Amazon Web Services with HTCondor

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Sanjay Padhi, Ph.D
AWS Research and Technical Computing
sanpadhi@amazon.com

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Today

- Amazon Web Services (AWS)
- Scientific Computing using AWS and HTCondor
- Machine Learning
AWS Global Infrastructure

16 Regions – 42 Availability Zones – 74 Edge Locations

Region & Number of Availability Zones

- **AWS GovCloud** (2)
- **EU**
  - Ireland (3)
  - Frankfurt (2)
  - London (2)
- **US West**
  - Oregon (3)
  - Northern California (3)
- **US East**
  - N. Virginia (5), Ohio (3)
  - Singapore (2)
  - Sydney (2), Tokyo (3), Seoul (2), Mumbai (2)
- **Canada**
  - Central (2)
- **China**
  - Beijing (2)
- **South America**
  - São Paulo (3)

**Announced Regions**
- Paris, Ningxia
Zoom In: AWS Region

Sample US Region

Availability Zone A
Availability Zone B
Availability Zone C

Zoom In: AWS AZ

Sample Availability Zone

Datacenter
Datacenter
Datacenter
Designed to host sensitive data and regulated workloads in the cloud

- Supports U.S. government compliance requirements, including ITAR and FedRAMP
- Operated by employees who are vetted "U.S. Persons"
- Root account holders are confirmed U.S. Persons
- Available to U.S. government agencies and organizations in government-regulated industries, that meet GovCloud (US) requirements for access
Architected for Government Security Requirements

ISO 9001 - Global Quality Standard
ISO 27001 - Security Management Standard
ISO 27017 - Cloud Specific Controls
ISO 27018 - Payment Card Standards
PCI DSS Level 1

FedRAMP - Government Data Standards
FedRAMP TIC - Trusted Internet Connection
FERPA - Educational Privacy Act

CJIS - Criminal Justice Information Services
DoD SRG - DoD Data Processing
FDA - Food and Drug Administration

FIPS - Government Security Standards
FISMA - Federal Information Security Management
GxP - Quality Guidelines and Regulations
HIPAA - Protected Health Information
SEC Rule 17a-4(f) - Financial Data Standards
ITAR - International Arms Regulations

FISC [Japan] - Financial Industry Information Systems
IRAP [Australia] - Australian Security Standards
MLPS Level 3 [China] - Multi-Level Protection
MTCS Tier 3 [Singapore] - Multi-Tier Cloud Security Standard
My Number Act [Japan] - Personal Information Protection

DNB (Netherlands) - Dutch Financial Regulations
EU Data Protection Framework
G-Cloud (UK) - UK Government Standards
IT-Grundschutz (Germany) - Baseline Protection Methodology
Privacy Shield - EU-US Data Transfer
UK Cyber Essentials Plus - Cyber Threat Protection

https://aws.amazon.com/compliance/
AWS: Pace of Innovation

2011: 80+
2012: 160
2013: 280
2014: 516
2015: 722
2016: 1017
AWS in the Public Sector

- 2,300+ government agencies
- 7,000+ educational institutions
- 22,000+ nonprofit organizations
Compute Services

Virtual Server Hosting, Container management, and Serverless Computing

Amazon EC2
Provides resizable cloud-based compute capacity in the form of EC2 instances, which are equivalent to virtual servers

Amazon EC2 Container Service
A highly scalable, high performance container management service

AWS Lambda
Run code without thinking about servers.
Scientific Computing using AWS and HTCondor
The Large Hadron Collider @ CERN includes 6,000+ researchers from over 40 countries and produces approximately 25PB of data each year.

The ATLAS and CMS experiments are using AWS for Monte Carlo simulations, processing, and analysis of LHC data.
80 Million electronic channels
  x 4 bytes
  x 40MHz

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~ 10 Petabytes/sec of information
x 1/1000 zero-suppression
x 1/100,000 online event filtering

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~ 100-1000 Megabytes/sec raw data to tape
1 to 10 Petabytes of raw data per year
written to tape, not counting simulations.

2000 Scientists (1200 Ph.D. in physics)
  ~ 180 Institutions
  ~ 40 countries

12,500 tons, 21m long, 16m diameter

Total weight
Overall diameter
Overall length
Magnetic field

: 14000 tonnes
: 15.0 m
: 28.7 m
: 3.8 T

SILICON TRACKER
Pixels (100 x 150 µm²)
~1m² ~66M channels
Microstrips (80-180µm)
~200m² ~9.6M channels

CRYSTAL ELECTROMAGNETIC CALORIMETER (ECAL)
~76k scintillating PbWO₄ crystals

PRESHOWER
Silicon strips
~16m² ~137k channels

SUPERCONDUCTING SOLENOID
Niobium-titanium coil
carrying ~18000 A

HADRON CALORIMETER (HCAL)
Brass + plastic scintillator
~7k channels

FORWARD CALORIMETER
Steel + quartz fibres
~2k channels

MUON CHAMBERS
Barrel: 250 Drift Tube & 480 Resistive Plate Chambers
Endcaps: 473 Cathode Strip & 432 Resistive Plate Chambers
Clouds provided elasticity in computing

Finite number of resources by the experiments (Compute as well as Storage)

“Burst” usage is modeled using delays (~months) due to (re)processing capabilities

Elasticity in the system is really essential
Tutorial for Scientific Computing using Amazon

Monday 2 Feb 2015, 08:00 → 18:00  Europe/Zurich
30-7-018 - Kjell Johnsen Auditorium (CERN)
Maria Girone (CERN), Sanjay Padhi (Univ. of California San Diego (US))
Streaming data interaction every 25 nano sec – Occupancy (Finding patterns)
~60,000 slots using AWS spot instances. A factor of 5 larger than Fermilab capacity!
Results from the CMS Use Case

