



Cold
Spring
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Laboratory

Advanced Sequencing Technologies & Applications

<http://meetings.cshl.edu/courses.html>



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Introduction to cloud computing

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Advanced Sequencing Technologies & Applications

November 6- 18, 2018



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/\$)

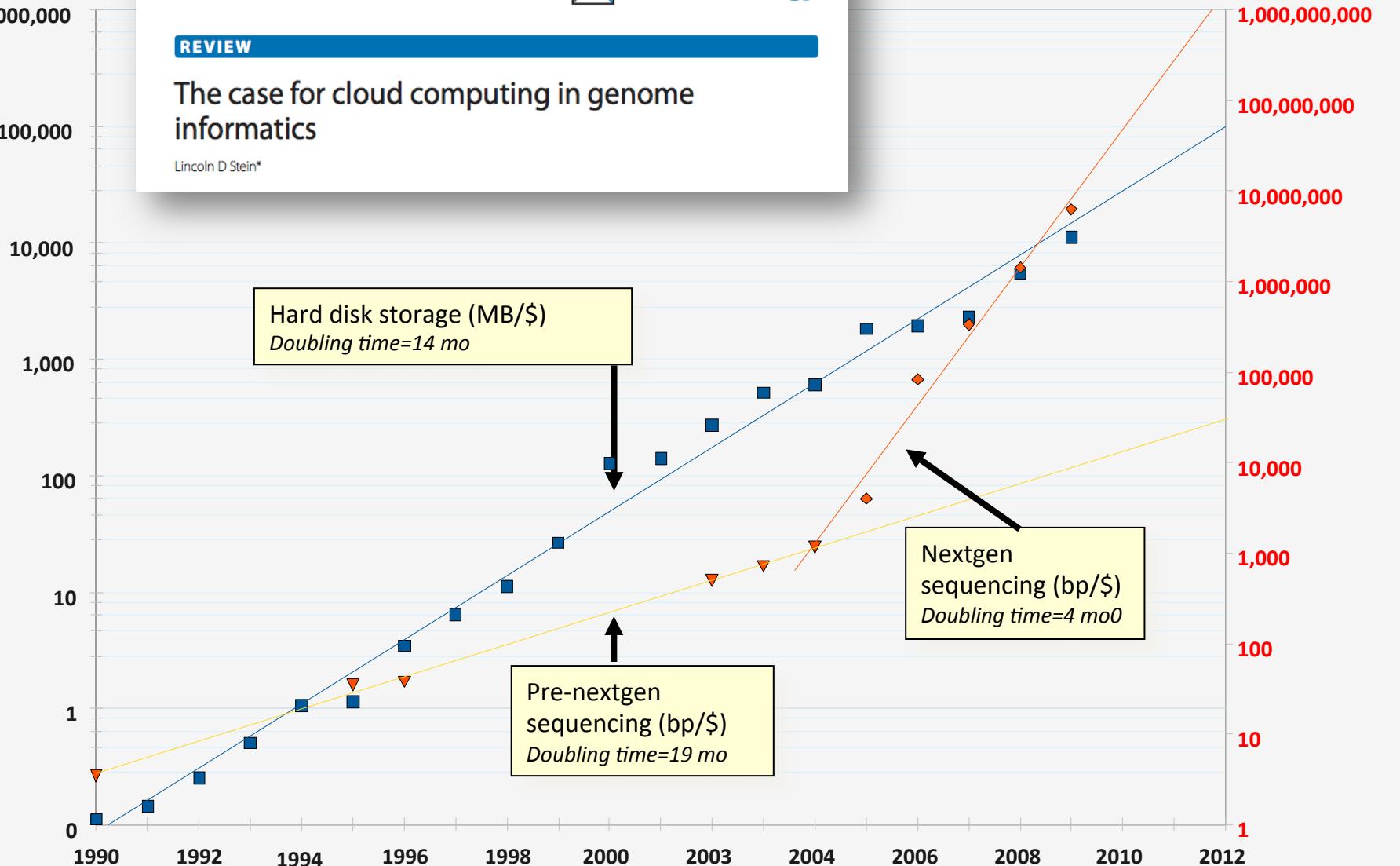
Stein *Genome Biology* 2010, 11:207
<http://genomebiology.com/2010/11/5/207>



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://github.com/griffithlab/rnaseq_tutorial/wiki/Intro-to-AWS-Cloud-Computing

<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:** 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:
 - Code Block:**

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

Login to AWS console



Coming Soon: Changes to Multi-Factor Authentication (MFA)

Entry of an MFA security code for IAM users will move from this sign-in page to a subsequent page

Account: 364840684323

User Name: cshl.student

Password:
 I have an MFA Token (more info)

Sign In

[Sign-in using root account credentials](#)



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

Select "EC2" service

The screenshot shows the AWS Management Console with the following interface elements:

- Top Bar:** AWS logo, Services dropdown, Resource Groups dropdown, User info (cshl.student @ cshlworkshops), Region (Oregon), and Support dropdown.
- Left Sidebar:** History, Console Home, EC2, Simple Queue Service, Billing, IAM, and S3.
- Search Bar:** Find a service by name or feature (for example, EC2, S3 or VM, storage).
- Services Grid:** Organized into sections:
 - Compute:** EC2 (highlighted with a red arrow), Lightsail, ECS, EKS, Lambda, Batch, Elastic Beanstalk.
 - Storage:** S3, EFS, S3 Glacier, Storage Gateway.
 - Database:** RDS, DynamoDB, ElastiCache, Neptune, Amazon Redshift.
 - Management Tools:** CloudWatch, AWS Auto Scaling, CloudFormation, CloudTrail, Config, OpsWorks, Service Catalog, Systems Manager, Trusted Advisor, Managed Services.
 - Media Services:** Elastic Transcoder, Kinesis Video Streams, MediaConvert, MediaLive, MediaPackage, MediaStore, MediaTailor.
 - Machine Learning:** Amazon SageMaker.
 - Mobile Services:** Mobile Hub, AWS AppSync, Device Farm.
 - AR & VR:** (empty)
 - Security, Identity & Compliance:** IAM, Cognito, Secrets Manager, GuardDuty, Inspector, Amazon Macie, AWS Organizations, AWS Single Sign-On, Certificate Manager, Key Management Service, CloudHSM, Directory Service, WAF & Shield, Artifact.
 - Desktop & App Streaming:** (empty)
 - IoT Core:** IoT 1-Click, IoT Device Management, IoT Analytics, Greengrass, Amazon FreeRTOS, IoT Device Defender.
 - Game Development:** Amazon GameLift.
- Region Selection:** Oregon (highlighted with a red arrow).
- Sort Options:** Group (selected) and A-Z.

Text Overlay: Make sure you are in Oregon region

Launch a new Instance

AWS Services Resource Groups

EC2 Dashboard

- Events
- Tags
- Reports
- Limits

INSTANCES

- Instances
- Launch Templates
- Spot Requests
- Reserved Instances
- Dedicated Hosts
- Scheduled Instances
- Capacity Reservations

IMAGES

- AMIs
- Bundle Tasks

ELASTIC BLOCK STORE

- Volumes
- Snapshots
- Lifecycle Manager

NETWORK & SECURITY

Resources

You are using the following Amazon EC2 resources in the US West (Oregon) region:

0 Running Instances	1 Elastic IPs
0 Dedicated Hosts	4 Snapshots
4 Volumes	0 Load Balancers
3 Key Pairs	5 Security Groups
0 Placement Groups	

Learn more about the latest in AWS Compute from AWS re:Invent 2017 by viewing the [EC2 Videos](#).

Create Instance

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

[Launch Instance](#)

Note: Your instances will launch in the US West (Oregon) region

Service Health

Service Status:

- US West (Oregon):

Availability Zone Status:

Scheduled Events

US West (Oregon):

No events

Account Attributes

Supported Platforms

- VPC

Default VPC

vpc-da25eda2

Resource ID length management

Console experiments

Additional Information

Getting Started Guide

Documentation

All EC2 Resources

Forums

Pricing

Contact Us

AWS Marketplace

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

Barracuda CloudGen Firewall for AWS -



Choose an AMI – Find the CSHL SEQTEC 2018 AMI in the My AMIs

The screenshot shows the AWS 'Choose an AMI' wizard interface. At the top, there's a navigation bar with the AWS logo, 'Services', 'Resource Groups', and other account details. Below it, a progress bar shows steps 1 through 7: '1. Choose AMI' (underlined), '2. Choose Instance Type', '3. Configure Instance', '4. Add Storage', '5. Add Tags', '6. Configure Security Group', and '7. Review'. A 'Cancel and Exit' button is also present.

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.

A search bar at the top says 'Search for an AMI by entering a search term e.g. "Windows"'.

The main area shows two AMIs listed:

- cshl-seqtech-2018v1 - ami-05466260c3c44a136**
Image for the 2018 Advanced Sequencing Technologies and Applications Course, Cold Spring Harbor Labs
Root device type: ebs Virtualization type: hvm Owner: 577255725291 ENA Enabled: Yes
Select (button)
- cshl-seqtech-2018v2 - ami-0ee7d04a5b96e28c6**
Advanced Sequencing Technologies and Applications - CSHL 2018
Root device type: ebs Virtualization type: hvm Owner: 577255725291 ENA Enabled: Yes
Select (button)

A red arrow points to the 'My AMIs' link in the sidebar, and another red arrow points to the 'Select' button for the second AMI.

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

Screenshot of the AWS CloudFormation console showing the "Step 2: Choose an Instance Type" step. The "m5.2xlarge" instance type is selected and highlighted with a red arrow pointing to the "Review and Launch" button, which is also highlighted with a red box.

	General purpose	m5d.xlarge	4	16	1 x 150 (SSD)	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5d.2xlarge	8	32	1 x 300 (SSD)	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5d.4xlarge	16	64	2 x 300 (SSD)	Yes	Up to 10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5d.12xlarge	48	192	2 x 900 (SSD)	Yes	10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5d.24xlarge	96	384	4 x 900 (SSD)	Yes	25 Gigabit	Yes
<input type="checkbox"/>	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	m5.12xlarge	48	192	EBS only	Yes	10 Gigabit	Yes
<input type="checkbox"/>	General purpose	m5.24xlarge	96	384	EBS only	Yes	25 Gigabit	Yes
<input type="checkbox"/>	General purpose	m4.large	2	8	EBS only	Yes	Moderate	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 Launch Wizard Step 3: Configure Instance Details page. The page shows configuration options for launching an instance, including network settings, IAM role, shutdown behavior, and termination protection. A red arrow points to the 'Protect against accidental termination' checkbox, which is checked. A red box highlights the 'Next: Add Storage' button at the bottom right.

Step 3: Configure Instance Details

Configure the instance to suit your requirements. You can launch multiple instances from the same AMI, request Spot instances to take advantage of the lower pricing, assign an access management role to the instance, and more.

Number of instances: 1

Purchasing option: Request Spot instances

Network: vpc-ebcc188e (172.31.0.0/16) (default)

Subnet: No preference (default subnet in any Availability Zone)

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

IAM role: None

Shutdown behavior: Stop

Enable termination protection: Protect against accidental termination

Monitoring: Enable CloudWatch detailed monitoring
Additional charges apply.

