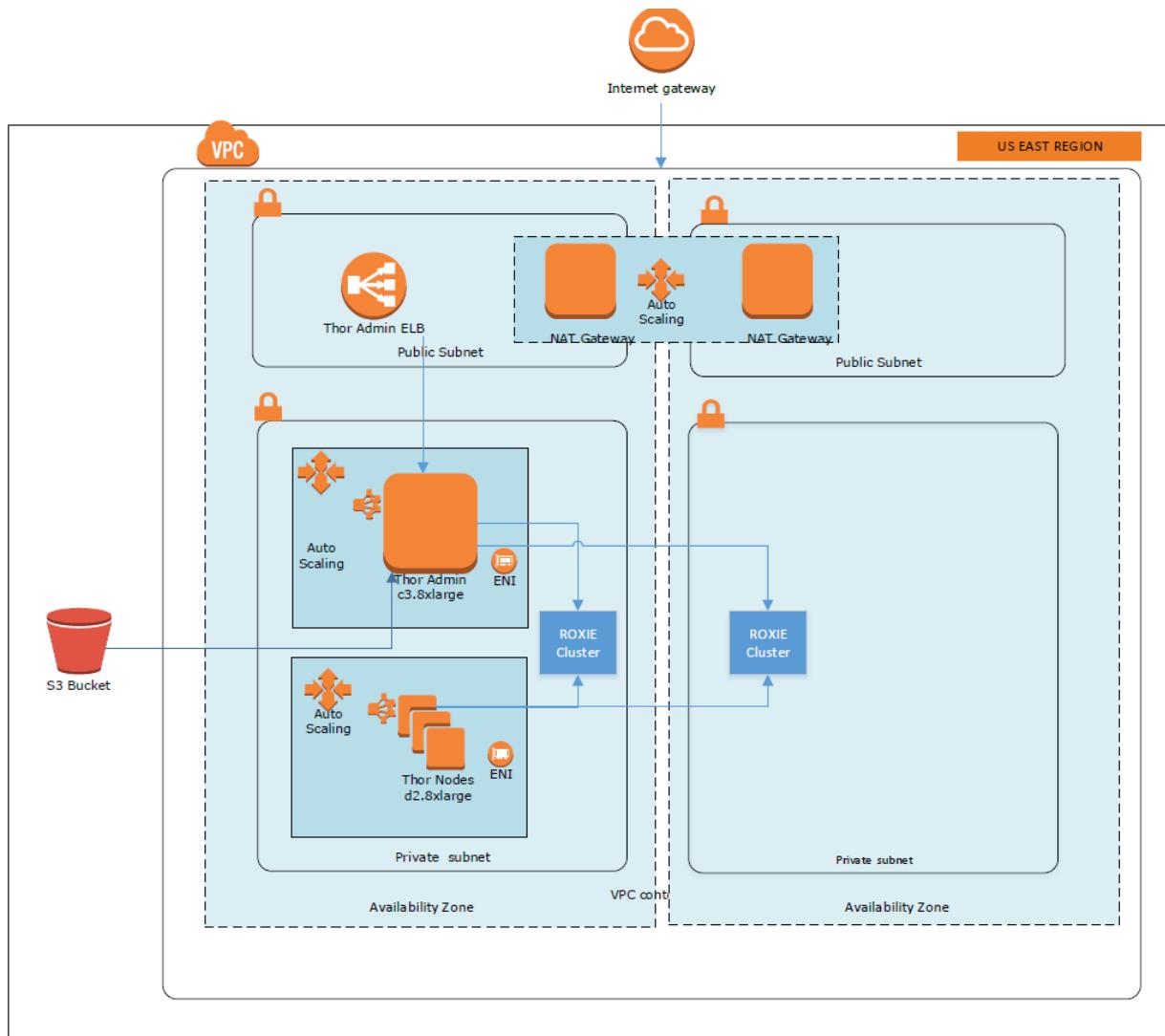
ModelvCPU	Mem (G)	Storage (G)	Cost per hour (reserved all upfront)
c3.4xlarge	16	32	2 x 160 SSD \$0.50