• All CMS requests fulfilled for the “Moriond” conference
  – 2.9 million jobs, 15.1 million wall hours
    • 9.5% badput – includes preemption from spot pricing
    • 87% CPU efficiency
  – 518 million events generated
ATLAS Workflow in Cloud – At Scale and Low Cost

- Joint project between AWS, BNL and ESNET
- Investigate the technical and financial feasibility of large-scale usage of Cloud
- AWS: Provided expertise & guidance
- BNL: ATLAS compatible VMs, provisioning infrastructure, VM life management
- ESNET: High performance connectivity between AWS and US site

M. Ernst: Director of the RHIC and ATLAS Computing Facility, Brookhaven National Laboratory

“ATLAS has met the challenge of data intensive computing at a scale not seen before”
“The joint project with the AWS Scientific Computing Team and ESnet has been crucial to the successful implementation”
“The cost of AWS/EC2 spot is slightly lower than dedicated farm resources at BNL”

Enabling Global Collaboration

Bring the users to the data, don’t send the data to the users
NOvA uses AWS to Shed Light on Neutrino Mysteries

Peter Shanahan (Co-spokesperson of the NOvA experiment):
“Our experience with Amazon Web Services shows its potential as a reliable way to meet our peak data processing needs at times of high demand”


Neutrinos are ghost like particles — Needed advanced ML analytics to detect
Scalability using AWS

18 hours
205,000 materials analyzed
156,314 AWS Spot cores at peak
2.3M core-hours
Total spending: $33K
(Under 1.5 cents per core-hour)
Development of HTCondor Annex
Machine Learning

Amazon AI: https://aws.amazon.com/amazon-ai/
Amazon Machine Learning: https://aws.amazon.com/machine-learning/
ARTIFICIAL INTELLIGENCE
Early artificial intelligence stirs excitement.

MACHINE LEARNING
Machine learning begins to flourish.

DEEP LEARNING
Deep learning breakthroughs drive AI boom.
Machine Learning

Supervised Learning:
- Learning from “labelled data”
- Classification, Regression, Prediction, Function Approx

Unsupervised Learning:
- Method to find similar groups in the data clusters
- Groups that are similar to near clusters
- Groups different far away from each other
Machine Learning (Classification, Regression and Ranking):

Euclidean Distance Score

Euclidean distance \( d \) = \( \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \)

Pearson Correlation Score

Regression line
Slope: 1.5; 95% Confidence Limits: 1.31, 1.71; R-Squared Percent = 61%
Y axis: Mice or Rats in the Building (by Household) - Percent of Households
Convolutional Neural Net

- Convolutional neural nets are a very successful deep learning method.
- Inspired by research showing that the cells in the visual cortex are only responsive to small portions of the visual field - “receptive field”.
- Some cells collect information from small patches – sensitive to edge-like features.
- Other cells collect information from large patches.
- Effectively, these cells are applying convolutional kernels across the visual field.
Amazon Rekognition - Image Detection and Recognition Powered by Deep Learning

https://aws.amazon.com/rekognition/
Automatic Grading of Diabetic Retinopathy through Deep Learning using AWS

Early Detection of Diabetic Complications
Skin Cancer Detection At Physician-Levels (or better)
Lung Cancer Detection With Deep Learning & Medical Imaging
OhioHealth

“We are excited about utilizing evolving speech recognition and natural language processing technology to enhance the lives of our customers. Amazon Lex represents a great opportunity for us to deliver a better experience to our patients. Everything we do at OhioHealth is ultimately about providing the right care to our patients at the right time and in the right place. Amazon Lex’s next generation technology and the innovative applications we are developing using it will help provide an improved customer experience. We are just scratching the surface of what is possible.”

- Michael Krouse, Senior Vice President Operational Support and Chief Information Officer, OhioHealth

Natural Language Understanding (NLU) & Automatic Speech Recognition (ASR) as in Amazon ALEXA - Powered by Deep Learning

https://aws.amazon.com/lex/
Incorporates ~47 different voices and fully managed services

https://aws.amazon.com/polly/
Deep Learning

Significantly improve many applications on multiple domains

- Image understanding
- Speech recognition
- Natural language processing
- Autonomy

“deep learning” trend in the past 10 years
Autonomous Driving Systems
“The future is here,
It’s just not evenly distributed yet”

William Gibson
Amazon AI: Building Intelligent Systems

Model Training

Inference in the Cloud

Inference at the Edge
Amazon AI: Democratized Artificial Intelligence

AI Services
- Amazon Rekognition
- Amazon Polly
- Amazon Lex
- More to come in 2017

AI Platform
- Amazon Machine Learning
- Amazon Elastic MapReduce
- Spark & SparkML
- More to come in 2017

AI Engines
- Apache MXNet
- TensorFlow
- Caffe
- Torch
- Theano
- CNTK
- Keras
AWS initiated collaborative program with the National Science Foundation (NSF)

The program by multiple directorates at NSF, provides funds up to $26.5 million in addition to $3 million in AWS Cloud Credits to perform cutting edge Big Data research on cloud for a period of 3-4 years (up to 2021)

This opens up a venue for collaborative programs with national, federal, and state agencies.

In today's era of data-driven science and engineering, we are pleased to work with the AWS Research Initiative via the NSF BIGDATA program to provide cloud resources for our Nation’s researchers to foster and accelerate discovery and innovation.”

Dr. Jim Kurose, Assistant Director of the National Science Foundation (NSF) for Computer and Information Science and Engineering Directorate (CISE)
Thank you!

Sanjay Padhi
sanpadhi@amazon.com