



UbiHPC Club 4.0: Introducción al desarrollo de software para vehículos aéreos no tripulados (UAVs) inteligentes -- Sección 3

Leonardo Camargo Forero, Ph.D

CEO **UbiHPC**
www.ubihpc.com



Agenda

- Tutorial de Amazon Web Services (pendiente sesión 2)
- High Performance Robotic Computing
- Desarrollo de software para cluster de UAVs
- Preguntas

Agenda del curso

Sección 1 (4 horas)



- Revisión de aplicaciones actuales con UAVs y aplicaciones futuras inmediatas
- Emprendimiento
- Tutorial de Python general
- Tutorial de Git y GitHub

Sección 2 (4 horas)



- Tutorial de ArduPilot SITL (Software In The Loop)
- Tutorial de DroneKit

Sección 3 (4 horas)

- Tutorial de Amazon Web Services
- High Performance Robotic Computing
- Desarrollo de software para cluster de UAVs

Sesión 4 (3 horas)

- Introducción a Deep Learning y Visión por computador con OpenCV.



Charla aplicaciones con UAVs y oportunidades en Universitat Politècnica de Catalunya

3

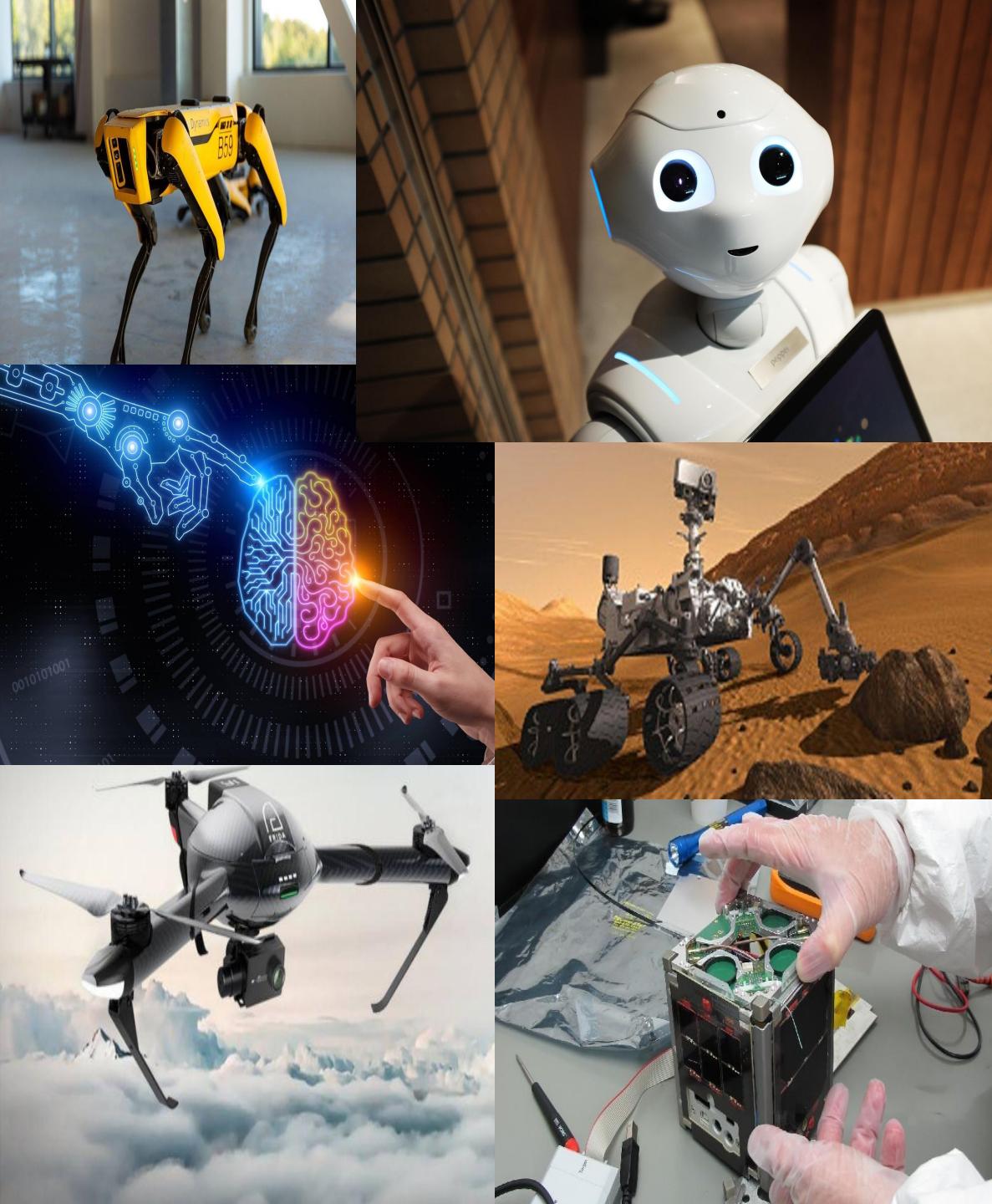


Charla integración de UAVs en espacio aéreo y oportunidades en Cranfield university

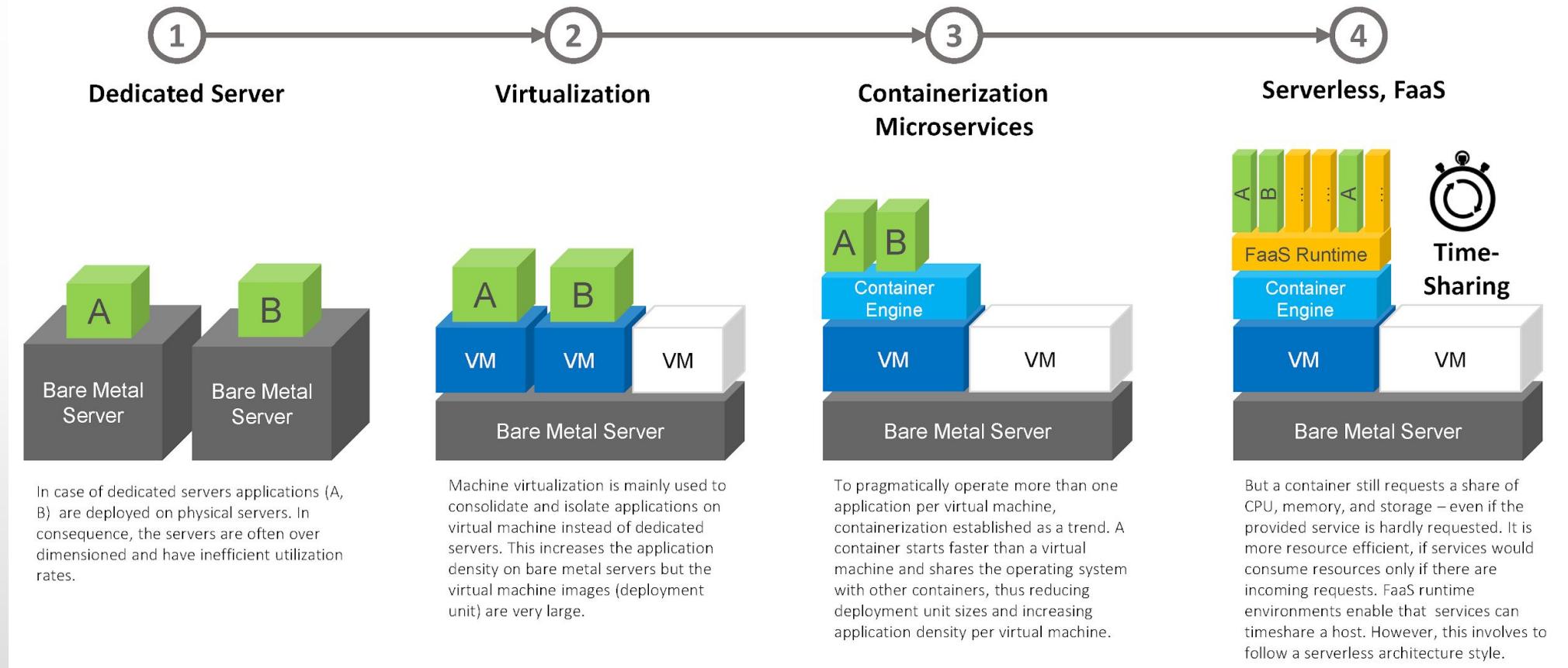


Charla SubT, Landing on an asteroid using computer vision y oportunidades en NASA Jet Propulsion Laboratory