- Ran load tests to verify performance

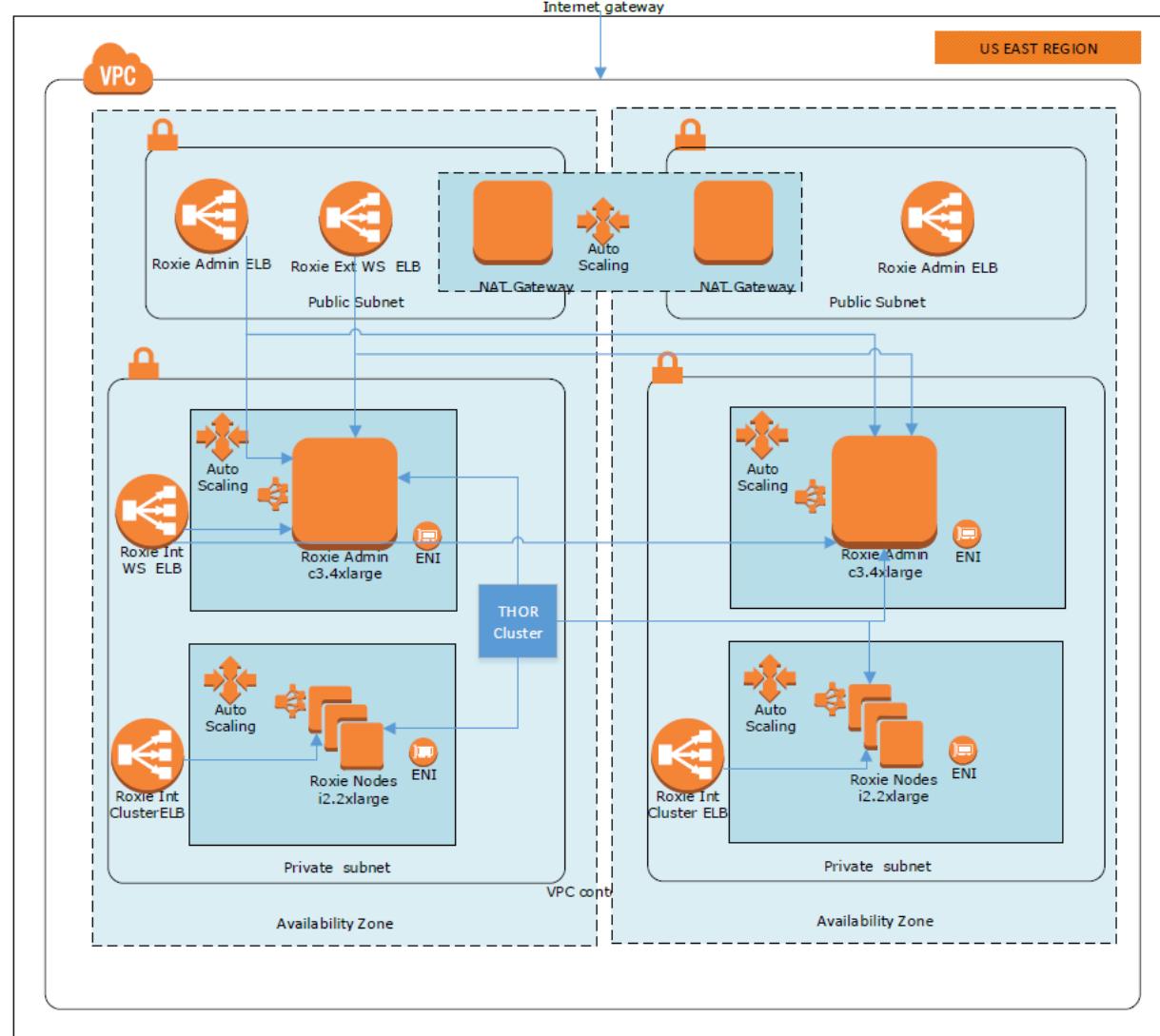
# AWS Resources

- Virtual Private Cloud (VPC)
  - Virtual network dedicated to your AWS account
  - Create private and public subnets in VPC
  - public subnet used for resources that must be connected to the Internet, and a private subnet used for resources that are isolated from Internet.
- Elastic Load Balancers (ELB)
  - Balance traffic across multiple EC2 instances.
  - Makes it easy to create an internet-facing entry point into your VPC in a multi-tier architecture.
- Auto Scaling Groups (ASG)
  - Detect impaired Amazon EC2 instances and unhealthy applications, and replace the instances without your intervention
  - Automatically scale up/down Amazon EC2 Fleet
- Security Groups (SG)
  - Acts as a virtual firewall that controls the traffic for one or more instances.
  - Specify IP ranges, protocols and ports

# AWS Thor Architecture



# AWS Roxie Architecture



# Thor Cluster Recoverability And Redundancy

- Auto Scaling Group detects impaired instances, terminates the instance and brings up new one in its place.
- New instance comes up with different IP, hence not recognized by HPCC configuration.
- All Instances bound to Elastic Network Interfaces (ENI) to maintain stable secondary private IP.
- Secondary Private IP are used in HPCC configuration by binding to secondary Ethernet interface (eth1)
- Recovery from Thor Slave Instance loss
  - Thor has replication is turned on by default.
  - Thor Slave data recovered from adjacent instance by running “start\_backupnode” command
- Recovery from Thor master Instance loss
  - Configured HPCC to turn on DALI replication
  - DALI metadata recovered from Dali replication instance.

# Roxie Cluster Recoverability And Redundancy

- Recovery from Roxie slave Instance loss
