



Cold
Spring
Harbor
Laboratory

Introduction to cloud computing

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Advanced Sequencing Technologies & Applications

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Learning Objectives

- Introduction to cloud computing concepts
- Introduction to cloud computing providers
- Use the Amazon EC2 console to create an instance for each student
 - Will be used for many hands-on tutorials throughout the course
- How to log into your cloud instance

Disk Capacity vs Sequencing Capacity, 1990-2012

Disk Storage
(Mbytes/\$)

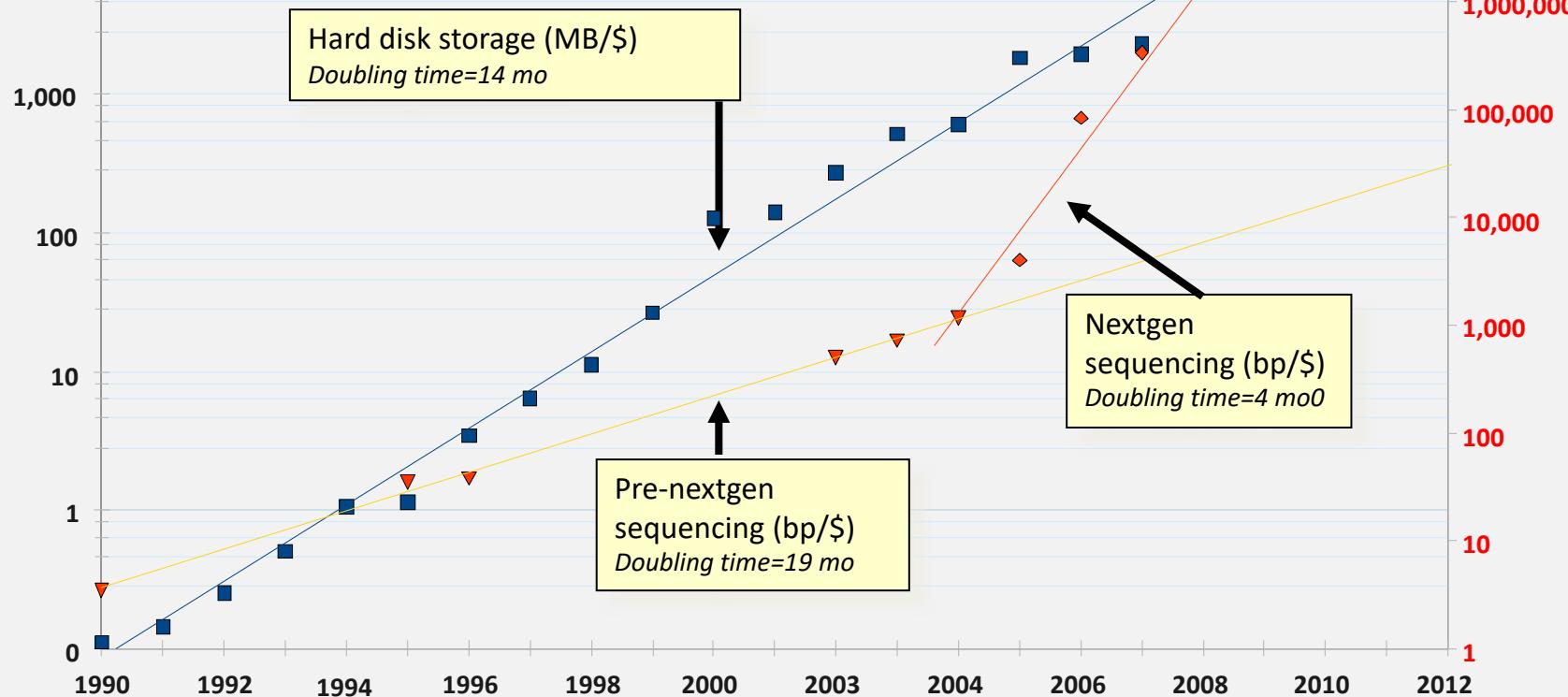
Stein Genome Biology 2010, 11:207
<http://genomebiology.com/2010/11/5/207>



REVIEW

The case for cloud computing in genome informatics

Lincoln D Stein*



About DNA and computers

- We hit the \$1000 genome* in ~2016
 - Need to think about the \$100 genome
- The doubling time of sequencing has been ~5-6 months.
- The doubling time of storage and network bandwidth is ~12 months.
- The doubling time of CPU speed is ~18 months.
- The cost of sequencing a base pair will eventually equal the cost of storing a base pair

What is the general biomedical scientist to do?

- Lots of data
- Poor IT infrastructure in many labs
- Where do they go?
- Write more grants?
- Get bigger hardware?

Cloud computing providers

- Amazon AWS
 - <https://aws.amazon.com/>
- Google cloud
 - <https://cloud.google.com/>
- Digital ocean
 - <https://www.digitalocean.com/>
- Microsoft Azure
 - <https://azure.microsoft.com/en-us/>
- More...

Amazon Web Services (AWS)

- Infinite storage (scalable): S3 (simple storage service)
- Compute per hour: EC2 (elastic cloud computing)
- Ready when you are High Performance Computing
- Multiple football fields of HPC throughout the world
- HPC are expanded at one container at a time:



Some of the challenges of cloud computing:

- Not cheap!
- Getting files to and from there
- Not the best solution for everybody
- Standardization
- PHI: personal health information & security concerns
- In the USA: HIPAA act, PSQIA act, HITECH act, Patriot act, CLIA and CAP programs, etc.
 - <http://www.biostars.org/p/70204/>

Some of the advantages of cloud computing:

- We received a grant from Amazon, so supported by ‘AWS in Education grant award’.
- There are better ways of transferring large files, and now AWS makes it free to upload files.
- A number of datasets exist on AWS (e.g. 1000 genome data).
- Many useful bioinformatics AMI’s (Amazon Machine Images) exist on AWS: e.g. cloudbiolinux & CloudMan (Galaxy) – now one for this course!
- Many flavors of cloud available, not just AWS

Key AWS concepts and terminology

- AWS - Amazon Web Services. A collection of cloud computing services provided by Amazon.
- EC2 - Elastic Compute. An AWS service that allows you to configure and rent computers to meet your compute needs on an as needed basis.
- EBS - Elastic Block Storage. A data storage solution that allows you to rent disk storage and associate that storage with your compute resources. EBS volumes are generally backed by SSD devices.

Key AWS concepts and terminology

- S3 - Simple storage service. Cheaper than EBS and allows for storage of larger amounts of data with some drawbacks compared to EBS. S3 volumes store data as objects that are accessed by an API or command line interface or other application designed to work with S3. EBS volumes on the other hand can be mounted as if they were a local disk drive associated with the Instance.
- SSD - Solid state drive. A particular type of storage hardware that is generally faster and more expensive than traditional hard drives.

Key AWS concepts and terminology

- HDD - Hard disk drive. A particular type of storage hardware that is generally cheaper and larger but slower than SSD. HDD drives are traditional hard drives that access data on a spinning magnetic disk.
- Ephemeral storage - Also known as Instance Store storage. Data storage associated with an EC2 instance that is local to the host computer. This storage does not persist when the instance is stopped or terminated. In other words, anything you store in this way will be lost if the system is stopped or terminated. Instance store volumes may be backed by SSD or HDD devices.

What is a Region?

- An AWS Region is set of compute resources that Amazon maintains (like the Data Center image shown before)
- Each Region corresponds to a physical warehouse of compute hardware (computers, storage, networking, etc.).
- At the time of writing there are 14 regions: (US East (N.Virginia), US East (Ohio), US West (Oregon), US West (N. California), Canada (Central), EU (Ireland), EU (Frankfurt), EU (London), Asia Pacific (Singapore), Asia Pacific (Sydney), Asia Pacific (Seoul), Asia Pacific (Tokyo), Asia Pacific (Mumbai) and South America (Sao Paulo).
- When you are logged into the AWS EC2 console you are always operating in one of these regions.

What is a Region?

- Current region shown in the upper right corner of console
- It is important to pay attention to what region you are using for several reasons.
 - When you create an EC2 instance (EBS volume, etc) in one region you won't see it in another region.
 - The cost to use many AWS resources varies by region.
 - The region may influence network performance when you are accessing the instance, especially if you need to transfer large amounts of data in or out.
 - Billing is tracked separately for each region
 - Generally you should choose a region that is close to you or your users. But cost is also a consideration.

What is difference between the 'Start', 'Stop', 'Reboot', and 'Terminate' (Instance States)?

- Start – turn on an EC2 instance that you have previously created
- Stop – turn off an EC2 instance that you have previously created
- Reboot – restart an EC2 instance
- Terminate – permanently stop and destroy an EC2 instance. Any associated EBS volumes may also be destroyed at this time depending on configuration

What is an AMI/snapshot?