Tutorial de AWS



Tutorial de AWS



Tutorial de AWS



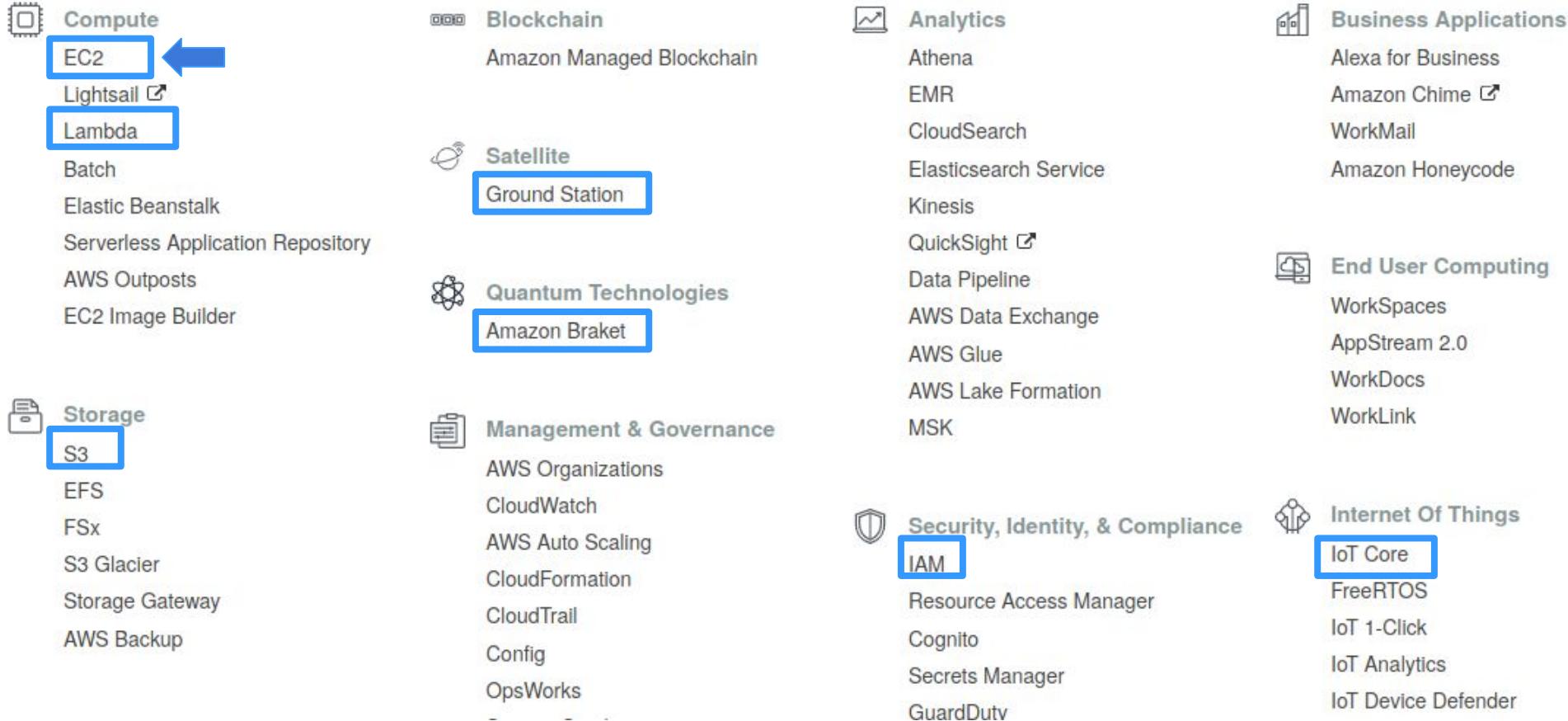
Amazon Web Services

- Costos (servidores, administración, personal)
- Escalabilidad
- Seguridad
- Resiliencia
- Multitud de servicios

Tutorial de AWS



Tutorial de AWS



Tutorial de AWS

EC2 Dashboard New

Events New

Tags

Limits

▼ Instances

- Instances **1** ←
- Instance Types
- Launch Templates
- Spot Requests
- Savings Plans
- Reserved Instances
- Dedicated Hosts New
- Scheduled Instances
- Capacity Reservations

Launch Instance Connect Actions

2

3

Amazon Linux AMI 2018.03.0 (HVM), SSD Volume Type - ami-00514a528eadbc95b Amazon Linux Free tier eligible	Select 64-bit (x86)
Red Hat Enterprise Linux 8 (HVM), SSD Volume Type - ami-098f16afa9edf40be (64-bit x86) / ami-029ba835ddd43c34f (64-bit Arm) Red Hat Free tier eligible	Select 64-bit (x86) 64-bit (Arm)
SUSE Linux Enterprise Server 15 SP2 (HVM), SSD Volume Type - ami-0a782e324655d1cc0 (64-bit x86) / ami-06ec4eaf39ca724d4 (64-bit Arm) SUSE Linux Enterprise Server 15 Service Pack 2 (HVM), EBS General Purpose (SSD) Volume Type. Public Cloud, Advanced Systems Management, Web and Scripting, and Legacy modules enabled. SUSE Linux Free tier eligible	Select 64-bit (x86) 64-bit (Arm)
Ubuntu Server 18.04 LTS (HVM), SSD Volume Type - ami-06b263d6ceff0b3dd (64-bit x86) / ami-0d324124b7b7eec66 (64-bit Arm) Ubuntu Server 18.04 LTS (HVM), EBS General Purpose (SSD) Volume Type. Support available from Canonical (http://www.ubuntu.com/cloud/services). Ubuntu Server Free tier eligible	Select 64-bit (x86) 64-bit (Arm)

Tutorial de AWS

	VCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
General Purpose - Current Generation					
a1.medium	1	N/A	2 GiB	EBS Only	\$0.0255 per Hour
a1.large	2	N/A	4 GiB	EBS Only	\$0.051 per Hour
a1.xlarge	4	N/A	8 GiB	EBS Only	\$0.102 per Hour
a1.2xlarge	8	N/A	16 GiB	EBS Only	\$0.204 per Hour
a1.4xlarge	16	N/A	32 GiB	EBS Only	\$0.408 per Hour
a1.metal	16	N/A	32 GiB	EBS Only	\$0.408 per Hour
t4g.nano	2	N/A	0.5 GiB	EBS Only	\$0.0042 per Hour
t4g.micro	2	N/A	1 GiB	EBS Only	\$0.0084 per Hour
t4g.small	2	N/A	2 GiB	EBS Only	\$0.0168 per Hour
t4g.medium	2	N/A	4 GiB	EBS Only	\$0.0336 per Hour
t4g.large	2	N/A	8 GiB	EBS Only	\$0.0672 per Hour
t4g.xlarge	4	N/A	16 GiB	EBS Only	\$0.1344 per Hour
t4g.2xlarge	8	N/A	32 GiB	EBS Only	\$0.2688 per Hour
t3.nano	2	Variable	0.5 GiB	EBS Only	\$0.0052 per Hour
t3.micro	2	Variable	1 GiB	EBS Only	\$0.0104 per Hour
t3.small	2	Variable	2 GiB	EBS Only	\$0.0208 per Hour
t3.medium	2	Variable	4 GiB	EBS Only	\$0.0416 per Hour