  - Configured HPCC to turn on cyclic redundancy.
  - Data automatically recovered when the replacement instance comes back up.
  - Even with the loss of a node, Roxie continues to function

# Disaster Recovery

- Thor
  - Periodic backups to AWS S3 storage
  - New Thor can be spun up and data recovered from AWS S3 in 7 hours.
- Roxie
  - Two Roxies in different Availability zone.
  - Back up of Roxie data in Thor and also in AWS S3.
  - New Roxie can be spun up and data recovered in 2 hours.

# Monitoring - Nagios

- Nagios
  - Open source monitoring tool.
  - Monitors processor load, disk usage, network services and system logs.
  - HPCC provides plugins to monitor Thor, Roxie and Middleware processes.
  - Provides alerts to users when things go wrong and alerts second time when problem is resolved.
  - Configured to send alerts to chat Slack channel.

# Monitoring - Nagios

**Nagios®**

**General**

- Home
- Documentation

**Current Status**

- Tactical Overview
- Map
- Hosts
- Services
- Host Groups
  - Summary
  - Grid
- Service Groups
  - Summary
  - Grid
- Problems
  - Services (Unhandled)
  - Hosts (Unhandled)
  - Network Outages

Quick Search:

**Reports**

- Availability
- Trends
- Alerts
  - History
  - Summary
  - Histogram

**Current Network Status**

Last Updated: Sat Sep 3 20:08:27 UTC 2016  
Updated every 90 seconds  
Nagios® Core™ 3.2.3 - [www.nagios.org](http://www.nagios.org)  
Logged in as nagiosadmin

[View Service Status Detail For All Host Groups](#)  
[View Host Status Detail For All Host Groups](#)  
[View Status Overview For All Host Groups](#)  
[View Status Summary For All Host Groups](#)

**Host Status Totals**

Up	Down	Unreachable	Pending
1	0	0	18

[All Problems](#) [All Types](#)

Ok	Warning	Unknown	Critical	Pending
141	0	0	0	0

[All Problems](#) [All Types](#)

