Using Cloud Compute Services for Radiance Simulations Andy McNeil

Disclaimers

- receive.

 This presentation is offered with no warranty, use at your own risk. Andy is a hobbyist at best. Consult a network security expert for much better advice regarding security than what you're about to

There is likely a better way to do everything I'm going to show you.





There is no cloud. It's just someone else's computer.

Why use someone else's computer?

- Computing resources scale with needs
 - Add and drop instances as your workload changes
 - No need to coordinate with coworkers for running jobs
- Zero up front cost | Hello Freelancers!
- Track costs by project and bill computing expense to client
 Use Linux-only Radiance features without having to get a linux /
- Use Linux-only Radiance feature mac computer

Andy's experience in 2015-2016

የጵ Lighting Team



Andrew McNeil – June 14, 2016 at 01:20 PM

As a contractor to Arup I (mostly) provide my own computing resources. For Radiance simulations I use the Amazon Elastic Compute Cloud (EC2). I've just been reviewing my usage statistics over the last 11 months, and thought I'd share with the lighting community.

With the EC2 you choose the specs of your instance when you request it. They have instances with specs ranging from 1 to 40 CPUs. I tended to use instances ranging from 32-40 cpus (depending on market pricing).

My usage statistics over the Past 11 months: Total Cost: \$888 Total CPU hours: 69,028 Cost per CPU hour: \$0.013

On average over the 11 months I had 8.5 CPUs for \$900, which is competitive with purchasing a high end desktop computer (assuming a 3-4 year life). But the real benefit is scalability. You see I didn't have an 8 CPU computer, I had practically unlimited computing resources at my disposal when I needed them. For example, right now I have 4 x 40 CPU instances running (160 CPUs total!) and it is only costing me \$1.40 an hour at spot market pricing.

- 11 months
- \$900
- 69,028 CPU hours

 (equivalent to 8.5 constantly running CPUs)
- 160+ CPUs running for short periods
- Zero CPUs most of the time

Who's Computer?

- AWS (Amazon)
- Azure (Microsoft)
- Google Cloud
- IBM Cloud
- Cloud & Heat Distributed mini data centers that also provide heat to buildings
- And lots more...

Considerations - just a lazy list

- Access
- Storage
- Instance Configurations
- Computing Costs
- Spot / Low-Priority / Preemptible offering
- Your employer's preference (and your client's preference)



- It was 2015 AWS was the leader in cloud services
- Now things are pretty even between biggest cloud providers (but I still use AWS 'cause I'm an old dog) 🐼

Getting Started with AWS in Twenty-one Easy Steps!

- 1. Create an AWS account
- 2. Choose a Region
- 3. Generate a key pair
- 4. Set up a security group
- 5. Choose spot or reserved instance
- 6. Select an instance type
- 7. Select a machine image
- 8. Launch instance
- 9. Connect to your instance
- 10. Install software
- 11. Save a machine image
- 12. Create persistent file storage

- 13. Mount persistent file storage
- 14. Upload Radiance model files
- 15. Start simulation
- 16. Set an alarm to terminate instance when simulation finishes
- 17. Launch an instance to retrieve results from file storage
- 18. Download results
- 19. Terminate instance
- 20. Get your cloud expenses and invoice your client
- 21. Bask in the glory of a job well done



AWS Regions

US East (Ohio)

US East (N. Virginia)

US West (N. California)

US West (Oregon)

Asia Pacific (Hong Kong)

Asia Pacific (Mumbai)

Asia Pacific (Osaka-Local)

Asia Pacific (Seoul)

Asia Pacific (Singapore)

Asia Pacific (Sydney)

Asia Pacific (Tokyo)

Canada (Central)

China (Beijing)

China (Ningxia)

EU (Frankfurt)

EU (Ireland)

EU (London)

EU (Paris)

EU (Stockholm)

Middle East (Bahrain)

South America (Sao Paulo)

Choose a region based on proximity and cost.

N. Virginia Oregon Mumbai Stockholm Canada Frankfurt Singapore London N. California Hong Kong Sydney Sao Paulo



N. California is the most expensive of the US regions, and typically the last to get new features.



Cost by AWS region: 5 c5.large, 20GB gp2 EBS storage each, 1 ELB, 5.1TB data processed

https://www.concurrencylabs.com/blog/choose-your-aws-region-wisely/





Key Pairs

- Key pairs are used to securely access your AWS resources.
- Each key pair has a public and private component.
 - AWS keeps the public part
 - You get the private part.
- The private key is downloaded to your computer when it is created
 - There is no way to get the private key again
 - If you lose the private key file you'll have to generate a new key pair and delete the old one



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To start, you have no key pairs in your account.

Click: "Generate Key Pair"

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Enter a name for your key pair and click create.



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andy_ohio.pem is downloaded to my computer when I click "create"

Move your private key file somewhere secure and memorable. *I like to* use a hidden folder for key files on my mac.







Security Groups

- Sets access rules
 - restrict to IP address or only within security group
- Set accessible ports
 - SSH port 22
 - NFS port 2049
 - HTTP port 80, HTTPS port 443
- simplest to use one that's already created.
- Useful for connecting EFS with ECS instances (we'll get to this later)



• When you launch an instance, a temporary security group is created, however it's



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Your account contains a default security group that allows inbound connections from other instances in the security group and nowhere else.

Click 'Create Security Group' to make a new security group.







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We'll create a security group with the following inbound access:

ssh from anywhere (so you can connect to the instance from your computer)

nfs from anywhere (we'll restrict nfs to this security group in the next step)







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885639356958	SSH & NFS
885639356958	default VPC security group



Now we have two security groups.

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- Owner	- Description
885639356958	SSH & NFS
885639356958	default VPC security group



Edit the inbound rules for the new secruity group by adding the ID of the security group in the source field for NFS.

This will restrict inbound NFS to only services in this security group.





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- Owner	- Description
885639356958	SSH & NFS
885639356958	default VPC security group



Now we have a custom security group.

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Instance Types

- - General Purpose \bullet
 - M balanced compute, memory, and storage lacksquare
 - T burstable
 - A ARM
 - Compute Optimized lacksquare
 - C: Lower cost per compute cycle
 - Storage Optimized
 - I: large SSD local storage \bullet
 - D: Very large HDD local storage (up to 48 TB)
 - H: Large HDD local storage (up to 16TB) and balanced compute and memory



Dozens of machine instances available organized into categories:

- Memory Optimized
 - R: more RAM per CPU
 - X: optimized for in memory database applications lowest cost per GiB of RAM
 - Z: more RAM per CPU with highest CPU clock speed \bullet (4.0 GHz)
- Accelerated Computing (GPU FGPA)
 - P: General Purpose GPU
 - G: Graphics intensive GPU
 - F: FGPAs



Information about instance types

- Amazon's info: https://aws.amazon.com/ec2/instance-types/
- https://www.ec2instances.info





• This 3rd-party website is sortable, filterable and includes prices:

Three ways to purchase an instance

- On-demand regular
- Reserved pay by the year
- Spot pseudo auction





On-Demand Instance

- You start and stop the instance.
- You are billed per hour at fixed rate, only for the time you use.
- Nothing can stop the instance except you.





Reserved Instance

- Discounts on long term reservations. The instance is yours for the duration of the term wether you use it or not.
- 38% discount for a 1-year reservation paid monthly
- 72% discount for a 3-year reservation paid in advance

You probably don't want to use reserved instances





SPOT Instance

- You can get discounted rates on spare capacity (up to 90%) discount).
- You bid the most you're willing to pay per hour.
- You pay the market clearing rate each hour (not your bid rate).
- If the market clearing rate exceeds your bid amount your instance is terminated without warning.









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Date

7/28/2019 3:45:04 PM UTC-0700

On-Demand price

\$26.6880

Availability Zone Price

📃 us-east-2b

\$26.6880

Close





My spot bidding strategy: Bid a few cents more than the on-demand price.







Matillion ETL for Amazon Redshift

By Matillion Rating ***** Starting from \$1.37/hr or from \$9,950/yr (17% savings) for software + AWS usage



Let's launch an instance!

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Quick Start		
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AWS Marketplace	Amazon Linux Free tier eligible	Amazon Linux 2 comes with five years support. It provides Linux kernel 4.14 tuned for o
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	Free tier eligible	Red Hat Enterprise Linux version 8 (HVM), EBS General Purpose (SSD) Volume Type Root device type: ebs Virtualization type: hvm ENA Enabled: Yes
	SUSE Linux	SUSE Linux Enterprise Server 15 SP1 (HVM), SSD Volume Type - ami-0e0 0b49a8f443e46ff20 (64-bit Arm)
	Free tier eligible	SUSE Linux Enterprise Server 15 Service Pack 1 (HVM), EBS General Purpose (SSD) Vol Management, Web and Scripting, and Legacy modules enabled.
		Root device type: ebs Virtualization type: hvm ENA Enabled: Yes
	0	Ubuntu Server 18.04 LTS (HVM), SSD Volume Type - ami-05c1fa8df71875 (64-bit Arm)

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I've always used Amazon Linux. I don't have a good reason.









Step 2: Choose an Instance Type

Amazon EC2 provides a wide selection of instance types optimized to fit different use cases. Instances are virtual servers that can run applications. They have varying combinations of CPU, memory, storage, and networking capacity, and give you the flexibility to choose the appropriate mix of resources for your applications. Learn more about instance types and how they can meet your computing needs.

Filter by:	All instance types	~	Current generation	*	Show/Hide Columns
r neor wy.	All motarios types		Sanon generation	_	onon/mac ociami

Currently selected: t2.micro (Variable ECUs, 1 vCPUs, 2.5 GHz, Intel Xeon Family, 1 GiB memory, EBS only)											
	Family	т Туре т	vCPUs (j) -	Memory (GiB) 👻	Instance Storage (GB)	EBS-Optimized Available	Network Performance	IPv6 Support			
0	General purpose	t2.nano	1	0.5	EBS only	-	Low to Moderate	Yes			
	General purpose	t2.micro Free tier eligible	1	1	EBS only	-	Low to Moderate	Yes			
	General purpose	t2.small	1	2	EBS only	-	Low to Moderate	Yes			
	General purpose	t2.medium	2	4	EBS only	-	Low to Moderate	Yes			
	General purpose	t2.large	2	8	EBS only	-	Low to Moderate	Yes			
	General purpose	t2.xlarge	4	16	EBS only	-	Moderate	Yes			
	General purpose	t2.2xlarge	8	32	EBS only	-	Moderate	Yes			
	General purpose	t3a.nano	2	0.5	EBS only	Yes	Up to 5 Gigabit	Yes			
	General purpose	t3a.micro	2	1	EBS only	Yes	Up to 5 Gigabit	Yes			
	General purpose	t3a.small	2	2	EBS only	Yes	Up to 5 Gigabit	Yes			
	General purpose	t3a.medium	2	4	EBS only	Yes	Up to 5 Gigabit	Yes			
	General purpose	t3a.large	2	В	EBS only	Yes	Up to 5 Gigabit	Yes			
	Conoral purposo	+2n ylarna	4	10	EBS only	Vaa	Lin to E Cianhit	Van			
					Cancel	Previous Review and La	aunch Next: Configure In	stance Detail			



Then you select the type of instance.

Make sure you only use the free tier eligible instance if you don't want to pay.