GPU Instances - Current Generation					
p3.2xlarge	8	31	61 GiB	EBS Only	\$3.06 per Hour
p3.8xlarge	32	97	244 GiB	EBS Only	\$12.24 per Hour
p3.16xlarge	64	201	488 GiB	EBS Only	\$24.48 per Hour
p2.xlarge	4	16	61 GiB	EBS Only	\$0.90 per Hour
p2.8xlarge	32	97	488 GiB	EBS Only	\$7.20 per Hour
p2.16xlarge	64	201	732 GiB	EBS Only	\$14.40 per Hour
g4dn.xlarge	4	N/A	16 GiB	125 GB NVMe SSD	\$0.526 per Hour
g4dn.2xlarge	8	N/A	32 GiB	225 GB NVMe SSD	\$0.752 per Hour
g4dn.4xlarge	16	N/A	64 GiB	225 GB NVMe SSD	\$1.204 per Hour
g4dn.8xlarge	32	N/A	128 GiB	900 GB NVMe SSD	\$2.176 per Hour
g4dn.12xlarge	48	N/A	192 GiB	900 GB NVMe SSD	\$3.912 per Hour
g4dn.16xlarge	64	N/A	256 GiB	900 GB NVMe SSD	\$4.352 per Hour
g3.4xlarge	16	58	122 GiB	EBS Only	\$1.14 per Hour
g3.8xlarge	32	97	244 GiB	EBS Only	\$2.28 per Hour
g3.16xlarge	64	201	488 GiB	EBS Only	\$4.56 per Hour
g3s.xlarge	4	13	30.5 GiB	EBS Only	\$0.75 per Hour

Tutorial de AWS

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	IPv6 Support
<input type="checkbox"/>	General purpose	t2.nano	1	0.5	EBS only	-	Low to Moderate	Yes
<input checked="" type="checkbox"/>	General purpose	t2.micro	1	1	EBS only	-	Low to Moderate	Yes
<input type="checkbox"/>	General purpose	t2.small	1	2	EBS only	-	Low to Moderate	Yes
<input type="checkbox"/>	General purpose	t2.medium	2	4	EBS only	-	Low to Moderate	Yes
<input type="checkbox"/>	General purpose	t2.large	2	8	EBS only	-	Low to Moderate	Yes
<input type="checkbox"/>	General purpose	t2.xlarge	4	16	EBS only	-	Moderate	Yes
<input type="checkbox"/>	General purpose	t2.2xlarge	8	32	EBS only	-	Moderate	Yes
<input type="checkbox"/>	General purpose	t3a.nano	2	0.5	EBS only	Yes	Up to 5 Gigabit	Yes
<input type="checkbox"/>	General purpose	t3a.micro	2	1	EBS only	Yes	Up to 5 Gigabit	Yes
<input type="checkbox"/>	General purpose	t3a.small	2	2	EBS only	Yes	Up to 5 Gigabit	Yes
<input type="checkbox"/>	General purpose	t3a.medium	2	4	EBS only	Yes	Up to 5 Gigabit	Yes
<input type="checkbox"/>	General purpose	t3a.large	2	8	EBS only	Yes	Up to 5 Gigabit	Yes

Cancel Previous Review and Launch Next: Configure Instance Details



Tutorial de AWS

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 Launch into Auto Scaling Group

Purchasing option Request Spot instances

Network

Subnet

Auto-assign Public IP

Placement group Add instance to placement group

Capacity Reservation

Domain join directory

IAM role

Shutdown behavior

Stop - Hibernate behavior Enable hibernation as an additional stop behavior

Enable termination protection Protect against accidental termination

Monitoring Enable CloudWatch detailed monitoring
Additional charges apply.

Tenancy
Additional charges will apply for dedicated tenancy.

Elastic Inference Add an Elastic Inference accelerator
Additional charges apply.

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Tutorial de AWS

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

Step 4: Add Storage

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

Volume Type	Device	Snapshot	Size (GiB)	Volume Type	IOPS	Throughput (MB/s)	Delete on Termination	Encryption
Root	/dev/sda1		8	General Purpose SSD (gp2)	100 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted

Add New Volume

Free tier eligible customers can get up to 30 GB of EBS General Purpose (SSD) or Magnetic storage. [Learn more](#) about free usage tier eligibility and usage restrictions.

Cancel Previous **Review and Launch** Next: Add Tags



Tutorial de AWS

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

Step 5: Add Tags

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

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

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

Key	(128 characters maximum)	Value	(256 characters maximum)	Instances	Volumes	
Name		intro-smart-uavs		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

[Add another tag](#) (Up to 50 tags maximum)

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8

Cancel Previous **Review and Launch** Next: Configure Security Group

Tutorial de AWS

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

Step 6: Configure Security Group

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

Assign a security group: Create a new security group

Select an existing security group

Security group name:

Description:

Type <small>i</small>	Protocol <small>i</small>	Port Range <small>i</small>	Source <small>i</small>	Description <small>i</small>
SSH	TCP	22	Custom <small>v</small> 0.0.0.0/0	e.g. SSH for Admin Desktop

Add Rule

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 access from known IP addresses only.

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Cancel Previous Review and Launch

Tutorial de AWS

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

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.

AMI Details

[Edit AMI](#)

 **Ubuntu Server 18.04 LTS (HVM), SSD Volume Type - ami-06b263d6ceff0b3dd**

Free tier eligible Ubuntu Server 18.04 LTS (HVM),EBS General Purpose (SSD) Volume Type. Support available from Canonical (<http://www.ubuntu.com/cloud/services>).
Root Device Type: ebs Virtualization type: hvm

Instance Type

[Edit instance type](#)

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

Security Groups

[Edit security groups](#)

Security group name

Description

Type <i>(i)</i>	Protocol <i>(i)</i>	Port Range <i>(i)</i>	Source <i>(i)</i>	Description <i>(i)</i>
SSH	TCP	22	0.0.0.0/0	

Instance Details

[Edit instance details](#)

Storage

[Edit storage](#)

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

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Next ↓

Tutorial de AWS

Select an existing key pair or create a new key pair X

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

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

Create a new key pair ▼

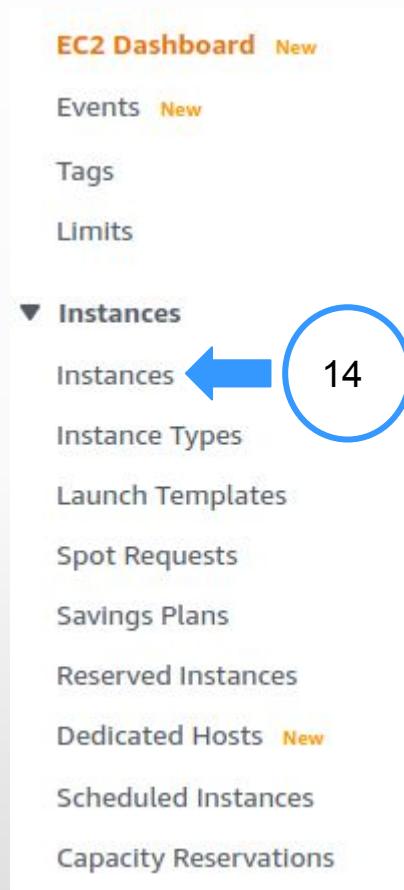
Key pair name
intro-smart-uavs

Download Key Pair

You have to download the **private key file** (*.pem file) before you can continue. **Store it in a secure and accessible location.** You will not be able to download the file again after it's created.