**thor** 1 of 22 ^ ▼ ×

Ok	Warning	Unknown	Critical	Pending
141	0	0	0	0

[All Problems](#) [All Types](#)

**Status Grid For All Host Groups**

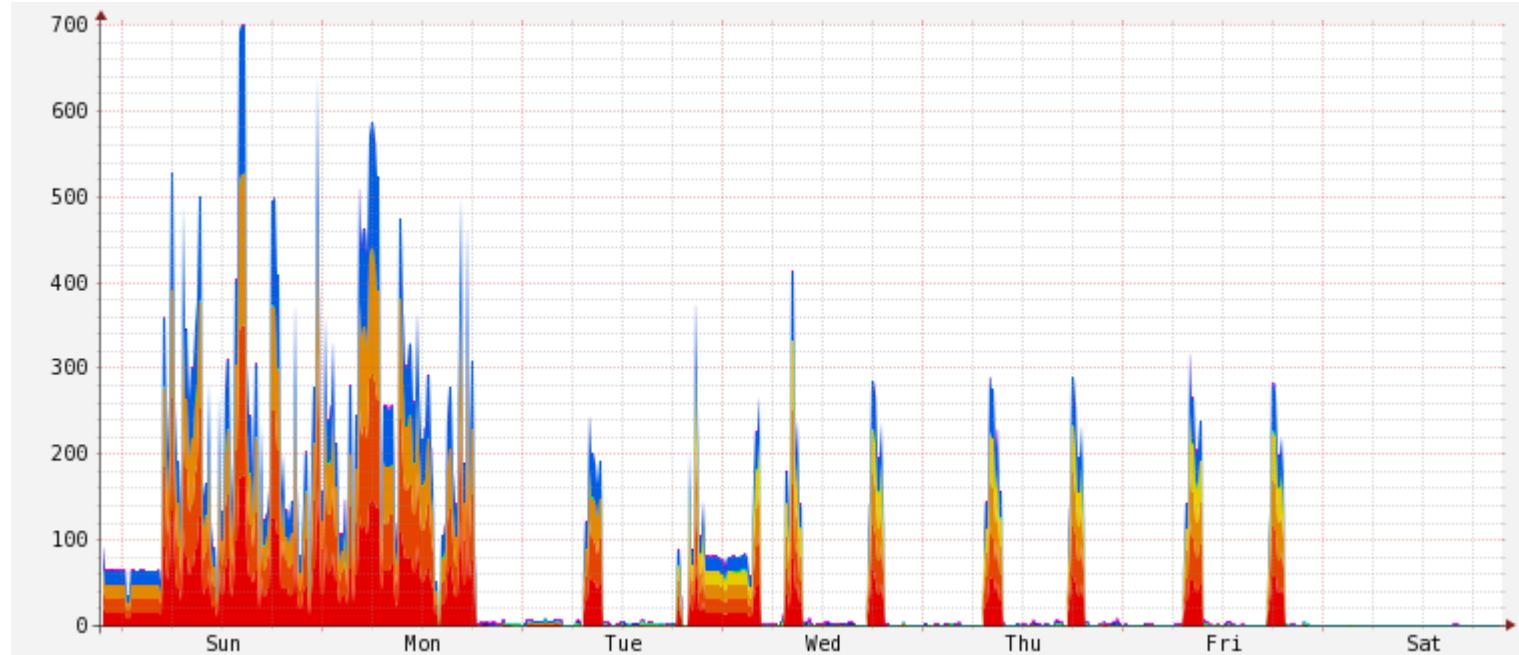
[DafilesrvProcess servers-prodroxie3-i-cbe236ca \(DafilesrvProcess-servers-prodroxie3-i-cbe236ca\)](#)