- AMI (Amazon Machine Image) – a template that specifies how to launch EC2 instances
 - Root volume with operating system (OS), pre-installed applications, etc
 - Launch permissions determine who can use the AMI
 - Specification of (data) volumes to attach when launched
- You can create an AMI for any instance you have created/configured
- AMI can be made public for sharing (region-specific)
- Creating an AMI involves creating a snapshot of the root and any attached volumes. You will be charged to store this snapshot.

I can not log into my EC2 instance, what might have gone wrong?

- Is your instance running?
- Are you providing the correct path to your key file?
- Is it the correct key file?
- Have you set the permissions for your key file correctly?
- Did you specify a valid user for your AMI (e.g., ubuntu)?
- Did you specify the correct IP address?
- Does the Security Group for the instance allow access for your connection protocol (e.g., SSH) and location?

How much does it cost to use AWS EC2 resources?

| Linux | RHEL | SLES | Windows | Windows with SQL Standard | Windows with SQL Web |
|--------------------------------------|------|--------------|-----------------------|---------------------------|----------------------|
| Windows with SQL Enterprise | | | | | |
| Region: US West (Oregon) | | | | | |
| vCPU | ECU | Memory (GiB) | Instance Storage (GB) | Linux/UNIX Usage | |
| General Purpose - Current Generation | | | | | |
| t2.nano | 1 | Variable | 0.5 | EBS Only | \$0.0058 per Hour |
| t2.micro | 1 | Variable | 1 | EBS Only | \$0.0116 per Hour |
| t2.small | 1 | Variable | 2 | EBS Only | \$0.023 per Hour |
| t2.medium | 2 | Variable | 4 | EBS Only | \$0.0464 per Hour |
| t2.large | 2 | Variable | 8 | EBS Only | \$0.0928 per Hour |
| t2.xlarge | 4 | Variable | 16 | EBS Only | \$0.1856 per Hour |
| t2.2xlarge | 8 | Variable | 32 | EBS Only | \$0.3712 per Hour |
| m4.large | 2 | 6.5 | 8 | EBS Only | \$0.1 per Hour |
| m4.xlarge | 4 | 13 | 16 | EBS Only | \$0.2 per Hour |
| m4.2xlarge | 8 | 26 | 32 | EBS Only | \$0.4 per Hour |

Data transfer (GB): In: free or \$0.01; Out: free, \$0.01 or \$0.02

EBS storage (GB/Month): \$0.10

S3 storage (GB/Month): \$0.023 standard, \$0.0125 infrequent access, or
\$0.004 glacier

Why am I still getting a monthly bill?

- Generally you get an accounting of usage and cost on a 30 day cycle
 - Pricing is per instance-hour (now instance-second!) consumed for each instance type.
 - Also charges for storage, transfers, etc
- Be aware of regions!
- Even when an instance is stopped, storage for root or other EBS volumes persist
- Creating AMIs/snapshots requires storage
- Explore the billing and cost management tools of AWS to track your spending, set warnings, etc

Amazon AWS documentation

https://rnabio.org/module-00-setup/0000/04/01/Intro_to_AWS/

<http://aws.amazon.com/console/>

In this workshop:

- Some tools (data) are
 - on your computer
 - on the web
 - on the cloud.
- You will become efficient at traversing these various spaces, and finding resources you need, and using what is best for you.
- There are different ways of using the cloud:
 1. Command line (like your own very powerful Unix box)
 2. With a web-browser (e.g. Galaxy): not in this workshop

Things we have set up:

- Loaded data files to a web server
- We brought up an Ubuntu (Linux) instance, and loaded a whole bunch of software for NGS analysis.
- We will clone this and create separate instances for everybody in the class.
- We've simplified the security: you basically all have the same login and file access, and opened ports. In your own world you would be more secure.

Logging into Amazon AWS

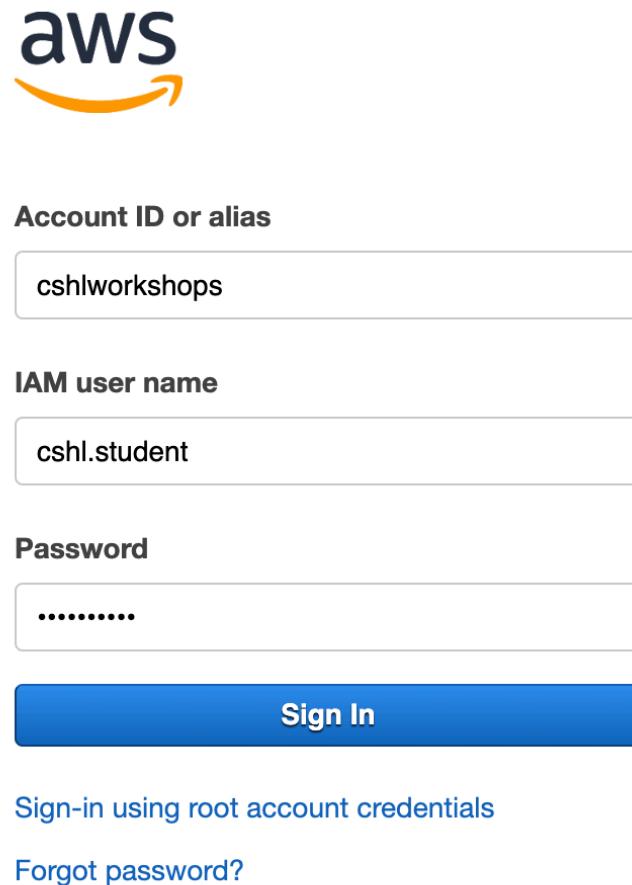
Go to course wiki, “Accessing the cloud” page

The screenshot shows a web browser window with the following details:

- Title Bar:** C-SEQTEC 2018: Wiki
- Toolbar:** Home, View, Edit, Info, History, Watch, Search: [empty input field], RSS icon, Print icon.
- Page Header:** Accessing The Cloud, Recently visited.
- Page Content:**
 - Section Title:** Instructions for students to access their AWC EC2 cloud instance
 - Text:** Most hands on components of this workshop will be performed on Amazon AWS EC2 instances. Each student is assigned their own instance (instance type) running the Ubuntu operating system. Use the following instructions to log in.
 - Text:** Visit AWS Console to create instance:
 - List:**
 - AWS Console Signin: <https://cshlworkshops.signin.aws.amazon.com/console>
 - User Name: cshl.student
 - Password: seqtec2018
 - Zone: US West (Oregon)
 - Course AMI: cshl-seqtech-2018v2 (ami-0ee7d04a5b96e28c6)
 - Text:** Download pem file (right-click and "Save Link As..."; take note of where you download it to):
 - List:**
 - [cshl_2018_student.pem](#)
 - Text:** Connect to AWS instance via Terminal:
 - Terminal Output:**

```
chmod 400 cshl_2018_student.pem
ssh -i cshl_2018_student.pem ubuntu@YOUR_IP_ADDRESS
```

Login to AWS console



The image shows the AWS sign-in page. It features the AWS logo at the top. Below it are three input fields: 'Account ID or alias' containing 'cshlworkshops', 'IAM user name' containing 'cshl.student', and 'Password' represented by a series of dots. A large blue 'Sign In' button is centered below these fields. A red arrow points to the right side of the 'Sign In' button. At the bottom of the page are two links: 'Sign-in using root account credentials' and 'Forgot password?'

Account ID or alias
cshlworkshops

IAM user name
cshl.student

Password
.....

Sign In

Sign-in using root account credentials

Forgot password?

<https://cshlworkshops.signin.aws.amazon.com/console>

Select "EC2" service

The screenshot shows the AWS Services menu. On the left, there's a sidebar with links like History, EC2, Console Home, S3, Billing, IAM, and Simple Queue Service. The main area is a grid of service categories. In the 'Compute' category, 'EC2' is highlighted with a red arrow pointing to it. To the right of the grid, large text reads 'Make sure you are in Virginia region', with a red arrow pointing to the 'N. Virginia' link in the top navigation bar.

History

Services ▾ Resource Groups ▾

Find a service by name or feature (for example, EC2, S3 or VM, storage).