Cancel Launch Instances

Tutorial de AWS



The screenshot shows the AWS EC2 Dashboard. On the left, under the 'Instances' section, there is a blue circle around the number '14' next to the 'Instances' link. A blue arrow points from this circle to the right towards the main content area. In the center, a modal window titled 'Connect to your instance' is displayed. At the top of the modal, there is a status bar showing the instance ID 'intro-smart-u...', type 't2.micro', region 'us-east-1e', and state 'running'. Below the status bar, there are two green arrows: one pointing up towards the instance ID and one pointing down towards the connection instructions. The modal contains the following text:

Connection method

- A standalone SSH client [\(i\)](#)
- Session Manager [\(i\)](#)
- EC2 Instance Connect (browser-based SSH connection) [\(i\)](#)

To access your instance:

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

Example:

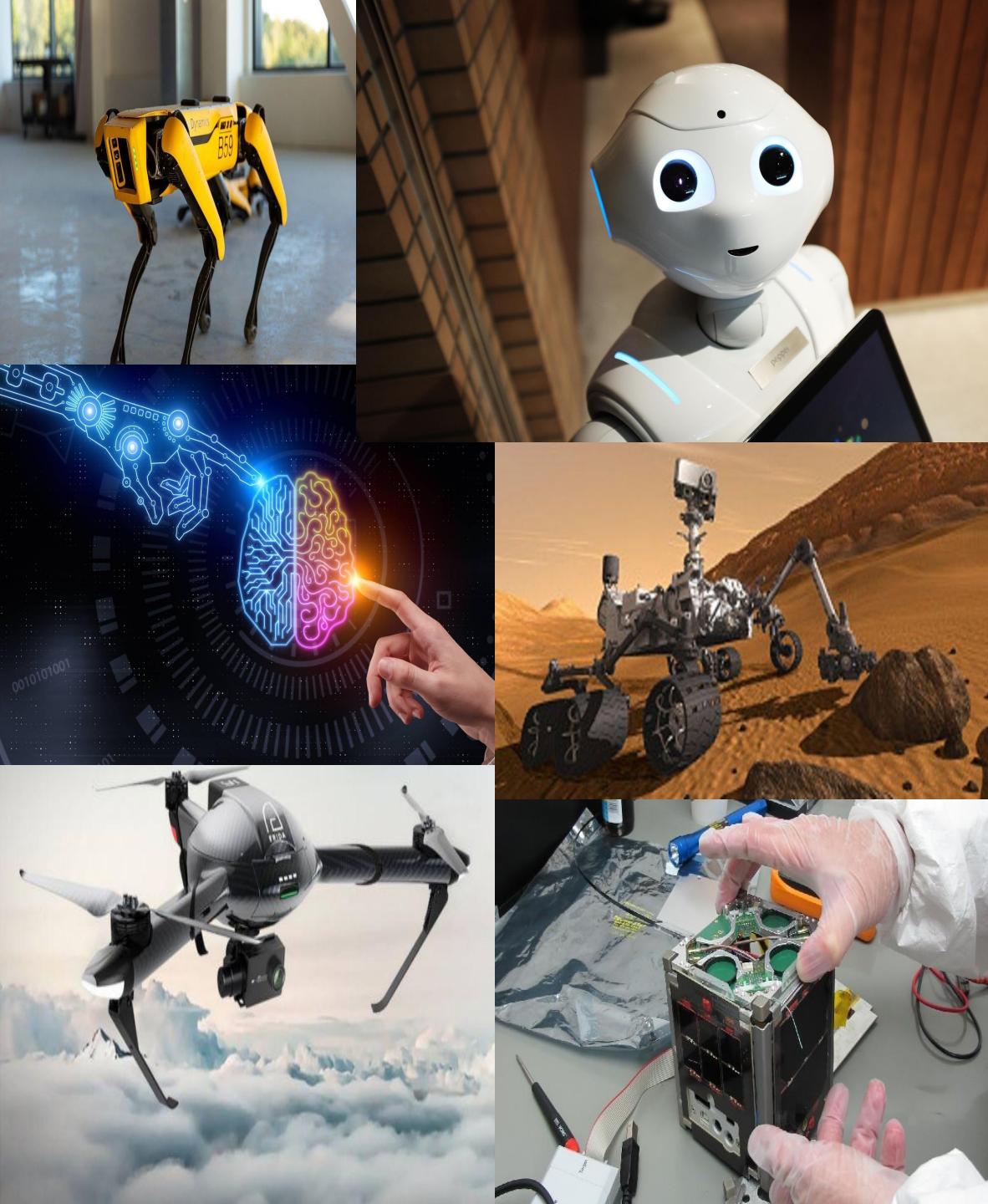
```
ssh -i "intro-smart-uavs.pem" ubuntu @your_public_DNS
```

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

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

[Close](#)

High Performance Robotic Computing



High Performance Computing a.k.a. Supercomputing

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¿Para qué se usa la supercomputación?



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La supercomputación está en todos lados

Porqué usar la supercomputación?



Supercomputación

Simulación

Diseño de aeronaves
Computational Fluid Dynamics (CFD)
Orígenes del universo
Inteligencia Artificial
Cyber-heart living heart (25M de variables)
Is Cancer written in our DNA?
Boeing lighter 787
Disney-Pixar
Avatar
Facebook/email keyword analysis

Demasiada complejidad computacional

22

Miles de años para obtener resultados



Incluso un PC poderoso

22 Next

Qué es la supercomputación (HPC)?