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 Launch into Auto Sca		ing G	iroup 🕕			
Purchasing option	()	Request Spot instances						
Network	(i)	vpc-fe0a3097 (default)	\$	С	Create new VPC			
Subnet	(i)	No preference (default subnet in any	Availability Zon 🛊		Create new subnet			
Auto-assign Public IP	()	Use subnet setting (Enable)	*					
Placement group	()	Add instance to placement group						
Capacity Reservation	()	Open	\$	С	Create new Capacity			
IAM role	()	None	\$	С	Create new IAM role			
Shutdown behavior	(i)	Stop	\$					
Enable termination protection	(i)	Protect against accidental termination	ion					
Monitoring	(i)	Enable CloudWatch detailed monitor Additional charges apply.	oring					
Tenancy	(j)	Shared - Run a shared hardware instance Additional charges will apply for dedicated tenancy.						
Elastic Inference	(i)	Add an Elastic Inference accelerato Additional charges apply.	۲					
T2/T3 Unlimited	()	Enable Additional charges may apply						

Advanced Details



Nothing to do here yet.

But we'll do some things here later.

Reservation

Review and Launch Next: Add Storage Previous Cancel © 2008 - 2019, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use







storage options in Amazon EC2.

Volume Type 🕕	Device (j)	Snapshot (j)	Size (GiB) (i)	Volume Type (i)	R
Root Add New Volume	/dev/xvda	snap- 077085afe6b3ee68d	8	General Purpose SSD (gp2)	1

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.



This is where you add EBS storage, if you decide to use that.

Review and Launch Cancel Previous Next: Add Tags © 2008 - 2019, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use







Launch Instance Wizard CC2 X +				
O https://us-east-2.console.aws.amazon.com/ec2/v2/home?region=us-east-2#LaunchinstanceV	Vizard:	Q	슈 🔋 🛰 🖾 🖾 Q	8 🎒 🗄
Apps 👩 TerrestrialLight E 🥝 LBNL71T 📔 Inbox (7) - moneil 🗞 Immersive Render 🥃 Halio API v3.0.0				
aws Services - Resource Groups - 🛠		斗 🔹 Andrew McNeil 👻	- Ohio - Support	¥
1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Stor	age 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 defin 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 y	e a tag with key = Name and value = Webserver. our Amazon EC2 resources.			
Key (128 characters maximum)	Value (256 characters maximum)	Instances (i)	Volumes ()	
project	radiance workshop		₽ €	3
Add another tag (Up to 50 tags maximum)				





If you want to track costs by project, add a tag here.

Also, you need to activate the tag in the cost management page (we'll do that towards the end)

Review and Launch Previous

Next: Configure Security Group







1.	Choo	se AMI 2.	Choose ins	tance Typ	pe 3.(Configure Instanc	e	4. Add Storage	5. Add Tags	6. Configure Security Group	7. Review
	a	WS	Services	\$ ~	Resour	rce Groups 🔻		*			
Арра	ø	TerrestrialLight E	S LBNL711	M Inbox (7) - mcneil	👌 Immersive Render	3	Halio API v3.0.0			
$\leftarrow \rightarrow$	С	ii https://us-ea	st-2.console.a	aws.amazon	n.com/ec2/v2	2/home?region=us-ea	st-2#	LaunchInstanceWizard:			
•••		Launch instance wia	rard EC2 \ 🗙	+							

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.

000

Assign a security group:
Oreate a new security group

	Select an existing security group	qu	
Security Group ID		Name	Description
sg-07c3608c40753cd0d		Basic	SSH & NFS
sg-6c47cc04		default	default VPC security group

Inbound rules for sg-07c3608c40753cd0d (Selected security groups: sg-07c3608c40753cd0d)

Туре ()	Protocol ()	Port Range ()	Source
SSH	TCP	22	0.0.0/0
SSH	TCP	22	::/0
NFS	TCP	2049	sg-07c36



Actions
Copy to new
Copy to new



We'll use the security group we created.

(i)	Description (i)		
)			
608c40753cd0d (Basic)			
Canc	el Previous Rev	iew and Launch	
leb Services, Inc. or its affiliates. All right	ts reserved. Privacy Polic	cy Terms of Use	





•••	1	Launch instance wi	rard EC2 \ 🗙	+						
$\leftarrow \ \rightarrow$	С	ii https://us-ea	ast-2.console.a	ws.amazor	n.com/ec2/v2	2/home?region=	us-east-2	#LaunchInstanceWizard:		
Арра	op Te	errestrialLight E	S LBNL711	M Inbox (7) - mcneil	👌 Immersive Re	nder	🕃 Halio API v3.0.0		
	a۱	WS	Services	\$ ~	Resou	rce Group	s v	*		

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 insta

Improve your instances' security. Your security group, Basic, 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 You can also open additional ports in your security group to facilitate access to the application or service you're running, e.g., HT

AMI Details

A

Amazon Linux 2 AMI (HVM), SSD Volume Type - ami-0d8f6eb4f641ef691

Amazon Linux 2 comes with five years support. It provides Linux kernel 4.14 tuned for optimal performance on Amazon EC2, systemd Free tier software packages through extras. eligible

Root Device Type: ebs Virtualization type: hvm

Instance Type

Instance Type	ECUs	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimi
t2.micro	Variable	1	1	EBS only	-

Security Groups

Security Group ID	Name	Des
sg-07c3608c40753cd0d	Basic	SSH &

All selected security groups inbound rules

Туре ()	Protocol (i)	Port Range ()	Source ()
SSH	TCP	22	0.0.0/0
SSH	TCP	22	::/0
NFS	TCP	2049	sg-07c3608

	Q	☆ 🦻 ₩ 题	💷 🖓 👂 🗐 💿
Д °	Andrew McNeil	- Ohio - S	Support 👻
ance and complete the launch	process.		
s from known IP addresses on TP (80) for web servers. Edit s	ily. security groups		
			Edit AMI
219, GCC 7.3, Glibc 2.26, Binut	tils 2.29.1, and the I	atest	
		Edit in:	stance type
ized Available	Network Perfo	rmance	
	Low to Moderat	te	
		Edit secu	urity groups
escription			- H
H&NFS			
	Description (i)		- H
8c40753cd0d (Basic)			
	Can	Previous	s Launch
Web Services, Inc. or its affiliates.	All rights reserved.	Privacy Policy	Terms of Use



Yes, the security group is open to the world, but they can't get in without your private key.


🔍 🔍 🔹 👔 Launch instan	ice wizard FC2 \ × +					
\leftarrow \rightarrow C iii https://	us-east-2.console.aws.amazon.com,	/ec2/v2/home?region=us-east-2#	LaunchinstanceWizard:			
🔛 Apps 🕜 TerrestrialLight	: E 🔇 LBNL7TT M Inbox (7) - mo	neil 👌 Immersive Render 🔮	Halio API v3.0.0			
aws	Services - Re	source Groups 🕞	*			
1. Choose AMI	2. Choose Instance Type	3. Configure Instance	4. Add Storage	5. Add Tags	6. Configure Security Group	7. Review

Step 7: Review Instance Launch

A

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 insta

Improve your instances' security. Your security group, Basic, 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 You can also open additional ports in your security group to facilitate access to the application or service you're running, e.g., HT

 AMI Details 				
🎁 🛛 Amazon Linux 2 AMI (HVN	I), SSD Select an	existing key pair or create	a new key pair	
Free tier Amazon Linux 2 comes with five eligible software packages through extra Root Device Type: ebs Virtualization	as. n type: hv to obtain the pa securely SSH in	ists of a public key that AWS stores, and a o connect to your instance securely. For W ssword used to log into your instance. For to your instance.	a private key file that you a Vindows AMIs, the private I r Linux AMIs, the private ke	
Instance Type ECUs	vCP Note: The select about removing	Note: The selected key pair will be added to the set of keys authoriz about removing existing key pairs from a public AMI.		
t2.micro Variable	1 Choose an	ı existing key pair		
 Security Groups 	Select a ke aws_ohio	y pair ledge that I have access to the selected p file. I won't be able to log into my instance	rivate key file (aws_ohio.pe e.	
Security Group ID				
sg-07c3608c40753cd0d			Cancel	
All selected security groups inbound re	ules			
Туре ()	Protocol (i)	Port Range (i)	Source ()	
SSH	TCP	22	0.0.0/0	
SSH	TCP	22	::/0	
NFS	TCP	2049	sg-07c3608d	

	Q 🕁) 🔊 👐 🖾 🖾 🖓 🖓 🌘 🔿
	Andrew Mallait -	Ohio - Ourset
		Unio + Support +
ance and complete the lau	unch process.	
	-	
from known IP addresse	s only.	
TP (80) for web servers. E	dit security groups	
		Edit AMI
×		
	Binutils 2.29.1, and the lates	st
i store. Together, kev file is required		
ey file allows you to		
		Edit instance type
nce. Learn more	Network Performs	ance
		1100
*	Low to Moderate	
*		
pem), and that		Edit security groups
aunch Instances		
	Description (i)	
8c40753cd0d (Basic)		
	Cancel	Previous Launch
Web Services. Inc. or its affilia	ates. All rights reserved	rivacy Policy Terms of Use



Pick the key you want to use, and then acknowledge that you have the key file.







🗢 🔍 🍵 👔 Instances EC2 Management C 🗙	+		
\leftarrow \rightarrow $_{\rm C}$ $_{\rm in https://us-east-2.console.ar$	ws.amazon.com/ec2/v2/home?region=us-east-2#Inst	tances:sort=instanceId	
🔛 Apps 🕜 TerrestrialLight E 🔇 LBNL/11	M Inbox (7) - moneil 🐐 Immersive Render 🔇 Ha	ilio AFI V3.0.0	
aws Services	- Resource Groups 🗸 🕈	k	
EC2 Dashboard	Launch Instance 👻 Connec	Actions V	
Events			
Tags	Q Filter by tags and attributes or se	arch by keyword	
Reports		- Instance Type - Availability Zone -	Instance State
Limits		Availability zone	· Instance State ·
	i-0558a0059	aa9097 t2.micro us-east-2b	🥥 pending
Instances			
Launch Templates			
Spot Requests			
Reserved Instances			
Dedicated Hosts			
Capacity Reservations			
- IMAGES			
AMIs			
Bundle Tasks			
	Instance:	Public DNS: ec2-18-222-35-37.us-east-2.co	mpute.amazonaws.co
	Description Status Checks	Monitoring Tags	
Sponshoto			
Shapshots	Instance ID	i-0558a0059aa90975a	P
Lifecycle Manager	Instance state	pending	
NETWORK & SECURITY	Instance type	t2.micro	
Security Groups	Elastic IPs		
Elastic IPs	Availability zone	us-east-2b	
Placement Groups	Security groups	Basic, view inbound rules, view outbound rules	Seco
Key Pairs	Scheduled events	-	
Network Interfaces	AMI ID	amzn2-ami-hvm-2.0.20190618-x86_64-gp2	
	Platform	(ami-0doloep4to41eto91) -	Ne
Load Balancers	IAM role	-	So
Target Groups	Key pair name	aws_ohio	
larger croups	Owner	885639356958	
AUTO SCALING	Launch time	August 11, 2019 at 11:13:03 AM UTC-7 (less	I
Launch Configurations		than one hour)	
Auto Scaling Groups	Termination protection	False	
	Lifecycle	normal	

