

Distributed Computing, Grids and Clouds

Julian Bunn, 2015

INTRODUCTION TO CLOUD COMPUTING

Distributed Computing

- ⦿ Run an application on one or more computers connected in a network
- ⦿ Computers are autonomous and possibly heterogeneous
- ⦿ Target problem is subdivided into separate tasks
- ⦿ Computers communicate via messages
- ⦿ cf Parallel Computing (tightly coupled Distributed Computing)

Grid Computing

- ⦿ “Distributed Computing with Authentication” – certificates etc.
- ⦿ Supported by e.g. Globus “toolkit”
- ⦿ No central control
- ⦿ “Virtual Organizations”
- ⦿ Typically used in research and academic communities
- ⦿ A bit long in the tooth and hard to use

Cloud Computing

- ⦿ “Cloud” is a metaphor for the network
- ⦿ Physical Infrastructure abstracted away
- ⦿ Resources accessed as “Services”
- ⦿ Resources are shared transparently – “Virtualised”
- ⦿ Inherently scalable
- ⦿ Guarantees of service
- ⦿ Mainly commercial (Amazon, Google ...)
and Pay As You Go
- ⦿ Simple to use

Cloud Services

- ⦿ “Software as a Service” (SaaS) e.g. Gmail, Google Apps (**App = Application**)
- ⦿ “Platform as a Service” (PaaS) e.g. Google App Engine, MS SQL Services
- ⦿ “Infrastructure as a Service” (IaaS) e.g. Amazon EC2

- ⦿ **SaaS** – user just uses the service
- ⦿ **PaaS** – service appears as potentially infinitely large computer running unknown OS
- ⦿ **IaaS** – Service hardware abstracted away

AMAZON EC2

“Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale [cloud computing](#) easier for developers.”

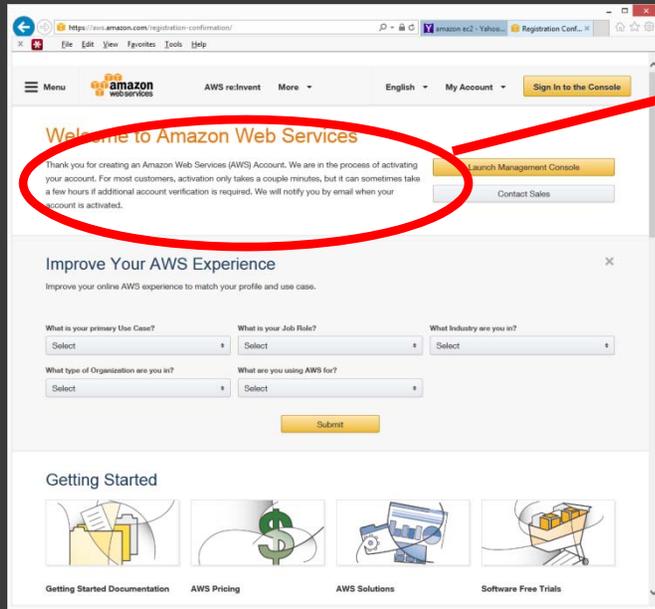
You can try Amazon EC2 for free (750 hours of “t2.micro” instances per month for a year).