Distribuir
Paralelizar
Concurrir
Optimizar

MPI



Supercomputador / cluster



Computación oportunista

HPC = High Performance Computing



Computación en Grid



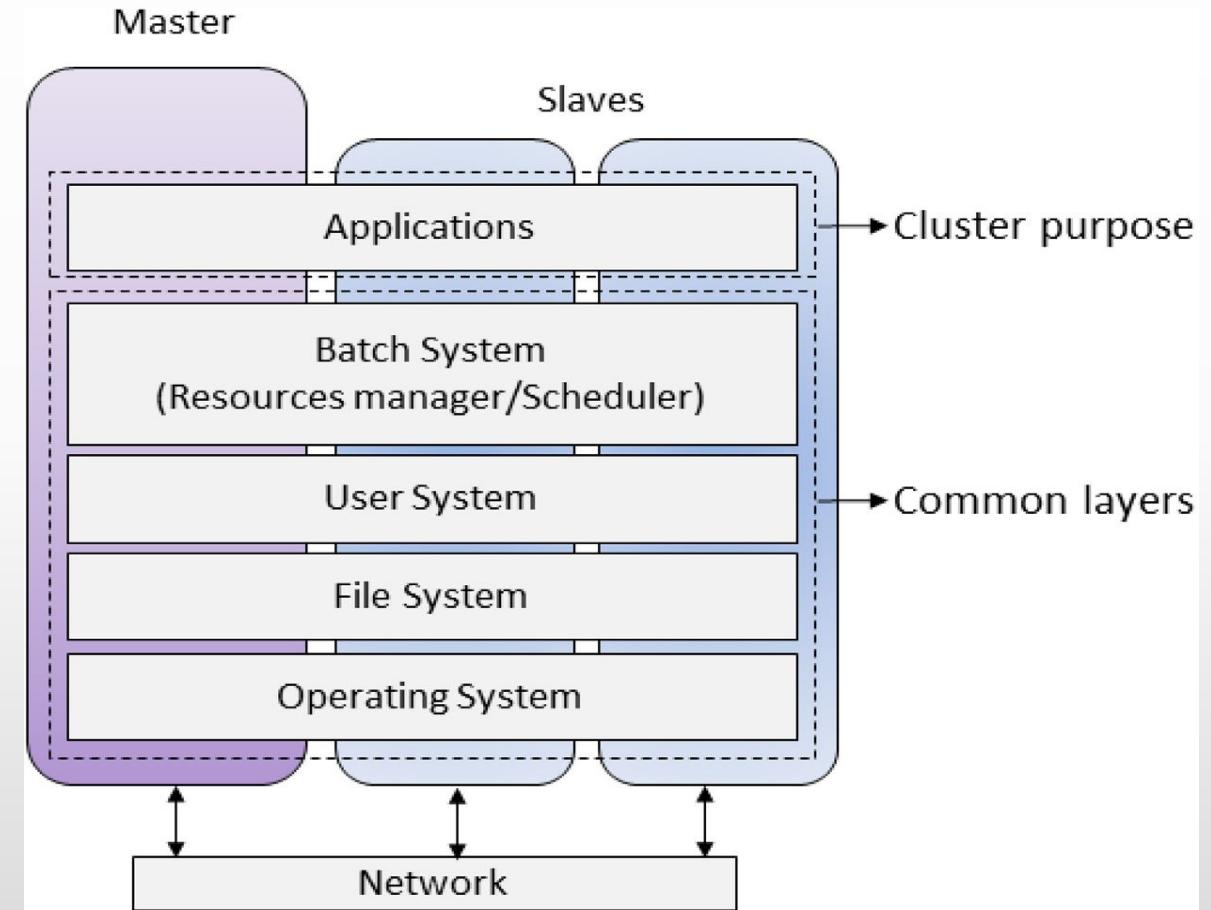
GPGPU



Supercomputador o cluster HPC

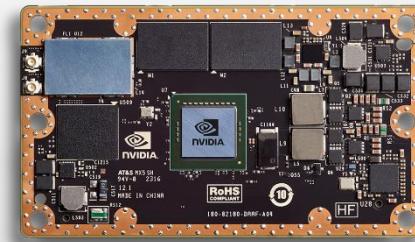
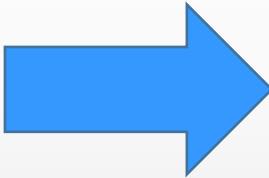


Supercomputador



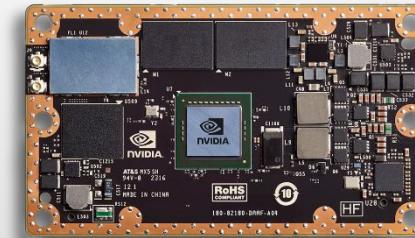
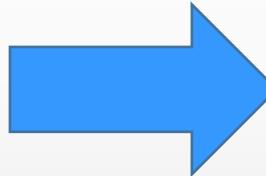
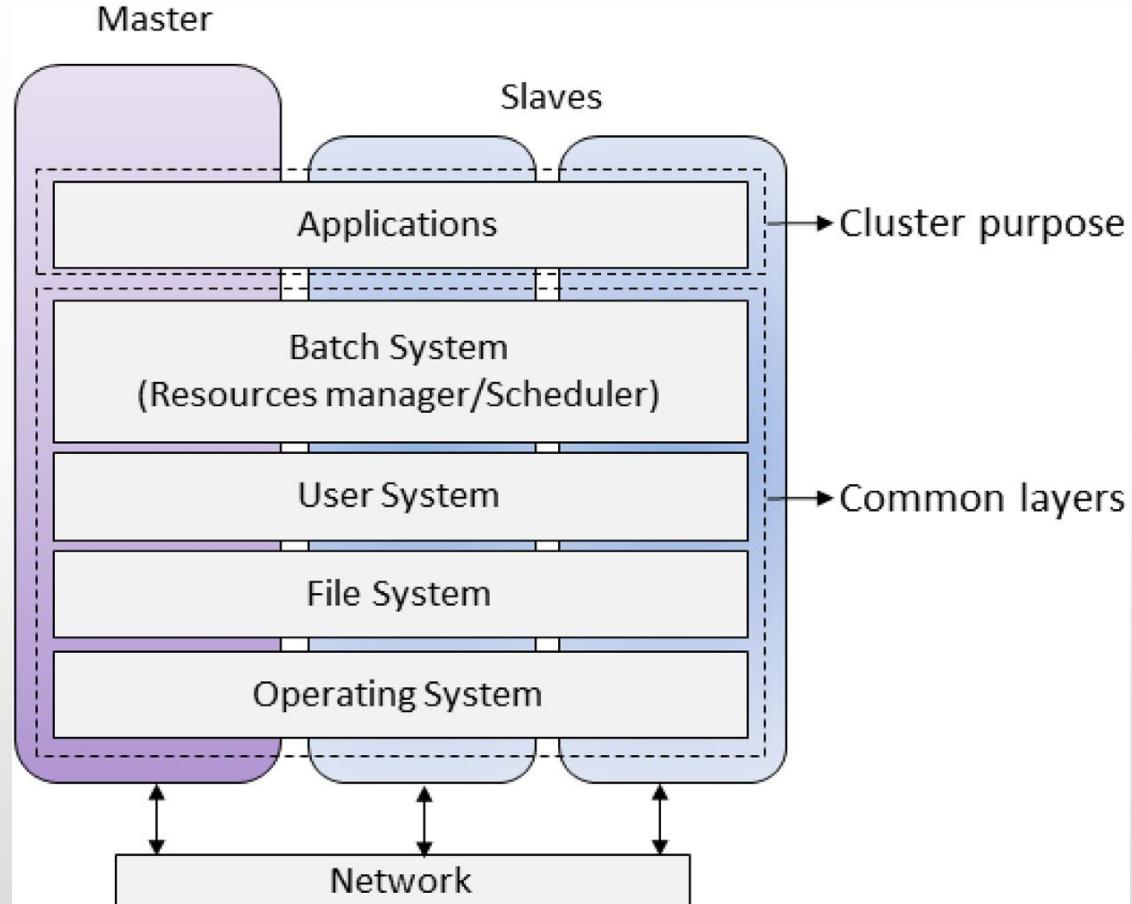
Arquitectura software