Q 🛧 🎘 🚾 🕼 Q 🔒 🛛 🌗	0
🗘 🎴 Andrew McNeil 👻 Ohio 👻 Support 👻	
▲ ⊕ ♦ (9
Status Checks - Alarm Status Public DNS (IPv4) - IPv4 Pub	lic
🛣 Initializing None 🍖 ec2-18-222-35-37.us-e 18.222.38	5.3



There it is, you did it! You are clouding!

om		
Public DNS (IPv4)	ec2-18-222-35-37.us-east-	
	2.compute.amazonaws.com	
IPv4 Public IP	18.222.35.37	
IPv6 IPs	-	
Private DNS	ip-172-31-16-190.us-east-2.compute.inte	ernal
Private IPs	172.31.16.190	
ndary private IPs		
VPC ID	vpc-fe0a3097	
Subnet ID	subnet-955219ee	
etwork interfaces	eth0	
urce/dest. check	True	
T2/T3 Unlimited	Disabled	
EBS-optimized	False	
Root device type	ebs	
Root device	/dev/xvda	
Block devices	/dev/xvda	
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Connecting to your instance

- Mac & Linux: use ssh
- Windows: use putty or your favorite ssh client



•••

î andy — -bash — 80×24

Last login: Sun Aug 11 11:39:28 on ttys008 amcn:~ andy\$ ssh -i aws_ohio.pem ec2-user@18.222.35.37

ssh command from mac

-i to use your private key file

ec2-user is the username for amazon linux

use the public IP for your instance



.

andy — ssh -i aws_ohio.pem ec2-user@18.222.35.37 — 80×24

Last login: Sun Aug 11 11:39:28 on ttys008 amcn:~ andy\$ ssh -i aws_ohio.pem ec2-user@18.222.35.37 The authenticity of host '18.222.35.37 (18.222.35.37)' can't be established. ECDSA key fingerprint is SHA256:pxosq3oYz00IHPIERekfuZUE0kLG/KnlG4AbWRXevuM. Are you sure you want to continue connecting (yes/no)?

yes you want to continue connecting.



👔 andy — -bash — 80×24 Last login: Sun Aug 11 11:39:28 on ttys008 amcn:~ andy\$ ssh -i aws_ohio.pem ec2-user@18.222.35.37 The authenticity of host '18.222.35.37 (18.222.35.37)' can't be established. ECDSA key fingerprint is SHA256:pxosq3oYz00IHPIERekfuZUE0kLG/KnlG4AbWRXevuM. Are you sure you want to continue connecting (yes/no)? yes Warning: Permanently added '18.222.35.37' (ECDSA) to the list of known hosts. WARNING: UNPROTECTED PRIVATE KEY FILE! Permissions 0644 for 'aws_ohio.pem' are too open. It is required that your private key files are NOT accessible by others. This private key will be ignored. Load key "aws_ohio.pem": bad permissions ec2-user@18.222.35.37: Permission denied (publickey,gssapi-keyex,gssapi-with-mic amcn:~ andy\$

whoops!

you need tighter permissions for your private key.



👔 andy — -bash — 80×24 Last login: Sun Aug 11 11:39:28 on ttys008 amcn:~ andy\$ ssh -i aws_ohio.pem ec2-user@18.222.35.37 The authenticity of host '18.222.35.37 (18.222.35.37)' can't be established. ECDSA key fingerprint is SHA256:pxosq3oYz00IHPIERekfuZUE0kLG/KnlG4AbWRXevuM. Are you sure you want to continue connecting (yes/no)? yes Warning: Permanently added '18.222.35.37' (ECDSA) to the list of known hosts. WARNING: UNPROTECTED PRIVATE KEY FILE! Permissions 0644 for 'aws_ohio.pem' are too open. It is required that your private key files are NOT accessible by others. This private key will be ignored. Load key "aws_ohio.pem": bad permissions ec2-user@18.222.35.37: Permission denied (publickey,gssapi-keyex,gssapi-with-mic amcn:~ andy\$ chmod 600 aws_ohio.pem

chmod 600 to prevent access from any other user.





● ● ●
ECDSA key fingerprint is SHA256:pxosq3oYz00IHPIERekfuZUE0kLG/Kn
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '18.222.35.37' (ECDSA) to the list o
<u> </u>
@ WARNING: UNPROTECTED PRIVATE KEY FILE! @
 බිබබබබබබබබබබබබබබබබබබබබබබබබබබබබබබ
Permissions 0644 for 'aws ohio.pem' are too open.
It is required that your private key files are NOT accessible b
This private key will be ignored.
Load key "aws ohio.pem": bad permissions
ec2-user@18.222.35.37: Permission denied (publickey.gssapi-keye
).
amcn:~ andy\$ chmod 600 aws ohio.pem
amcn:~ andv\$ ssh -i aws ohio.pem ec2-user@18.222.35.37
Last login: Sun Aug 11 18:37:28 2019 from c-67-169-62-4.hsd1.ca
5
(/ Amazon Linux 2 AMI
https://aws.amazon.com/amazon-linux-2/
4 package(s) needed for security, out of 12 available
Run "sudo vum update" to apply all updates.

[ec2-user@ip-172-31-16-190 ~]\$

- nlG4AbWRXevuM.
- of known hosts.

- by others.
- ex,gssapi-with-mic
- a.comcast.net

then ssh again and viola!









📝 PuTTY Key Generator	?
<u>File Key Conversions H</u> elp	
Key No key.	
Actions Generate a public/private key pair	<u>G</u> enerate
Load an existing private key file	<u>L</u> oad
Save the generated key Save pub	olic key <u>S</u> ave private
Parameters Type of key to generate:	
● <u>R</u> SA ○ <u>D</u> SA ○ <u>E</u> CDSA ○ I Number of <u>b</u> its in a generated key:	Ed <u>2</u> 5519 OSSH- <u>1</u> (F 2048

Click "Load"

 \times

ate ke

Browse to and select your pem file from amazon.





ا 😴	PuTTY ł	Key Generator					?	
<u>F</u> ile	<u>K</u> ey	Conversions	<u>H</u> elp					
K	ey							
Ī	<u>P</u> ublic k	ey for pasting i	nto OpenSSH a	authorized_k	eys file:			
ssh-rsa AAAAB3NzaC1yc2EA 3We0fZ8XuM7ZM9eSa +my7qysnfKulkCtPKTg +E7h/2frNaichsWL4xQ			AAADAQABAA alFp0M2ypawlt IgQwLjBRRq1I w7FWbkhJ6MI	ABAQCKXE LlvSCT u05Wt71MH k1nTfRzq5n	3bxVuc9/UAHOjir PTux0uOCjyQE1 m3E4kT+F4FX78	nUAVmsy2 YyS 8cD/	WTi2uOpO	
I	Key <u>fi</u> ng	erprint	ssh-rsa 2048	76:19:5e:1c	:83:ae:2d:19:cf.ea	a:ec:c2:56:8	6:52:01	
H	Key <u>c</u> on	nment	imported-op	imported-openssh-key				
-	Key p <u>a</u> s	sphrase:						
(C <u>o</u> nfirm	passphrase:						
A	ctions							
(Generat	e a public/priva	ate key pair				<u>G</u> enera	
I	Load an	existing private	e key file				<u>L</u> oad	
:	Save the	e generated ke	у		Save p <u>u</u> blic k	key	<u>S</u> ave privat	
P	aramet	ers						
(Type of <u> R</u> SA	key to generat	e: <u>D</u> SA		A ○Ed <u>2</u>	5519	() SSH- <u>1</u>	
1	Number	of <u>b</u> its in a gen	erated key:				2048	









🔀 PuTTY Configuration		?
Example 2 Putty Configuration Category: Session Logging Terminal Keyboard Bell Features Window Appearance Behaviour Translation Selection	Basic options for your PuTTY sess Specify the destination you want to connect to Host Name (or IP address) 18.222.35.37 Connection type: Raw Orelenet Rlogin SSH Load, save or delete a stored session Saved Sessions	? sion <u>P</u> ort 22
 Selection Colours Connection Data Proxy Telnet Rlogin SSH Serial 	Default Settings	L S
<u>A</u> bout <u>H</u> elp	Always Never Only on cle	an exit

\times Select Session, if not already selected Enter the public IP address of ◯ Se<u>r</u>ial your instance Load Sa<u>v</u>e <u>D</u>elete Cancel



🔀 PuTTY Configurat	ion				?
Category:					
Category: Keyboard Bell Features Window Appearance Behaviour Translation Selection Colours Connection Data Proxy Telnet Rlogin SSH Kex Host keys Cipher Auth TTY X11 Tunnels Bugs		✓ Display Bypass Authenticatio ✓ Attempt ✓ Invate Key C:\Users\ar	Options contro pre-authentication authentication on methods authentication TIS or Crypto keyboard-int on parameters ent forwarding empted chang file for authen mcneil\Deskto	Iling SSH authenti ation banner (SSH entirely (SSH-2 or auth (SSH-1) eractive" auth (SSI ges of username in tication: op\aws_ohio.ppk	cation -2 only) nly) H-2) n SSH-2 Bro <u>w</u> se.
More bugs	×			0	
<u>A</u> bout	<u>H</u> elp			<u>O</u> pen	<u>C</u> ancel

Select "Connection" -> "SSH" -> "Auth"

 \times

Click Browse, and select the private key ppk file.

Then click "Open"





Putty 18.222.35.37 - Putty

🚰 login as: ec2-user



dip-172-31-16-190:~

Iogin as: ec2-user
Authenticating with public key "imported-openssh-key"
Last login: Sun Aug 11 19:36:48 2019 from c-67-169-62-4.hsd1.ca.comcast.net

Amazon Linux 2 AMI

https://aws.amazon.com/amazon-linux-2/ [ec2-user@ip-172-31-16-190 ~]\$



And you're in!

Look at that screen. Your family is going to think you're a nefarious hacker.



Regardess of OS, It's the same from here...

- Bourne-Again Shell (bash)
- package manager: yum









Installing Software

- Amazon Linux uses yum package manager
 - First run yum update to get security and other updates
 - Then install packages needed to compile Radiance

sudo yum -y update sudo yum -y install tcsh gcc gcc-c++ libX11-devel

Commands for installing RADIANCE

create a directory for Radiance mkdir Radiance cd Radiance

download Radiance HEAD from radiance-online.org wget --no-check-certificate http://www.radiance-online.org/software/snapshots/radiance-HEAD.tgz wget --no-check-certificate http://www.radiance-online.org/download-install/radiance-source-code/latest-release/radR52supp.tar.gz

unpack tarballs

- tar -xf radiance-HEAD.tgz
- tar -xf radR52supp.tar.gz

compile and install radiance

cd ray

sudo ./makeall install

set raypath and copy cal files to raypath echo RAYPATH=.:/usr/local/lib/ray/ > .bash profile echo export RAYPATH > .bash profile sudo cp src/cal/cal/* /usr/local/lib/ray/.

check installation rtrace -version

Run Mark Stock's Benchmark

Install git sudo yum -y install git

clone benchmark repo git clone https://github.com/markstock/Radiance-Benchmark4.git

run the benchmark export NCPU=16; make smp



File Storage Options

	price per GB	
Simple Storage Service (S3)	\$0.02	 object store good for storage
Elastic Block Store (EBS)	\$0.10	 Can be a Easy to a Limited to Size is fix
Elastic File System (EFS)	\$0.30	 Can be s Must be a startup Spans av Size is el

orage in flat environment archiving tarballs of old projects, but not for active

attached to a single EC2 instance attach when launching instance o one availability zone (most regions have three zones) xed and set when provisioned (you pay for empty GB)

simultaneously attached to many EC2 instances mounted like a network drive (at the command line or with script)

vailability zones (but limited to region)

astic, you only pay for GB used by your data

Andy recommends EFS



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Amazon Elastic File System (EFS)

Amazon EFS provides file storage for use with your EC2 instances.