Group A-Z

Compute

- EC2
- Lightsail ↗
- ECR
- ECS
- EKS
- Lambda
- Batch
- Elastic Beanstalk
- Serverless Application Repository

Robotics

- AWS RoboMaker

Customer Enablement

- AWS IQ ↗
- Support
- Managed Services

Analytics

- Athena
- EMR
- CloudSearch
- Elasticsearch
- Kinesis
- QuickSight ↗
- Data Pipeline
- AWS Glue
- AWS Lake Formation
- MSK

Business Applications

- WorkSpaces
- AppStream 2.0
- WorkDocs
- WorkLink

Storage

- S3
- EFS
- FSx
- S3 Glacier
- Storage Gateway
- AWS Backup

Satellite

- Ground Station

Security, Identity, & Compliance

- IAM
- Resource Access Manager
- Cognito
- Secrets Manager
- GuardDuty
- Inspector
- Amazon Macie ↗
- AWS Single Sign-On
- Certificate Manager

Management & Governance

- AWS Organizations
- CloudWatch
- AWS Auto Scaling
- CloudFormation
- CloudTrail

Internet Of Things

- IoT Core
- Amazon FreeRTOS
- IoT 1-Click
- IoT Analytics
- IoT Device Defender
- IoT Device Management
- IoT Events
- IoT Greengrass
- IoT SiteWise
- IoT Things Graph

Database

- RDS
- DynamoDB

N. Virginia

Support

Make sure you are in Virginia region

Launch a new Instance

Screenshot of the AWS EC2 Dashboard showing the 'Create Instance' button highlighted with a red arrow.

The dashboard displays the following information:

- EC2 Dashboard** sidebar:
 - Events
 - Tags
 - Reports
 - Limits
 - INSTANCES**: Instances, Launch Templates, Spot Requests, Savings Plans, Reserved Instances, Dedicated Hosts, Scheduled Instances, Capacity Reservations
 - IMAGES**: AMIs, Bundle Tasks
 - ELASTIC BLOCK STORE**: Volumes, Snapshots, Lifecycle Manager
- Resources** section:

You are using the following Amazon EC2 resources in the US East (N. Virginia) region:

| | |
|---------------------|-------------------|
| 3 Running Instances | 0 Elastic IPs |
| 0 Dedicated Hosts | 4 Snapshots |
| 5 Volumes | 0 Load Balancers |
| 3 Key Pairs | 3 Security Groups |
| 0 Placement Groups | |

Learn more about the latest in AWS Compute from AWS re:Invent by viewing the [EC2 Videos](#).
- Create Instance** section:

To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.

Launch Instance button (highlighted with a red arrow).

Note: Your instances will launch in the US East (N. Virginia) region
- Migrate a Machine** section:

Use CloudEndure Migration to simplify, expedite, and automate large-scale migrations from physical, virtual, and cloud-based infrastructure to AWS.

[Get started with CloudEndure Migration](#)
- Service Health** section:

Service Status:

 - US East (N. Virginia):
- Scheduled Events** section:

US East (N. Virginia):

No events
- Account Attributes** sidebar:
 - Supported Platforms**: VPC
 - Default VPC**: vpc-ad2c8fd7
 - Console experiments**: Settings
- Additional Information** sidebar:
 - [Getting Started Guide](#)
 - [Documentation](#)
 - [All EC2 Resources](#)
 - [Forums](#)
 - [Pricing](#)
 - [Contact Us](#)
- AWS Marketplace** sidebar:

Find free software trial products in the AWS Marketplace from the [EC2 Launch Wizard](#). Or try these popular software:

 - [CloudEndure Migration](#)

Choose an AMI – Find the CSHL SEQTEC 2019 AMI in the My AMIs

aws Services Resource Groups 🔍 cshl.student @ cshlworkshops N. Virginia Support

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags 6. Configure Security Group 7. Review

Step 1: Choose an Amazon Machine Image (AMI)

An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. You can select an AMI provided by AWS, our user community, or the AWS Marketplace; or you can select one of your own AMIs.

Search for an AMI by entering a search term e.g. "Windows"

Quick Start

1 to 2 of 2 AMIs

My AMIs (highlighted with a red arrow)

cshl-seqtech-2019 - ami-0031e653e6b611b81
Root device type: ebs Virtualization type: hvm Owner: 577255725291 ENA Enabled: Yes
Select 64-bit (x86)

cshl-seqtec-2019 - ami-018b3bf40f9926ac5
Root device type: ebs Virtualization type: hvm Owner: 577255725291 ENA Enabled: Yes
Select 64-bit (x86)

AWS Marketplace

Community AMIs

Ownership
 Owned by me
 Shared with me

Architecture
 32-bit (x86)
 64-bit (x86)
 64-bit (Arm)

Root device type

Choose “m5.2xlarge” instance type, then “Next: Configure Instance Details”.

The screenshot shows the AWS CloudFormation console interface. The top navigation bar includes links for Services, Resource Groups, and various account and region details. Below the navigation is a progress bar with steps 1 through 7. Step 2, "Choose Instance Type", is currently active and highlighted with an orange underline. The main content area is titled "Step 2: Choose an Instance Type". A table lists various Amazon Machine Image (AMI) options, each with columns for instance type, memory, vCPUs, storage, networking, and availability. The "m5.2xlarge" row is highlighted with a blue selection box and has a red arrow pointing to the "Yes" value in the "Supports Enhanced Networking" column. At the bottom of the page are three buttons: "Cancel", "Previous", "Review and Launch", and "Next: Configure Instance Details", with the last one being highlighted by a red border.

| | General purpose | m5.large | 2 | 8 | EBS only | Yes | Up to 10 Gigabit | Yes |
|-------------------------------------|-----------------|-------------|----|-----|----------|-----|------------------|-----|
| <input type="checkbox"/> | General purpose | m5.xlarge | 4 | 16 | EBS only | Yes | Up to 10 Gigabit | Yes |
| <input checked="" type="checkbox"/> | General purpose | m5.2xlarge | 8 | 32 | EBS only | Yes | Up to 10 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m5.4xlarge | 16 | 64 | EBS only | Yes | Up to 10 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m5.8xlarge | 32 | 128 | EBS only | Yes | 10 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m5.12xlarge | 48 | 192 | EBS only | Yes | 10 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m5.16xlarge | 64 | 256 | EBS only | Yes | 20 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m5.24xlarge | 96 | 384 | EBS only | Yes | 25 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m5.metal | 96 | 384 | EBS only | Yes | 25 Gigabit | Yes |
| <input type="checkbox"/> | General purpose | m4.large | 2 | 8 | EBS only | Yes | Moderate | Yes |
| <input type="checkbox"/> | General purpose | m4.xlarge | 4 | 16 | EBS only | Yes | High | Yes |
| <input type="checkbox"/> | General purpose | m4.2xlarge | 8 | 32 | EBS only | Yes | High | Yes |
| <input type="checkbox"/> | General purpose | m4.4xlarge | 16 | 64 | EBS only | Yes | High | Yes |

Step 2: Choose an Instance Type

1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags 6. Configure Security Group 7. Review

Cancel Previous Review and Launch Next: Configure Instance Details

Select "Protect against accidental termination", then "Next: Add Storage".

Screenshot of the AWS Step 3: Configure Instance Details page. The page shows various configuration options for an instance, including IAM role, CPU options, shutdown behavior, and EBS-optimized instance settings. A red arrow points to the 'Protect against accidental termination' checkbox under the 'Enable termination protection' section. A red box highlights the 'Create new IAM role' button. The 'Next: Add Storage' button is also highlighted with a red box.

Step 3: Configure Instance Details

Auto-assign Public IP: Use subnet setting (Enable)

Placement group: Add instance to placement group

Capacity Reservation: Open | Create new Capacity Reservation

IAM role: None | Create new IAM role

You do not have permissions to list instance profiles. Contact your administrator, or check your IAM permissions.

CPU options: Specify CPU options

Shutdown behavior: Stop

Stop - Hibernate behavior: Enable hibernation as an additional stop behavior

Enable termination protection: Protect against accidental termination ←

Monitoring: Enable CloudWatch detailed monitoring
Additional charges apply.

EBS-optimized instance: Launch as EBS-optimized instance

Tenancy: Shared - Run a shared hardware instance
Additional charges will apply for dedicated tenancy.

Elastic Inference: Add an Elastic Inference accelerator
Additional charges apply.

Cancel Previous Review and Launch Next: Add Storage

You should see "snap-xxxxxxx" (32GB) and "snap-xxxxxxx" (250GB) as the two storage volumes selected. Then, "Next: Tag Instance"

The screenshot shows the AWS EC2 instance creation process at Step 4: Add Storage. The '4. Add Storage' tab is active. Two EBS volumes are listed in the table:

| Volume Type | Device | Snapshot | Size (GiB) | Volume Type | IOPS | Throughput (MB/s) | Delete on Termination | Encryption |
|-------------|-----------|----------------------|------------|---------------------------|------------|-------------------|-------------------------------------|---------------|
| Root | /dev/sda1 | snap-0a7ab6edcdfe0af | 32 | General Purpose SSD (gp2) | 100 / 3000 | N/A | <input checked="" type="checkbox"/> | Not Encrypted |
| EBS | /dev/sdb | snap-03d6703e94734 | 250 | General Purpose SSD (gp2) | 750 / 3000 | N/A | <input checked="" type="checkbox"/> | Not Encrypted |

A red box highlights the second row (EBS volume). Below the table, a note states: "Free tier eligible customers can get up to 30 GB of EBS General Purpose (SSD) or Magnetic storage. [Learn more](#) about free usage tier eligibility and usage restrictions." At the bottom right, buttons include: Cancel, Previous, Review and Launch, and Next: Add Tags (which is highlighted with a red box).

