

TCSS 562:
SOFTWARE ENGINEERING
FOR CLOUD COMPUTING

AWS Overview and Demo,
Cloud Enabling Technology

Wes J. Lloyd
School of Engineering and Technology
University of Washington – Tacoma



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OFFICE HOURS – FALL 2025

■ Thursdays:

- 6:00 to 7:00 pm - CP 229 & Zoom

■ Friday – *** THIS WEEK ***

- 11:00 am to 12:00 pm – ONLINE via Zoom

■ Or email for appointment

➤ Office Hours set based on Student Demographics survey feedback

➤ * - Friday office hours may be adjusted or canceled due meeting conflicts or other obligations. Adjustments will be announced via Canvas.

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OBJECTIVES – 10/30

■ Questions from 10/28

■ Tutorials Questions

■ Tutorial 6 – Serverless Databases

■ Class Activity 2 - Intro to Amazon EC2

■ AWS Overview and demo

■ Class Activity 3 - Intro to AWS Lambda (Tutorial 4 Demo)

■ Ch. 5: Cloud Enabling Technology

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ONLINE DAILY FEEDBACK SURVEY

■ Daily Feedback Quiz in Canvas – Take After Each Class

■ Extra Credit for completing

Announcements

Assignments

Discussions

Zoom

Grades

People

Pages

Files

Quizzes

Collaborations

UW Libraries

UW Resources

Upcoming Assignments

Class Activity 1 – Implicit vs. Explicit Parallelism
Available until Oct 11 at 11:59pm | Due Oct 7 at 7:50pm | ~10 pts

Tutorial 1 - Linux
Available until Oct 19 at 11:59pm | Due Oct 15 at 11:59pm | ~20 pts

Past Assignments

TCSS 562 - Online Daily Feedback Survey - 10/5
Available until Dec 18 at 11:59pm | Due Oct 6 at 8:59pm | ~1 pts

TCSS 562 - Online Daily Feedback Survey - 9/30
Available until Dec 18 at 11:59pm | Due Oct 4 at 8:59pm | ~1 pts

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TCSS 562 - Online Daily Feedback Survey - 10/5

Started: Oct 7 at 1:13am

Quiz Instructions

Question 1

0.5 pts

On a scale of 1 to 10, please classify your perspective on material covered in today's class:

12345678910

Mostly Review To MeEqual New and ReviewMostly New to Me

Question 2

0.5 pts

Please rate the pace of today's class:

12345678910

SlowJust RightFast

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MATERIAL / PACE

Please classify your perspective on material covered in today's class (42 respondents, 28 in-person, 14 online):

1-mostly review, 5-equal new/review, 10-mostly new

Average - 6.71 (↓ - previous 7.19)

Please rate the pace of today's class:

1-slow, 5-just right, 10-fast

Average - 5.45 (↓ - previous 5.49)

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FEEDBACK FROM 10/28

- When I deploy a function to AWS Lambda, does It act just like it does on my local machine?
- For example: If the function contains an infinite loop, does it terminate at some point or does It execute as usual ?
- An AWS Lambda function with an infinite loop will run until it reaches it's configured **timeout** value:
- Under "Configuration", "General Configuration"

→

CodeTestMonitorConfigurationAliasesVersions

General configuration

TriggersPermissionsDestinationsFunction URI

General configuration Info

Description-

Timeout0 min 15 sec

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FEEDBACK - 2

- There are 15 ways to deploy a 4-component application on the cloud, but how do we know which offers the best performance and lowest cost ?
 - For an application with multiple components "brute-force" testing may be necessary:
 - D – Database
 - M – Web Application Server
 - F – File Server
 - L – Logging Server
 - Combining or separating individual components changes the total CPU, disk, and especially network I/O
 - When two components that exchange data are on the same server, network I/O (data transfer) is faster
 - Transfer may not require sending data over an external link
- The Amazon "best practice" is to deploy every component with isolated infrastructure, this is known as "**service isolation**"

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SAMPLE QUESTION 1

- CPU hyperthreads are equivalent to physical CPUs cores and provide identical performance and throughput.

A. True
B. False

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SAMPLE QUESTION 2

- Which taxonomy classification is most often associated with Graphical Processing Units (GPUs)?