Create file system

Getting started guide



Create

Create an Amazon EFS file system to store your files in the Amazon cloud. A file system grows and shrinks automatically with the files you put in, and you pay only for what you use.



Access

Write files to and read files from your Amazon EFS file system by using the NFSv4 protocol. Any number of EC2 instances can work with your file system at the same time, and your instances can be in multiple Availability Zones in a region.

Elastic File System documentation & support

Getting started guide | Documentation | Support | Forums





Step 1: Configure file system access

Step 2: Configure optional settings

Step 3: Review and create

Configure file system access

An Amazon EFS file system is accessed by EC2 instances running inside one of your VPCs. Instances connect to a file system by using a network interface called a mount target. Each mount target has an IP address, which we assign automatically or you can specify.

vpc-fe0a3097 (default)	*	0
	vpc-fe0a3097 (default)	vpc-fe0a3097 (default)

Create mount targets

Instances connect to a file system by using mount targets you create. We recommend creating a mount target in each of your VPC's Availability Zones so that EC2 instances across your VPC can access the file system.

Availability Zone	Subnet	0	IP address
us-east-2a	subnet-4b494322 (default)	Ŧ	Automatic 🖉
us-east-2b	subnet-955219ee (default)	Ŧ	Automatic 🖉
us-east-2c	subnet-b99b0cf4 (default)	Ŧ	Automatic @





Create file system

Step 1: Configure file system access

Step 2: Configure optional settings

Step 3: Review and create

Configure optional settings

Add tags

You can add tags to describe your file system. A tag consists of a case-sensitive key-value pair. (For example, you can define a tag with key-value pair with key = Corporate Department and value = Sales and Marketing.) At a minimum, we recommend a tag with key = Name.

Кеу	Value
Name	Add New Value
Add New Key	

Enable lifecycle management NEW!

Automatically save up to 85% on your EFS bill as your access patterns change by enabling Lifecycle Management for your file system. Based on the policy you choose, any files in your file system that are not accessed for a period of time will automatically move to the EFS Infrequent Access (EFS IA) storage class. EFS IA provides price/performance that's cost-optimized for files not accessed every day. 🗹 Learn more

Life	cycle policy 14 days since last access	•
Choose t	hroughput mode	
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0	Provisioned	

Choose performance mode

We recommend General Purpose performance mode for most file systems. Max I/O performance mode is optimized for applications where tens, hundreds, or thousands of EC2 instances are accessing the file system - it scales to higher levels of aggregate throughout and operations per second with a tradeoff of slightly.

() O 🛆 🍨 Andrew McNeil 👻 Ohio 👻 Support 👻

Remove Θ

ughput mode for applications that require more throughput than allowed by

Lifecycle policy automatically moves files not recently accessed to lower cost storage

The next time its accessed there will be latency of up to 100ms. but then it's put back into the faster more expensive storage.



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		Mount	targets							
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				us-east-2c	subnet-b99b0cf4 (default)	172.31.46.223	fsmt- 90a32ce9	eni- 0c81bc56240e39e4a		Creating

172 31 23 217 fsmt-

us-east-2h

vnc-fe0a3097

subnet-955219ee

eni-Creating Your file system id is used for mounting to instances.

There are mount instructions on the EFS page if you ever forget. You don't need to download this pdf again just for mounting instructions.



Mounting Elastic File Storage

Install tools
sudo yum install -y amazon-efs-utils

create mount point
mkdir efs

mount
sudo mount -t efs fs-8e7921f7:/ efs

change owner and group if it's your first time mounting the file system
sudo chown ec2-user efs
sudo chgrp ec2-user efs

Saving a custom machine image

- It'd be nice to not have to do all this setup every time, right?
- Machine Images You can save the state of the machine
- Configuration script Allows you to run updates and mount EFS drives when the instance is started

Machine Images

 Remember this step when launching an instance? ----



Q. Search for an

Quick Start

My AMIs

AWS Market

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oose an A	mazon Ma	ichine Image (AMI)	Cancel an
ate that contains	the software config	guration (operating system, application server, and applications) required to launch your instance. You can select an AMI provided by AWS,	our user com
ace; or you can s	select one of your (own AMIs.	
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		K < 1 to	38 of 38 AMI
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		Amazon Linux 2 AMI (HVM), SSD Volume Type - ami-0d8f6eb4f641ef691 (64-bit x86) / ami-0f378490dca16e3f4 (64-bit Arm)	Select
olace	Amazon Linux	Amazon Linux 2 comes with five years support. It provides Linux kernel 4.14 tuned for optimal performance on Amazon EC2, systemd 219, GCC 7.3,	8 64-bit (x8)
	Free ber eligible	Glibc 2.26, Binutils 2.29.1, and the latest software packages through extras.	64-bit (An
MIs		Root device type: ebs Virtualization type: hvm ENA Enabled: Yes	
	Û	Amazon Linux AMI 2018.03.0 (HVM), SSD Volume Type - ami-02f706d959cedf892	Select
y U	Amazon Linux	The Amazon Linux AMI is an EBS-backed, AWS-supported image. The default image includes AWS command line tools, Python, Ruby, Perl, and	C4 bit (v9
	Free tier eligible	Java. The repositories include Docker, PHP, MySQL, PostgreSQL, and other packages.	04-Dit (X
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		Root device type: ebs Virtualization type: hvm ENA Enabled: Yes	
	3	SUSE Linux Enterprise Server 15 SP1 (HVM), SSD Volume Type - ami-0e0bae59dc35fe89a (64-bit x86) / ami-	Select
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		Web and Scripting, and Legacy modules enabled.	
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	0	Ubuntu Server 18.04 LTS (HVM), SSD Volume Type - ami-05c1fa8df71875112 (64-bit x86) / ami-0606a0d9f566249d3 (64-bit	Select
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Machine Images



• Let's create a machine image!

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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.

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	You have not created any AMIs. You can launch instances using AMIs provided by AWS, our user community, or through the AWS Marketpla
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EC2 Dashboard Events Tags Tags Reports Limits INSTANCES INSTANCES Launch Templates Spot Requests Reserved Instances	Launch Instance Connect Conn	t Actions A arcf Connect Get Windows Password Create Template From Instance Launch More Like This aa9 Instance State Instance Settings Image Networking CloudWatch Monitoring	Instance State - running nage istance (instance store /
Dedicated Hosts Capacity Reservations IMAGES AMIS Bundle Tasks	Instance: i-0558a0059aa90975a	Public DNS: ec2-18-222-35-37.us-east-2.cor	npute.amazonaws.co
Volumes	Description Status Checks	Monitoring Tags	
Snapshots Lifecycle Manager	Instance ID	i-0558a0059aa90975a	P
	Instance state	running	
Security Groups	Instance type	t2.micro	
	Elastic IPs		
Elastic IPs	Availability zone	us-east-2b	
Placement Groups	Security groups	Basic, view inbound rules, view outbound rules	Secor
Key Pairs	Scheduled events	No scheduled events	
Network Interfaces	AMI ID	amzn2-ami-hvm-2.0.20190618-x86_64-gp2 (ami-0d8f6eb4f641ef691)	
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Select the instance from which you want to generate a machine image.

Make sure it's not busy, it will be rebooted to make the image!



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Elastic IPs	astic IPs When you create an EBS image, an EBS snapshot will also be created for each of the above volumes.						
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	Placement Groups	Security groups	Basic, view inbound rules, view outbou	ind rules Secon
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Select the instance from which you want to generate a machine image.

Make sure it's not busy, it will be rebooted to make the image!

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/2-31-16-190 ~]\$ Connection to 18.222.35.37 closed by remote host.
l8.222.35.37 closed.

Block devices	/dev/xvda			
Veb Services, Inc. or	its affiliates. All rights reserved.	Privacy Policy	Terms of Use	



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Snapshots					
Lifecycle Manager					
NETWORK & SECURITY					
Security Groups					
Flastic IPs					
Placement Groups		000		-	1
Koy Poire	Image: ami-01ad2181030130131				
Network Interferen	Details Permissions Tags				
Network Interfaces					_
LOAD BALANCING				E	Edit
Load Balancers	AMI ID ami-01ad2f81030f30f31	AMI Name	Radiance		
Target Groups	Owner 885639356958	Source	885639356958/Radiance		
AUTO SCALING	Status available	State Reason	-		
Launch Configurations	Creation date August 11, 2019 at 12:11:09 PM UTC-7	Platform	other Linux		
Auto Scaling Groups	Virtualization type hym	Image Type	HEΔD 2010-08-11		
	Boot Device Name /dev/xvda	Root Davice Type	ebs		
			5.74 		

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	₽ •	Andrew McNeil - Ohio	✓ Support ✓	
			∆ 0 ♦ Ø	
		0 K K	1 to 1 of 1 > >	
- Visibility -	Status	- Creation Date	- Platforn	
Private	available	August 11, 2019 at	: 12:11:09 Other Lii	

There's our new image!



Configuration / Startup script

- instance, for example:
 - sudo yum -y update (for security)
 - sudo mount -t efs myfilesystem:/ efs
- an instance.



There are some things you'll want to run every time you start an

Configuration scripts can be provided as a text file when launching

Or you could put this in a @reboot cron job on the machine image.


Example Configuration Script

aws_startup.bsh:

#! /bin/bash

yum -y update mount -t efs fs-8e7921f7:/ /home/ec2-user/efs

When provided as a configuration script, it is run with root privileges, so you don't need sudo.

	1. CI	100	se AMI 2	. Choose in	istance Type	3. Co	onfigure Instanc	e	4. Add Storage	5. Add Tags	6. Configure Security Group	7. Review
		a	WS	Service	s v Re	source	e Groups 🕞	1	•			
iii A	pps	oP 1	IerrestrialLight E	S LBNL711	M Inbox (7) - mo	neil 🗞	Immersive Render	S Ha	ilio API v3.0.0			
\leftarrow	→ (Э	ii https://us-ea	ast-2.console.	aws.amazon.com/	ec2/v2/ho	xme?region=us-eas	st-2#Lau	inchinstanceWizard:an	ni=ami-01ad2f81030f3	0f31	
• •	•	Û	Launch instance wi	zard EC2 \ ×	+							

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.