Tenancy: Shared tenancy (multi-tenant hardware)
Additional charges will apply for dedicated tenancy.

Advanced Details

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"

Step 4: Add Storage

Your instance will be launched with the following storage device settings. You can attach additional EBS volumes and instance store volumes to your instance, or edit the settings of the root volume. You can also attach additional EBS volumes after launching an instance, but not instance store volumes. [Learn more](#) about storage options in Amazon EC2.

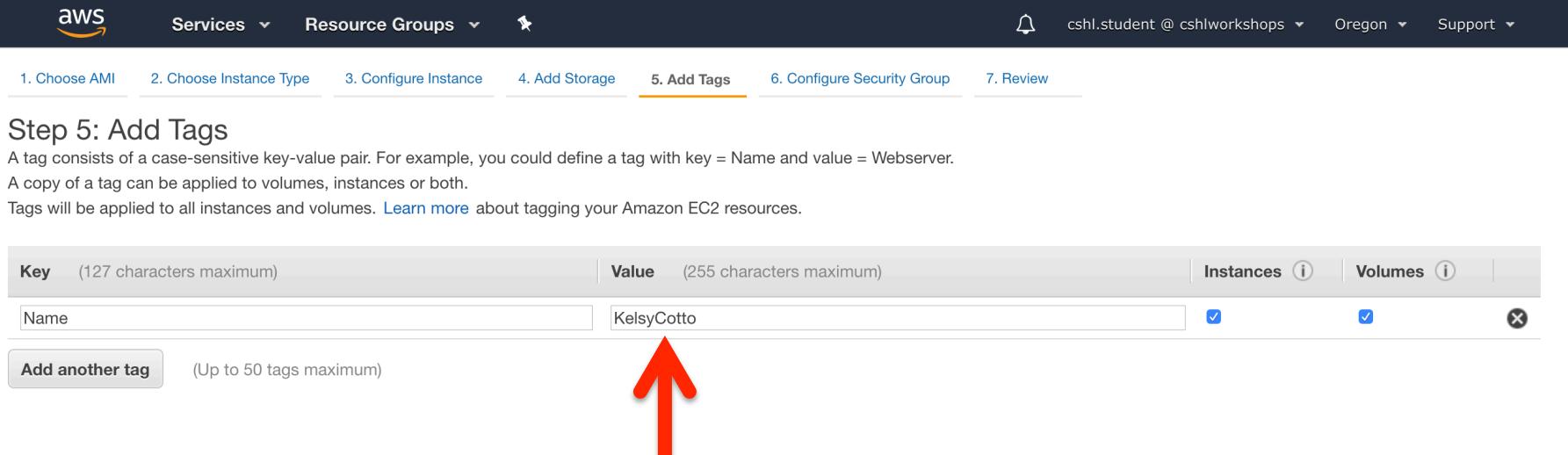
Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Delete on Termination	Encrypted
Root	/dev/sda1	snap-6f450833	32	General Purpose (SSD)	96 / 3000	<input checked="" type="checkbox"/>	Not Encrypted
EBS	/dev/sdb	snap-11e6954e	500	General Purpose (SSD)	1500 / 3000	<input checked="" type="checkbox"/>	Not Encrypted

Add New Volume

... 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.

Cancel Previous Review and Launch **Next: Tag Instance**

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



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 (127 characters maximum) | Value (255 characters maximum) | Instances | Volumes |

Name	KelsyCotto	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="button" value="X"/>
------	------------	-------------------------------------	-------------------------------------	----------------------------------

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".

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

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-2ca82259	default	default VPC security group	Copy to new
sg-02a3720173e534fb1	launch-wizard-1	launch-wizard-1 created 2018-11-08T22:48:01.401-05:00	Copy to new
sg-0503d434ee857a234	launch-wizard-2	launch-wizard-2 created 2018-11-08T22:59:54.648-05:00	Copy to new
sg-0eb1322ac3c3d6e54	Mosh	Full access on mosh ports	Copy to new
<input checked="" type="checkbox"/> sg-0e1e3e42604e6f94e	SSH and HTTP	launch-wizard-1 created 2018-11-01T13:09:50.250-05:00	Copy to new

Inbound rules for sg-0e1e3e42604e6f94e (Selected security groups: sg-0e1e3e42604e6f94e)

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

The screenshot shows the AWS Instance Launch Wizard at Step 7: Review Instance Launch. The top navigation bar includes the AWS logo, Services, Resource Groups, a user icon, and links for cshl.student @ cshlworkshops, Oregon, and Support.

The main content area shows the review steps: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance, 4. Add Storage, 5. Add Tags, 6. Configure Security Group, and 7. Review. Step 7 is currently selected.

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.

Warning 1: 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. [Don't show me this again](#)

Warning 2: 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](#)

AMI Details (highlighted by a red arrow)

cshl-seqtech-2018v1 - ami-05466260c3c44a136

Image for the 2018 Advanced Sequencing Technologies and Applications Course, Cold Spring Harber Labs

Root Device Type: ebs Virtualization type: hvm

Instance Type (highlighted by a red arrow)

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

Buttons at the bottom: Cancel, Previous, **Launch** (highlighted by a red box)

Choose an existing key pair: "cshl_2018_student" and then Launch.