A. SIMD
B. MIMD
C. SISD
D. MISD

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SAMPLE QUESTION 3

- In Tutorial 4, after creating a new AWS Lambda function in the AWS Management Console, and uploading the Java jar file, what must be done before attempting to call the function using the AWS CLI?

A. Permission must be granted to write to the CloudWatch logs

B. The function memory size and timeout needs to be adjusted

C. The function handler must be updated

D. A REST 'POST' endpoint must be created using the Amazon API Gateway

E. All of the above

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TERM PROJECT PROPOSALS

- 14 Total term project proposals received
- Team 13 has uploaded proposal 3 times to Canvas
 - There should only be 1 proposal uploaded by the team lead
- Review over weekend
- Status & Feedback to be provided:
 - proposals accepted, or
 - revisions requested

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Slides by Wes J. Lloyd

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- **Tutorials Questions**
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TUTORIAL 3 – DUE OCT 30 (TEAMS OF 2)

- Best Practices for Working with Virtual Machines on Amazon EC2
- https://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2025_tutorial_3.pdf
- Creating a spot VM
- Creating an image from a running VM
- Persistent spot request
- Stopping (pausing) VMs
- EBS volume types
- Ephemeral disks (local disks)
- Mounting and formatting a disk
- Disk performance testing with Bonnie++
- Cost Saving Best Practices

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TUTORIAL 4 – DUE NOV 9

- Introduction to AWS Lambda with the Serverless Application Analytics Framework (SAAF)
https://faculty.washington.edu/wlloyd/courses/tcss562/tutorials/TCSS462_562_f2025_tutorial_4.pdf
- Set up Java development environment
- Introduction to Maven build files for Java
- Create and Deploy “hello” Java AWS Lambda Function
- Create API Gateway REST endpoint
- Sequential testing of “hello” AWS Lambda Function
 - API Gateway endpoint, AWS Lambda CLI Function invocation, AWS Function URL
- Profiling function performance with SAAF
- Concurrent function testing with faas_runner
- Performance analysis using faas_runner reports
- Two function pipeline development task: Caesar Cipher

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TUTORIAL 5 – TO BE POSTED

- Introduction to Lambda II: Working with Files in S3 and CloudWatch Events
- Customize the Request object (add getters/setters)
 - Why do this instead of HashMap ?
- Import dependencies (jar files) into project for AWS S3
- Create an S3 Bucket
- Give your Lambda function(s) permission to work with S3
- Write to the CloudWatch logs
- Use of CloudTrail to generate S3 events
- Creating CloudWatch rule to capture events from CloudTrail
- Have the CloudWatch rule trigger a target Lambda function with a static JSON input object (hard-coded filename)
- **Optional:** for the S3 PutObject event, dynamically extract the name of the file put to the S3 bucket for processing

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CATCH UP FROM 10/28

- Switch to Lecture 9 slides
- L9.72 to L9.97

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AWS OVERVIEW AND DEMO



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ONLINE CLOUD TUTORIALS

- From the eScience Institute @ UW Seattle:
 - <https://escience.washington.edu/>
 - Online cloud workshops
 - Introduction to AWS, Azure, and Google Cloud
 - Task: Deploying a Python DJANGO web application
 - Self-guided workshop materials available online:
 - <https://cloudmaven.github.io/documentation/>
- AWS Educate provides access to many online tutorials / learning resources:
 - <https://aws.amazon.com/education/awseducate/>

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- AWS Management Console
- Elastic Compute Cloud (EC2)
- Instance Storage: Virtual Disks on VMs
- Elastic Block Store: Virtual Disks on VMs
- Elastic File System (EFS)
- Amazon Machine Images (AMIs)
- EC2 Paravirtualization
- EC2 Full Virtualization (hvm)
- EC2 Virtualization Evolution
- (VM) Instance Actions
- EC2 Networking
- EC2 Instance Metadata Service
- Simple Storage Service (S3)
- AWS Command Line Interface (CLI)
- Legacy / Service Specific CLIs
- AMI Tools
- Signing Certificates
- Backing up live disks
- Cost Savings Measures
- Disk images and S3

