Introduction to
Amazon Web Services

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Introduction

- Fourth Paradigm – Data intensive scientific discovery
  - DNA Sequencing machines, LHC
- Commercial Cloud Platforms
  - Amazon Web Services
  - Microsoft Azure Platform
  - Google AppEngine

Cloud Computing

- On demand computational services over web
  - Spiky compute needs of the scientists
- Horizontal scaling with no additional cost
  - Increased throughput
- Cloud infrastructure services
  - Storage, messaging, tabular storage
  - Cloud oriented services guarantees
  - Virtually unlimited scalability

Amazon Web Services

- Compute
  - Elastic Compute Service (EC2)
  - Elastic MapReduce
  - Auto Scaling
- Storage
  - Simple Storage Service (S3)
  - Elastic Block Store (EBS)
  - AWS Import/Export
- Messaging
  - Simple Queue Service (SQS)
  - Simple Notification Service (SNS)
- Database
  - SimpleDB
  - Relational Database Service (RDS)
- Content Delivery
  - CloudFront
- Networking
  - Elastic Load Balancing
  - Virtual Private Cloud
- Monitoring
  - CloudWatch
- Workforce
  - Mechanical Turk

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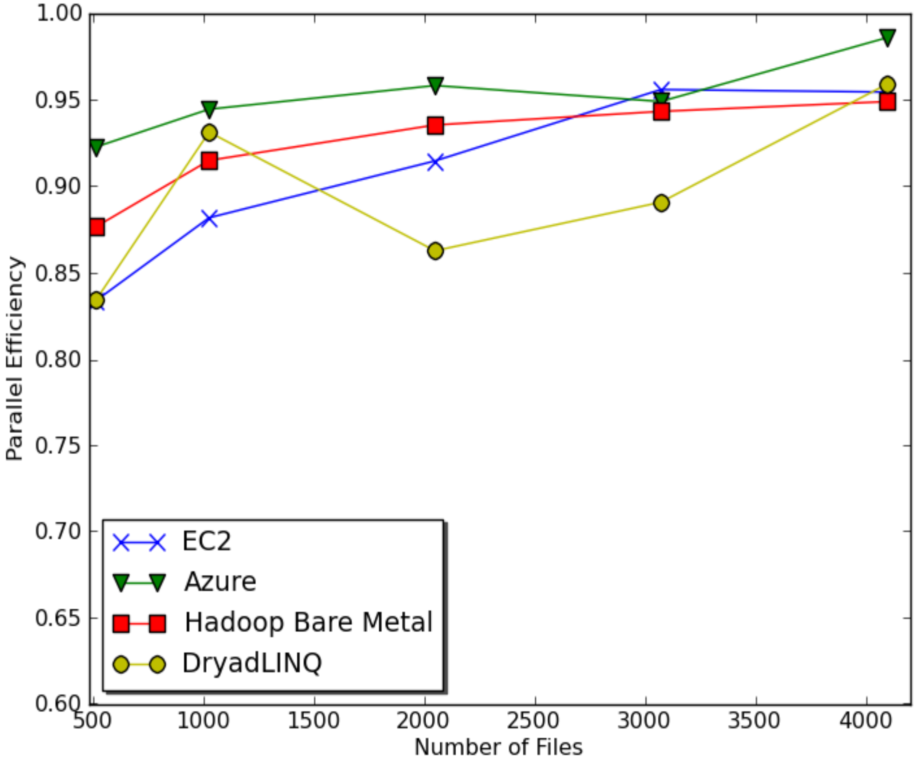
Demo Application