Create a tag like “Name=KelsyCotto” [use your own name]. Then hit "Next: Configure Security Group".

AWS Services Resource Groups 1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags 6. Configure Security Group 7. Review

Step 5: Add Tags

A tag consists of a case-sensitive key-value pair. For example, you could define a tag with key = Name and value = Webserver.

A copy of a tag can be applied to volumes, instances or both.

Tags will be applied to all instances and volumes. [Learn more](#) about tagging your Amazon EC2 resources.

Key (128 characters maximum) Value (256 characters maximum) Instances (i) Volumes (i)

Name

Add another tag (Up to 50 tags maximum)

Important: Don't forget to name your instance! (FirstnameLastname)

Cancel Previous Review and Launch Next: Configure Security Group

Select an Existing Security Group, choose "SSH_HTTP". Then hit "Review and Launch".

The screenshot shows the AWS EC2 instance creation wizard at Step 6: Configure Security Group. The user has selected the 'Select an existing security group' option and chosen the 'SSH and HTTP' group. The 'Review and Launch' button is highlighted with a red box.

Step 6: Configure Security Group

A security group is a set of firewall rules that control the traffic for your instance. On this page, you can add rules to allow specific traffic to reach your instance. For example, if you want to set up a web server and allow Internet traffic to reach your instance, add rules that allow unrestricted access to the HTTP and HTTPS ports. You can create a new security group or select from an existing one below. [Learn more](#) about Amazon EC2 security groups.

Assign a security group:

- Create a new security group
- Select an existing security group

| Security Group ID | Name | Description | Actions |
|----------------------|-----------------|---|-----------------------------|
| sg-384f5b79 | default | default VPC security group | Copy to new |
| sg-06a8108faf3523284 | launch-wizard-1 | launch-wizard-1 created 2019-10-23T14:17:30.512-05:00 | Copy to new |
| sg-048f9a165ed38304a | launch-wizard-2 | launch-wizard-2 created 2019-10-24T11:23:58.265-05:00 | Copy to new |
| sg-0087dc3a8b6e37a2d | SSH and HTTP | created 2019-11-08T09:43:29.293-05:00 | Copy to new |

Inbound rules for sg-0087dc3a8b6e37a2d (Selected security groups: sg-0087dc3a8b6e37a2d)

| Type | Protocol | Port Range | Source | Description |
|------|----------|------------|-----------|-------------|
| HTTP | TCP | 80 | 0.0.0.0/0 | |
| HTTP | TCP | 80 | ::/0 | |
| SSH | TCP | 22 | 0.0.0.0/0 | |

[Cancel](#) [Previous](#) [Review and Launch](#)

Review the details of your instance, note the warnings, then hit Launch

AWS Services Resource Groups 1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags 6. Configure Security Group 7. Review cshl.student @ cshlworkshops N. Virginia Support

Step 7: Review Instance Launch

Please review your instance launch details. You can go back to edit changes for each section. Click **Launch** to assign a key pair to your instance and complete the launch process.

⚠ Improve your instances' security. Your security group, SSH and HTTP, is open to the world.
Your instances may be accessible from any IP address. We recommend that you update your security group rules to allow access from known IP addresses only.
You can also open additional ports in your security group to facilitate access to the application or service you're running, e.g., HTTP (80) for web servers. [Edit security groups](#)

⚠ Your instance configuration is not eligible for the free usage tier
To launch an instance that's eligible for the free usage tier, check your AMI selection, instance type, configuration options, or storage devices. Learn more about [free usage tier](#) eligibility and usage restrictions.

AMI Details Edit AMI
cshl-seqtech-2019 - ami-0031e653e6b611b81
Root Device Type: ebs Virtualization type: hvm

Instance Type Edit instance type

| Instance Type | ECUs | vCPUs | Memory (GiB) | Instance Storage (GB) | EBS-Optimized Available | Network Performance |
|---------------|------|-------|--------------|-----------------------|-------------------------|---------------------|
| m5.2xlarge | 31 | 8 | 32 | EBS only | Yes | Up to 10 Gigabit |

Security Groups Edit security groups
Cancel Previous Launch

Choose an existing key pair: "cshl_2019_student" and then Launch.

Step 7: Review Instance Launch

Please review your instance launch details. You can go back to edit changes for each section. Click **Launch** to assign a key pair to your instance and complete the launch process.

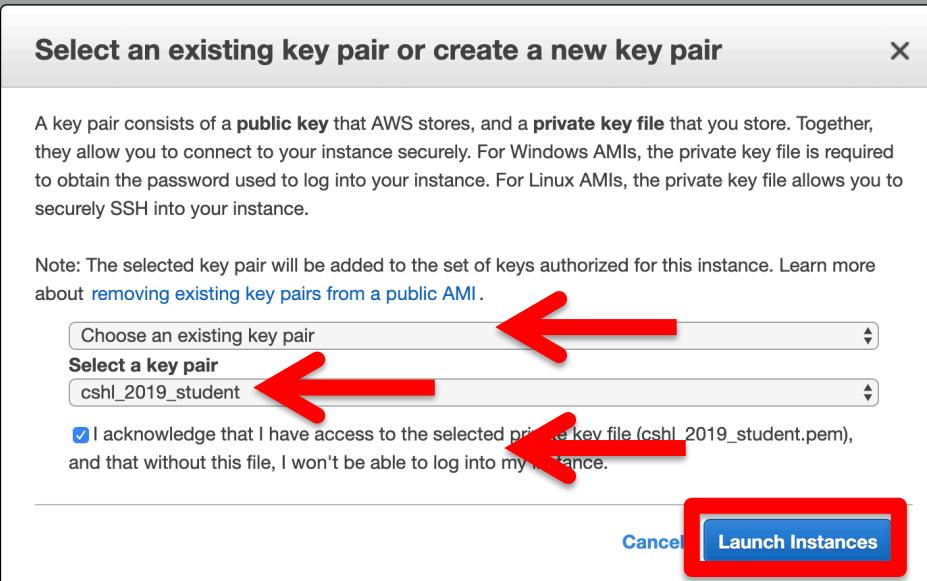
Select an existing key pair or create a new key pair

A key pair consists of a **public key** that AWS stores, and a **private key file** that you store. Together, they allow you to connect to your instance securely. For Windows AMIs, the private key file is required to obtain the password used to log into your instance. For Linux AMIs, the private key file allows you to securely SSH into your instance.

Note: The selected key pair will be added to the set of keys authorized for this instance. Learn more about [removing existing key pairs from a public AMI](#).

Choose an existing key pair
Select a key pair
cshl_2019_student
 I acknowledge that I have access to the selected private key file (cshl_2019_student.pem), and that without this file, I won't be able to log into my instance.

Cancel **Launch Instances** Launch



View Instances to see your new instance spinning up!



Launch Status

- ✓ Your instances are now launching

The following instance launches have been initiated: [i-08e73e43f17783273](#) [View launch log](#)

- ℹ Get notified of estimated charges

[Create billing alerts](#) to get an email notification when estimated charges on your AWS bill exceed an amount you define (for example, if you exceed the free usage tier).

How to connect to your instances

Your instances are launching, and it may take a few minutes until they are in the **running** state, when they will be ready for you to use. Usage hours on your new instances will start immediately and continue to accrue until you stop or terminate your instances.

Click [View Instances](#) to monitor your instances' status. Once your instances are in the **running** state, you can **connect** to them from the Instances screen. [Find out](#) how to connect to your instances.