SETTING UP FOR EC2

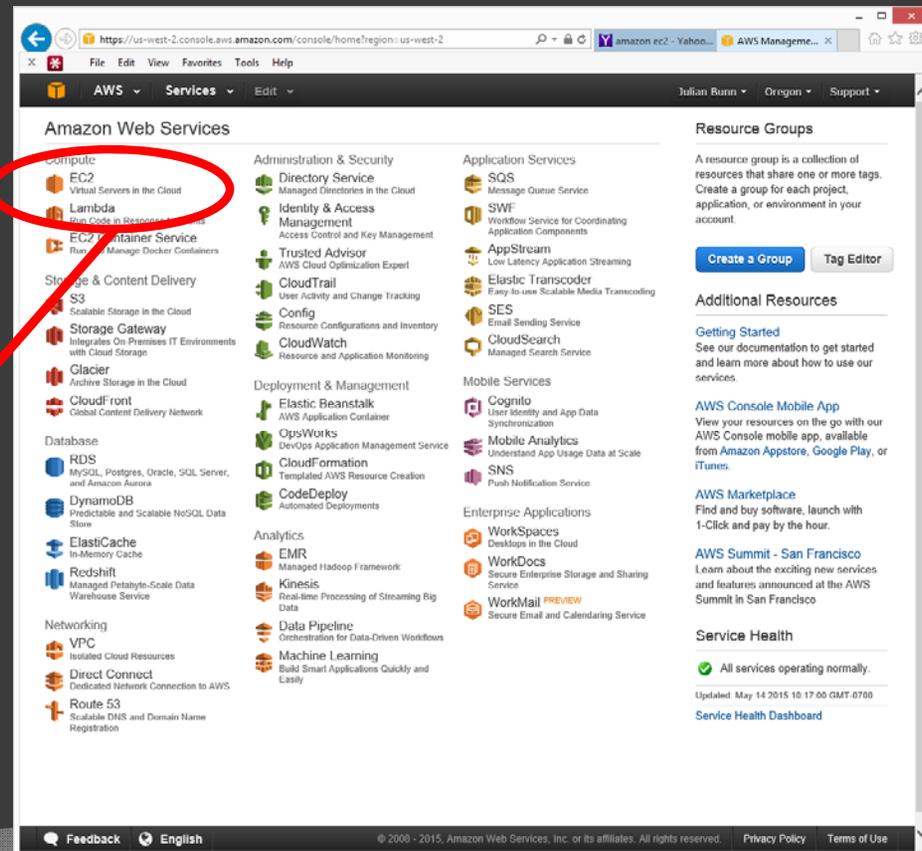
- ◎ Create an account
 - Go to <http://aws.amazon.com/ec2/>
 - Click “Try AWS for Free”
 - Create a new user using your email address
 - You will need to enter a credit card number (I used a gift card with a few \$ on it)
 - Amazon will call your ‘phone and ask you to enter the on-screen PIN
 - Sign up for the basic free support plan

Use the Management Console

(There is sometimes a delay before you can use the Management Console.)



Select the "EC2" service



Launch an EC2 Instance

The screenshot displays the AWS Management Console interface for the EC2 service in the US West (Oregon) region. The 'Resources' section shows 0 Running Instances, 0 Elastic IPs, 0 Volumes, 0 Snapshots, 0 Key Pairs, 0 Load Balancers, 0 Placement Groups, and 1 Security Groups. A blue button labeled 'Launch Instance' is circled in red. The 'Service Health' section indicates that the service is operating normally across all three availability zones (us-west-2a, us-west-2b, and us-west-2c). The 'Account Attributes' section shows the Default VPC as vpc-a560e2c0. The 'AWS Marketplace' section lists several software products available for purchase.

Resources

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

- 0 Running Instances
- 0 Elastic IPs
- 0 Volumes
- 0 Snapshots
- 0 Key Pairs
- 0 Load Balancers
- 0 Placement Groups
- 1 Security Groups

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):
This service is operating normally.

Availability Zone Status:

- us-west-2a: Availability zone is operating normally
- us-west-2b: Availability zone is operating normally
- us-west-2c: Availability zone is operating normally

[Service Health Dashboard](#)

Scheduled Events

US West (Oregon):
No events

Account Attributes

Supported Platforms

VPC

Default VPC

vpc-a560e2c0

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:

- [Vyatta Virtual Router/Firewall/VPN](#)
Provided by Vyatta, Inc.
Rating ★★★★★
Pay by the hour for software and AWS usage
[View all Networking](#)
- [Alert Logic Threat Manager for AWS](#)
Provided by Alert Logic, Inc.
Rating ★★★★★
Pay by the hour for software and AWS usage
[View all Security Software](#)
- [TIBCO Spotfire Analytics Platform \(Hourly\)](#)
Provided by TIBCO Software, Inc.
Rating ★★★★★
Pay by the hour for software and AWS usage

© 2008 - 2015, Amazon Web Services, Inc. or its affiliates. All rights reserved. [Privacy Policy](#) [Terms of Use](#)

Choose the Machine Image type

Step 1: Choose an Amazon Machine Image (AMI)

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

Cancel and Exit

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.