High Performance Robotic Computing



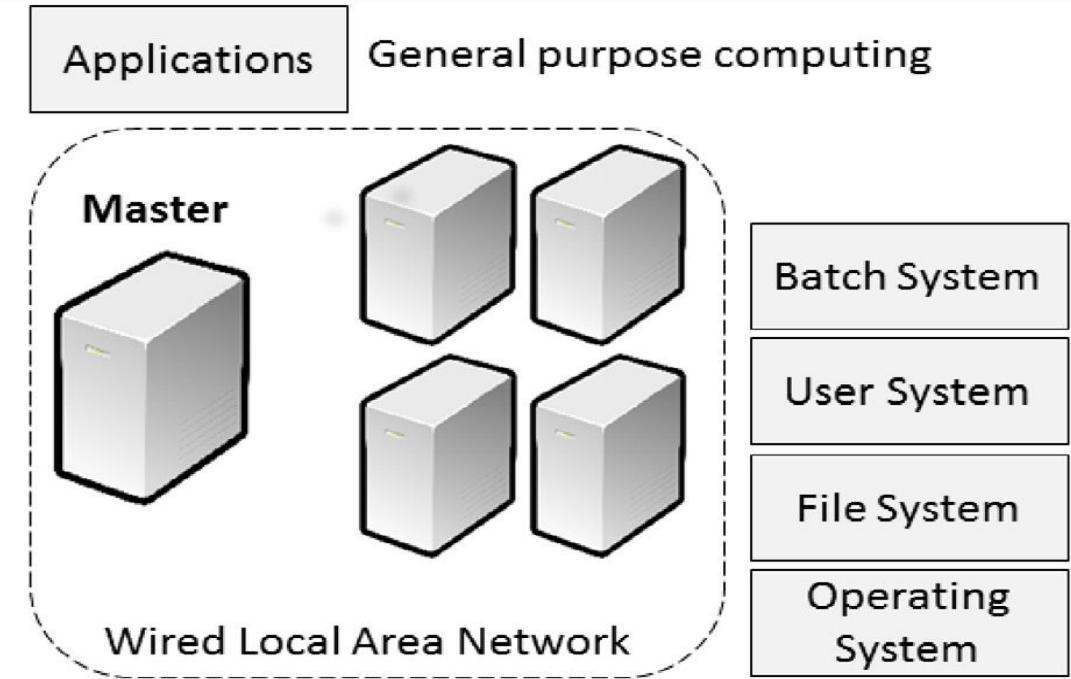
25

High Performance Robotic Computing

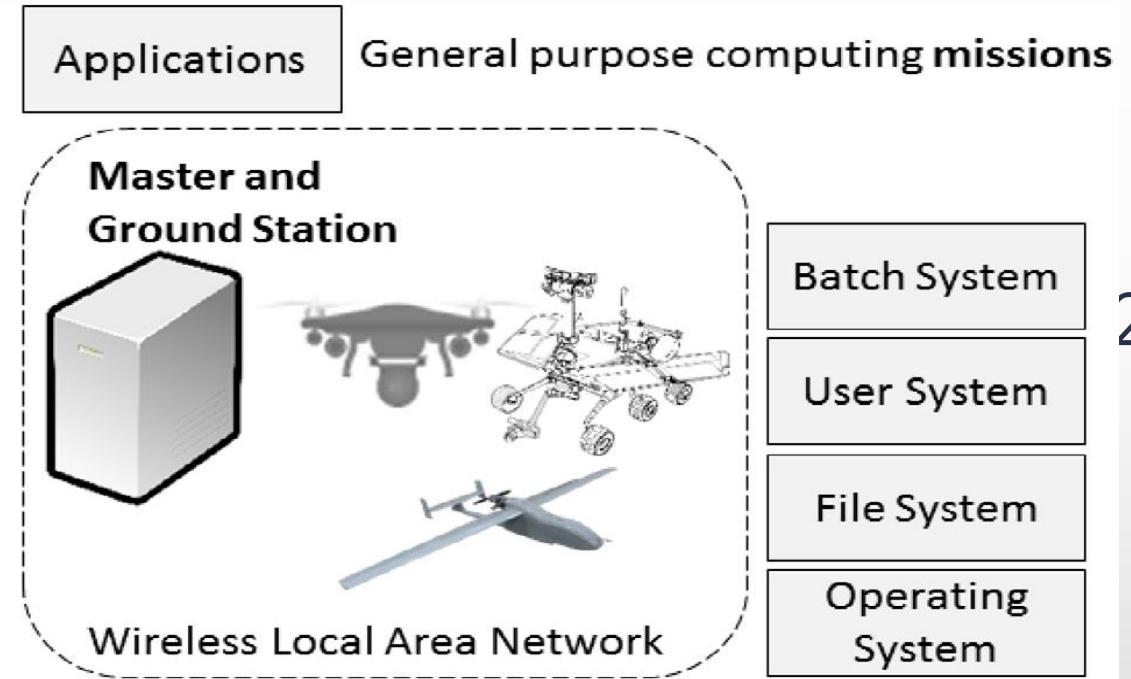


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High Performance Robotic Computing

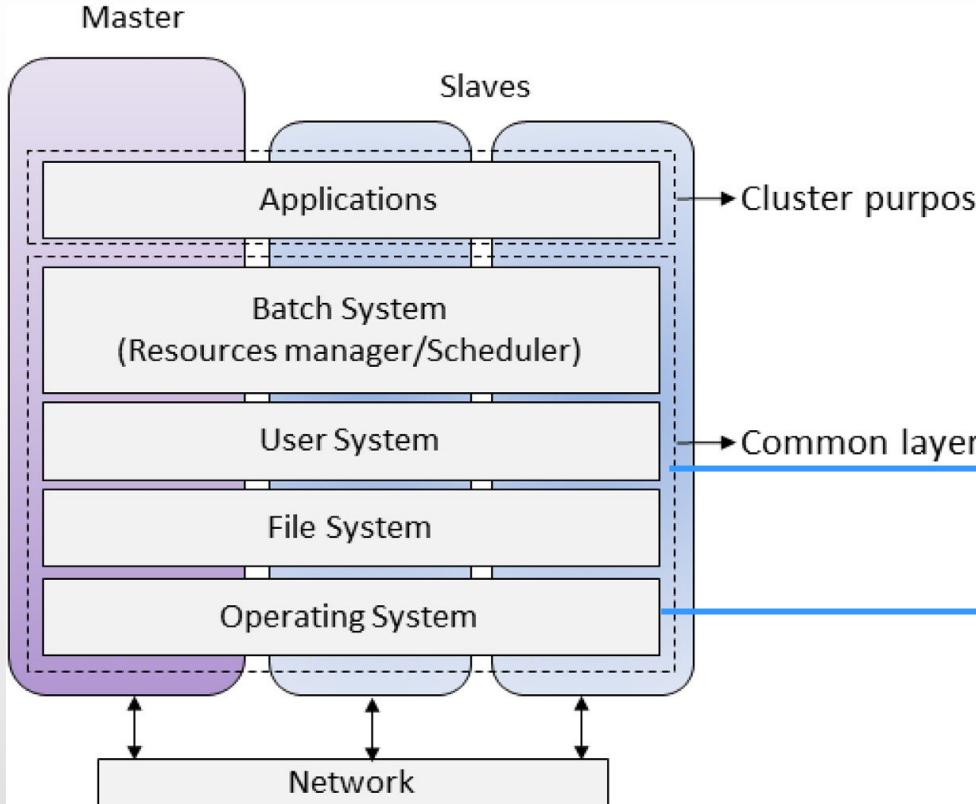


a. Traditional High Performance Computing cluster



b. High Performance Robotic Computing cluster

High Performance Robotic Computing



General configuration

Software Installation (as root or with sudo)

```
apt-get install openssh-server nfs-common
apt-get install python-mpi4py openmpi-common openmpi-bin openmpi-doc libopenmpi-dev
```

Add hosts to /etc/hosts , one line per host (as root or with sudo)

```
<IP> <FQDN> <Hostname>
```

Create home directory for HPRC cluster's users (as root or with sudo)

```
mkdir -p /export/home
```

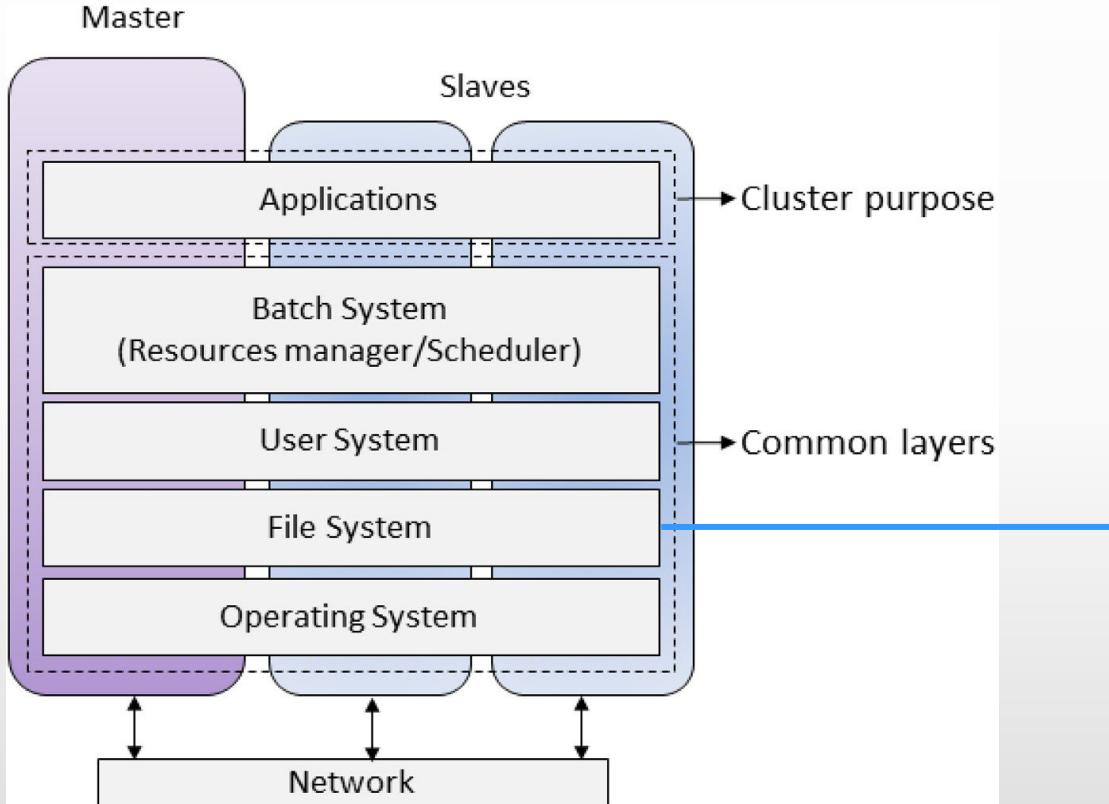
Create user (as root or with sudo)

```
useradd -u <user_ID> -m -d /export/home/<username> -s /bin/bash <username>
passwd <username>
su <username>
```