▼ Here are some helpful resources to get you started

- [How to connect to your Linux instance](#)
- [Amazon EC2: User Guide](#)
- [Learn about AWS Free Usage Tier](#)
- [Amazon EC2: Discussion Forum](#)

While your instances are launching you can also

[Create status check alarms](#) to be notified when these instances fail status checks. (Additional charges may apply)

[Create and attach additional EBS volumes](#) (Additional charges may apply)

[Manage security groups](#)

[View Instances](#)

Find YOUR instance, select it, and then hit connect for instructions on how to connect (It may take some time for your instance to be ready)

The screenshot shows the AWS EC2 Instances page. On the left, there's a sidebar with navigation links: EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES (with Instances selected), Launch Templates, Spot Requests, Savings Plans, Reserved Instances, Dedicated Hosts, Scheduled Instances, Capacity Reservations, and IMAGES (with AMIs selected). The main content area has tabs at the top: Launch Instance, Connect (which is highlighted with a red box), and Actions. Below that is a search bar and a table of instances. The table columns are: Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS (IPv4). There are four instances listed: Instructor_test_insta..., command_line_boot..., developer_instance, and KelsyCotto. A red arrow points to the KelsyCotto row, and a red box highlights the 'Connect' tab.

| Name | Instance ID | Instance Type | Availability Zone | Instance State | Status Checks | Alarm Status | Public DNS (IPv4) |
|--------------------------|----------------------|---------------|-------------------|----------------|----------------|--------------|--------------------------|
| Instructor_test_insta... | i-06601eed1b1bfa657 | m5.2xlarge | us-east-1c | running | 2/2 checks ... | None | ec2-34-239-1-158.co... |
| command_line_boot... | i-00ebf20b2fb63ce3d | t2.xlarge | us-east-1b | terminated | | None | ec2-34-239-1-158.co... |
| developer_instance | i-0088e20bb99bbbd... | m5.2xlarge | us-east-1c | running | 2/2 checks ... | None | ec2-54-157-116-180.co... |
| KelsyCotto | 17783273 | m5.2xlarge | us-east-1c | running | Initializing | None | ec2-3-219-34-153.co... |

Take note of your Public DNS/IP and the instructions on changing permissions for the key file (Note, we will login as ubuntu NOT root)

The screenshot shows the AWS EC2 dashboard with a modal window titled "Connect To Your Instance". The modal provides instructions for connecting to an instance using a standalone SSH client, EC2 Instance Connect, or a Java SSH Client. It includes steps for opening an SSH client, locating the private key file, changing permissions, and connecting using the Public DNS. An example command is provided: `ssh -i "cshl_2019_student.pem" root@ec2-3-219-34-153.compute-1.amazonaws.com`. A note cautions users to ensure the AMI owner has not changed the default AMI username. A "Close" button is at the bottom right of the modal.

aws Services Resource Groups

EC2 Dashboard Events Tags Reports Limits

INSTANCES Instances Launch Templates Spot Requests Savings Plans Reserved Instances Dedicated Hosts Scheduled Instances Capacity Reservations

IMAGES AMIs Bundle Tasks

ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager

NETWORK & SECURITY Security Groups Elastic IPs

Connect To Your Instance

I would like to connect with A standalone SSH client EC2 Instance Connect (browser-based SSH connection) A Java SSH Client directly from my browser (Java required)

To access your instance:

1. Open an SSH client. (find out how to [connect using PuTTY](#))
2. Locate your private key file (cshl_2019_student.pem). The wizard automatically detects the key you used to launch the instance.
3. Your key must not be publicly viewable for SSH to work. Use this command if needed:
`chmod 400 cshl_2019_student.pem`
4. Connect to your instance using its Public DNS:
`ec2-3-219-34-153.compute-1.amazonaws.com`

Example:

```
ssh -i "cshl_2019_student.pem" root@ec2-3-219-34-153.compute-1.amazonaws.com
```

Please note that in most cases the username above will be correct, however please ensure that you read your AMI usage instructions to ensure that the AMI owner has not changed the default AMI username.

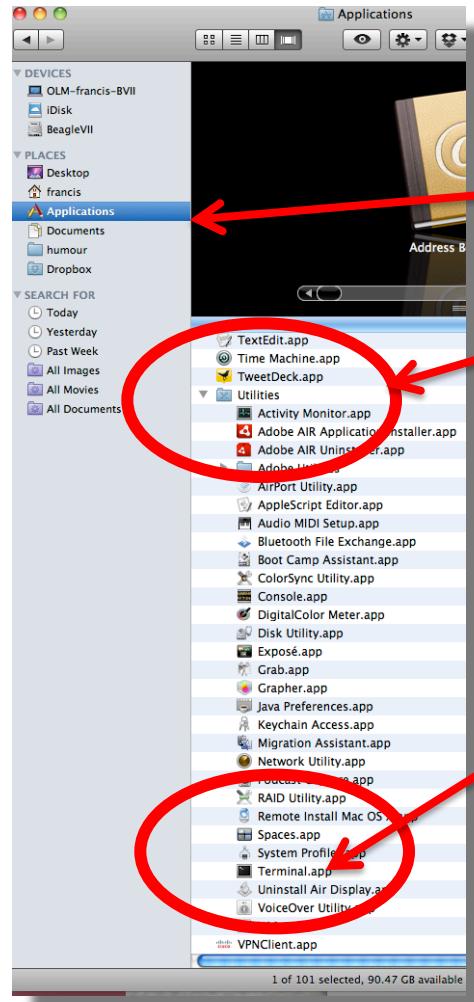
If you need any assistance connecting to your instance, please see our [connection documentation](#).

Close

1 to 4 of 4

| | Alarm Status | Public DNS (IPv4) |
|------|--------------|-----------------------|
| None | None | ec2-34-239-1-158.co |
| None | None | ec2-54-157-116-180.co |
| None | None | ec2-3-219-34-153.co |

Opening a ‘terminal session’ on a Mac

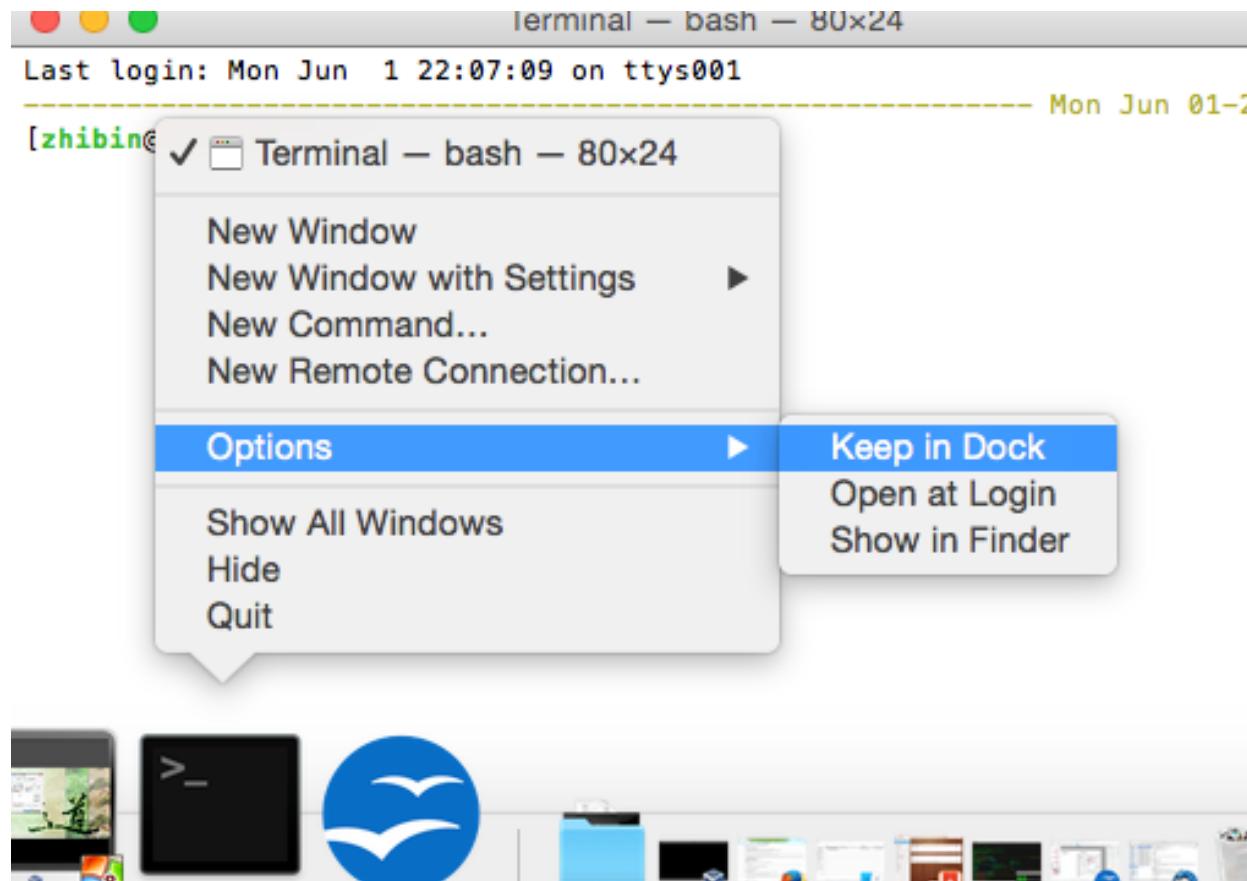


In a Finder window
'Applications' -> 'Utilities' -> 'Terminal'