Q, ami-01ad2f81030f30f31	X
Quick Start (0)	< 1 to 1 of 1 AMIs > >
My AMIs (1)	Badiance - ami-01ad2f81030f30f31
AWS Marketplace (3232)	HEAD 2019-08-11 Boot device type: ebs. — Virtualization type: hym. — Owner: 885639356958 — ENA Enabled: Yes
Community AMIs (0)	
 Ownership Owned by me Shared with me 	The following results for "ami-01 ad2f81030f30f31" were found in other catalogs: <u>3232 results in AWS Marketplace</u> AWS Marketplace provides partnered Software that is pre-configured to run on AWS
 Architecture 32-bit (x86) 64-bit (x86) 64-bit (Arm) 	
 Root device type EBS Instance store 	



When we go to launch an instance the new image is available.



Services	 Resource Groups 	\$				🗘 🎴 Andrew McNeil 👻 Ohio 👻	Support +
ose AMI 2. Choose Inst	ance Type 3. Configure Instance	4. Add Storage	5. Add Tags	6. Configure Security Group	7. Review		
2: Choose an	Instance Type						
General purpose	t3.nano	2	0.5	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	t3.micro	2	1	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	t3.small	2	2	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	t3.medium	2	4	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	t3.large	2	8	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	t3.xlarge	4	16	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	t3.2xlarge	8	32	EBS only	Yes	Up to 5 Gigabit	Yes
General purpose	m5ad.large	2	8	1 x 75 (SSD)	Yes	Up to 10 Gigabit	Yes
General purpose	m5ad.xlarge	4	16	1 x 150 (SSD)	Yes	Up to 10 Gigabit	Yes
General purpose	m5ad.2xlarge	8	32	1 x 300 (SSD)	Yes	Up to 10 Gigabit	Yes
General purpose	m5ad.4xlarge	16	64	2 x 300 (SSD)	Yes	Up to 10 Gigabit	Yes
General purpose	m5ad.12xlarge	48	192	2 x 900 (SSD)	Yes	10 Gigabit	Yes
General purpose	m5ad.24xlarge	96	384	4 x 900 (SSD)	Yes	20 Gigabit	Yes
General purpose	m5a.large	2	8	EBS only	Yes	Up to 10 Gigabit	Yes
General purpose	m5a.xlarge	4	16	EBS only	Yes	Up to 10 Gigabit	Yes
General purpose	m5a.2xlarge	8	32	EBS only	Yes	Up to 10 Gigabit	Yes
General purpose	m5a.4xlarge	16	64	EBS only	Yes	Up to 10 Gigabit	Yes
General purpose	m5a.8xlarge	32	128	EBS only	Yes	Up to 10 Gigabit	Yes
General purpose	m5a.12xlarge	48	192	EBS only	Yes	10 Gigabit	Yes

I'm going to launch a 16 CPU instance this time.

NOT FREE TIER!



•••	Û	Launch instance v	vizard EC2 \ x	+									
$\leftarrow \rightarrow$	С	ii https://us-	east-2.console.a	awstamazor	n.com/ec2/v2	2/home?	region=us-	east-3	2#LaunchinstanceW	izard:ami	ami-01ad2f81030f	30f31	
Арра	P	TerrestrialLight E	S LBNL711	M Inbox ((7) - moneil	😽 Imn	nərsivə Rənde	эг	S Halio API v3.0.0				
	ō	aws	Service	s 🗸	Resou	rce G	roups	¥	*				

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		Launch into Auto Scaling Group 🕕				
Purchasing option		🗹 Request Spot in	istances					
Current price	-	Availability Zone	Current price					
		us-east-2a	\$0.1596	1				
		us-east-2b	\$0.1596					
		us-east-2c	\$0.6295					
Maximum price	()	\$ 1						
Persistent request	()	🗌 Persistent reque	est					
Launch group	()	(Optional)						
Request valid from	(i)	Any time Edit						
Request valid to	(i)	Any time Edit						
Network	()	vpc-fe0a3097 (de	fault)	* *	С	Create new VPC		
Subnet	(i)	No preference (de	efault subnet in	any Availability Zon 🛊		Create new subnet		
Auto-assign Public IP		Use subnet settin	ig (Enable)	\$				
Placement group	(i)	Add instance to	placement gro	oup				
Capacity Reservation	(j)	Open		* *	С	Create new Capacity Reservat		
IAM role	1	None		*	С	Create new IAM role		
CPU options	(j)	Specify CPU op	otions					
Monitoring	()	Enable CloudWi Additional charges	atch detailed m apply.	nonitoring				
	\sim							



And let's do a spot request too.

Cancel	Previous	Review and Laur	nch N	ext: Add Storag	ge				
eb Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use									

hoose AMI 2. Choose Instance 2. Choose Instance 2. Choose Instance 2. Choose Instance 3. Maximum 9. Persistent rec 1. Launch g 1. Request valid 1. R	ance Type 3. Co nstance D	onfigure Instance 4. Add Storage	5. Add Tags	6 Configure					
p 3: Configure Ins Maximum Persistent red Launch g Request valid Request valid Request valid Su Auto-assign Pub Placement g Capacity Reserve IAW CPU op Monite EBS-optimized inst	nstance D			o. Configure	e Security Group	7. Review			
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Auto-assign Pub Placement g Capacity Reserve IAM CPU op Monite EBS-optimized inst Elastic Infer	Network ()	vpc-fe0a3097 (default)		÷ C	Create new VPC	;			
Auto-assign Pub Placement g Capacity Reserve IAM CPU op Monite EBS-optimized inst Elastic Infer	Subnet 🕕	No preference (default subnet	in any Availability Zo	on ‡	Create new subr	net			
Placement g Capacity Reserve IAM CPU op Monite EBS-optimized inst Elastic Infer	Public IP 🧻	Use subnet setting (Enable)		*					
Capacity Reserve IAN CPU op Monite EBS-optimized inst Elastic Infer	t group 🕕	Add instance to placement r	quore						
IAM CPU op Monite EBS-optimized inst Elastic Infer	ervation (i)	Open		÷a	Create naw Can	poitu Pogonusti			
IAM CPU op Monite EBS-optimized inst Elastic Infer					Create new Capa	acity neservation	20		
CPU op Monite EBS-optimized inst Elastic Infer	AM role 🕕	None		÷C	Create new IAM	role			
Monite EBS-optimized inst Elastic Infer	options (i)	Specify CPU options						 	
EBS-optimized inst Elastic Infer	nitoring (j)	Enable CloudWatch detailed	monitoring						
EBS-optimized inst Elastic Infer		Additional charges apply.							
Elastic Infer	nstance (j)	Launch as EBS-optimized in	stance						
	ference 🕕	Add an Elastic Inference acc	elerator						
		Additional charges apply.							
vanced Details									
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User		Choose File awa startup bab	aneauy Daseo4 enco						
		choose nie aws_startup.osh							



We can add our configuration script as a file under advanced details.



Launch instance wizard EC2 \ × +		
← → C iii https://us-east-2.console.aws.amazon.com/ec2/v2/home?region=us-east-2#LaunchInstanceWizard:ami=ami-01ad2f81030/	0f30f31 🔍 🕁 🚦	a w. 🖾 💷 Q. 🖇 i 🌗 🕻
📅 Apps 🛷 TerrestrialLight E 🔇 LBNE7TT M Inbox (7) - moneil 🗞 Immersive Render 🔇 Halio API v3.0.0		
aws Services - Resource Groups - 🛠	💭 🍨 Andrew McNeil 👻 Ol	hio 🗝 Support 👻
1. Choose AMI 2. Choose Instance Type 3. Configure Instance 4. Add Storage 5. Add Tags	6. Configure Security Group 7. Review	
Step 5: Tag Spot Request A tag consists of a case-sensitive key-value pair. For example, you could define a tag with key = Na Note that these tags will be applied to this Spot instance request and not to any instances launched	ame and value = Webserver. Learn more about tagging your Amazon EC2 resources. ed to fulfill this request.	
Key (128 characters maximum)	Value (256 characters maximum)	
project	radiance workshop	\otimes
Add another tag (Up to 50 tags maximum)		

Tagging the spot request does not tag the instance. You need to tag the instance when it launches.

Review and Launch Cancel Previous

Next: Configure Security Group



	1. C	hoo	se AMI 2.	Choose Ins	stance Ty	pe 3.	Confi	gure Instance	,	4. Add Storage	5. Add Tags	6. Configure Security Group	7. Review
		a	WS	Services	\$ -	Resou	rce (Groups 🗸		*			
	Ajojos	Ф	TerrestrialLight E	S LBNL711	M Inbox ((7) - moneil	₿ Im	amersive Render	0	Halio API v3.0.0			
÷	\rightarrow	С	ii https://us-ea:	st-2.console.a	aws.amazoi	n.com/ec2/v3	2/home	?region=us-eas	t-2#L	aunchinstanceWizard:a	mi=ami-01ad2f81030f3	30f31	
•	•	Û	Launch instance wiz	ard EC2 \ ×	+								

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 real Internet traffic to reach your instance, add rules that allow unrestricted access to the HTTP and HTTPS ports. You can create a new security groups.

Assign a security group:
Oreate a new security group

Select an existing security group

Security Group ID	Name	Description
sg-07c3608c40753cd0d	Basic	SSH & NFS
sg-6c47cc04	default	default VPC security group

A Warning

Rules with source of 0.0.0.0/0 allow all IP addresses to access your instance. We recommend setting security group rules to allow

Inbound rules for sg-07c3608c40753cd0d (Selected security groups: sg-07c3608c40753cd0d)

Туре ()	Protocol (j)	Port Range ()	Source
SSH	TCP	22	0.0.0/0
SSH	TCP	22	::/0
NFS	TCP	2049	sg-07c3