Quick Start

- My AMIs
- AWS Marketplace
- Community AMIs
- Free tier only ⓘ

Logo	AMI Name	Description	Architecture	Action
Amazon Linux	Amazon Linux AMI 2015.03 (HVM), SSD Volume Type - ami-e7527ed7	The Amazon Linux AMI is an EBS-backed, AWS-supported image. The default image includes AWS command line tools, Python, Ruby, Perl, and Java. The repositories include Docker, PHP, MySQL, PostgreSQL, and other packages.	64-bit	Select
Red Hat	Red Hat Enterprise Linux 7.1 (HVM), SSD Volume Type - ami-4dbf9e7d	Red Hat Enterprise Linux version 7.1 (HVM), EBS General Purpose (SSD) Volume Type	64-bit	Select
SUSE Linux	SUSE Linux Enterprise Server 12 (HVM), SSD Volume Type - ami-d7450be7	SUSE Linux Enterprise Server 12 (HVM), EBS General Purpose (SSD) Volume Type. Public Cloud, Advanced Systems Management, Web and Scripting, and Legacy modules enabled.		Select
Ubuntu	Ubuntu Server 14.04 LTS (HVM), SSD Volume Type - ami-5189a661	Ubuntu Server 14.04 LTS (HVM), EBS General Purpose (SSD) Volume Type. Support available from Canonical (http://www.ubuntu.com/cloud/services).		Select
Windows	Microsoft Windows Server 2012 R2 Base - ami-8fd3f9bf	Microsoft Windows 2012 R2 Standard edition with 64-bit architecture. [English]	64-bit	Select

Are you launching a database instance? Try Amazon RDS. [Hide](#)

Amazon RDS Amazon Relational Database Service (RDS) makes it easy to set up, operate, and scale a relational database of your choice (MySQL, PostgreSQL, Oracle, SQL Server) in the cloud. It provides cost-efficient and resizable capacity while managing time-consuming database management tasks, freeing you up to focus on your applications and business. [Learn more.](#)

Feedback English © 2008 - 2015, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use

Restrict to Free Tier

This one looks fine – it has Python

Choose the Instance type

t2.micro

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

Currently selected: t2.micro (Variable ECUs, 1 vCPUs, 2.5 GHz, Intel Xeon Family, 1 GiB memory, EBS only)

	Family	Type	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimized Available	Network Performance
<input checked="" type="checkbox"/>	General purpose	t2.micro <small>Free tier eligible</small>	1	1	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	t2.small	1	2	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	t2.medium	2	4	EBS only	-	Low to Moderate
<input type="checkbox"/>	General purpose	m3.medium	1	3.75	1 x 4 (SSD)	-	Moderate
<input type="checkbox"/>	General purpose	m3.large	2	7.5	1 x 32 (SSD)	-	Moderate
<input type="checkbox"/>	General purpose	m3.xlarge	4	15	2 x 40 (SSD)	Yes	High
<input type="checkbox"/>	General purpose	m3.2xlarge	8	30	2 x 80 (SSD)	Yes	High
<input type="checkbox"/>	Compute optimized	c4.large	2	3.75	EBS only	Yes	Moderate
<input type="checkbox"/>	Compute optimized	c4.xlarge	4	7.5	EBS only	Yes	High
<input type="checkbox"/>	Compute optimized	c4.2xlarge	8	15	EBS only	Yes	High
<input type="checkbox"/>	Compute optimized	c4.4xlarge	16	30	EBS only	Yes	High
<input type="checkbox"/>	Compute optimized	c4.8xlarge	36	60	EBS only	Yes	High