Or on your dock

Add the terminal App to your dock



Creating a working directory on your Mac called ‘cshl’

```
obis-air:~ ogriffit$ pwd
/Users/ogriffit
obis-air:~ ogriffit$ ls
Applications   Desktop          Dropbox        Movies       Public      gittemp     temp
Attachments    Documents         Google Drive   Music        bin         igv
Box Sync       Downloads        Library        Pictures    git         ncbi
obis-air:~ ogriffit$ mkdir cshl
obis-air:~ ogriffit$ cd cshl
obis-air:cshl ogriffit$ ls -la
total 0
drwxr-xr-x  2 ogriffit  staff   68 Nov 13 22:18 .
drwxr-xr-x+ 58 ogriffit  staff  1972 Nov 13 22:18 ..
obis-air:cshl ogriffit$ █
```

mkdir cshl
cd cshl

Download .pem file to cshl directory from course wiki

C-SEQTEC 2019: Wiki

Home View Edit Info History Watch Search: RSS Print

Instructions For Students To Access Their Awc Ec2 Cloud Instance Recently visited

Instructions For Students To Access Their Awc Ec2 Cloud Instance last modified by Kelsy Cotto on November 8, 2019 9:42:52 AM EST

Most hands on components of this workshop will be performed on the cloud using Amazon AWS EC2 instances. Each student is assigned their own instance running the Ubuntu operating system. Use the following instructions to log in.

Visit AWS EC2 Console to create instance:

- AWS Console Signin: <https://cshlworkshops.signin.aws.amazon.com/console>
- User Name: cshl.student
- Password: seqtec2019
- Services -> Compute -> EC2
- Zone: US East (us-east-1) (N. Virginia)
- Course AMI: cshl-seqtec-2019 (ami-018b3bf40f9926ac5)
- Instance Type: m5.2xlarge

Download pem file (right-click and "Save Link As..."; take note of where you download it to):

- [cshl_2019_student.pem](#) 

Connect to AWS instance via Terminal:

```
chmod 400 cshl_2019_student.pem
ssh -i cshl_2019_student.pem ubuntu@YOUR_IP_ADDRESS
```

Viewing the ‘key’ file once downloaded

cat cshl_2019_student.pem

```
Kelsys-MacBook-Pro:keys kcotto$ cat cshl_2019_student.pem
-----BEGIN RSA PRIVATE KEY-----
MIIEpAIBAAKCAQEAgGtpnqERTEu/SCmeF2r1HMESMao0fEJiAwQwk2/SNXK8izr0IH0zTVvmE1D
VUwWq7pkvhjh05pDb+2U9HiZe3sxLv3S1NrkATYF/NsrpwB+q1vwqzGW9sQ6uj45RWrPkiZlsaj
TQZmyFRu+t1JTRU3hQDqA0MRWTx1Wxv0gFzuZy/qb+DALuFQsInrEKnijrwdLmd6usaBTvhc0gFS
B9oEelH0bZHJTZFw/wP+Z0uZq0Ujir7Qw0LTM45QH/L0dBdUl3k/mBeez00yvnKMwj8E4Xi0rQ0t
hHtQ7F9iSILK80W1rRH0qwxwt9ycEH1JtNMQmUTif0vE2XJ6l06chQIDAQABAoIBABG7P/FHu/Qp
WFgg+89myuqR6GvA2X55CFSzFyG0aQyrj5jDleFtdu2uXiISG8gUBZYvlzxx82a0C0P5j04SBq0
xD/qR1ukY/jyXyPn77w/ExmaNoLjj1W9RUSH0JYLIZVpFPGes3u5zGSGDTSDNhw3sSdWhq1FX3l
7vY5b6UAQgahXf0dpGFxt6P6qb/BKFQFsThXk7GXMyS/kr4w7ZlhPWHRMSu2UBdS/a/beAVN76qU
E/10HR30oAuqghusZabpbX7MJl00VcvIAQgeF8Z+xf2uugDEAKut1PxW0+yvGM4SpZZ0skFZz6YI
pBnX4ELWPhCeMzq4Ml8QY6ptR2UCgYEAc6YfNlymg24NJU8PANx8navTi50WYuXWXrj0mrLr3SR
/XY+w26cgipM+K5eQFXSr4Yb8BQKjRktMzBzf5nKdaX4pzYIquQH02B0HDhTooHAhkbTMTmKukv4
oEW06wcEE6RQifw4xbMEnfQfHJB121am+jwI8Xb7idwMG4pU/nsCgYEAtD0x4bNC1X3A5by50uY0
WXrtgQszCXYcbkrpbjRET12f9hgz9MRMHY/xH/XGvMutZSFV2rCZRwd7lm+QWGadk/MQS0kouzW6
gSasyjFq+MKCkqYnS3/JTbx8yrLzmz10LtX6pwmwg0Zy8aJjYHo9a2/EI8Tjh2d0SxeadIRVYP8C
gYAToiXww1Vdu+dj/7TDLqYCdHOVAXJX/utI9Q3yoIryuh+bWmFvEIvAmIGXyyQZRyoZwgIS4A
PNH03+bEa+69wbzlhksiK5g8GKgISVdlC4rZZXB5ehgTmWV7IgJ89y/SF4G/ITyo30K0ohALh597
NcvNEzzqruTja1IIMvTKMwKBgQClM+QP1Tqc0TbVlfvClviXuJBLsiJLCImYeZL0nZVmIMusbhxX
b8ZQYGSyUz09nu1Xau1G1QDvXvf089CzWL1SomxBoH1FJQvGwa9FFYQRIVPHuqut8rs4oPGn0QzC
h7M7QCJcr00oAcrSLLkQmgz+phIw7BzFr039J4HFiRInjQKBgQCtdEvcbyk8Jh4WH3z0wpkc43f
U8DZhZwjRQpGWLD8CPj9RgRnE4+1PCH6s/RLQf7SiE1ZjX/0Ud0WPEvr0j5sVjy0IujohRbty0CM
oqWeSeUb1sLogRvMrTfCEpl/rz3GpoQ1SC/5s6XvjnnKK8RN8s7MseLuuJ63T/CRBpIs8A==
-----END RSA PRIVATE KEY-----Kelsys-MacBook-Pro:keys kcotto$
```

Changing file permissions of your ‘key’ file (Mac/Linux)

ls -l (long listing)

```
-rw-r--r--@ 1 kcotto staff 1696 Nov 9 09:19 cshl_2019_student.pem
```

 rwx : owner

 rwx : group

 rwx: world

 r read (4)

 w write (2)

 x execute (1)

Which ever way you add these 3 numbers, you know which integers were used (6 is always 4+2, 5 is 4+1, 4 is by itself, 0 is none of them etc ...)

So, when you have:

chmod 400 <file name>

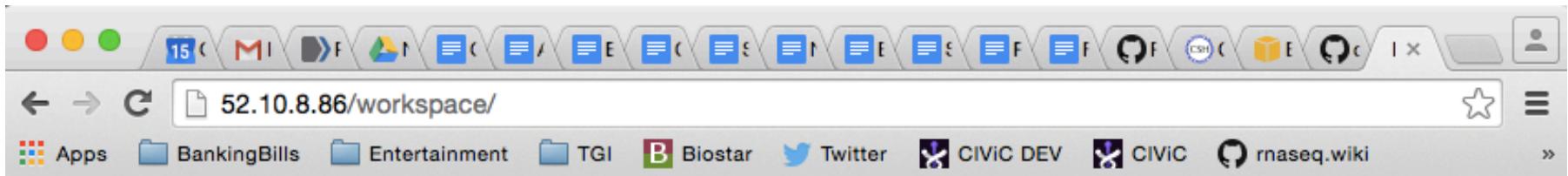
It is “r” for the the file owner **only**

Logging into your instance

Mac/Linux

```
cd ~/cshl  
chmod 400 cshl_2019_student.pem  
ssh -i cshl_2019_student.pem ubuntu@[YOUR PUBLIC IP]
```

Copying files from AWS to your computer (using a web browser)



Index of /workspace

| | Name | Last modified | Size | Description |
|--|----------------------------------|-------------------------------|----------------------|-----------------------------|
|  | Parent Directory | | - | |
|  | Homo sapiens/ | 2015-11-13 06:45 | - | |
|  | README.txt | 2014-06-17 23:53 | 5.3K | |
|  | bam-demo/ | 2015-11-14 21:03 | - | |
|  | data/ | 2015-11-13 01:39 | - | |
|  | scratch/ | 2015-11-13 19:43 | - | |
|  | tools/ | 2015-11-13 01:54 | - | |

Apache/2.4.7 (Ubuntu) Server at 52.10.8.86 Port 80

http://[YOUR PUBLIC DNS OR IP]/

Logging out of your instance

Mac/Linux – simply type exit

```
exit
```

Note, this disconnects the terminal session (ssh connection) to your cloud instance. But, your cloud instance is still running! See next slide for how to stop your instance.