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ach your instance. For example, if yo group or select from an existing one	ou want to set below. Learn	up a web more abo	server and a ut Amazon E	allow EC2
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access non known i addresses o				
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🔛 Apps 🧽 TerrestrialLight E 🔇 LBNL/11	M Inbox (7) - moneil 🧕 Immersive Render 🥥 H	alio API v3.0.0	
aws Services	- Resource Groups -	۶	
EC2 Dashboard	Launch Instance 🗸 Conne	ct Actions V	
Events			
Tags	Q Filter by tags and attributes or se	earch by keyword	
Reports		Availability Zar	- Instance State -
Limits		Availability zor	ie · instance state ·
	i-0558a005	9aa9097 t2.micro us-east-2b	irunning
INSTANCES	i-09f1b883f	8de003e6 m5ad.4xlarge us-east-2a	🥚 running
Instances			
Launch Templates			
Spot Requests			
Reserved Instances			
Dedicated Hosts			
Capacity Reservations			
IMAGES			
AMIs			
Bundle Tasks	Instance: i-00f1b222f2de003e6	Public DNS: cc2 166-229 us-cost-	a a a 2 compute omozonowa
Bundle Tasks	Instance: i-09f1b883f8de003e6	Public DNS: ec2	2.compute.amazonaws.
Bundle Tasks ELASTIC BLOCK STORE Volumes	Instance: i-09f1b883f8de003e6 Description Status Checks	Public DNS: ec2 Monitoring Tags	2.compute.amazonaws.
Bundle Tasks ELASTIC BLOCK STORE Volumes Spapshots 	Instance: i-09f1b883f8de003e6 Description Status Checks	Public DNS: ec2	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifequele Manager 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID	Public DNS: ec2- Monitoring Tags i-09f1b883f8de003e6	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state	Public DNS: ec2 Monitoring Tags i-09f1b883f8de003e6 running	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type	Public DNS: ec2 Monitoring Tags i-09f1b883f8de003e6 running m5ad.4xlarge	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6 running m5ad.4xlarge	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs Availability zone	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs Placement Groups 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs Availability zone Security groups	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6	2.compute.amazonaws.
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs Placement Groups Key Pairs 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs Availability zone Security groups Scheduled events	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6 i-09f1b883f8de003e6 running m5ad.4xlarge us-east-2a Basic. view inbound rules. view outbound rules No scheduled events No scheduled events	2.compute.amazonaws.
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 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs Placement Groups Key Pairs Network Interfaces LOAD BALANCING Load Balancers 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs Availability zone Security groups Scheduled events AMI ID Platform IAM role	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6 ionning running m5ad.4xlarge us-east-2a Basic. view inbound rules. view outbound rules No scheduled events Radiance (ami-01ad2f81030f30f31) - - - - - - - - - - - - - - - - - -	2.compute.amazonaws.
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 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs Placement Groups Key Pairs Network Interfaces LOAD BALANCING Load Balancers Target Groups 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs Availability zone Security groups Scheduled events AMI ID Platform IAM role Key pair name Owner	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6 - running m5ad.4xlarge us-east-2a Basic. view inbound rules. view outbound rules No scheduled events Radiance (ami-01ad2f81030f30f31) - - aws_ohio 885639356958 Auroust 11, 2010 of 10x20145, DM LTC0, 7 (base)	Seco
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 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs Placement Groups Key Pairs Network Interfaces LOAD BALANCING Load Balancers Target Groups AUTO SCALING Launch Configurations 	Instance: i-09f1b883f8de003e6 Description Status Checks Instance ID Instance state Instance type Elastic IPs Availability zone Security groups Scheduled events AMI ID Platform IAM role Key pair name Owner Launch time	Public DNS: ec2 -166-239.us-east- Monitoring Tags i-09f1b883f8de003e6 i-09f1b883f8de003e6 running m5ad.4xlarge us-east-2a Basic. view inbound rules. view outbound rules No scheduled events Radiance (ami-01ad2f81030f30f31) - - aws_ohio 885639356958 August 11, 2019 at 12:32:45 PM UTC-7 (less than one hour) False	2.compute.amazonaws.
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	슈 Andrew M	vicNeil + Ohio +	Support +
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			2 of 2 > >
Status Checks 🗵	Alarm Status	Public DNS (IPv4)	- IPv4 Public
🥝 2/2 checks	None 🍖	ec2-18-222-35-37.us-	B 18.222.35.3
🛣 Initializing	None 🍡	ec2-18-217-166-239.u	is 18.217.166.

Now that the spot request is fulfilled, you should remember to tag the resulting instance.

compute.amazonaws.com		
Public DNS (IPv4)	ec2-18-217-166-239.us-east-	
	2.compute.amazonaws.com	
IPv4 Public IP	18.217.166.239	
IPv6 IPs	-	
Private DNS	ip-172-31-8-156.us-east-2.compute.internal	
Private IPs	172.31.8.156	
Secondary private IPs		
VPC ID	vpc-fe0a3097	
Subnet ID	subnet-4b494322	
Network interfaces	eth0	
Source/dest. check	True	
T2/T3 Unlimited	-	
EBS-optimized	True	
Root device type	ebs	
Root device	/dev/xvda	
Block devices	/dev/xvda	
Elastic Graphics ID	-	
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EC2 Dashboard Events	Launch Instance	Connect	ons ♥						Δ •	e ø	6
Tags	Q Filter by tags and a	attributes or search by ke	word					0	< < 1 to 2	of 2 >	>
Reports	Name	Instance ID	Instance Type	fucilability Zone -	Inctance State -	Status Checks -	Alarm Status	Dublic	DNR (IDvd)	- IDu4	Dubli
Limits	Name	instance iD ~	instance type	Availability Zone +	instance state +	Status Checks +	Alarm Status	Public	DNS (IPV4)	* 1244	Publi
		i-0558a0059aa9097	t2.micro	us-east-2b	🥚 running	2/2 checks	None	ec2-18-	222-35-37.us-e	18.22	2.35.
Instances		i-09f1b883f8de003e6	m5ad.4xlarge	us-east-2a	🥚 running	🛣 Initializing	None	👌 ec2-18-	217-166-239.us	. 18.21	7.166
Launch Templates											
Spot Bequests											
Beserved Instances											
Dedicated Hosts											
Canacity Reservations											
oupdoity neservations											
IMAGES											
Aiviis Buradha Talaha											
Bundle Tasks	Instance: i-09f1b883	3f8de003e6 Public	DNS: ec2-18-217-	166-239.us-east-2.co	mpute.amazonaws	.com					
ELASTIC BLOCK STORE											
Volumes	Description Stat	tus Checks Monito	ring Tags								
Snapshots											
Lifecycle Manager	Add/Edit lags										
NETWORK & SECURITY	Key				Value						
Security Groups											
Elastic IPs				This resource	currently has no tags	:					
Placement Groups											
Key Pairs											
Network Interfaces											
LOAD BALANCING											
Load Balancers											
Target Groups											
AUTO SCALING											
Launch Configurations											
Auto Scaling Groups											
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		<u>A</u>	0 🕈 🖸
	C) K < 1 to 2	2 of 2 > >
Status Checks 👻 Ala	rm Status Pub	ic DNS (IPv4)	- IPv4 Public
🥝 2/2 checks Nor	ne 🍗 ec2-	18-222-35-37.us-e	18.222.35.3
🛣 Initializing Nor	ne 🍖 ec2-	18-217-166-239.us	18.217.166.

Now you should remember to tag your spot fulfilled instance.



•	Instances EC2 Management C ×	+			
÷	→ C iii https://us-east-2.console.a	ws.amazon.com/ec2/v2/home?region=us-east-2#Insta	nces:sort=instanceId		
	Apps 🧬 TerrestrialLight E 🔇 LBNL/11	M Inbox (7) - moneil 🦉 Immersive Render 🥥 Hali	o API v3.0.0		
	aws Services	👻 Resource Groups 👻 🕯	;		
	EC2 Dashboard	Launch Instance 👻 Connect	Actions V		
	Events				
	Tags 4	Q Filter by tags and attributes or sea	arch by keyword		
	Reports	Name - Instance ID	 Instance Type 	pe 👻 Availability Zone	- Instance State -
	Limits	L055820059	29097 t2 micro	us-cast-2h	
-	INSTANCES		agoor tz.micro	us-east-20	
L	Instances		nibad.4xiarge	5 US-685(-28	- running
	Launch Templates		r		
	Spot Requests		Add/Edit T	200	
	Reserved Instances		Add/Edit 1a	igs	
	Dedicated Hosts		Apply tags to you	r resources to help orga	anize and identify the
	Capacity Reservations		A tag consists of	a case-sensitive kev-va	alue pair. For example
-	IMAGES		with key = Name	and value = Webserver.	. Learn more about t
	AMIs		resources.		
	Bundle Tasks	Instance: i-09f1b883f8de003e6	Key	Value	
-	ELASTIC BLOCK STORE		noy	Value	
	Volumes	Description Status Checks	project	radiar	nce workshop
	Snapshots		projoot		
	Lifecycle Manager	Add/Edit Tags	Create Tag		Sav
-	NETWORK & SECURITY	Kou			Gancer
	Security Groups	Rey			
	Elastic IPs			This resour	rce currently has no tags
	Placement Groups				
	Key Pairs				
	Network Interfaces				
-	LOAD BALANCING				
	Load Balancers				
	Target Groups				
-	AUTO SCALING				
	Launch Configurations				
	Auto Scaling Groups				



Now you should remember to tag your spot fulfilled instance.



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\leftarrow \rightarrow C iii https://us-east-2.console.av	ws.amazon.com/ec2/v2/hc	ome?region=us-east-2#Instances:sort=i	nstanceld						ର୍ 🕁 🏂 ₩.	甄 暉 (2 🕴 🍈 🤇
🗰 Apps 👩 TerrestrialLight E 🔇 LBNL/11	M Inbox (7) - moneil 👌	Immersive Render 🧕 Halio API v3.0.0									
aws Services	s - Resource	e Groups 👻 🛠					₽ •	Andrew I	McNeil 🔻 Ohio 🔫	Supp	ort v
EC2 Dashboard Events Tags	Launch Instanc	s and attributes or search by k	ions ♥ eyward						▲	to 2 of 2	• •
Reports	Name	- Instance ID	 Instance Type 	- Availability Zone	• - Instance State -	Status Checks 🗵	Alarm Sta	itus	Public DNS (IPv4)	Ŧ	IPv4 Publi
Limits		i-0558a0059aa9097	t2.micro	us-east-2b	running	2/2 checks	None	20	ec2-18-222-35-37.u	s-e	18.222.35.3
 INSTANCES Instances 		i-09f1b883f8de003e6	m5ad.4xlarge	us-east-2a	🥥 running	🛣 Initializing	None	6	ec2-18-217-166-23	9.us	18.217.166
Launch Templates Spot Requests Reserved Instances Dedicated Hosts Capacity Reservations											
IMAGES AMIS											
 Bundle Tasks ELASTIC BLOCK STORE Volumes Snapshots 	Description	f1b883f8de003e6 Public Status Checks Monito	oring Tags	-166-239.us-east-2	.compute.amazonaws	s.com					
Lifecycle Manager NETWORK & SECURITY	Key	93			Value						
Security Groups Elastic IPs Placement Groups Key Pairs	project				radiance workshop					Show (Column
 Network Interfaces LOAD BALANCING Load Balancers Target Groups AUTO SCALING Launch Configurations Auto Scaling Groups 											

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Status Checks 👻	Alarm Statu	18	Public DN	IS (IPv4)	Ŧ	IPv4 P	ublic
🥝 2/2 checks	None	6	ec2-18-22	2-35-37.us	-e	18.222	.35.3
🛣 Initializing	None	6	ec2-18-21	7-166-239.	us	18.217	.166.

Now you should remember to tag your spot fulfilled instance.



Upload model files - Mac / Linux

- scp (secure copy)
- Copies files over ssh (similar syntax to ssh)
 - copy this

-i key.pem : private key

-r : recursive (copies directories and contents)





scp -i aws_ohio.pem -r my model/ ec2-user@18.222.35.37:~/efs/

to here



Upload model files - Windows

- pscp (PuTTY secure copy)
- Copies files over ssh
 - pscp -i aws_ohio.ppk -r my_model/ ec2-user@18.222.35.37: copy this
 - -i key.ppk : private key
 - -r : recursive (copies directories and contents)



to here

Uploading David's example files

#These commands are run locally.

upload zip files

scp -i ~/aws_ohio.pem 01_genBSDF.zip ec2-user@18.222.35.37:~/efs/. scp -i ~/aws_ohio.pem example_noResults.zip ec2-user@18.222.35.37:~/efs/.

Start Simulation!!!!

- nohup (very important)
 - keeps a process running until it finishes, even if you log out
 - sends stdout to a file, nohup.out by default
 - to stop a process running with nohup, us ps to get the process id and kill to end it.