The screenshot shows the AWS Step 7: Review Instance Launch interface. A modal dialog box titled "Select an existing key pair or create a new key pair" is open. Inside the dialog, there are two dropdown menus: "Choose an existing key pair" (containing "cshl_2018_student") and "Select a key pair" (also containing "cshl_2018_student"). Below these is a checkbox statement: "I acknowledge that I have access to the selected private key file (cshl_2018_student.pem), and that without this file, I won't be able to log into my instance." A red arrow points to the "Choose an existing key pair" dropdown, another red arrow points to the "Select a key pair" dropdown, and a third red arrow points to the acknowledgement checkbox. The "Launch Instances" button at the bottom right of the dialog is also highlighted with a red box. The background shows the main launch configuration page with sections for AMI Details, Instance Type (m4.xlarge), and Security Groups.

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.

Your instance configuration

To launch an instance that's eligible for free usage tier, you must agree to the terms and conditions. Learn more about free usage tier eligibility and terms and conditions.

Improve your instances' security

Your instances may be accessible from the Internet. You can also open additional ports in your security groups.

AMI Details

cshl-seqtech-2018v2 - ami-0f1a2345678901234

Advanced Sequencing Technology

Root Device Type: ebs Virtualization Type: hvm

Instance Type

Instance Type	ECUs	Memory (GiB)	Disk (GiB)	Network	Storage	Volume Type
m4.xlarge	13	4	16	EBS only	Yes	High

Security Groups

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

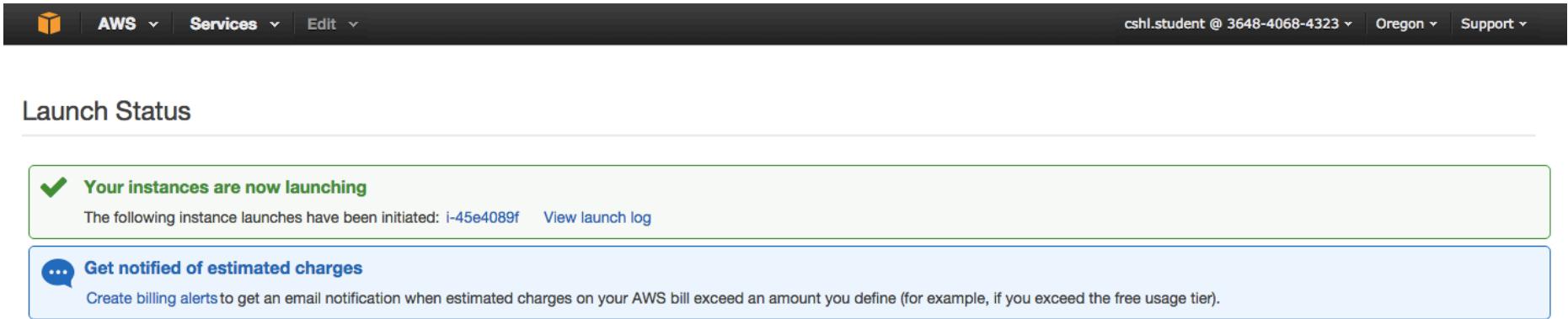
Select a key pair

I acknowledge that I have access to the selected private key file (cshl_2018_student.pem), and that without this file, I won't be able to log into my instance.

Cancel Launch Instances

Cancel Previous Launch

View Instances to see your new instance spinning up!



The screenshot shows the AWS CloudWatch Launch Status page. At the top, there's a navigation bar with icons for CloudWatch Metrics, AWS, Services, Edit, and user information (cshl.student @ 3648-4068-4323, Oregon, Support). Below the navigation is a section titled "Launch Status". It contains a green box with a checkmark and the text "Your instances are now launching" followed by "The following instance launches have been initiated: i-45e4089f" and a link to "View launch log". There's also a blue box with a speech bubble icon and the text "Get notified of estimated charges" followed by "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 like EC2 Dashboard, Events, Tags, Reports, Limits, INSTANCES, Instances, Launch Templates, Spot Requests, Reserved Instances, Dedicated Hosts, Scheduled Instances, Capacity Reservations, IMAGES, AMIs, Bundle Tasks, and ELASTIC BLOCK STORE. The main area has a header with 'Launch Instance', 'Connect' (which is highlighted with a red box), and 'Actions'. Below 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 three instances listed:

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS (IPv4)
cshl-2018-m...	i-00fe7afc1e68869f5	m5.2xlarge	us-west-2a	stopped	None	None	ec2-34-212-44-228.us...
KelsyCotto	i-0e3be57bca76f271d	m4.xlarge	us-west-2c	running	Initializing	None	ec2-34-211-56-245.us...
cshl-2018-in...	i-0e3be57bca76f271d	m5.2xlarge	us-west-2a	stopped	None	None	ec2-34-211-56-245.us...

A red arrow points to the 'KelsyCotto' instance, and another red box highlights the 'Connect' button at the top of the page.

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 the instance using a standalone SSH client or a Java SSH Client. It lists four steps for access: 1. Open an SSH client, 2. Locate the private key file, 3. Change permissions on the key file, and 4. Connect using the Public DNS. An example command is provided: `ssh -i "cshl_2018_student.pem" root@ec2-34-211-56-245.us-west-2.compute.amazonaws.com`. A note states that the username is likely "root" but to check the AMI usage instructions. 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 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 Placement Groups

Launch

Connect To Your Instance

I would like to connect with A standalone SSH client (i) A Java SSH Client directly from my browser (Java required) (i)

To access your instance:

1. Open an SSH client. (find out how to [connect using PuTTY](#))
2. Locate your private key file (`cshl_2018_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_2018_student.pem`
4. Connect to your instance using its Public DNS:
`ec2-34-211-56-245.us-west-2.compute.amazonaws.com`