When you are done for the day you can “Stop” your instance – Don’t Terminate!

The screenshot shows the AWS EC2 Dashboard. On the left, there's a sidebar with various navigation options like EC2 Dashboard, Events, Tags, Reports, Limits, Instances, Images, AMIs, and more. A red arrow points to the 'Instances' tab. In the main area, a table lists several instances. One instance, 'instructor_test2', is selected. A context menu is open over this instance, with 'Instance State' expanded. Under 'Instance State', another red arrow points to the 'Stop' option, which is highlighted. The table columns include Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS. The 'Instance State' column shows various statuses like running, stopped, and pending. The 'Status Checks' column shows 2/2 checks passing. The 'Alarm Status' column shows 'None'. The 'Public DNS' column shows the public DNS for each instance.

Go to AWS EC2 Dashboard, select “Instances” tab, then find your instance. Right-click and chose ‘Instance State’ -> ‘Stop’

Next morning, you can “Start” your instance again

The screenshot shows the AWS EC2 Dashboard. On the left sidebar, the 'Instances' tab is selected, indicated by a red arrow. In the main content area, a list of instances is displayed. One instance, named 'JasonWalker' with Instance ID i-3246aae8, is shown as 'stopped'. A context menu is open over this instance, also indicated by a red arrow. The menu options include 'Connect', 'Get Windows Password', 'Launch More Like This', 'Instance State' (which is currently 'stopped'), 'Stop', 'Reboot', 'Networking', and 'Terminate'. Below the table, the instance details are shown: 'Instance: i-3246aae8 (JasonWalker)' and 'Private IP: 172.31.5.175'. A large red box highlights the instructions in the bottom right corner.

Go to AWS EC2 Dashboard, select “Instances” tab, then find your instance. Right-click and chose ‘Instance State’ -> ‘Start’

When you restart your instance you will need to find your new Public DNS or IP address. Select your instance and “Connect” or look in Description tab. Then go back to instructions for “Logging into your instance”

The screenshot shows the AWS EC2 Instances page. On the left, there's a sidebar with navigation links like EC2 Dashboard, Events, Tags, Reports, Limits, Instances, AMIs, and more. The main area displays a table of instances with columns for Name, Instance ID, Instance Type, Availability Zone, Instance State, Status Checks, Alarm Status, and Public DNS. A red arrow points to the 'Connect' button at the top of the table header. Below the table, a specific instance is selected: 'instructor_test2' (Instance ID: i-068e6cdc). The 'Description' tab is active, showing details such as Instance ID, Instance state, Public DNS, and Public IP. A second red arrow points to the 'Public IP' field, which contains '52.10.8.86'.

| Name | Instance ID | Instance Type | Availability Zone | Instance State | Status Checks | Alarm Status | Public DNS |
|------------------|-------------|---------------|-------------------|----------------|----------------|--------------|-----------------------------|
| instructor_test2 | i-068e6cdc | m3.2xlarge | us-west-2c | running | 2/2 checks ... | None | ec2-52-10-8-86.us-west-2... |
| JasonWalker | i-3246aae8 | m3.2xlarge | us-west-2c | stopped | | None | |
| pengpeng | i-6740acbd | m3.2xlarge | us-west-2c | stopped | | None | |
| ALesiak | i-0d42aed7 | m3.2xlarge | us-west-2c | stopped | | None | |
| djcoughlin | i-3540acef | m3.2xlarge | us-west-2c | stopped | | None | |
| jakesaunders | i-a747ab7d | m3.2xlarge | us-west-2c | stopped | | None | |
| YunjuSung | i-6540acb | m3.2xlarge | us-west-2c | stopped | | None | |
| Jonathan.Wan | i-6640acbc | m3.2xlarge | us-west-2c | stopped | | None | |
| KateD | i-a241ad78 | m3.2xlarge | us-west-2c | stopped | | None | |
| JenTudor | i-0e42aed4 | m3.2xlarge | us-west-2c | stopped | | None | |
| YanZhang | i-0342aed9 | m3.2xlarge | us-west-2c | stopped | | None | |
| ArenMarshall | i-0242aed8 | m3.2xlarge | us-west-2c | stopped | | None | |

Instance: i-068e6cdc (instructor_test2) Public DNS: ec2-52-10-8-86.us-west-2.compute.amazonaws.com

Description Status Checks Monitoring Tags

| | | | |
|----------------|------------|------------|--|
| Instance ID | i-068e6cdc | Public DNS | ec2-52-10-8-86.us-west-2.compute.amazonaws.com |
| Instance state | running | Public IP | 52.10.8.86 |

So, at this point:

- Your Mac desktop is ready for the workshop
- If it is not, you know where to get the information you need
- You know how to login to AWS
- The next step is to login to your linux machine on AWS and learn the basics of a linux command line