Cancel Previous **Review and Launch** Next: Configure Instance Details

Launch the Instance

The screenshot shows the AWS Management Console interface for launching an EC2 instance. The page is titled "Step 7: Review Instance Launch" and includes a progress bar with seven steps: 1. Choose AMI, 2. Choose Instance Type, 3. Configure Instance, 4. Add Storage, 5. Tag Instance, 6. Configure Security Group, and 7. Review. A warning message states: "Improve your instances' security. Your security group, launch-wizard-1, is open to the world." Below this, there are sections for "AMI Details", "Instance Type" (showing a table with columns: Instance Type, ECUs, vCPUs, Memory (GiB), Instance Storage (GB), EBS-Optimized Available, and Network Performance), "Security Groups" (showing a table with columns: Type, Protocol, Port Range, and Source), "Instance Details", "Storage", and "Tags". At the bottom right, the "Launch" button is circled in red.

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

Step 7: Review Instance Launch

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

⚠ Improve your instances' security. Your security group, launch-wizard-1, 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 [Edit AMI](#)

▼ Instance Type [Edit instance type](#)

Instance Type	ECUs	vCPUs	Memory (GiB)	Instance Storage (GB)	EBS-Optimized Available	Network Performance
t2.micro	Variable	1	1	EBS only	-	Low to Moderate

▼ Security Groups [Edit security groups](#)

Security group name: launch-wizard-1
Description: launch-wizard-1 created 2015-05-14T10:35:22.904-07:00

Type	Protocol	Port Range	Source
SSH	TCP	22	0.0.0.0

▶ Instance Details [Edit instance details](#)

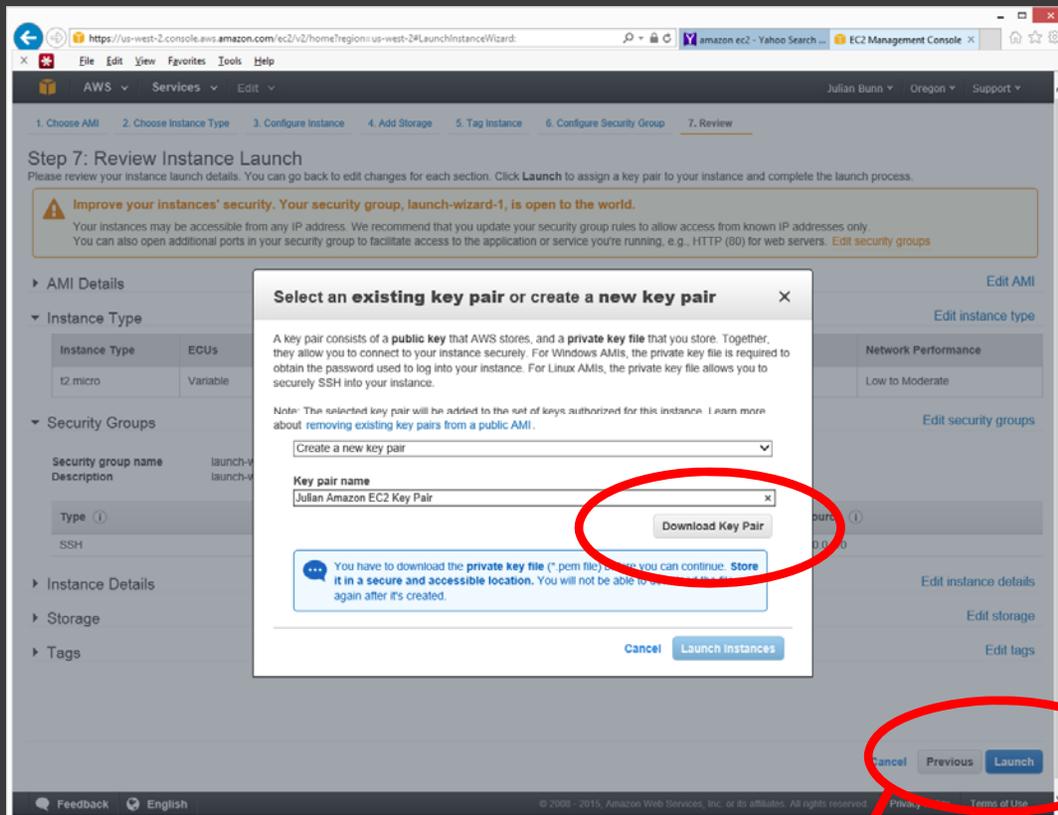
▶ Storage [Edit storage](#)