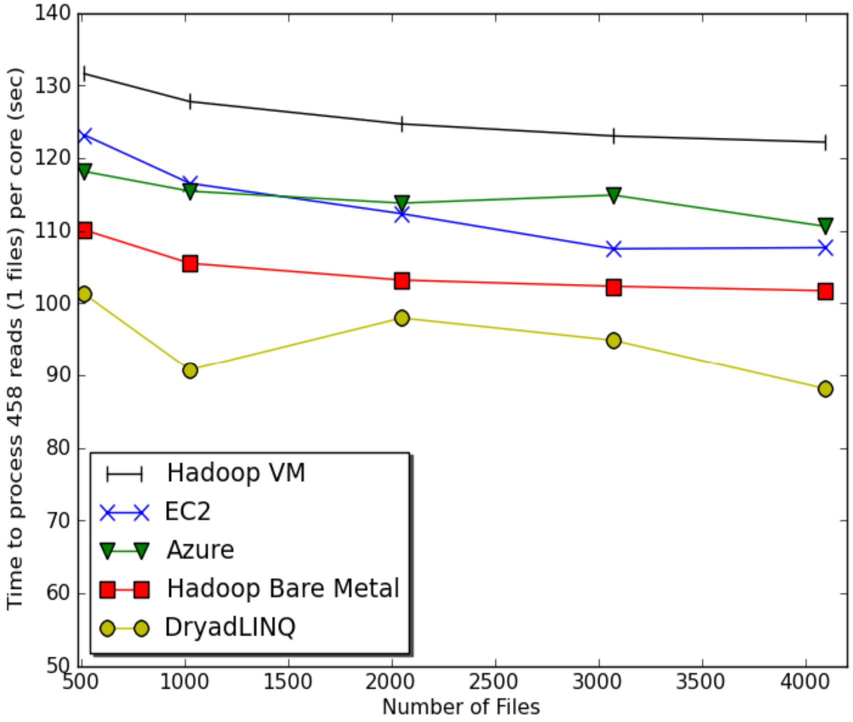
- Job queue based embarrassingly parallel application execution
  - BLAST, Monte Carlo simulations, many image processing applications, parametric studies
- Cap3 – Sequence Assembly*
  - Assembles DNA sequences by aligning and merging sequence fragments to construct whole genome sequences
- Executable available at http://seq.cs.iastate.edu/cap3.html
- Demo programs
  - http://salsahpc.indiana.edu/tutorial/apps/aws/

* Huang, X. and Madan, A. (1999) CAP3: A DNA sequence assembly program. *Genome Res.*, **9**, 868-877.

Sequence Assembly in the Clouds



Cap3 parallel efficiency



Cap3 – Per core per file (458 reads in each file) time to process sequences

Cost to assemble to process 4096 FASTA files*

- **Amazon AWS total :11.19 $**

*Compute 1 hour X 16 HCXL (0.68$ * 16)*	*= 10.88 $*
10000 SQS messages	*= 0.01 $*
Storage per 1GB per month	*= 0.15 $*
Data transfer out per 1 GB	*= 0.15 $*