Host	Services	Actions
192.168.1.102 [192.168.1.102]	check disks check for mydfilesrv of type DafilesrvProcess check for mydal of type DafServerProcess check for myespam service for instance myesp of type EspProcess check for myasha of type SashServerProcess check for myws_eid service for instance myesp of type EspProcess check for ssh connectivity check load	
192.168.1.103 [192.168.1.103]	check disks check for check_all_disks check for check_load check for check_procs check for check_users check for mydfilesrv of type DafilesrvProcess check for myroxi of type RoxieServerProcess check for ssh connectivity check load	
192.168.1.104 [192.168.1.104]	check disks check for check_all_disks check for check_load check for check_procs check for check_users check for mydfilesrv of type DafilesrvProcess check for myroxi of type RoxieServerProcess check for ssh connectivity check load	
192.168.1.105 [192.168.1.105]	check disks check for check_all_disks check for check_load check for check_procs check for check_users check for mydfilesrv of type DafilesrvProcess check for myroxi of type RoxieServerProcess check for ssh connectivity check load	
192.168.1.106 [192.168.1.106]	check disks check for check_all_disks check for check_load check for check_procs check for check_users check for mydfilesrv of type DafilesrvProcess check for myroxi of type RoxieServerProcess check for ssh connectivity check load	
192.168.1.107 [192.168.1.107]	check disks check for check_all_disks check for check_load check for check_procs check for check_users check for mydfilesrv of type DafilesrvProcess check for myroxi of type RoxieServerProcess check for ssh connectivity check load	

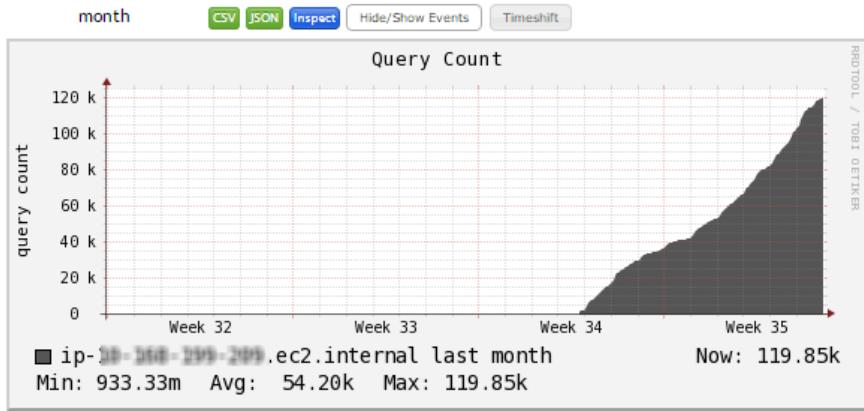
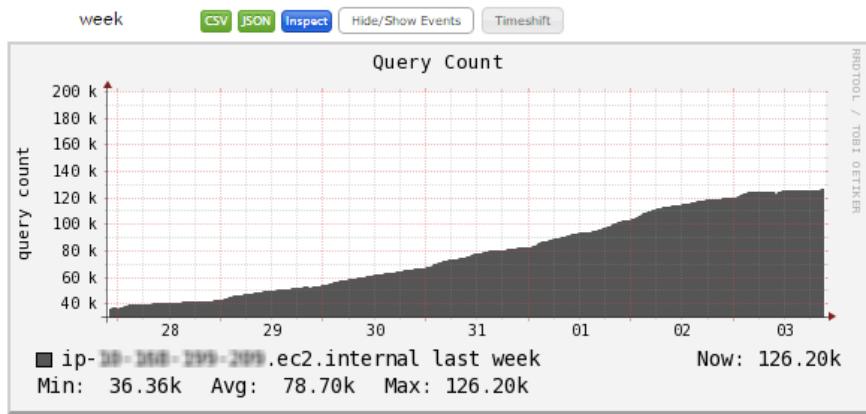
# Monitoring - Ganglia

- Open source system monitoring tool
- Allows user to view live or historical statistics like CPU load averages/ network utilization.
- HPCC plugin for Roxie metrics allows to view historical data on Roxie metrics
  - Query Count
  - Cache Hits
  - Query Failures