▶ Tags [Edit tags](#)

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

Feedback English © 2008 - 2015, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use

Create a Key Pair for access



Once you have the Key Pair downloaded, launch your Instance

You save the Key/Pair file (.pem) on your local machine.

It's a text file:

```
-----BEGIN RSA PRIVATE KEY-----
MIIEpAIBAAKCAQEAq7iMKYnXAdjwFtultbRszAZxAY6iHk41nrcN0ZUXFDfmoqkdysoZBjB0Rb
bm/qroEWS2LLGcmEFnxDNBplqIMJZ9EU0j75XoMTYJoXykQZwZxNv6pdGxrULgdnUCbtCFdajgm/
gGulNcHj/Mdu450YdgPnW MKSC9+bBMFMIX11mPWVvuGx+thH8jV90c2510WniCzNGafwzhtSX2uF
oaUJUZd3/VEKjZ6AnuQj0tSR6xGHdpxtbelfomdegoKwnAYr4Nn2H94JZUGNj+z2dy9onZusgKW
esQMMyW2ND+FiPI6bqO9VvAAHzuqgTORHdJeNbl/G93PFyHs6Zx4QIDAQABAoIBADm9cl.8odNGf
MiJNT+rgLhBxZL05H7g4kOHMirk37bPZcUURxnh21pFk3PJDQD Vyk9AAAdH49pY6JzoQL5hOj84D
uN7aEnX/BHM9mP9K8CLGwMs7XVnTYxig7aRIQvIVDS9Xx4+oQWY2S2QGu/QazfLjty+FU Pnr5kk
Zoezw18kUYFogTAcS3rsvWqzLVsvfwgUJzeGnSKqAL+svPSrZ2Xl/CKZhsHBvjyeGYdUybnclde
XMd1BLHymP/os9Xcq+RCYhatu3XFH2dvolZz33AjGiVXFuo+0nOmHE4To6iQ8sLF1ZpSk+E2n5V4
qilEqr8ZVbaSzAGCEi0grf4+Q00CgYEA3FJScgt3RLrK+Bjlk9V5Y7zFpBx7CoaJ0qG55HaY+kC
LHdfPsAOVPrzChsIEaYKsmw/pfsh35h6UmE8JNBOD31i0FYnjG2RceA7/19sMjGDJZC1w0EcQC
2AEByDyZsaDutRsjnKmAiyHc9fK5q44HUmXYOzDsCA19zP9Ne9c2GyEax4qf/syTbRYH5MK5r1Dt
TOLcQn2h/llQHryM10p8r87ktVVD/qKR0YiF05iIRom2rq0vRnPX8BONrYmji0sET2TFN9Clgh
rUj+XnLWMD7JFLTrTmJeYtrf94MwdHnvq68Vsl26STUMrjd9ajYWilHia0Okjhje7I29eBEwcC
gYAEoDXa7YkxatAynukBArE85Cv0YQQ0B8lud6x0E/PoXl30ddCpGLAsU70lweAUPB
GaADmRQTIIDH2XFarddPF/YU2MdojhHb/HyIBYyJElahWPY2Us8WxS7068wXQVqeD3EDetKI12/O
ikzdDgZn8q84lujojeeQQKBgQCcIh8FA4FgLUJSlqMjyt0MqBsTuCPr5+TzFArDmlzEm8hFiuu
81xj+FRNsg6gZ/zJoolB4lyg3K3NN8R63XMefyL2jxGeBMqPEXsSamN27y4FVaX3ao3C7nQpe8Wo
TZO2FzjQe2gx1pWuaoRgVTwhzsc4jnRjompT4/QASFWkBgQDR0CM30mW6BjARHXEzbydT1VccZM
jxYZJXkP0TniSK0Hqk3QD9lIdouYroG3QxpriV+p1bHaVz/N2xZZYZAZ9sYsV86W00NH5OXex
3UZwVynpoN58YoPmr2pAKQXqfydlA4sYzK50lDlaA3aN73gHAcSr/O1ABms3CW5LIUq==
-----END RSA PRIVATE KEY-----
```