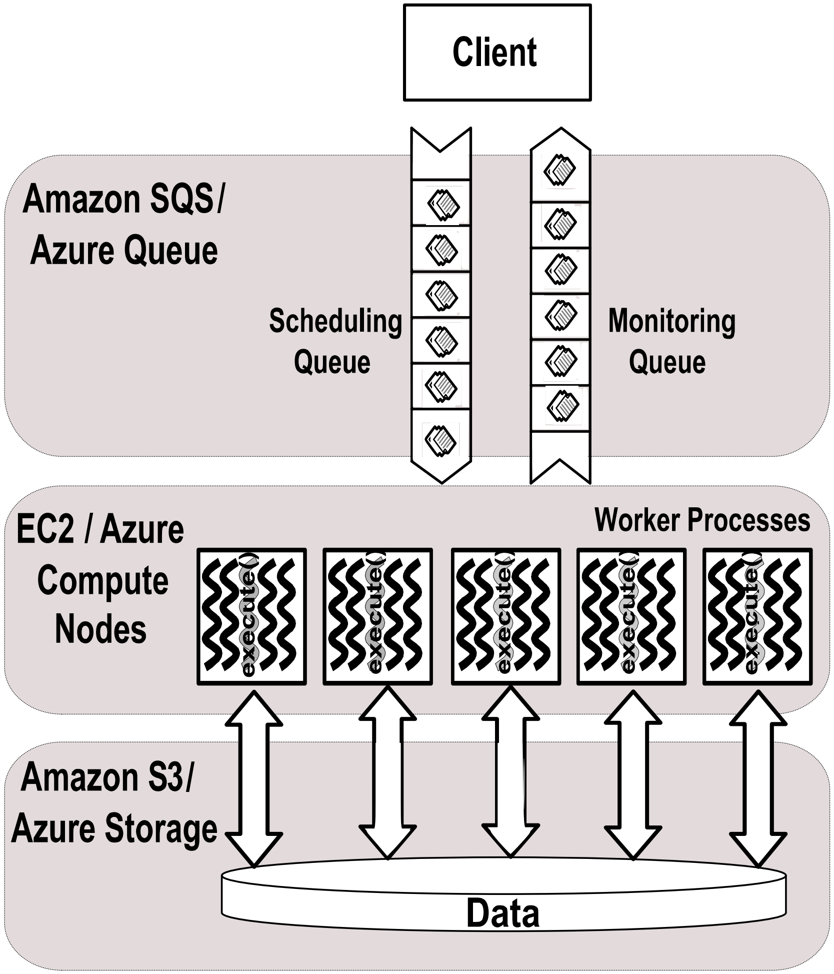
- **Azure total : 15.77 $**

*Compute 1 hour X 128 small (0.12 $ * 128)*	*= 15.36 $*
10000 Queue messages	*= 0.01 $*
Storage per 1GB per month	*= 0.15 $*
Data transfer in/out per 1 GB	*= 0.10 $ + 0.15 $*

- **Tempest (amortized) : 9.43 $**
  - 24 core X 32 nodes, 48 GB per node
  - Assumptions : 70% utilization, write off over 3 years, including support

* ~ 1 GB / 1875968 reads (458 reads X 4096)

Architecture



Security Credentials

- Access Keys
  - Making a REST or Query API request
  - JAVA SDK for S3, SQS, SimpleDB
- EC2 Key Pairs
  - Launching/connecting to EC2 instances
- X.509 Certificate
  - SOAP API
  - Command line tools

AWS Toolkit for Eclipse

- Open source plug-in for Eclipse
- AWS Java SDK
  - Java API for AWS services
- Amazon SimpleDB management
  - Configure, edit, query
- Amazon EC2 management
  - Deploy, debug, manage

Installing AWS Toolkit in Eclipse

- Installing
  - Java 1.5 or higher
  - Eclipse 3.5 or higher (Java EE distribution recommended)
  - http://aws.amazon.com/eclipse
  - http://media.amazonwebservices.com/videos/eclipse-java-sdk-video.html

Simple Storage Service (S3)

- Internet Data Storage
  - Reliable, Simple, Scalable, and Inexpensive
- Three Concepts
  - Buckets
    - Analogous to a folder with no nesting
    - URL accessible
    - Option to enforce geographical constraints
  - Objects
    - Actual data stored in buckets, e.g. PDF, Video, etc.
    - Up to 5 gigabytes
    - Unlimited number of objects
    - Retrievable via HTTP, HTTPS, or BitTorrent
    - Private, public or selectively for users
  - Keys
    - Unique key to identify each object in a bucket

Simple Storage Service (S3)

- Access Logs
  - Option to enable to logs for buckets
- Pricing
  - Data storage
    - 0.15$ per GB for first 50TB to 0.055$ per GB for over 5000TB
  - Data transfer in
    - 0.1$ per GB (free till Nov,2010)
  - Data Transfer out
    - 0.15$ per GB up to 10TB to 0.08$ per GB for over 150TB
  - Requests
    - PUT, COPY, POST, LIST -> 0.01 $ per 1000 requests
    - Others -> 0.01$ for 10,000 requests
- Reduced Redundant Storage
  - 2/3 of the storage cost

Using S3 as the Data Storage

- S3 management console
- Uploading the input data to S3
- Downloading/uploading files (s3 objects) programmatically
- Run Sample
  - AWSStepOne eclipse project

AWS Import/Export

- Accelerates Moving Large Scale Data
  - In to and out of AWS using portable storage
  - Utilized Amazon's high-speed internal network
  - Often faster than Internet upload/download for large data
- Simple Steps
  - Prepare a portable storage device
  - Request AWS with S3 bucket, key, and shipping address
  - Receive an ID, digital signature, an AWS shipping address
  - Identify and authenticate storage device with digital signature
  - Ship it and wait for Amazon to ship it back ☺
- Data migration, content distribution, offsite backup, disaster recovery, direct data interchange

Simple Queue Service

- Reliable and Scalable Distributed Messaging Framework
  - Create, store, and retrieve text messages (up to 8 KB)
  - Eventual consistency
- Messages
  - Stored until retrieved or four days
  - MessageID, ReceiptHandle, MD5OfBody, Body
- Queues
  - Possible to create unlimited number of queues
- Concerns
  - Queue order, i.e. FIFO, is not guaranteed
  - Message deletion in a queue is not guaranteed
  - Querying a queue is not guaranteed to return all messages
  - Guarantee at least once delivery, but not exactly once