Running David's BSDF example

unpack zip files
unzip 01_genBSDF.zip
unzip example_noResults.zip

change permission to make scripts executable
this can be avoided if script has 'bash myscript.sh' instead of './myscript.sh'
cd example_noResults
chmod +x *.sh scripts/*.sh

copy cal file to current directory so script can find it cp ../01_genBSDF/window7_2side.cal .

run command
nohup time bash oo_all.sh &

Benchmarks on David's example

Instance Type	VCDU	Dhysical Prodessor	Clock	Memory	File	Time	On De	emand	Spot (18 A	ug, 15
instance type	VCFU	Fligsteal Flouesson	Speed	(GiB)	Storage	(S)	Rate/hr	Cost	Rate/hr	Со
c5.24xlarge	96	2nd Gen Xeon Platinum 8175CL	3.0 GHz	192	EBS	263	\$4.08	\$0.298	\$0.91	\$0.0
c5.24xlarge	96	2nd Gen Xeon Platinum 8175CL	3.0 GHz	192	EFS	441	\$4.08	\$0.500	\$0.91	\$0. ⁻
m5.24xlarge	96	Intel Xeon Platinum 8175	3.1 GHz	384	EBS	276	\$4.61	\$0.354	\$0.96	\$0.0
m5d.24xlarge	96	Intel Xeon Platinum 8175	3.1 GHz	384	SSD	278	\$5.42	\$0.419	\$0.96	\$0.0
m5d.24xlarge	96	Intel Xeon Platinum 8175	3.1 GHz	384	EFS	463	\$5.42	\$0.697	\$0.96	\$0. ⁻
c5.18xlarge	72	Intel Xeon Platinum 8124M	3 GHz	144	EBS	309	\$3.06	\$0.263	\$0.80	\$0.0
c5.18xlarge	72	Intel Xeon Platinum 8124M	3 GHz	144	EBS	501	\$3.06	\$0.426	\$0.80	\$0. ⁻
c5.12xlarge	48	2nd Gen Xeon Platinum 8175CL	3.0 GHz	96	EBS	464	\$2.04	\$0.263	\$0.46	\$0.0
c5.12xlarge	48	2nd Gen Xeon Platinum 8175CL	3.0 GHz	96	EFS	638	\$2.04	\$0.362	\$0.46	\$0.0
m5.12xlarge	48	Intel Xeon Platinum 8175	3.1 GHz	192	EBS	483	\$2.06	\$0.276	\$0.54	\$0.0
m5.12xlarge	48	Intel Xeon Platinum 8175	3.1 GHz	192	EFS	665	\$2.06	\$0.380	\$0.54	\$0. ⁻
c5.9xlarge	36	Intel Xeon Platinum 8124M	3 GHz	72	EBS	592	\$1.53	\$0.252	\$0.39	\$0.0
c5.9xlarge	36	Intel Xeon Platinum 8124M	3 GHz	72	EFS	774	\$1.53	\$0.329	\$0.39	\$0.0
c5.4xlarge	16	Intel Xeon Platinum 8124M	3 GHz	32	EBS	1220	\$0.68	\$0.230	\$0.15	\$0.0
c5.4xlarge	16	Intel Xeon Platinum 8124M	3 GHz	32	EFS	1415	\$0.68	\$0.267	\$0.15	\$0.0



Compute optimized instances completed the script in less time and cost less.





Number of vCPUs

Compute OptimizedGeneral Purpose

Increasing CPU count has diminishing returns, but for this simulation up to 96 CPUs are still effective.





• Compute Optimized Instances



The simulation cost increases with more vCPUs.



On Demand SPOT •

Cost is hourly price time simulation time. This assumes the instance is terminated immediately. Spot prices subject to variability.



Using instance attached storage (EBS) for simulation files was faster than using network attached storage (EFS)



Number of CPUs (log scale)

Instance Attached Storage Network Attached Storage

100



Alarms

- Alarms take an action when the instance usage crosses a threshold.
- For example (and the only reason I use alarms):
 - Terminate the instance when the CPU is below 1% for 10 minutes
- Alarms cost \$0.10 each, though they save money by terminating idle instances (just make sure your results are on or moved to persistent storage).

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\leftarrow \rightarrow C iii https://us-east-2.console.av	vs.amazon.com/ec2/v2/home?region=us-ea	st-2#Instances:sort=instanceId						Q 1	🗩 🗰 🌆 😡	ହ 🕴 🍈 📀
🔛 Apps 🧬 TerrestrialLight E 🔇 LBNL711	M Inbox (7) - moneil 👸 Immersive Render	. 🔮 Halio API V3.0.0								
aws Services	 Resource Groups 	• %					₽ •	Andrew McNeil 👻	Ohio 👻 Supp	oort 👻
EC2 Dashboard	Launch Instance 👻 C	onnect Actions V							Δ 🙃	0 D
Events										+ 0
Tags 4	Q Filter by tags and attribute	s or search by keyword						0	< 1 to 3 of 3	3 > >
Reports	Name - Insta	nce ID 🔺 Inst	ance Type 👻 Availat	oility Zone 👻 In:	stance State 👻	Status Checks	Alarm Stat	tus Public Di	IS (IPv4) -	IPv4 Public
Limits	i-055	Ba0059aa9097 t2.m	icro us-east	-2b 🥚	running	2/2 checks	None	ec2-18-2 2	2-35-37.us-e	18.222.35
INSTANCES	i-088-	4a292ab5e3d8 t2.xl	arge us-east	-2a 🥚	running	2/2 checks	None	b ec2-13-59	-13-222.us-e	13.59.13.22
Instances	_		-	0	a a					
O I Resource for another determinant biochamic house new control of the second										
Spot Requests	Description Status Che	cks Monitoring	Tags							
Reserved Instances										
Dedicated Hosts	Cloudwatch alarms:	V No alarms configu	red						Create A	larm
Capacity Reservations	CloudWatch metrics: Ba	asic monitoring. Enable	Detailed Monitoring				Sho	owing data for:	Last Hour 💲	Ð
 IMAGES 										
AMIs	Below are your CloudWat	ch metrics for the selec	ted resources (a maxin	num of 10). Click	on a graph to s	see an expanded vi	ew. All times s	shown are in UTC.	View all	
Bundle Tasks	Cloudwatch metrics									- 1
ELASTIC BLOCK STORE	CPU Utilization (Percent)	Dis	k Reads (Bytes)		Disk Read O	perations (Operation	s)			
Volumes	0.06		1		1					
Snapshots	0.041	0.7	5		0.75					
Lifecycle Manager	0.021	0.2	15		0.25					- 1
NETWORK & SECURITY	0.011		0		0					
Security Groups	8/11	8/11 20:00	B/11 19:30	8/11 20:00		8/11 19:30	8/11 20:00			
Elastic IPs	10.00	20.00	10.00	20.00		10.00	20.00			
Placement Groups	Dick Whitee (Butes)	Die	k Write Operations (Op	aratione)	Notwork In (Butos)				
Key Pairs	1	Dis	1	erations/	8 000	Dytes)				
Network Interfaces	0.75	0.7	5		6,000		1			
LOAD BALANCING	0.5	0	.5		4,000					
Load Balancers	0.25	0.2	15		2,000					
Target Groups	8/11	8/11	8/11	8/11	0	8/11	8/11			
AUTO SCALING	19:30	20:00	19:30	20:00		19:30	20:00			
Launch Configurations										
Auto Scaling Groups	Network Out (Bytes)	Ne	twork Packets In (Count)	Network Pac	ckets Out (Count)				
	8,000	80			60					
🗨 Feedback 🔇 English	(US)			© 2008	8 - 2019, Amazon	Web Services, Inc. or	its affiliates. All	rights reserved.	rivacy Policy Te	erms of Use

Click on monitoring tab

Then on Create Alarm button



aws Services - Re	esource Groups	i v \$k					Δ.	Andrew	McNeil 🔻 Ohio 🔫	Support 👻
EC2 Dashboard	Instance 🔻	Connect	ns 👻						2	4 6 4
Tags	er by tags and attril	outes or search by key	ward							to 3 of 3 \rightarrow \rightarrow
Reports	ame - Ir	stance ID 🔶	Instance Type	- Availability Zon	e 👻 Instance State 🕤	Status Checks	- Alarm	Status	Public DNS (IPv4)	- IPv4 Pub
Limits	i-i	0558a0059aa9097	t2.micro	us-east-2b	running	2/2 checks .	None	1	ec2-18-222-35-37.	us-e 18.222.3
	j(0884a292ab5e3d8	t2.xlarge	us-east-2a	running	2/2 checks	. None	1	ec2-13-59-13-222.	us-e 13.59.13.
Launch Templates Instances Spot Requests Reserved Instances Dedicated Hosts	You can use	Alarm CloudWatch alarms	to be notified aut	omatically wheneve	er metric data reaches	a level you define.				×
Canacity Reservations	To edit an alam	n, first choose whom to no	tify and then define wh	nen the notification should	d be sent.					
Clou	d 🗌 Sei	nd a notification to:	No SNS topics	found	*	CPU Utiliza	tion Percent			
Mages Rolo		Take the action:	Recover this	instance (i)		0.5			i-0884a292;	ab5e3d881
Sundle Tasks Cloud	ď		 Stop this inst Terminate this 	ance 🕕 sinstance 🕕		0.301				
			Reboot this in	istance (i)		0.201				
olumes 0.06	6	AWS will use the exis	sting Service Link	ed Role to perform	this EC2 action.	0				
0.051 mapshots 0.041	1	AWSServiceRoleFo	rCloudWatchEve	ents (show IAM polic	cy document)		8/11 16:00	8/11 18:00	8/11 20:00	
ifecycle Manager 0.021	- 3 -									
UETWORK & SECURITY	1	Whenever:	Average 4	of CPU Utilizatio	n 🗘					
ecurity Groups		ls:	< 🛊 0.5	Pe	rcent					
lastic IPs										
lacement Groups		For at least:	3 consecut	ive period(s) of 5 N	/linutes 🛊					
Cey Pairs Disk	V	Name of alarm:	awsec2-i-0884a	292ab5e3d881-Hig	h-CPU-Utiliz					
letwork Interfaces										
OAD BALANCING 0.5									Cancel Cres	te Alarm
oad Balancers 0.25	-									
arget Groups 0	8/11	8/11	0	8/11 8/11	0	8/11	8/11			
JTO SCALING	19:30	20:00	1	9:30 20:0	0	19:30	20:00			
unch Configurations										

Alarms cost \$0.10 each.

They save money by terminating idle instances (just make sure your results are on or moved to persistent storage).

Download Results

- If you used an alarm to terminate your instance, you'll need to launch another instance to get your results.
- Use scp (Mac/Linux) or pscp (Windows) to download your result.
 - scp -i aws ohio.pem -r ec2-user@18.222.35.37:~/efs/my model/results/ .

pscp -i aws ohio.ppk -r ec2-user@18.222.35.37:~/efs/my model/results/ .





Downloading Results

#These commands are run locally.
download results file
scp -i ~/aws_ohio.pem -r ec2-user@18.222.35.37:~/efs/example_noResults/result .

Terminate Instance

- When you're done, you terminate your instance
- Not much else to say, this one is pretty self explanatory.