Check Launch and View Instances

Launch Status

✓ **Your instances are now launching**

The following instance launches have been initiated: [i-88b2007f](#) [Hide launch log](#)

Creating security groups	Successful (sg-57bc9032)
Authorizing inbound rules	Successful
Initiating launches	Successful
Launch initiation complete	

Get notified of estimated charges

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

How to connect to your instances

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

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

Here are some helpful resources to get you started

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

Instances

Launch Instance Connect Actions

Filter by tags and attributes or search by keyword

Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS	Public IP	Key Name	Monitoring	Launch Time	Sec
	i-88b2007f	t2.micro	us-west-2b	running	2/2 checks...	None	ec2-52-10-130-99-us-w...	52.10.130.99	Julian Amazon...	disabled	May 14, 2015 at 10:45:23 A...	lau

ssh to your Instance

- Look for the public IP/DNS of your Instance

status Checks		Monitoring		Tags	
Instance ID	i-88b2007f	Public DNS	ec2-52-10-130-99.us-west-2.compute.amazonaws.com		
Instance state	running	Public IP	52.10.130.99		
Instance type	t2.micro	Elastic IP	-		

- From a command prompt on your local machine, ssh to your Instance:

```
C:\Users\Julian>ssh -i JulianAmazonEC2KeyPair.pem ec2-user@52.10.130.99
```

```
  _|  _|_ )  
  _| ( /   Amazon Linux AMI  
  _|\_|_|
```

```
https://aws.amazon.com/amazon-linux-ami/2015.03-release-notes/  
11 package(s) needed for security, out of 36 available  
Run "sudo yum update" to apply all updates.  
[ec2-user@ip-172-31-27-10 ~]$
```

Using your Instance - Example

```
[ec2-user@ip-172-31-27-10 ~]$ cat > test.py  
print 'Hello World!'  
[ec2-user@ip-172-31-27-10 ~]$ python test.py  
Hello World!
```

Google App Engine

- ⦿ Run your Web Applications on Google's Infrastructure
- ⦿ **Idea**: upload your Web App, and it's ready to serve users
- ⦿ App can be written in Java, JavaScript, Ruby, Python
- ⦿ Persistent storage, automatic scaling and load balancing, authentication
- ⦿ Task Queues (work outside Web requests)
- ⦿ Resources used measured in GBytes and CPU Hours

App Engine Datastore

- ⦿ Distributed storage with a Query Engine and Transactions
- ⦿ Unlike traditional relational database
- ⦿ Objects (“entities”) have kind and properties
- ⦿ Queries return entities of a kind sorted by values of properties
- ⦿ No schema

App Engine Services and Tasks

- ◎ URL Fetch
- ◎ Mail
- ◎ Memcache (in-memory key/value pairs)
- ◎ Image manipulation
- ◎ (Others you create in code)
- ◎ Tasks
 - Cron-like
 - Asynchronous to Web requests

Alternatives?

- ⦿ “AppScale” – from UC Santa Barbara
- ⦿ Open Source implementation of App Engine
- ⦿ Executes in Eucalyptus (IaaS and compatible with e.g. Amazon EC2)
- ⦿ Could be deployed in a private cloud