Simple Queue Service

- Visibility Timeout
  - When received, the message will be locked in the queue for a given time
  - Message reappears when the lock “expires”, unless deleted by the earlier recipient
- Access through REST as well as SOAP API’s
- Queue sharing
- Pricing
  - 0.01$ for 10,000 requests
  - Data transfer in
    - 0.10$ per GB after Nov, 2010
  - Data transfer out
    - 0.15$ per GB up to 10TB TO 0.08$ per GB over 150 TB

Using the Queue to Schedule Jobs

- Queue Operations
  - CreateQueue
  - putMessage
  - getMessage
    - visibility time out
  - deleteMessage
- Fault tolerance
- Run sample
  - AWSSampleTwo Eclipse project

Simple Notification Service (SNS)

- Notification Service
  - Scalable, flexible, and cost-effective
  - Topic based publishing
  - Multiple protocol support, e.g. HTTP, email, etc.
  - Eliminates polling through push mechanism
- Simple Steps
  - Create a topic
    - Identify subject or event type
  - Set policies
    - Publisher/subscriber limiting, protocol, etc.
  - Add subscribers
  - Publish message

SimpleDB

- Non-relational data store
  - No need to pre-define schema
- Dataset Indexing and Querying Framework
  - Highly available, scalable, secure, and fast
  - Store and retrieve structured data
  - Eventual consistency
    - Optional consistent reads
  - No transactions
    - Conditional puts/deletes
      - Condition based on existing value

SimpleDB

- Domains
  - Containers to store and query structured data
    - Analogous to a spreadsheet
  - No cross domain querying
- Items
  - Individual objects within domains
    - Analogous to a row in worksheet
    - Contains attributes with values; similar to columns and cells

SimpleDB

- Limitations
  - Domain size, domains per AWS account, Attributes, etc.
- Pricing
  - Free tier
    - 25 machine hours, 1 GB storage
  - Machine utilization
    - 0.14$ per machine hour
  - Data transfer in
    - 0.10$ per GB after Nov, 2010
  - Data transfer out
    - 0.15$ per GB up to 10TB TO 0.08$ per GB over 150 TB
  - Structured storage
    - 0.25$ per GB per month

Using the SimpleDB for monitoring & metadata storage

- Operations
  - CreateDomain
  - ReplaceableItem List
  - batchPutAttributes
- Run sample
  - AWSSampleThree Eclipse project
- Check the Eclipse SimpleDB management view

Relational Database Service (RDS)

- Relational Database as-a-service
  - Full capabilities of MySQL database
  - Easy deployment, managed, secure, scalable, and reliable
- Simple Steps
  - Use AWS Management Console/API to launch a database instance (DB Instance)
  - Connect to DB Instance with any MySQL supported tool
  - Monitor through Amazon CloudWatch
- Features
  - Automated backups
  - DB snapshots
  - Multi-AZ deployments
    - Enhanced availability though multiple availability zones

SimpleDB vs RDS

- SimpleDB
  - No administrative burden at all
  - Scales up/down automatically
  - Highly available
    - No downtime
  - No joins, no transactions
  - Flexible
- RDS
  - Existing applications that require relational database
  - Need to decide the scaling decisions
    - How much storage, what size instance, etc

Elastic Compute Service

- Lease Linux as well as Windows VM’s
  - 32 bit as well as 64 bit VM’s
  - Pay as you go
    - Just a credit card to get going
  - Dynamically scale up/down
  - Increase throughput by horizontal scaling for the same cost
  - ‘root’ access to VM’s
- Pre-configured, template images
  - Create AMI to store customized images

Elastic Compute Service

- Purchasing options
  - On demand
  - Reserved
    - One time fee + usage
  - Spot
    - Bit for unused EC2 capacity
    - Sometimes going 33% of the price of on demand
  - Cluster compute instances
- Elastic IP addresses