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←	→ C iii https://us-east-2.console.av	ws.amazon.com/ec2/v2/home?region=us-east-2#Inst	ances:sort=instanceState
	Apps 🧬 TerrestrialLight E 🔇 LBNL711	M Inbox (7) - moneil 👸 Immersive Render 🤤 Ha	iio API v3.0.0
	aws services	- Resource Groups - 1	
	EC2 Dashboard	Launch Instance - Connec	t Actions A
	Events		
	Taos	Q Filter by tags and attributes or se	arch Connect
	Beports		Get Windows Password
	Limite	Name - Instance ID	Create Template From Instance ility Zone Instance State
	Limits	i-06db84b46	9e3 Jaunch More Like This
-	INSTANCES	i-0fa6727b0/	Instance State Start
	Instances		Instance Settings Stop
	Launch Templates		Networking
	Spot Requests		CloudWatch Monitoring
	Reserved Instances		
	Dedicated Hosts		
	Capacity Reservations		
	cupacity reconnutions	Instance: i-0fa6727b0599802de	Public DNS: ec2-3-17-176-79 us-east-2 compute amazonaws con
-	IMAGES		Public Diro. coz-o-n-no-ro.uo-cast-z.compute.amazonawa.com
	AMIS	Description Status Checks	Monitoring Tags
	Bundle Tasks		
-	ELASTIC BLOCK STORE	Instance ID	i-0ta6727b0599802de
	Volumes	Instance state	running
	Snapshots	Instance type	c5.4xlarge
	Lifecycle Manager	Elastic IPs	
_		Availability zone	us-east-2a
-	NETWORK & SECURITY	Security groups	Basic, view inbound rules, view outbound rules Secon
	Security Groups	Scheduled events	No scheduled events
	Elastic IPs	AMI ID	RadianceWorkshop (ami-0a1c68afad094b151)
	Placement Groups	Platform	- Ne
	Key Pairs	IAM role	- Sou
	Network Interfaces	Key pair name	aws_ohio
-	LOAD BALANCING	Owner	885639356958
	Load Balancers	Launch time	August 18, 2019 at 6:02:55 PM UTC-7 (2 hours)
	Target Groups	lifecuele	spot
		Monitoring	basic
-	AUTO SCALING	Alarm status	None Elastic Inference
	Launch Configurations	Kernel ID	- Capa
	Auto Scaling Groups	RAM disk ID	- Capacity Rese
		Placement aroun	-

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	\bigcirc < < 1 to 2 of 2 > >
Status Checks 👻 Alarm Status	Public DNS (IPv4) - IPv4 Public
🥝 2/2 checks None 🍡 🍖	ec2-18-218-51-41.us-e 18.218.51.4
🥝 2/2 checks None 🍡 🍃	ec2-3-17-176-79.us-ea 3.17.176.79

Possibly the easiest step.

m		_	
Public DNS (IPv4)	ec2-3-17-176-79.us-east-		
	2.compute.amazonaws.com		
IPv4 Public IP	3.17.176.79		
IPv6 IPs	-		
Private DNS	ip-172-31-13-185.us-east-2.compute.internal		
Private IPs	172.31.13.185		
ondary private IPs			
VPC ID	vpc-fe0a3097		
Subnet ID	subnet-4b494322		
etwork interfaces	eth0		
ource/dest. check	True		
T2/T3 Unlimited	-		
EBS-optimized	True		
Root device type	ebs		
Root device	/dev/xvda		
Block devices	/dev/xvda		
lastic Graphics ID	-		
ce accelerator ID	-		
acity Reservation	-		
ervation Settings	Open		



Invoice your client

- Activate tags for cost tracking
- Be diligent about tagging resources (this is the hard part) Resources can NOT be tagged retroactively
- Use cost explorer to aggregate costs for each project

•	🔍 🕒 😭 EC2 Management Console 🛛 🗙	+	
÷	→ C iii https://us-east-2.console.av	vs.amazon.com/ec2/v2/home?region=us-east-2#Home:	
	Apps 🕜 TerrestrialLight E 📀 LBNL711	M Inbox (7) - moneil 🧕 Immersive Render 🌚 Halio API v3.0.0	
	aws Services	👻 Resource Groups 👻 🛠	
I	EC2 Dashboard	Resources	
	Events	You are using the following Amazon EC2 resources in the US East	(Ohio) region:
	Reports Limits INSTANCES Instances Launch Templates Spot Requests Reserved Instances Dedicated Hosts Capacity Reservations IMAGES AMIs Bundle Tasks	 2 Running Instances 0 Dedicated Hosts 2 Volumes 2 Key Pairs 0 Placement Groups Learn more about the latest in AWS Compute from AWS re:Inv Create Instance To start using Amazon EC2 you will want to launch a virtual server, Launch Instance	 0 Elastic IPs 2 Snapshots 0 Load Balancers 4 Security Groups
-	ELASTIC BLOCK STORE	Note: Your Instances will launch in the US East (Ohio) region	Cohodulad Evento
	Snapshots Lifecycle Manager NETWORK & SECURITY Security Groups Elastic IPs Placement Groups Key Pairs Network Interfaces LOAD BALANCING Load Balancers Target Groups AUTO SCALING Launch Configurations Auto Scaling Groups	Service Status: US East (Ohio): Availability Zone Status: us-east-2a: Availability zone is operating normally us-east-2b: Availability zone is operating normally us-east-2c: Availability zone is operating normally Service Health Dashboard	US East (Ohio): No events

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By Barracuda Networks, Inc. Rating ***** Starting from \$0.60/hr or from \$4,599/yr (12% savings) for software + AWS usage fees View all Infrastructure Software

Matillion ETL for Amazon Redshift

By Matillion

Rating ***** Starting from \$1.37/hr or from \$9,950/yr (17% savings) for software + AWS usage fees View all Business Software

Trend Micro Deep Security

By Trend Micro Bating





Important Information about these Costs



Click cost allocation tags



🔍 🔍 📦 Billing Management Console 🛛 🖌 🚽					
→ C iii https://console.aws.amazon.co	om/billing/home?region=us-east-2#/preferences/tags				
Apps 🛷 TerrestrialLight E 🔇 LBNL/11 M	Inbox (7) - moneil 🦉 Immersive Render 🧐 Halio API v3.0.0				
dwS Services	- Resource Groups - 🔸				
Home	Cost Allocation Tags				
Cost Management	AWS-Generated Cost Allocation Tags				
Cost Explorer	rer A resource created by tag is an AWS-generated cost allocation tag containing resource creator information the				
Budgets	is only available in the Billing & Cost Management console, and will not appear anywhere else in the AWS co				
Budgets Reports	Activate				
Cost & Usage Reports	Liser-Defined Cost Allocation Tage				
Cost allocation tags					
Billing	Activating tags for cost allocation talls AWS that the associated cost data for these tags should be made avai				
Bills	can be used as a dimension of grouping and filtering in Cost Explorer, as well as for refining AWS budget crit				
Payment history	Activate Undo				
Credits					
Preferences	Filter: Ah Q Search for a tag key				
Billing preferences	Tag key*				
Payment methods					
Consolidated billing	✓ project				
Tax settings					
	Project				
	aws:ec2spot:fleet-request-id				



that is automatically applied to the resources that you create. This feature console, including the Tag Editor.

ailable throughout the billing pipeline. Once activated, cost allocation tags teria.

Tags per page:	100	\$
\$	Status	\$
	Active	
	Inactive	
	Inactive	
	Inactive	

Select the tag(s) to track for cost allocations

Activate them



🔍 🔍 🌼 Billing Management Console 🛛 🗙 🕓	+	
\leftarrow \rightarrow C iii https://console.aws.amazon.c	xom/billing/home?region=us-east-2#/	
🔛 Apps 🕜 TerrestrialLight E 🔇 LBNL711 N	1 Inbox (7) - moneil 🧕 Immersive Render 🚭 Halio API v3.0.0	
aws Services	- Resource Groups - 🔸	
Home	Billing & Cost Management Dashboard	
Cost Management		
Cost Explorer	Getting Started with AWS Billing & Cost Management	Month-to-
Budgets	 Manage your costs and usage using AWS Budgets 	The chart below
Budgate Deports	 Visualize your cost drivers and usage trends via Cost Explorer 	
Duugeis Hepoilis	Dive deeper into your costs using the Cost and Usage Reports with	
Cost & Usage Reports	Athena integration	
Cost allocation tags	Learn more: Check out the AWS What's New webpage	
-	Do you have Reserved Instances (RIs)?	

Billing

Bills

Payment history

Credits

Preferences

Billing preferences

Payment methods

Consolidated billing

Tax settings

Spend Summary Welcome to the AWS Billing & Cost Management console. Your last month, month-todate, and month-end forecasted costs appear below.

recommendations-via Cost Explorer.

Access the RI Utilization & Coverage reports—and RI purchase

Current month-to-date balance for August 2019

\$19.01



Cost Explorer

EC2

EFS

Important Information about these Costs







Click cost explorer button



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	💭 🕈 Andrew McNeil 👻 Global 👻 Support 👻
	⊙ -
8% ooth	August trends € Service usage Amazon Elastic Compute Cloud - Compute costs are up \$14.00 (623%) AmazonCloudWatch costs are up \$0.01 (5%) Account usage Andrew McNeil (885639356958) costs are up \$14.58 (330%) Region usage us-west-2 costs are up \$3.95 (89%)

View all reports

Last accessed

5 days ago

Click explore costs

•••	📦 Cas	l Reports	×	+										
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	aw	5 7	Service	es 👻	Resou	rce Group	5 v	*						
Ø	AWS	Cost I	Manage	ment	> Cost	t Explorer	: Cost	& Usag	Ð					
n		What's	New A	dvanced	options,	such as ex	cluding r	efunds an	d credits	, have be	en moved :	to the new '	Charge Type' 1	ilter. Lear
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		0.0	Aug-0	5*	Aug	07*	Aug-0	9~	Aug-1	1*	Aug-13*		Aug-15°	Aug-17*

To see usage data, filter by "Usage Type" or "Usage Type Group" filters with matching units (e.g., hours).

	5*	Aug-16*	Aug-17*	Aug-18*
Total cost (\$)	30	0.30	0.30	0.27

"Charges for your current billing period shown on these reports are estimated charges. Estimated charges shown on this page, or shown on any notifications that we send to you, may differ from your actual charges for this statement period after the date you view this page. One-time fees and subscription charges are assessed separately from usage and i date that they occur.

"Forecasted charges are estimated based on your historical charges and may differ from your actual charges for the forecast period. Forecasted charges are provided solely for your convenience and do not take into account char after the date on which you view this page.

All charges and prices are in US dollars.



ih Bar 👻	▲ FILTERS	CLEAR ALL
More 💌	Service	Include all 💌
	Linked Account	Include all 💌
	Region	Include all 🔻
	Instance Type	Include all 💌
	Usage Type	Include all 👻
	Usage Type Group	Include all 🔻
	Тад	
	project	Include only 👻
	radiance workshop 🗙	
	API Operation	Include all 👻
	Charge Type	Exclude only 👻
	Refund X Credit X	2
	Availability Zone	Include all 🔻
nload CSV	Platform	Include all 💌
Total	Purchase Option	Include all 🔻
Iotal	Tenancy	Include all 👻
2.31	Database Engine	Include all 👻
period. This is because curring charges, on the	Legal Entity	Include all 👻
to your use of services	Billing Entity	Include all 🔻

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You can filter by may attributes, including tags.

And you can download a CSV.



Bask in the glory!