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Services by category		AWS: provides an ever expanding array of cloud services...	
1 Compute - EC2 - Lightbulb - Lambda - Batch - Elastic Beanstalk - Serverless Application Repository - AWS Outposts - EC2 Instance Builder - AWS App Runner - AWS Sinspace Weaver	2 Customer Enablement - AWS IQ - Managed Services - Activate for Startups - Support	3 Machine Learning - Amazon SageMaker - Amazon Augmented AI - Amazon CodeGuru - Amazon DevOps Guru - Amazon Comprehend - Amazon Forecast - Amazon Fraud Detector - Amazon Kendra - Amazon Personalize - Amazon Polly - Amazon Rekognition - Amazon Transcribe - Amazon Translate - AWS DeepComposer - AWS DeepLens - AWS DeepRecall - AWS Panorama - Amazon Monitor - AWS HealthLake - Amazon Lookout for Vision - Amazon Lookout for Equipment - Amazon Lookout for Metrics - Amazon Lex - Amazon Comprehend Medical - AWS HealthOmics - Amazon Bedrock - AWS HealthImaging	4 AWS Cost Management - AWS Cost Explorer - AWS Budgets - AWS Application Cost Profilers - AWS Application Cost Profiler - AWS Billing Conductor - Billing
5 Containers - Elastic Container Registry - Elastic Container Service - Elastic Kubernetes Service - Red Hat OpenShift Service on AWS	6 Robotics AWS RoboMaker	7 Blockchain Amazon Managed Blockchain	8 Front-end Web & Mobile - AWS Amplify - AWS AppSync - Device Farm - Amazon Location Service
9 Storage - S3 - EFs - F5x - S3 Glacier - Storage Gateway - AWS Backup - AWS Elastic Disaster Recovery	10 Satellite Ground Station	11 Quantum Technologies Amazon Braket	12 Application Integration - Step Functions - Amazon AppFlow - Amazon EventBridge - Amazon MQ - Simple Notification Service - Simple Queue Service - SWF - Managed Apache Airflow
13 Database - RDS - ElasticCache - Neptune - Amazon QLDB - Amazon DocumentDB - Amazon Keyspaces - Amazon Timestream - DynamoDB - Amazon MemoryDB for Redis	14 Management & Governance - AWS Organizations - CloudWatch - AWS Auto Scaling - CloudFormation - Config - OpsWorks - Service Catalog - Systems Manager - Trusted Advisor - Control Tower - AWS License Manager - AWS Well-Architected Tool - AWS Health Dashboard - AWS Chatbot - Lambda Wizard - AWS Compute Optimizer - Resource Groups & Tag Editor - Amazon Grafana - Amazon Prometheus - AWS Resilience Hub - Incident Manager - Service Quotas - AWS Proton - CloudTrail - AWS Resource Explorer - AWS User Notifications - AWS Textract	15 Analytics - Athena - Amazon Redshift - CloudSearch - Amazon OpenSearch Service - Kinesis - QuickSight - Data Pipeline - AWS Data Exchange - AWS Lake Formation - MSK - AWS Glue DataBrew - Amazon FinSight - AWS Glue - EMR - AWS Clean Rooms - Amazon DataZone - AWS Entity Resolution - Managed Apache Flink	16 Business Applications - Amazon Connect - Amazon Pinpoint - Amazon Marketplace - Amazon Chime - Amazon Simple Email Service - Amazon WorkDocs - Amazon WorkMail - AWS Supply Chain - AWS AppFabric - AWS Wicker - Amazon Chime SDK
17 Migration & Transfer - AWS Migration Hub - AWS Application Migration Service - Application Discovery Service - Database Migration Service - AWS Transfer Family - Datalysix - AWS Mainframe Modernization	18 Media Services - Kinesis Video Streams - MediaConvert - MediaLive - MediaPackage - MediaStore	19 Security, Identity, & Compliance - IAM - Resource Access Manager - Cognito	20 End User Computing - WorkSpaces - AppStream 2.0 - WorkSpaces Web
21 Networking & Content Delivery - VPC - CloudFront - Route 53 - API Gateway	22 Internet of Things - IoT 1-Click - IoT Analytics - IoT Device Defender - IoT Device Management - IoT Greengrass - IoT SiteWise - IoT Core - IoT Events - AWS IoT FleetWise		