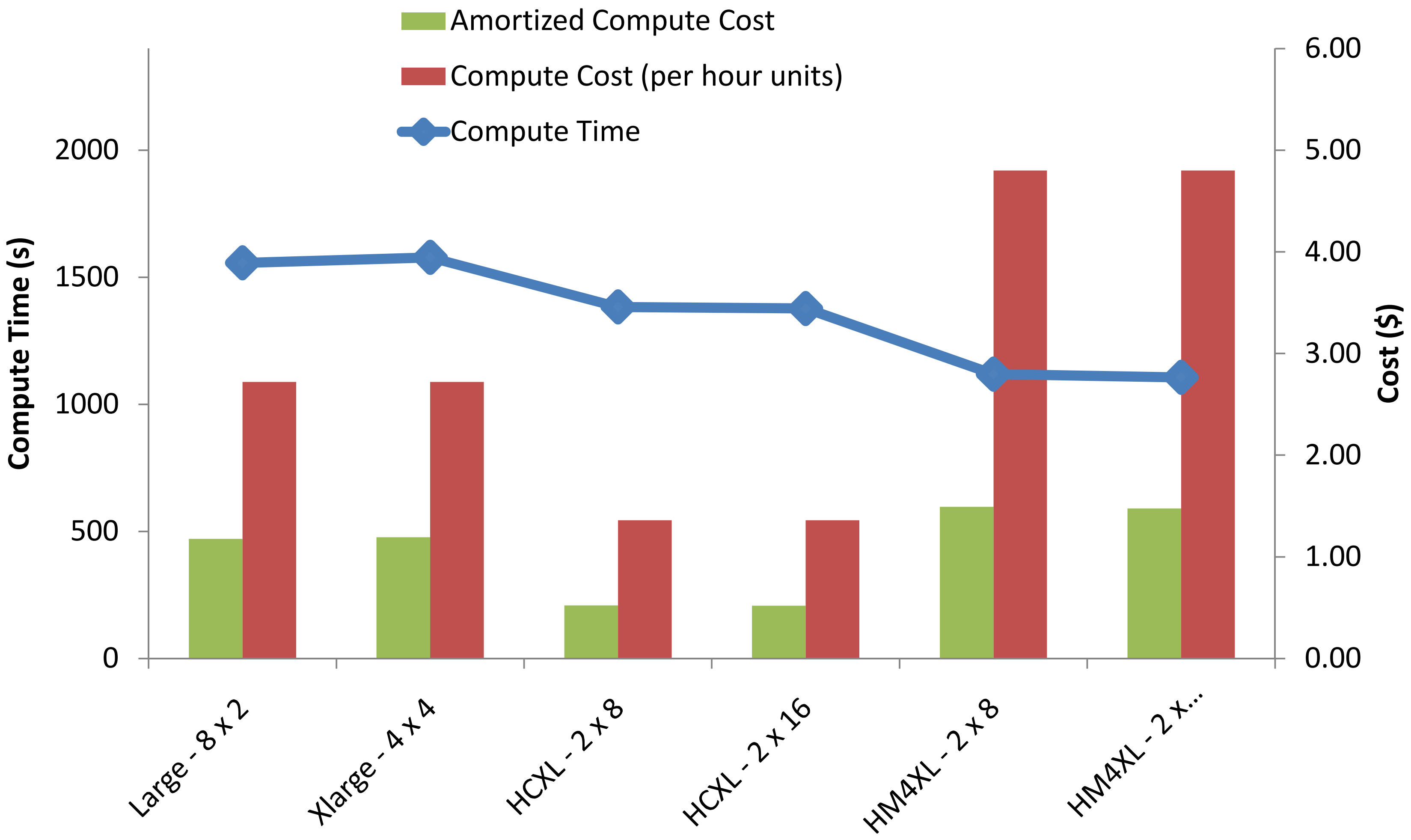
Elastic Compute Service

- Pricing
  - Standard, High-memory, High-CPU, cluster

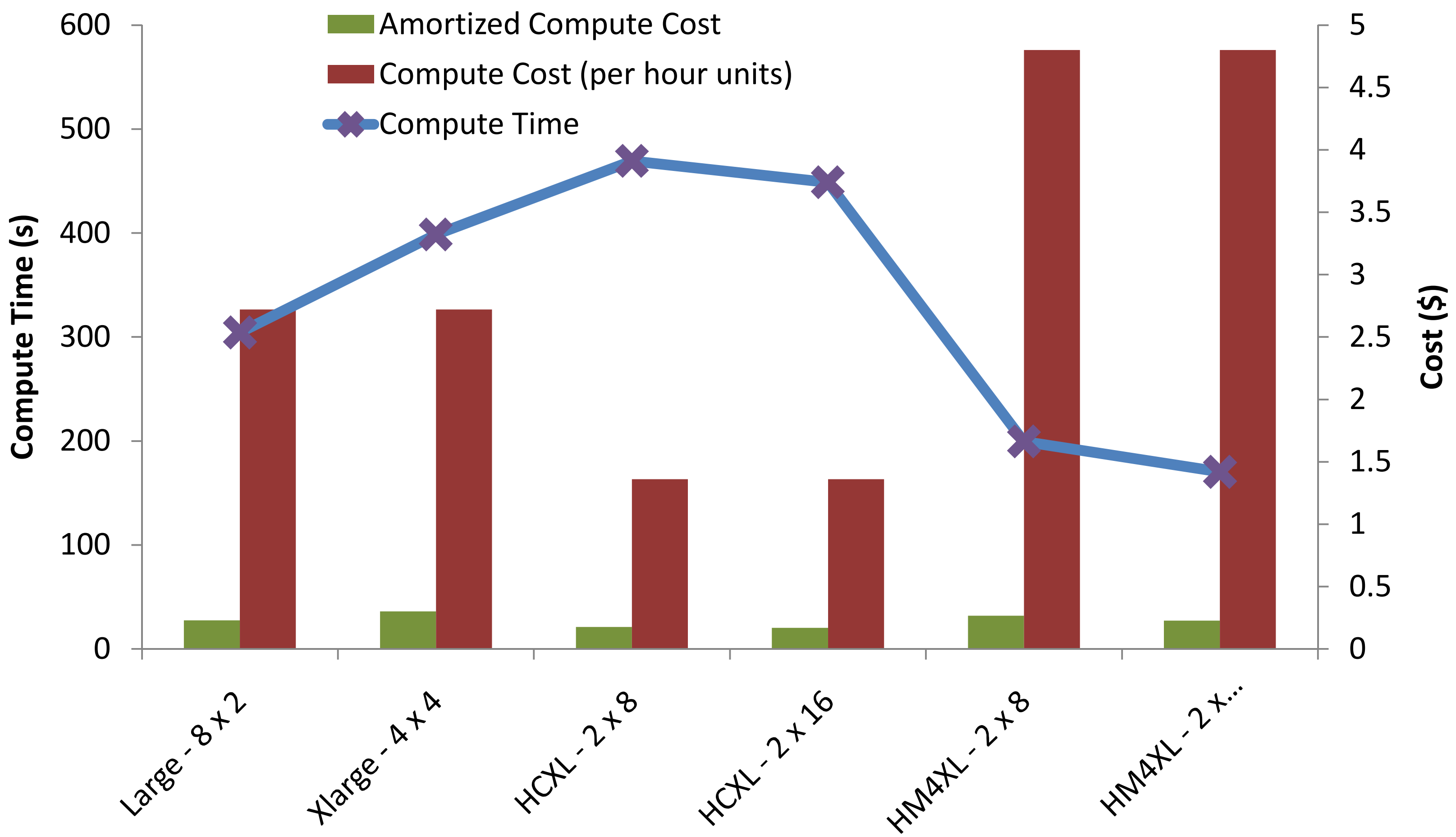
Instance Type	Memory	EC2 compute units	Actual CPU cores	Cost per hour
Large	7.5 GB	4	2 X (~2Ghz)	0.34$
Extra Large	15 GB	8	4 X (~2Ghz)	0.68$
High CPU Extra Large	7 GB	20	8 X (~2.5Ghz)	0.68$
High Memory 4XL	68.4 GB	26	8X (~3.25Ghz)	2.40$
Cluster 4XL	23 GB	33.5	*	1.60$

* 2 x Intel Xeon X5570, quad-core “Nehalem” architecture

Sequence Assembly Performance with different EC2 Instance Types



GTM Interpolation performance with different EC2 Instance Types



- **EC2 HM4XL best performance. EC2 HCXL most economical. EC2 Large most efficient**

HPC in AWS

- Newest announcement
  - Cluster compute instances
- Features
  - Ability to group them in to clusters
  - Low latency full duplex 10 Gbps between instances
  - Published processor architecture
  - Hardware virtual machine
- Limitations
  - No spot or reserved instances
  - No Auto scaling