Only in the master node: Generate SSH keys for and configure passwordless authentication

```
ssh-keygen -t rsa
cd ~/.ssh
cat id_rsa.pub >> authorized_keys
chmod 600 authorized_keys
```

High Performance Robotic Computing



File system

File system Installation: In a HPRC cluster, the file system can be any technology traditionally used in Supercomputing. For a simple cluster, Network File System (NFS) will suffice. For this example, the folder /export/home will be shared from the master node. Such folder corresponds to the user space for this configuration

Master node

```
apt-get install nfs-kernel-server
```

Edit the file /etc/exports and add the following lines:

```
/export/home <Network/Mask>(rw,no_root_squash)
```

Execute the following commands

```
service rpcbind restart  
/etc/init.d/nfs-kernel-server restart  
exportfs
```

Slave nodes

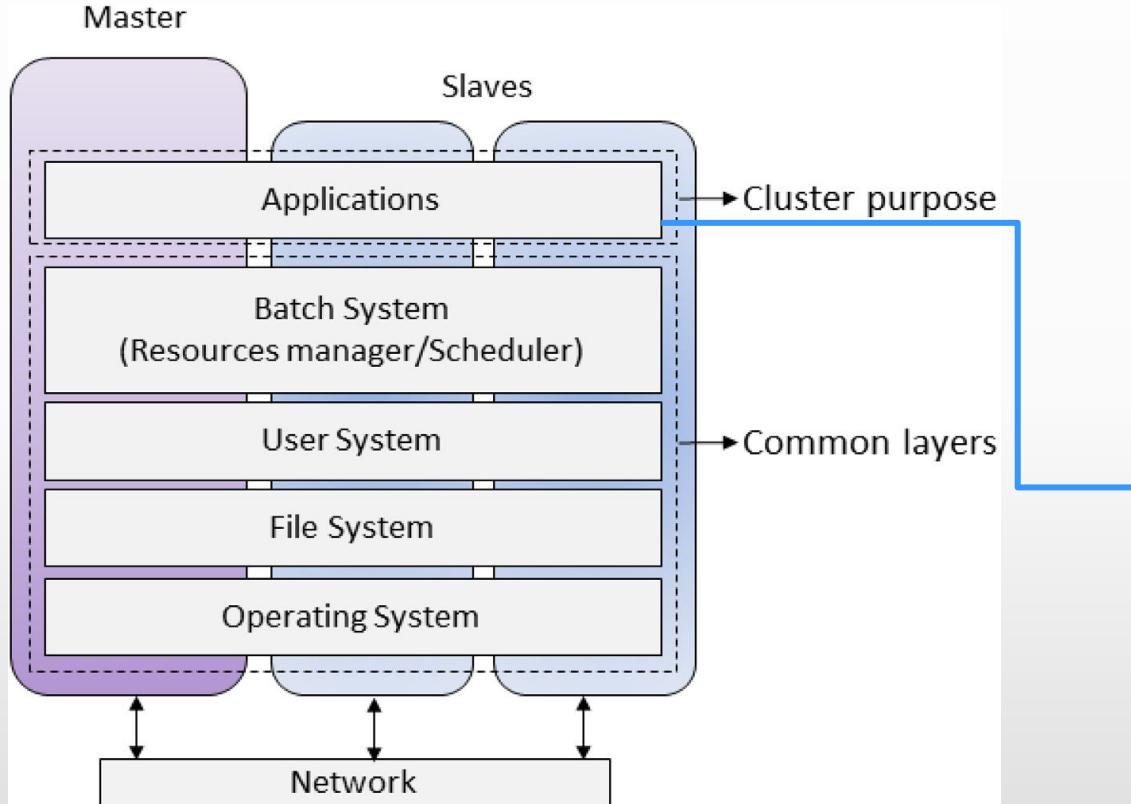
Edit the file /etc/fstab and add the following lines:

```
<SERVER_IP>:/export/home /export/home nfs defaults,proto=tcp,port=2049 0 0
```

Mount NFS shared folder

```
mount <SERVER_IP>:/export/home /export/home
```

High Performance Robotic Computing



Traditional supercomputing (HPC) examples

Hello world with mpi4py

PI computation with mpi4py

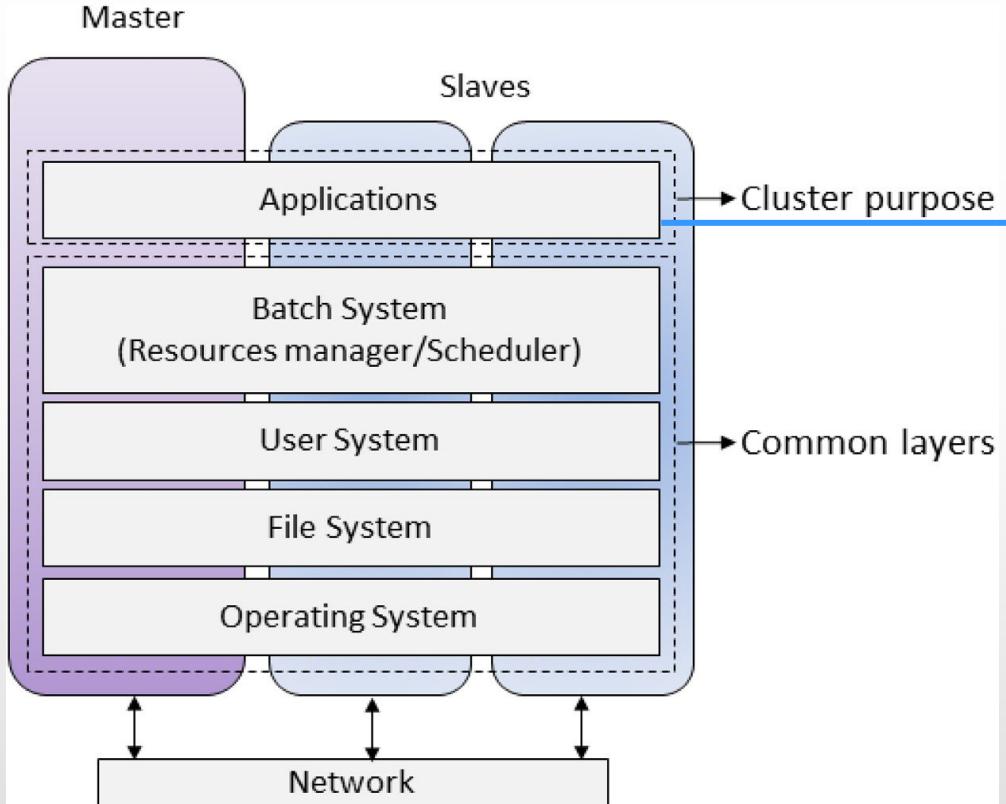
To execute these examples use the following command:

```
mpirun -np <X> --hostfile <hostfile> python <pythonSoftware>
```

where,

X = Quantity of MPI parallel processes
<pythonSoftware> The corresponding software
<hostfile> is a text file with the hostnames of the computers in your cluster, e.g.
<Hostname1>
<Hostname2>
<Hostname3>