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AWS EC2

- Elastic Compute Cloud
- Instance types: <https://ec2instances.info>
 - On demand Instance – full price
 - Reserved Instance – contract based where customer guarantees VM rental for a fixed period of time (e.g. 1 year, 3 years, etc.)
Deeper discounts with longer term commitments
 - Spot Instance – portion of cloud capacity reserved for low cost instances, when demand exceeds supply instances are randomly terminated with 2-minute warning
 - Users can make diverse VM requests using different types, zones, regions, etc. to minimize instance terminations
 - Developers can design for failure because often only 1 or 2 VMs in a cluster fail at any given time. They then need to be replaced.
 - Dedicated host – reserved private HW (server)
 - Instance families -
General, compute-optimized, memory-optimized, GPU, etc.

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AWS EC2 - 2

- Storage types
 - Instance storage - ephemeral storage
 - Temporary disk volumes stored on disks local to the VM
 - Evolution: physical hard disk drives (HDDs)
 - Solid state drives (SSDs)
 - Non-volatile memory express (NVMe) drives (closer to DRAM speed)
 - EBS - Elastic block store
 - Remotely hosted disk volumes
 - EFS - Elastic file system
 - Shared file system based on network file system
 - VMs, Lambdas, Containers mount/interact with shared file system
 - Somewhat expensive

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INSTANCE STORAGE

- Also called ephemeral storage
- Persisted using images saved to S3 (simple storage service)
 - ~2.3¢ per GB/month on S3
 - 5GB of free tier storage space on S3
- Requires “burning” an image
- Multi-step process:
 - Create image files
 - Upload chunks to S3
 - Register image
- Launching a VM
 - Requires downloading image components from S3, reassembling them... is potentially slow
- VMs with instance store backed root volumes not pause-able
- Historically root volume limited to 10-GB max– **faster imaging...**

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ELASTIC BLOCK STORE

- EBS provides 1 drive to 1 virtual machine (**1 : 1**) (**not shared**)
- EBS cost model is different than instance storage (uses S3)
 - ~10¢ per GB/month for General Purpose Storage (GP2)
 - ~8¢ per GB/month for General Purpose Storage (GP3)
 - 30GB of free tier storage space
- EBS provides “live” mountable volumes
 - Listed under volumes
 - **Data volumes**: can be mounted/unmounted to any VM, dynamically at any time
 - **Root volumes**: hosts OS files and acts as a boot device for VM
 - In Linux drives are linked to a mount point “directory”
- Snapshots back up EBS volume data to S3
 - Enables replication (required for horizontal scaling)
 - EBS volumes not actively used should be snapshotted, and deleted to save EBS costs...

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EBS VOLUME TYPES - 2

- Metric: I/O Operations per Second (IOPS)
- General Purpose 2 (GP2)
 - 3 IOPS per GB, min 100 IOPS (<34GB), max of 16,000 IOPS
 - 250MB/sec throughput per volume
- General Purpose 3 (GP3 – new Dec 2020)
 - Max 16,000 IOPS, Default 3,000 IOPS
 - GP2 requires creating a 1TB volume to obtain 3,000 IOPS
 - GP3 all volumes start at 3000 IOPS and 125 MB/s throughput
 - 1000 additional IOPS beyond 3000 is \$5/month up to 16000 IOPS
 - 125 MB/s additional throughput is \$5/month up to 1000 MB/s throughput

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EBS VOLUME TYPES - 3

- Provisioned IOPS (IO1)
 - Legacy, associated with GP2
 - Allows user to create custom disk volumes where they pay for a specified IOPS and throughput
 - 32,000 IOPS, and 500 MB/sec throughput per volume MAX
- Throughput Optimized HDD (ST1)
 - Up to 500 MB/sec throughput
 - 4.5 ¢ per GB/month
- Cold HDD (SC1)
 - Up to 250 MB/sec throughput
 - 2.5 ¢ per GB/month
- Magnetic
 - Up to 90 MB/sec throughput per volume
 - 5 ¢ per GB/month

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ELASTIC FILE SYSTEM (EFS)