Example:

```
ssh -i "cshl_2018_student.pem" root@ec2-34-211-56-245.us-west-2.compute.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.

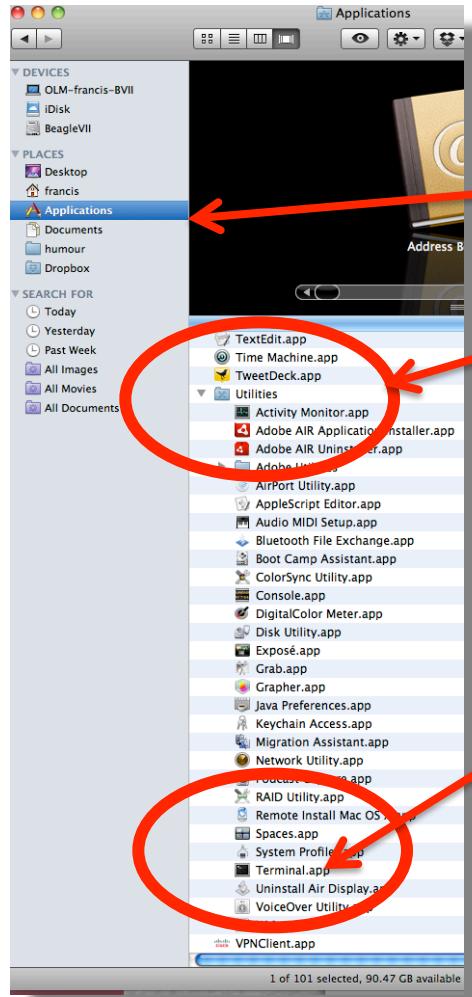
If you need any assistance connecting to your instance, please see our [connection documentation](#).

Close

Instance type m4.xlarge IPv6 IPs -

Status Public DNS (IPv4)
ec2-34-212-44-228.us...
ec2-34-211-56-245.us...
45.us-west-2.compute.amazonaws.com

Opening a ‘terminal session’ on a Mac

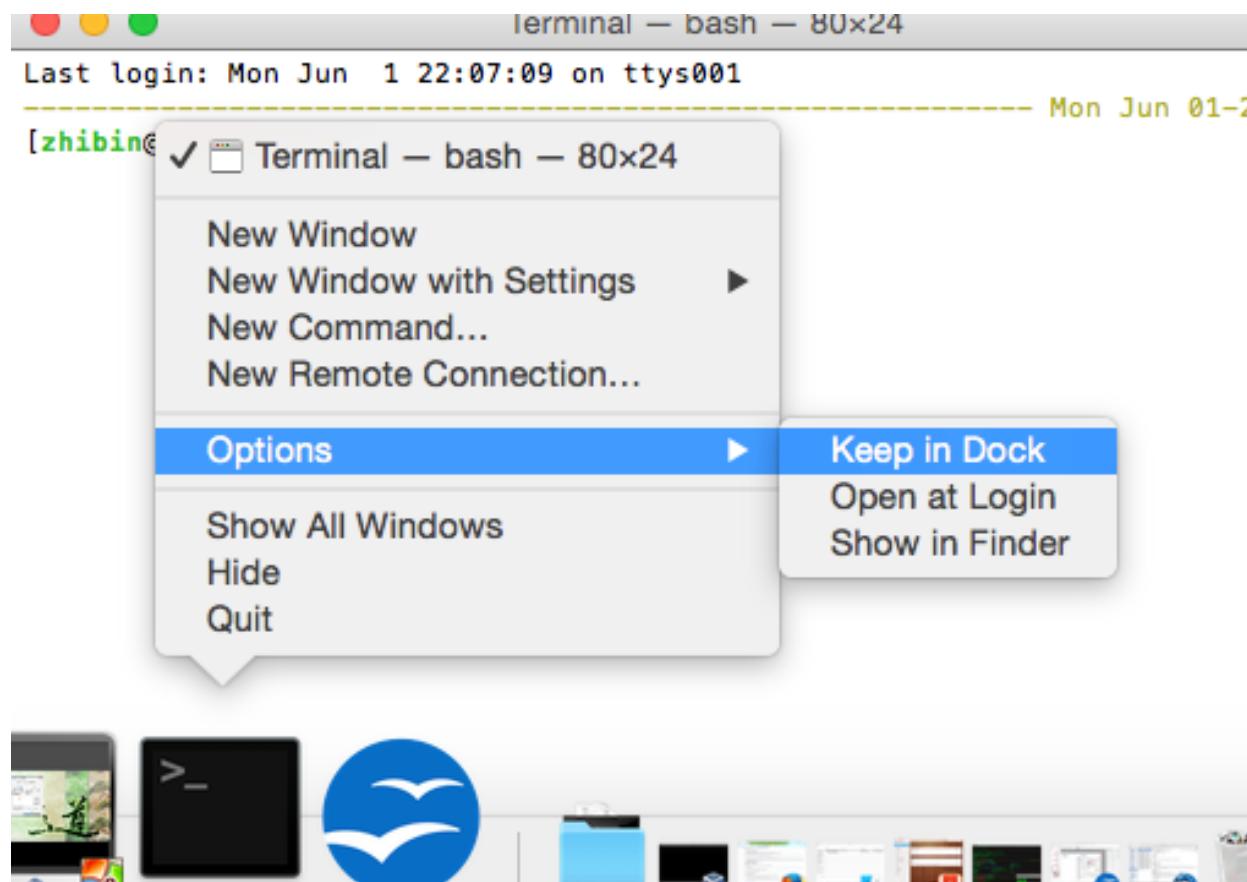


In a Finder window
'Applications' -> 'Utilities' -> 'Terminal'



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 2018: Wiki

Home View Edit Info History Watch Search:

Accessing The Cloud ▶ Recently visited

Accessing The Cloud last modified by Malachi Griffith on November 9, 2018 8:55:29 AM EST

Instructions for students to access their AWC EC2 cloud instance

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.

Visit AWS Console to create instance:

- 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)

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

- [cshl_2018_student.pem](#)

Connect to AWS instance via Terminal:

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



Viewing the ‘key’ file once downloaded

`cat cshl_2018_student.pem`