CloudWatch

- Monitor Amazon Cloud Resources
  - EC2 instances, EBS volumes, Elastic Load Balancers, and RDS database instances
  - Insight to resource utilization, performance, and demand patterns
  - Exposed through Amazon Management Console, API, command line tools
- Pay only for monitoring EC2 instances
- Enables AutoScaling for EC2 instances
  - Dynamically add/remove instances based on CloudWatch metrics
- Pricing
  - 0.015$ per instance hour

Auto Scaling

- Automatically Scale Up/Down EC2 Capacity
  - Conditions are set based on CloudWatch metrics
  - Seamlessly handles demand spikes and drops
  - Consumed through API/command line tools
- Common Uses
  - Automatically scaling EC2 fleet
    - Close follow up of the demand curve
  - Maintaining EC2 fleet at a fixed size
    - Keep healthy EC2 instance number constant
  - Auto scaling with Elastic Load Balancing
    - Efficient load balancing
- Pricing
  - Free with CloudWatch

Deploying the Application in EC2

- Launching instances
  - Spot instances
  - Security groups
- Log-in to instances

- Public AMI for this demo
  - ami-af0ae1c6
  - You need to fill you keys ☺

AMI

- Amazon Machine Images
- Installing the program
- Saving AMI

Run the Program

- Launch the workers
- Run the Driver program
- Monitor using CloudWatch

Elastic MapReduce

- MapReduce as-a-service
  - Utilizes Apache Hadoop, Amazon EC2, and Amazon S3
- Simple Steps
  - Develop MapReduce program
    - Many language support, e.g. Pig, Java, Ruby, C++, etc.
  - Upload data to S3
  - Create and monitor "job flow" through AWS Management Console/command line/API
- Pros
  - Reliable, secure, elastic, and easy
  - Third party tools
  - Seamless integration with EC2, S3
- Cons
  - No tweaking of Hadoop
  - Only supports Hadoop MapReduce framework

EMR bucket names

- S3N Native File System for Hadoop
  - Bucket names should not contain underscores “_”
  - Bucket names should be between 3 and 63 characters long
  - Bucket names should not end with a dash
- Tips for EMR
  - Include at least 3 slashes in the paths
    - S3n://wc-input/
  - Do not use an existing bucket for output
  - More tips
    - http://soam.org/?p=59

Running WordCount using EMR

- Upload data to S3
  - Create a logs folder
- Create job flow
- Debugging & logging
- Monitoring using Lynx
- Download output

Elastic Block Store (EBS)

- Data you save in the running instance are not persistent
- Block level storage volumes
- Off the instance persistent storage
- Ideal for applications like databases
- Pricing
  - 0.10 $ per GB per month provisioned
  - 0.10 $ per million I/O requests

Elastic Load Balancing

- Automatic Distribution of Incoming Traffic
  - Distribute across single or multiple Availability Zones
  - Avoid routing to unhealthy EC2 instances
  - Session affinity load balancing
  - Metrics reported by CloudWatch
  - Auto scale capacity
  - Greater fault tolerance

Virtual Private Cloud (VPC)

- Secure and Seamless Bridge
  - Between a company’s IT infrastructure and AWS cloud
  - Isolated AWS compute resources via VPN
  - Extend existing management capabilities to cloud resources, e.g. security, firewalls, etc.
- Features
  - Bridge with encrypted VPN connection
  - Add EC2 instances to VPC
  - Route traffic between VPC and Internet over VPN to examine/monitor data flow
- Pricing
  - 0.05$ per VPN connection per hour
  - Data transfer out – 0.15$ per GB to 0.08$ per GB

CloudFront

- Content Delivery as-a-service
  - Delivers static and streaming content
  - Global network of edge locations
    - US, Europe, Hong Kong/Singpore, Japan
  - Automatic routing of objects to nearest edge location
  - Reliable, scalable, and fast
- Simple Steps
  - Store the original versions of files in a S3 bucket
  - Create a distribution and register the bucket
  - Use the distribution’s domain name to as an access point

Mechanical Turk

- Marketplace for Human Intelligence Work
  - Access a virtual community of on-demand workers
  - Programmatically access marketplace
  - Define Human Intelligence Tasks (HITs)
    - Identifying objects in an image, transcribing audio, etc.
  - Load HITs to marketplace
  - Qualify workforce
    - Enable qualification tests for tasks requiring special skills
  - Pay only for accepted work/output
  - Retrieve results via service API

Thank You!

- Questions? ☺

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