- EFS provides 1 volume to many client (1 : n) shared storage
- Network file system (based on NFSv4 protocol)
- Shared file system for EC2, Fargate/ECS, Lambda
- Enables mounting (sharing) the same disk “volume” for R/W access across multiple instances at the same time
- Different performance and limitations vs. EBS/Instance store
- Implementation uses abstracted EC2 instances
- ~ 30 ¢ per GB/month storage – **default burstable throughput**
- **Throughput modes:**
- Can modify modes only once every 24 hours
- **Burstable Throughput Model:**
 - Baseline – 50kb/sec per GB
 - Burst – 100MB/sec per GB (for volumes sized 10GB to 1024 GB)
 - Credits - .72 minutes/day per GB

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ELASTIC FILE SYSTEM (EFS) - 2

- **Burstable Throughput Rates**
 - Throughput rates: baseline vs burst
 - Credit model for bursting: maximum burst per day

Information subject to revision

File System Size (GiB)	Baseline Aggregate Throughput (MiB/s)	Burst Aggregate Throughput (MiB/s)	Maximum Burst Duration (Min/Day)	% of Time File System Can Burst (Per Day)
10	0.5	100	7.2	0.5%
256	12.5	100	180	12.5%
512	25.0	100	360	25.0%
1024	50.0	100	720	50.0%
1536	75.0	150	720	50.0%
2048	100.0	200	720	50.0%
3072	150.0	300	720	50.0%
4096	200.0	400	720	50.0%

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ELASTIC FILE SYSTEM (EFS) - 3

Information subject to revision

- **Throughput Models**
- **Provisioned Throughput Model**
- **For applications with:**
 - high performance requirements, but low storage requirements
- **Get high levels of performance w/o overprovisioning capacity**
- **\$6 MB/s-Month (Virginia Region)**
 - Default is 50kb/sec for 1 GB, .05 MB/s = 30 ¢ per GB/month
- **If file system metered size has higher baseline rate based on size, file system follows default Amazon EFS Bursting Throughput model**
 - No charges for Provisioned Throughput below file system's entitlement in Bursting Throughput mode
 - Throughput entitlement = 50kb/sec per GB

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ELASTIC FILE SYSTEM (EFS) - 4

Information subject to revision

Performance Comparison, Amazon EFS and Amazon EBS

	Amazon EFS	Amazon EBS Provisioned IOPS
Per-operation latency	Low, consistent latency.	Lowest, consistent latency.
Throughput scale	10+ GB per second.	Up to 2 GB per second.

Storage Characteristics Comparison, Amazon EFS and Amazon EBS

	Amazon EFS	Amazon EBS Provisioned IOPS
Availability and durability	Data is stored redundantly across multiple AZs.	Data is stored redundantly in a single AZ.
Access	Up to thousands of Amazon EC2 instances, from multiple AZs, can connect concurrently to a file system.	A single Amazon EC2 instance in a single AZ can connect to a file system.
Use cases	Big data and analytics, media processing workflows, content management, web serving, and home directories.	Boot volumes, transactional and NoSQL databases, data warehousing, and ETL.

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AMAZON MACHINE IMAGES

- AMIs
- Unique for the operating system (root device image)
- Two types
 - Instance store
 - Elastic block store (EBS)
- Deleting requires multiple steps
 - Deregister AMI
 - Delete associated data - (*files in S3*)
- Forgetting both steps leads to costly “orphaned” data
 - No way to instantiate a VM from deregistered AMIs
 - Data still in S3 resulting in charges

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EC2 VIRTUALIZATION - PARAVIRTUAL

- 1st, 2nd, 3rd, 4th generation → XEN-based
- 5th generation Instances → AWS Nitro virtualization
- XEN - two virtualization modes
- XEN Paravirtualization “paravirtual”
 - 10GB Amazon Machine Image – base image size limit
 - Addressed poor performance of old XEN HVM mode
 - I/O performed using special XEN kernel with XEN paravirtual mode optimizations for better performance
 - Requires OS to have an available paravirtual kernel
 - PV VMs: will use common **AKI** files on AWS – **Amazon kernel Image(s)**
 - Look for common identifiers