# Monitoring Ganglia CPU Load



# Monitoring – Ganglia Roxie Metrics



# Thor Cloud Formation Template

## Parameters

---

<b>ClusterNameSuffix</b>	<input type="text" value="1"/>	Cluster Name is formed by combining environment parameter with this suffix
<b>Environment</b>	<input type="text" value="cert"/>	The environment these instance(s) will support
<b>MasterInstanceType</b>	<input type="text" value="c3.8xlarge"/>	HPCC Thor Master EC2 instance type
<b>NagiosS3BucketFolder</b>	<input type="text" value="s3://"/>	S3 bucket folder that contains the scripts/configs for Nagios
<b>NumberOfSlaveInstances</b>	<input type="text" value="5"/>	Minimum number of THOR Slave instances to be launched
<b>NumberOfSlavesPerNode</b>	<input type="text" value="16"/>	Number of THOR Slave nodes per Slave instance
<b>ScriptsS3BucketFolder</b>	<input type="text" value="s3://"/>	S3 bucket folder that contains the scripts that are executed in the UserData section.
<b>SlaveInstanceType</b>	<input type="text" value="d2.8xlarge"/>	HPCC Thor Slave EC2 instance type
<b>UserNameAndPassword</b>	<input type="text" value=""/>	(Optional) Enter like: username/password Used to log into ECL Watch and ECL IDE.

# Future Enhancements

- Cut down S3 backup times - copy only deltas
- Tools for expansion of cluster
- Upgrade HPCC Version to resolve following issues,
  - Restore super files from S3
  - Roxie ESP should handle change of IP for Load balancer.

# Summary

- HPCC on AWS has worked great.
- Easy installation/configuration of HPPC on AWS Cloud Platform
- New cluster can be brought up in 30 minutes
- Robust and requires very little maintenance.
- Nagios and Ganglia – monitoring tools
- Easy to scale up/down
- AWS Cloud provides layer of security
- More and more cost effective as Amazon comes up with new instance types

# Acknowledgements

- Bob Mann
- Edward Lewis
- Tim Humphrey
- Jake Smith
- Anthony Fishbeck
- Richard Chapman
- John Holt
- Stuart Ort
- Arjuna Chala
- Jonathan Burger
- Fernando Uceta
- Gleb Aronsky

# Thank You

# Appendix

# SciVal - Benchmarking

Deselect all Hide tags

Institutions and Groups

Researchers and Groups

Publication Sets

Countries and Groups

- EU28 - European Union
- Germany
- India
- Japan
- United Kingdom
- United States
- Argentina
- China
- France
- Malaysia
- Nepal
- New Zealand
- North America
- Philippines
- Russian Federation
- Singapore
- Taiwan
- Thailand
- Turkey
- United States and Canada
- Viet Nam