```
GSC-Systemss-MacBook-Pro-3:cshl kcotto$ cat cshl_2018_student.pem
-----BEGIN RSA PRIVATE KEY-----
MIIEpAIBAAKCAQEATgc+HFIf9S1YofCDwMH0C7S/o+t7sr/X660u7P5KhE22EQuHFVtku4BkPM
oEEUYbtCwBR5dJvoqSoMBfd7/PQnLhPdWuVRVc4XiPZGhsq4E9jZFodzDS9aPAq1aRbHFxbjTCoi
clsKWqcdQQ2g5vLC0P4kqBRnB+KPicuGjPrN5ZrMefZcm57eYTmF9BAWoL67xh+vnNghKH82eXUj
fvk93PuzOKYKAkm5qzkpFTTSjKH5ip264JX44Kr8iNjeycGMpKxD2iZ4CPeiq/w1Zh8PWRfDzlnP
/PzKtrpWW+rkbZ/+hJIe2y8q7IbzUvKCrVzsG1QHfwUzUAZUw5DZ+QIDAQABoIBAQCJqLsLY9d7
U5Uj/T8pfLTl8Ti8JNgotjNDMxfMwND0LRyh0AvhYlncbn4QUlVS1guQoJYb3p3eHZRD6Ka3/VBx
TVWrKOgmYh+6jiJyJQkrETu5MDrbwTlTiMfZtzuifHr0xEPSsCL01Bsh03QNU/cLMrz4avfbRai
c51dyULbAkghWD/FHQzsgQ7KqdM615pLy1u2JvQ0wdlR6emEEB900zfDrSBZzmBGeoJd1EkepEtg
2Lgyjs4CLMxKIiqTMaLY2fCJ3Xm9II5s10ryGoo8lvujKSICJM2zyVIbVgEfwc0lZ1020i97IcjU
GSqjDr0/EGu2iCi+8NvQ+u1R0JsVAoGBA070xzZ6k02yLRi2Pq7l13D67M9YaG1PeqOrE3M1nwmm
5uAWhmcBAGfGeLH8myJDBmcqtfochsCDyggkI9Ept5UmwxlZ1Ecq8C+Bsj/aDL/jvY+7AxfpK+GIU
L00kXA9FaTiCe0VukFDyR4zIlP4sy68iFcKAwIn+tDHywPi+7BzAoGBAoI2bbdvEDRfNB09bi1g
qo5Kbo92oXFewEB55/qHj1hABj+W7hU2V4tavNG1w2RJ9y36Zp0S8QsY1LyiaaZ9i4Zow27rJG1N
2L3B+JeF3ib1JHb94aLiFPsi492k4Wco1QHRSk5dXZykCpwWrkTImgzQErtaQM035DXG5zWz6gzj
AoGAUqHU7fLvU3PlAmGrRYHhn9E16PHSkJKp4reW/3T9FuCBUXkzmPbRwesHyiSYQ06iByN92LK
SWpzKzqsd7yPCK+XtrgfIfNrS/1ev01YYoYuEZcaH1ajLA8U1RhWOXWwTfnq4rQcNdHCil2moErP
WM25ppwteMrad1c50PtCPB8CgYAkK0Z+PircmPd1Ifof32hi2Tq53YxXGyNuYgQmMi+bXcga1hCH
B30v0ZiLV57Y1Y4vfT24Lhx8xw05jFyzXcvzrhCqCq4MtW66340Nr+bJU0ypmegZ8t2j8tZLura1
2+jPcZiV9D/e2rgzbmsDkdIvr59ZrzDhupEjsph5Bk+YVQKBgQC6vNLisnJDX+dbLB6My2D1ZSJ+
paubgw7fi78PsAezNLWX8iHzBBEuDcxVU7TD8fsFIttBEipUERCMAQRxQ0KjrdxRHTc4G7DcDwG
vQ601EwNyPK0Mn8FzEGBb9WT7bk50x9iNox2YYzpRwZdTScpFaxwErihSaf+VetF2+lijQ==
-----END RSA PRIVATE KEY-----GSC-Systemss-MacBook-Pro-3:cshl 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_2018_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>

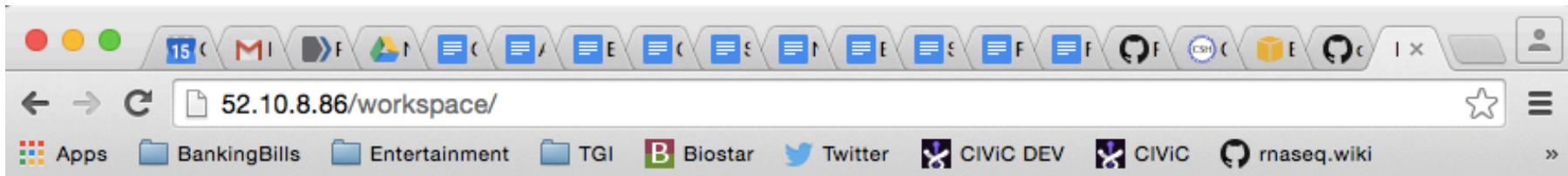
It is “r” for the the file owner **only**