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EC2 VIRTUALIZATION - HVM

- **XEN HVM mode**
 - Full virtualization – no special OS kernel required
 - Computer entirely simulated
 - MS Windows runs in “hvm” mode
 - Allows work around: 10GB instance store root volume limit
 - Kernel is on the root volume (under /boot)
 - No AKIs (kernel images)
 - Commonly used today (*EBS-backed instances*)

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EC2 VIRTUALIZATION - NITRO

- **Nitro based on Kernel-based-virtual-machines**
 - Stripped down version of Linux KVM hypervisor
 - Uses KVM core kernel module
 - I/O access has a direct path to the device
- **Goal:** provide indistinguishable performance from bare metal

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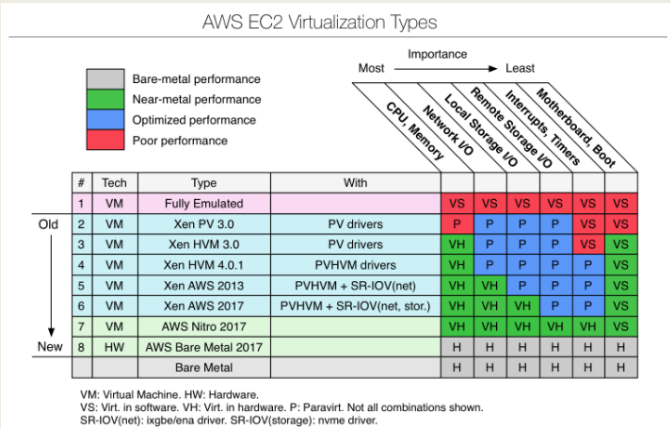
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EVOLUTION OF AWS VIRTUALIZATION

From: <http://www.brendangregg.com/blog/2017-11-29/aws-ec2-virtualization-2017.html>



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INSTANCE ACTIONS

- Stop
 - Costs of “pausing” an instance
- Terminate
- Reboot
- Image management
- Creating an image
 - EBS (snapshot)
- Bundle image
 - Instance-store

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EC2 INSTANCE: NETWORK ACCESS

- Public IP address
- Elastic IPs
 - Costs: in-use FREE, not in-use ~12 ¢/day
 - Not in-use (e.g. “paused” EBS-backed instances)
- Security groups
 - E.g. firewall
- Identity access management (IAM)
 - AWS accounts, groups
- VPC / Subnet / Internet Gateway / Router
- NAT-Gateway

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WE WILL RETURN AT 4:50 PM



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SIMPLE VPC

Recommended when using Amazon EC2

Destination	Target
10.0.0.0/16	local
0.0.0.0/0	igw-id

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VPC SPANNING AVAILABILITY ZONES

Destination	Target
10.0.0.0/16	local

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INSPECTING INSTANCE INFORMATION

- EC2 VMs run a local metadata service
- Can query instance metadata to self discover cloud configuration attributes
- Find your instance ID:

```
curl http://169.254.169.254/  
curl http://169.254.169.254/latest/  
curl http://169.254.169.254/latest/meta-data/  
curl http://169.254.169.254/latest/meta-data/instance-id  
; echo
```
- `ec2-get-info` command
- Python API that provides easy/formatted access to metadata

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SIMPLE STORAGE SERVICE (S3)

- Key-value blob storage
- What is the difference vs. key-value stores (NoSQL DB)?
- Can mount an S3 bucket as a volume in Linux
 - Supports common file-system operations
- Provides eventual consistency
- Can store Lambda function state for life of container.

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AWS CLI

- Launch Ubuntu 16.04 VM
 - Instances | Launch Instance
- Install the general AWS CLI
 - `sudo apt install awscli`
- Create config file
[default]

```
aws_access_key_id = <access key id>  
aws_secret_access_key = <secret access key>  
region = us-east-1
```

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AWS CLI - 2

- **Creating access keys:** IAM | Users | Security Credentials | Access Keys | Create Access Keys

Access key ID	Created	Last used	Status
AKIAJZVNGFP6PP6MZYQ	2017-04-02 22:56 PDT	2017-04-04 00:13 PDT with ec2 in N/A	Active Make inactive