+ Add Countries and Groups

✗ Remove all entities from this section

Research Areas

## Benchmarking

View data sources

2008 to 2015

Computer Science

ASJC

Chart

Table

Export

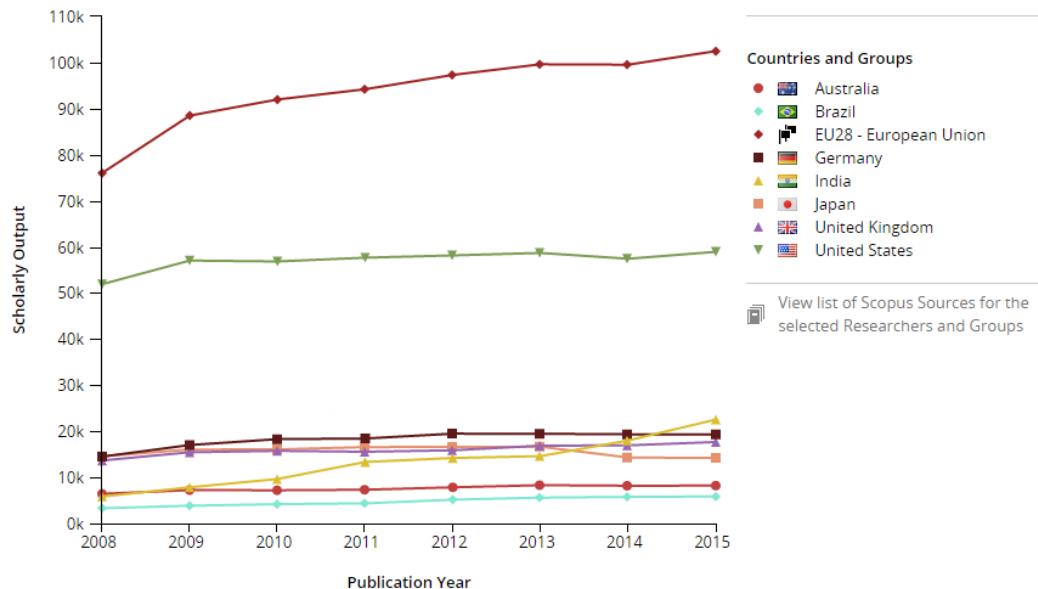
y-axis

x-axis

Bubble size

### Scholarly Output

### Publication Year



View list of Scopus Sources for the selected Researchers and Groups

# AWS Thor Instances

- Large multi-core EC2 instances with very high network bandwidth (10G) used for Thor
- Thor master, HPCC middleware server processes (DALI, ECL Server, DFU , ECL Agent ...) share a single EC2 instance.

Model	vCPU	Mem	Storage	Cost per hour(reserved all upfront)
c3.8xlarge	32	60	2 x 320 SSD	\$0.99

- Run in multi-slave mode with 16 Thor slaves per EC2 instance.

Model	vCPU	Mem	Storage	Cost per hour(reserved all upfront)
i2.8xlarge	32	244	8 x 800 (Inst SSD)	\$2.84
d2.8xlarge	36	244	24 x 2000 (Inst HDD)	\$2.69
c4.8xlarge	36	60	2 T (EBS SSD) \$0.99 + 1.71 = \$2.70	

( Instance + Provisioning cost - 4 volumes, each with 2T , 400 IOPS)

- Same SciVal Weekly Job was run with following configurations,

Slave	# Slaves	Master	Time Taken Hours
i2.8xlarge	2	c3.8xlarge	28
<b>d2.8xlarge</b>	2	c3.8xlarge	29
c4.8xlarge	2	c3.8xlarge	45

- Configured in Multi-Thor mode with two queues.

# AWS Roxie Instances

- Picked Smallest EC2 instance with high bandwidth (1G) for Roxie

ModelvCPU	Mem	Storage	Cost per hour (reserved all upfront)
i2.2xlarge	8	64	2 x 800 SSD \$0.71

- 4 instances used to have enough disk capacity to fit in data/indexes
- Single EC2 to run all HPCC middleware admin processes

ModelvCPU	Mem	Storage	Cost per hour (reserved all upfront)
c3.4xlarge	16	32	2 x 160 SSD \$0.50

- Ran load tests to verify performance

# Monitoring Nagios

## Nagios alerts posted on Slack channel

 nagios BOT 4:50 PM  
⚠ HOST: prodthor1--Master ip-██████████.ec2.internal SERVICE: check **disks**  
MESSAGE: **DISK** WARNING - free space: / 3707 MB (47% inode=80%): /dev 30191 MB (99%  
inode=99%): /dev/shm 30199 MB (100% inode=99%): /mnt 267570 MB (40% inode=99%):  
/var/lib/HPCCSystems 267570 MB (40% inode=99%): COMMENT: See Nagios

 nagios BOT 5:40 PM  
✓ HOST: prodthor1--Master ip-██████████ ec2.internal SERVICE: check **disks**  
MESSAGE: **DISK** OK - free space: / 3702 MB (47% inode=80%): /dev 30191 MB (99%  
inode=99%): /dev/shm 30199 MB (100% inode=99%): /mnt 367453 MB (56% inode=99%):  
/var/lib/HPCCSystems 367453 MB (56% inode=99%): COMMENT: See Nagios