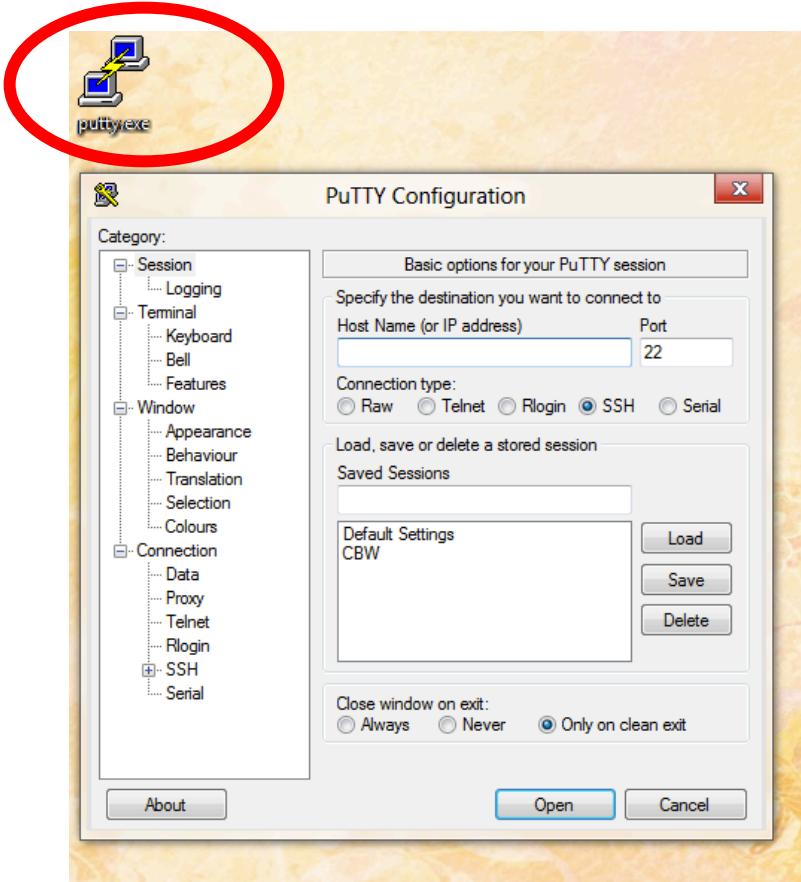
Break

Obtain the course SSH key file

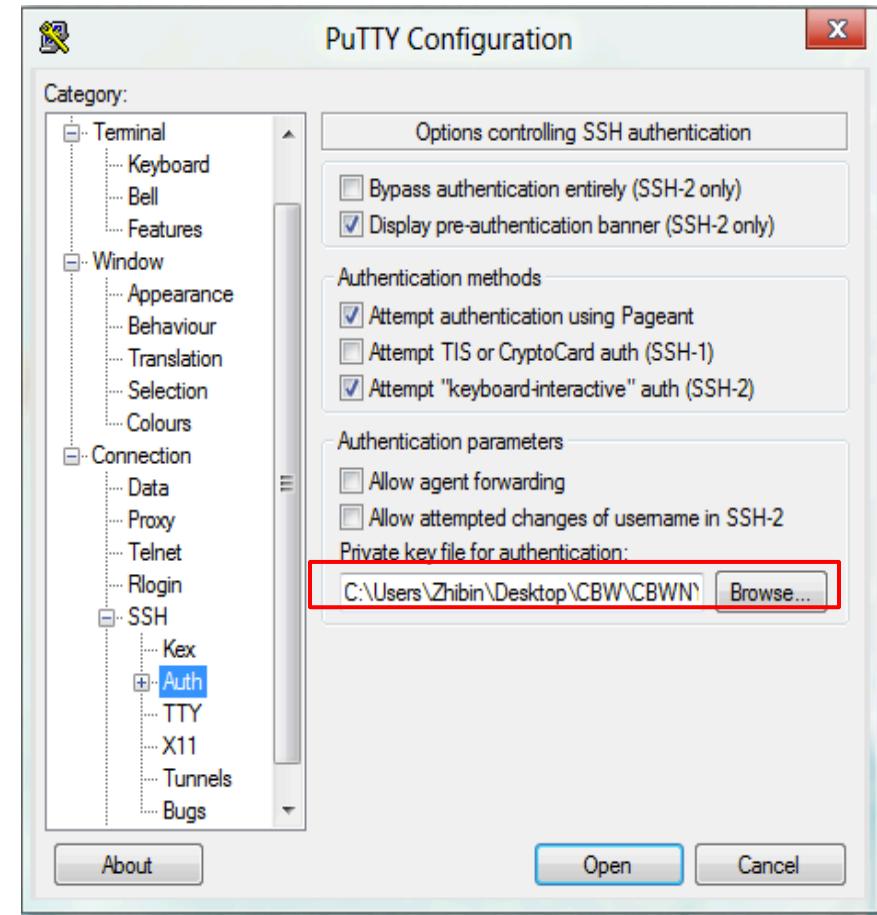
- NOTE for Mac users. You will need to use a “.pem” file
- **NOTE for Windows Users.** You will need to use a “.ppk” file instead.
 - This is created from the “.pem” file.
 - <https://aws.amazon.com/premiumsupport/knowledge-center/convert-pem-file-into-ppk/>
- The SSH key file will be used to securely login to your student instance on the cloud

Logging into your instance (Windows)

Open PuTTY

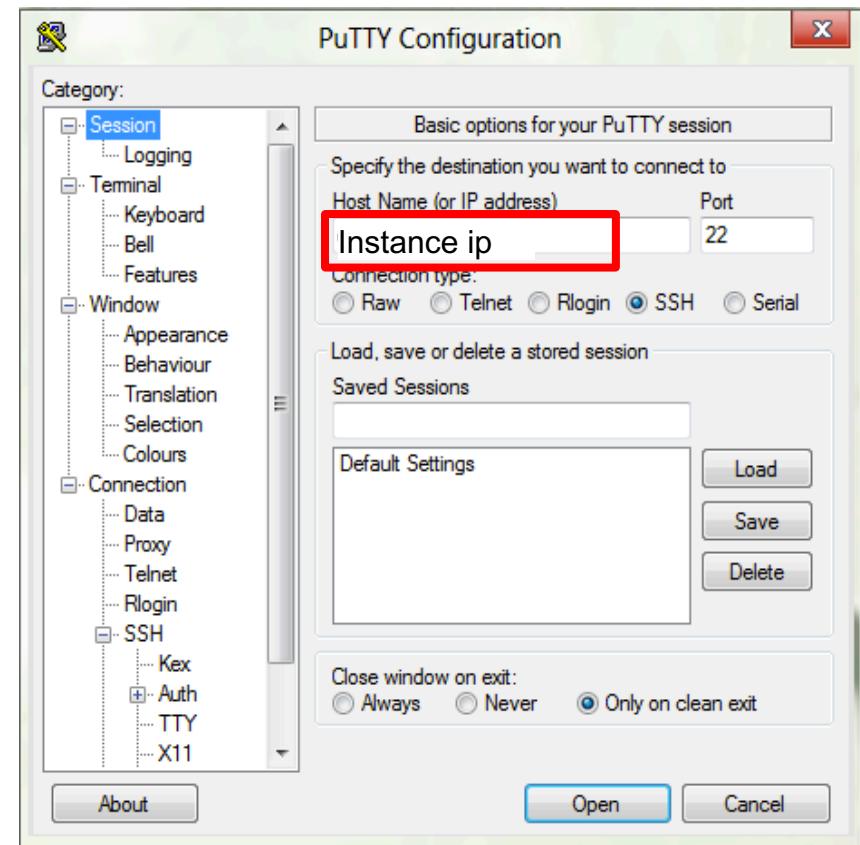
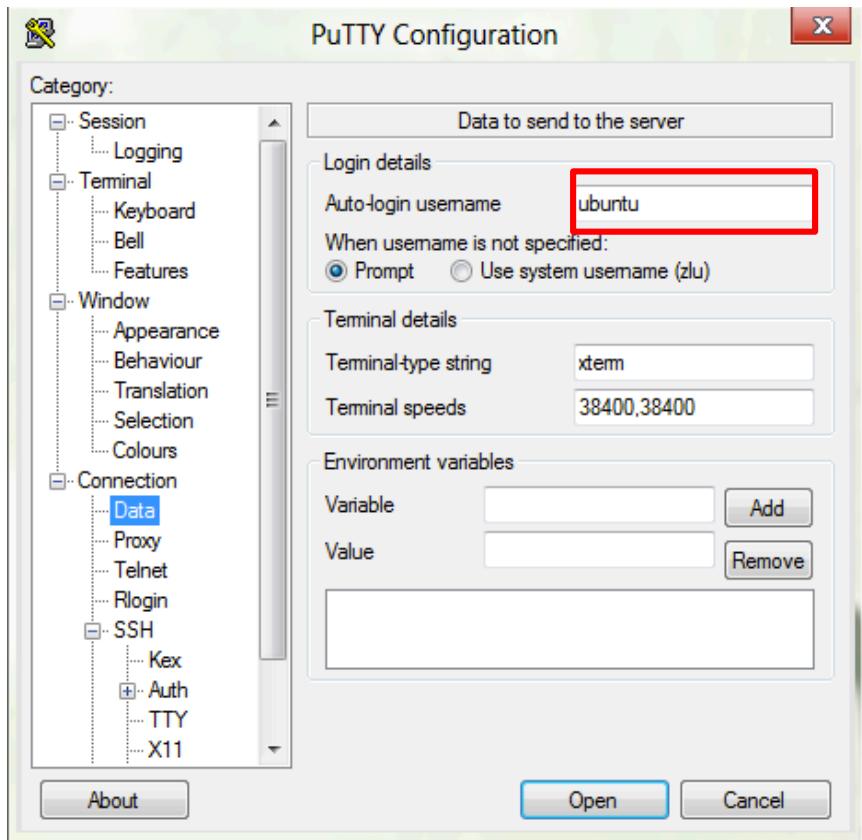


Browse to the
cshl_2018_student.ppk file



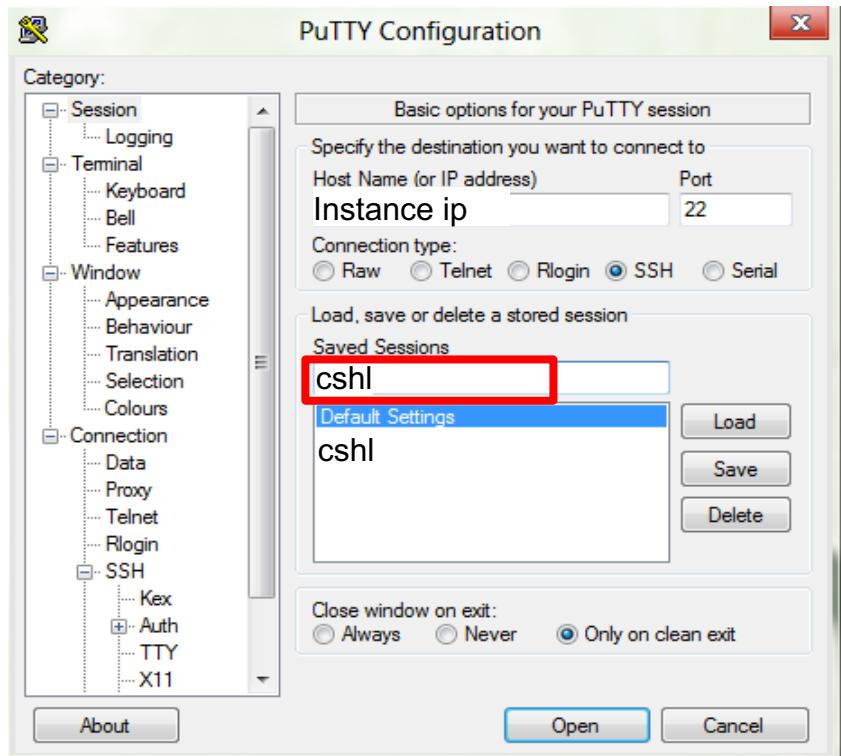
Logging into your instance (Windows)

Enter the user name ‘ubuntu’ Enter the host name



Logging into your instance (Windows)

Open PuTTY



Break