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AWS CLI - 3

- Export the config file
 - Add to /home/ubuntu/.bashrc

```
export AWS_CONFIG_FILE=$HOME/.aws/config
```
- Try some commands:
 - `aws help`
 - `aws command help`
 - `aws ec2 help`
 - `aws ec2 describes-instances --output text`
 - `aws ec2 describe-instances --output json`
 - `aws s3 ls`
 - `aws s3 ls vmscaleruw`

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LEGACY / SERVICE SPECIFIC CLI(S)

- `sudo apt install ec2-api-tools`
- Provides more concise output
- Additional functionality
- Define variables in .bashrc or another sourced script:
 - `export AWS_ACCESS_KEY={your access key}`
 - `export AWS_SECRET_KEY={your secret key}`
- `ec2-describe-instances`
- `ec2-run-instances`
- `ec2-request-spot-instances`
- EC2 management from Java:
 - <http://docs.aws.amazon.com/AWSJavaSDK/latest/javadoc/index.html>
- Some AWS services have separate CLI installable by package

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AMI TOOLS

- Amazon Machine Images tools
- For working with disk volumes
- Can create live copies of any disk volume
 - Your local laptop, ec2 root volume (EBS), ec2 ephemeral disk
- Installation:
<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ami-tools-commands.html>
- AMI tools reference:
<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ami-tools-commands.html>
- Some functions may require private key & certificate files

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PRIVATE KEY AND CERTIFICATE FILE

- Install openssl package on VM

```
# generate private key file
$openssl genrsa 2048 > mykey.pk

# generate signing certificate file
$openssl req -new -x509 -nodes -sha256 -days 36500 -key mykey.pk -outform PEM -out signing.cert
```

- Add signing.cert to IAM | Users | Security Credentials |
- - new signing certificate - -
- From: http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/setup-ami-tools.html?icmpid=docs_iam_console#ami-tools-create-certificate

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PRIVATE KEY, CERTIFICATE FILE

- These files, combined with your `AWS_ACCESS_KEY` and `AWS_SECRET_KEY` and `AWS_ACCOUNT_ID` enable you to publish new images from the CLI
- Objective:
 1. Configure VM with software stack
 2. Burn new image for VM replication (**horizontal scaling**)
- An alternative to bundling volumes and storing in S3 is to use a containerization tool such as Docker. . .
- Create image script . . .

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SCRIPT: CREATE A NEW INSTANCE STORE
IMAGE FROM LIVE DISK VOLUME

```
image=$1
echo "Burn image $image"
echo "$image" > image.id
mkdir /mnt/tmp
AWS_KEY_DIR=/home/ubuntu/.aws
export EC2_URL=http://ec2.amazonaws.com
export S3_URL=https://s3.amazonaws.com
export EC2_PRIVATE_KEY=${AWS_KEY_DIR}/mykey.pk
export EC2_CERT=${AWS_KEY_DIR}/signing.cert
export AWS_USER_ID={your account id}
export AWS_ACCESS_KEY={your aws access key}
export AWS_SECRET_KEY={your aws secret key}
ec2-bundle-vol -s 5000 -u ${AWS_USER_ID} -c ${EC2_CERT} -k ${EC2_PRIVATE_KEY}
--ec2cert /etc/ec2/amiutils/cert-ec2.pem --no-inherit -r x86_64 -p $image -i
/etc/ec2/amiutils/cert-ec2.pem
cd /tmp
ec2-upload-bundle -b tcss562 -m $image.manifest.xml -a ${AWS_ACCESS_KEY} -s
${AWS_SECRET_KEY} --url http://s3.amazonaws.com --location US
ec2-register tcss562/$image.manifest.xml --region us-east-1 --kernel aki-
88aa75e1
```

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MAKE A DISK FROM AN IMAGE FILE

```
# ***** ON THE LOCAL COMPUTER *****  
# create 1200 MB virtual disk = 1,258,291,200 bytes  
sudo dd if=/dev/zero of=vhd.img bs=1M count=1200  
# format the disk using the ext4 filesystem  
sudo mkfs.ext4 vhd.img  
# mount the disk at "/mnt"  
sudo mount -t auto -o loop vhd.img /mnt  
# check that the disk is mounted  
df -h  
# create a hello file (or copy data) to the new virtual disk  
cd /mnt  
sudo echo "hello world !" > hello.txt  
ls -l  
cd  
# unmount the virtual disk  
sudo umount /mnt
```