Logging into your instance

Mac/Linux

```
cd ~/cshl  
chmod 400 cshl_2018_student.pem  
ssh -i cshl_2018_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.

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, 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' link in the sidebar. In the main content area, there's a table of instances. One instance named 'JasonWalker' is highlighted with a red box and has a context menu open over it. The context menu has several options: Connect, Get Windows Password, Launch More Like This, Instance State, Instance Settings, Image, Networking, CloudWatch Monitoring, and Terminate. The 'Instance State' option is expanded, and its sub-option 'Start' is also highlighted with a red arrow. Below the table, there's a status bar showing 'Instance: i-3246aae8 (JasonWalker)' and 'Private IP: 172.31.5.175'. A large red box encloses the entire central area of the dashboard.

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. Another red arrow points to the 'Public IP' field in the 'Description' tab at the bottom right.

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

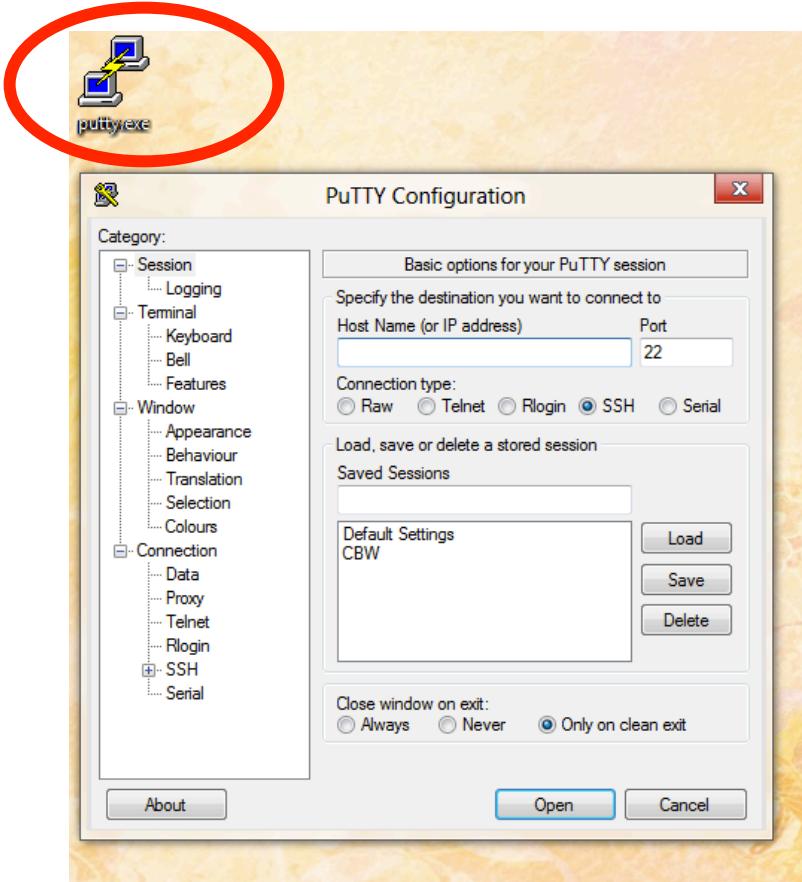
Break

Obtain the course SSH key file

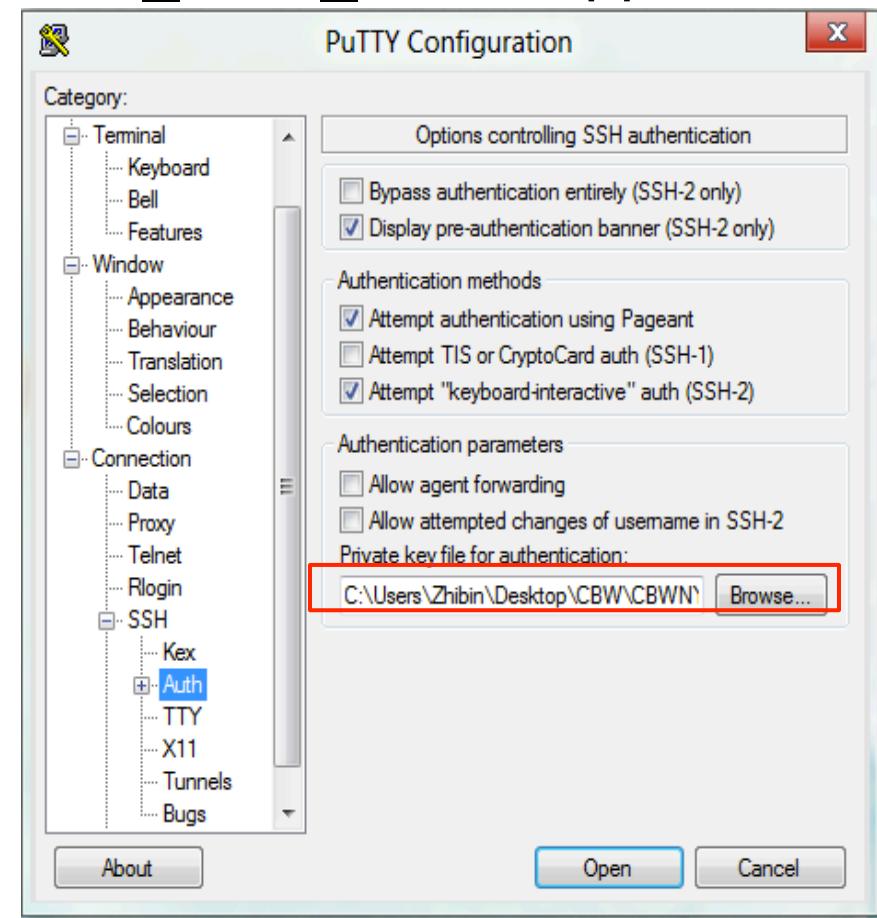
- NOTE for Mac users. You will need to use a “.pem” file
- **NOTE for Windows Users.** You will need to use a “.ppk” file instead.
 - This is created from the “.pem” file.
 - <https://aws.amazon.com/premiumsupport/knowledge-center/convert-pem-file-into-ppk/>
- The SSH key file will be used to securely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

Logging into your instance (Windows)

Open PuTTY

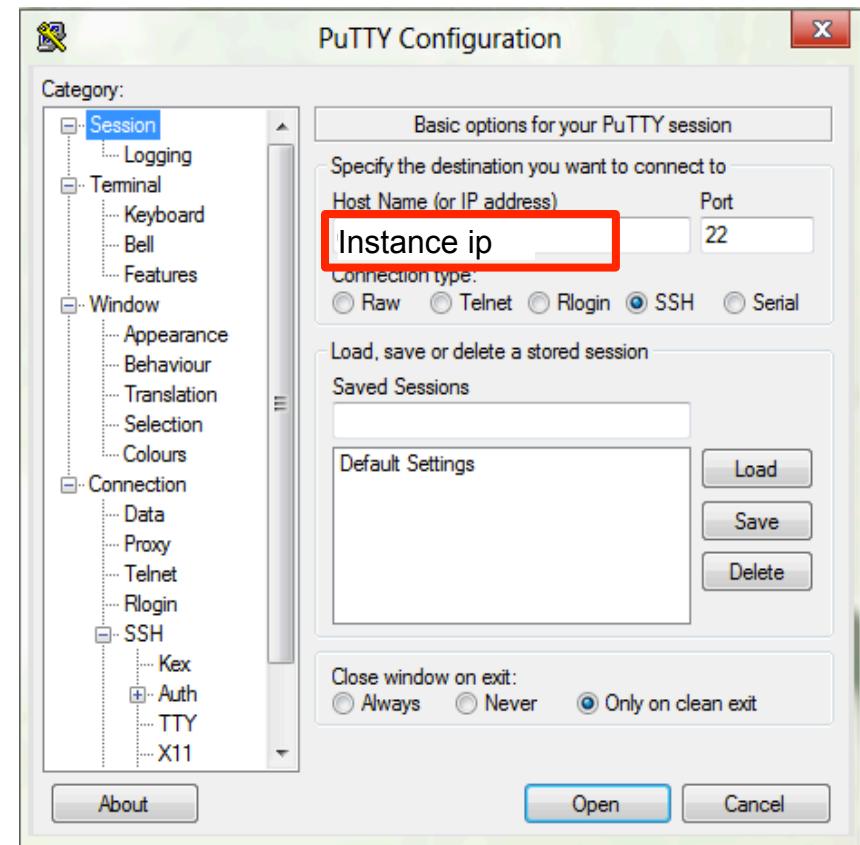
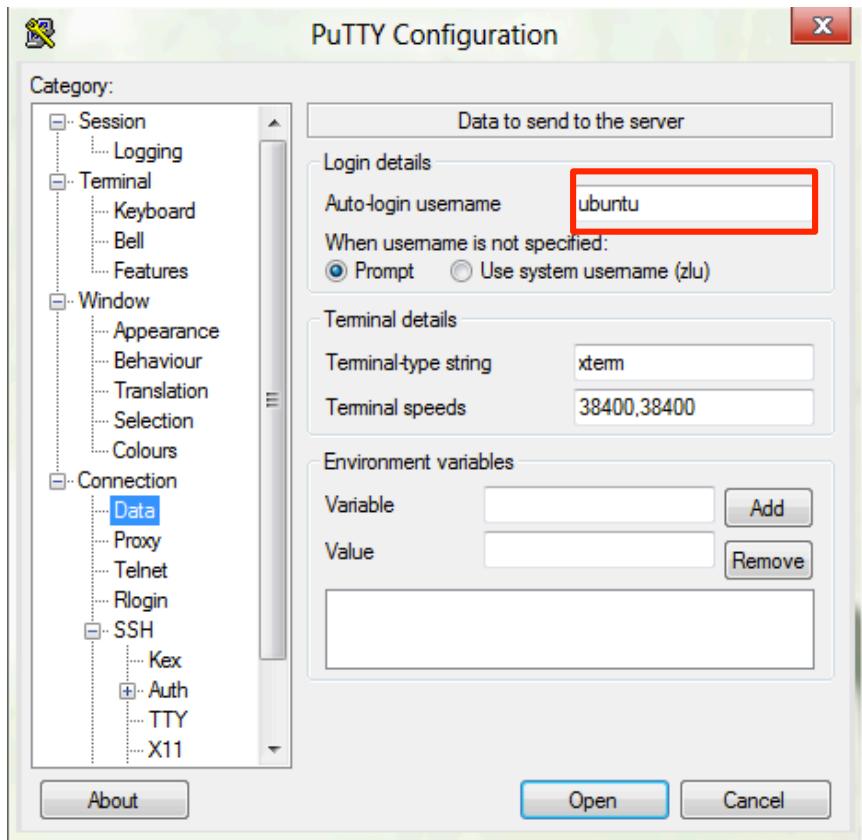


Browse to the
cshl_2018_student.ppk file



Logging into your instance (Windows)

Enter the user name ‘ubuntu’ Enter the host name



Logging into your instance (Windows)

Open PuTTY