# SciVal Module – Benchmarking Metrics

## Published

Scholarly Output 

Subject Area Count

Scopus Source Title Count

*h*-indices 

## Cited

Citation Count 

Field-Weighted Citation Impact 

Outputs in Top Citation Percentiles 

Publications in Top Journal Percentiles 

Citations per Publication 

Cited Publications

## Viewed

Views Count

Outputs in Top Views Percentiles

Views per Publication

## Economic Impact

Academic-Corporate Collaboration 

Academic-Corporate Collaboration Impact 

Citing-Patents Count

Patent-Cited Scholarly Output

Patent-Citations Count

Patent-Citations per Scholarly Output

# SciVal Module - Collaboration

## Collaboration with the University of Amsterdam

Year range: 2013 to 2015

Export ▾ Shortcuts ▾



Overview Current co-authors Potential co-authors

Stanford University

419 ▼

co-authors with the University of Amsterdam

2.47

Field-Weighted Citation Impact

Co-authored

417 ▲

publications

University of Amsterdam

441 ▲

co-authors with Stanford University

5.15

Field-Weighted Citation Impact

1.99

Field-Weighted Citation Impact

Authors	24,218 ▲	-	11,630 ▲
Scholarly Output	36,634 ▲	-	21,572 ▲
Views count (from Scopus)	548,325	27,383	307,893
Field-Weighted Views Impact	1.39	8.62	1.43
Citation Count	336,221	10,699	157,504

Show all

# SciVal Entities And Metric Computation

- Predefined Entities
  - Institution / Group of Institutions
  - Country / Group of Countries
  - Institution departments
  - Predefined Research Area
- User Defined Entities
  - User Created Group of Institutions
  - User Created Group of Countries
  - User Created Researcher and Group of Researchers
  - User Created Research Areas
- Predefined Defined Entities are large so always precomputed
- User Defined Entities are precomputed when entity contains > 5000 documents
- User Defined Entities containing <= 5000 documents are dynamic. Metrics are computed on the fly.
- Computations
  - Total number of Precomputed Entities is about 600,000
  - # Years : 20 , # Subject Areas : 1050
  - Number of Metrics : 30
  - Number of Top-N lists : 20

# SciVal Jobs

- Weekly Job
  - Full latest Scopus snapshot
  - All Predefined Entities
  - Larger User Entities with over 5000 documents
- Delta Job
  - Same Scopus Snapshot
  - Any new large user defined entities created since last weekly or delta job.

# Roxie Cloud Formation Template

## Parameters

---

<b>ClusterNameSuffix</b>	<input type="text" value="1"/>	Cluster Name is formed by combining environment parameter with this suffix
<b>Environment</b>	<input type="text" value="cert"/>	The environment these instance(s) will support
<b>HpccPlacementGroup</b>	<input type="text" value="scival_large"/>	The Placement group for an Availability Zones in the region in your VPC
<b>MasterInstanceType</b>	<input type="text" value="c3.4xlarge"/>	HPCC Roxie Admin EC2 instance type
<b>NagiosS3BucketFolder</b>	<input type="text" value="s3://"/>	S3 bucket folder that contains the scripts/configs for Nagios
<b>NumberOfRoxieNodes</b>	<input type="text" value="5"/>	Number of Roxie nodes in deployed HPCC System
<b>RoxieInstanceType</b>	<input type="text" value="i2.2xlarge"/>	HPCC Roxie EC2 instance type
<b>ScriptsS3BucketFolder</b>	<input type="text" value="s3://"/>	S3 bucket folder that contains the scripts that are executed in the UserData section.
<b>UserNameAndPassword</b>	<input type="text" value=""/>	(Optional) Enter like: username/password Used to log into ECL Watch and ECL IDE.