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COMPRESS IMAGE, PUSH TO S3

```
# compress the disk  
bzip2 vhd.img  
  
# push the disk image to S3  
aws s3 cp vhd.img.bz2 s3://tcss562-f21-images
```

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RESTORE ON THE CLOUD

```
# ***** ON THE AWS EC2 VM *****  
# with the awscli installed and configured  
  
# download the image from S3  
aws s3 cp s3://tcss562-f21-images/vhd.img.bz2 vhd.img.bz2  
  
# uncompress the image  
bzip2 -d vhd.img.bz2  
  
# we need to calculate the number of sectors for the  
partition  
# disk sectors are 512 bytes each  
# divide the disk size by 512 to determine sectors  
# sectors = 1258291200 / 512 = 2459648  
  
# create a disk partition for this disk that is  
# 2459648 sectors in size using the ephemeral drive or  
# a newly mounted EBS volume that is unformatted  
  
sudo fdisk /dev/nvme1n1
```

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PARTITION THE DISK

Welcome to fdisk (util-linux 2.34).

Command (m for help): **n**

Partition type
 p primary (0 primary, 0 extended, 4 free)
 e extended (container for logical partitions)

Select (default p): **p**

Partition number (1-4, default 1): **1**

First sector (2048-97656249, default 2048): **2048**

Last sector, +/-sectors or +/-size{K,M,G,T,P} (2048-97656249, default 97656249): **2459648**

Created a new partition 1 of type 'Linux' and of size 1.2 GiB.

Command (m for help): **t**

Selected partition **1**

Hex code (type L to list all codes): 83

Changed type of partition 'Linux' to 'Linux'.

Command (m for help): **w (to write and exit)**

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COPY DATA TO NEW DISK PARTITION

```
# now check if the partition has been created.
# it should be listed as /dev/nvme1n1p1:
ls /dev/nvme1n1*

# now copy the data to the partition
sudo dd if=vhd.img of=/dev/nvme1n1p1

# mount the disk
sudo mount /dev/nvme1n1p1 /mnt

# and check if the hello file is there
cat /mnt/hello.txt

# we were able to copy the disk image to the cloud
# and we never had to format the cloud disk
# this examples copies a filesystem from a local disk
# to the cloud disk
```

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FOR MORE INFORMATION

- Example script:
<https://faculty.washington.edu/wlloyd/courses/tcss562/examples/copy-disk-to-cloud.sh>
- URLs:
<https://help.ubuntu.com/community/DriveImaging>
<https://www.tecmint.com/create-virtual-harddisk-volume-in-linux/>

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COST SAVINGS MEASURES

- **From Tutorial 3:**
- **#1: ALWAYS USE SPOT INSTANCES FOR COURSE/RESEARCH RELATED PROJECTS**
- **#2: NEVER LEAVE AN EBS VOLUME IN YOUR ACCOUNT THAT IS NOT ATTACHED TO A RUNNING VM**
- **#3: BE CAREFUL USING PERSISTENT REQUESTS FOR SPOT INSTANCES**
- **#4: TO SAVE/PERSIST DATA, USE EBS SNAPSHOTS AND THEN**
- **#5: DELETE EBS VOLUMES FOR TERMINATED EC2 INSTANCES.**
- **#6: UNUSED SNAPSHOTS AND UNUSED EBS VOLUMES SHOULD BE PROMPTLY DELETED !!**
- **#7: USE PERSISTENT SPOT REQUESTS AND THE “STOP” FEATURE TO PAUSE VMS DURING SHORT BREAKS**

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OBJECTIVES – 10/30

- Questions from 10/28
- Tutorials Questions
- Tutorial 6 - Serverless Databases - Next Week
- Class Activity 2 - Intro to Amazon EC2
- AWS Overview and demo
- **Class Activity 3 - Intro to AWS Lambda (Tutorial 4 Demo)**
- Ch. 5: Cloud Enabling Technology

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CLOUD ENABLING TECHNOLOGY



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QUESTIONS



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