High Performance Robotic Computing



```
#!/usr/bin/env python
"""
Parallel Hello World
"""

from mpi4py import MPI
import sys

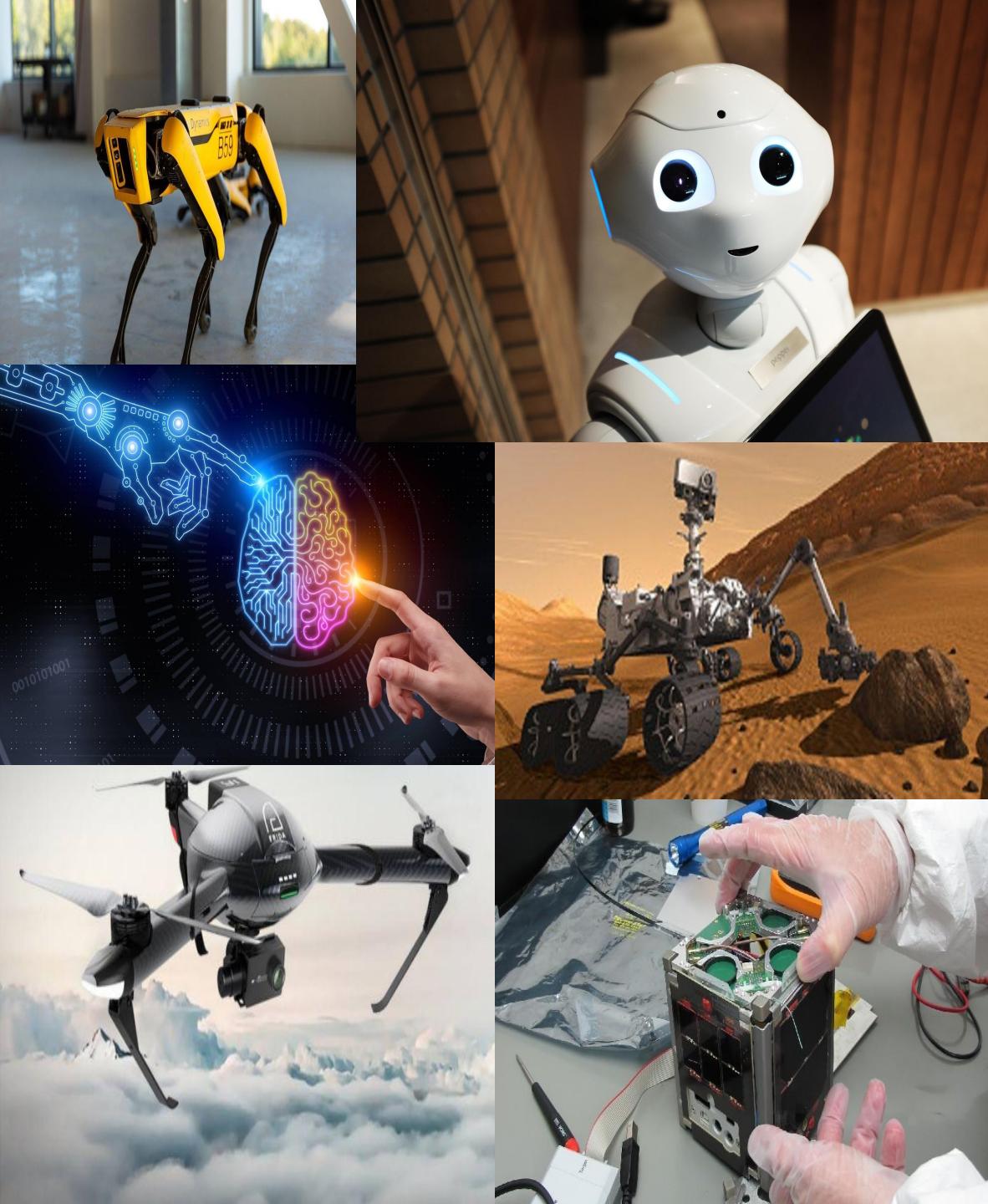
size = MPI.COMM_WORLD.Get_size()
rank = MPI.COMM_WORLD.Get_rank()
name = MPI.Get_processor_name()

sys.stdout.write(
    "Hello, World! I am process %d of %d on %s.\n"
    % (rank, size, name))
```

`mpirun -np <X> --hostfile <hostfile> python <pythonSoftware>`

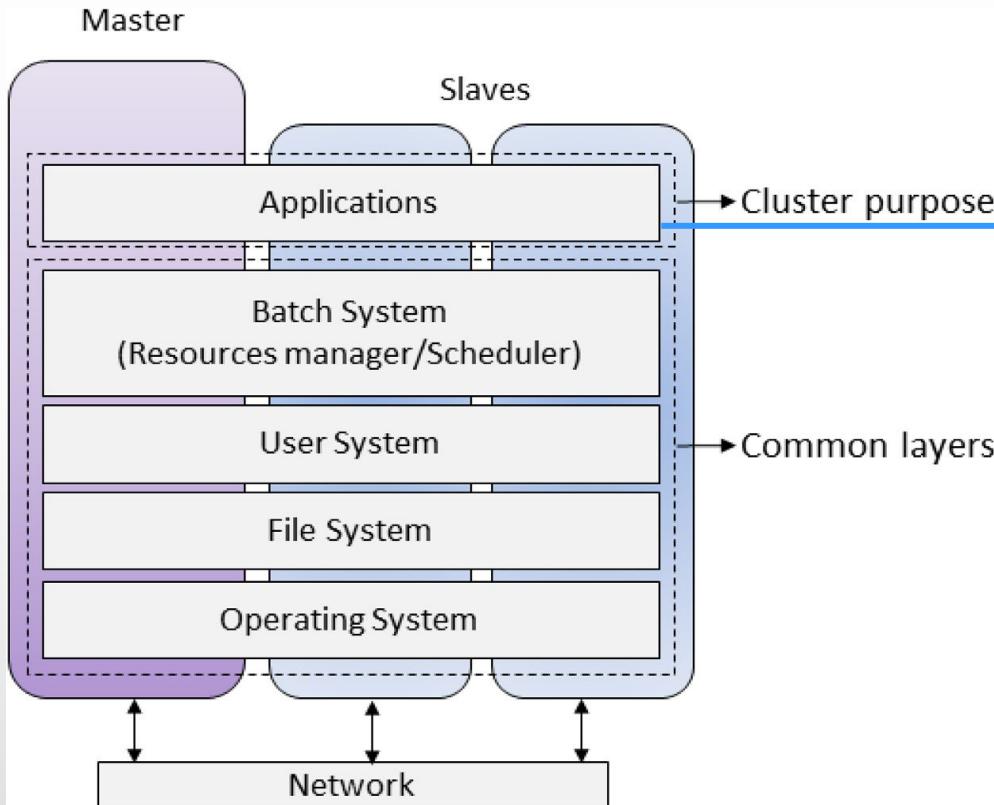
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<pythonSoftware> The corresponding software
<hostfile> is a text file with the hostnames of the computers in your cluster, e.g.
<Hostname1>
<Hostname2>
<Hostname3>



Desarrollo de software para cluster de UAVs

Desarrollo de software para cluster de UAVs



Usage

To execute the software, launch the following command:

```
mpirun -np X --rankfile <rankfile> python parallelVicsek.py -v <vehicleType> -s <simTime> -t <telemetryFolder>
```

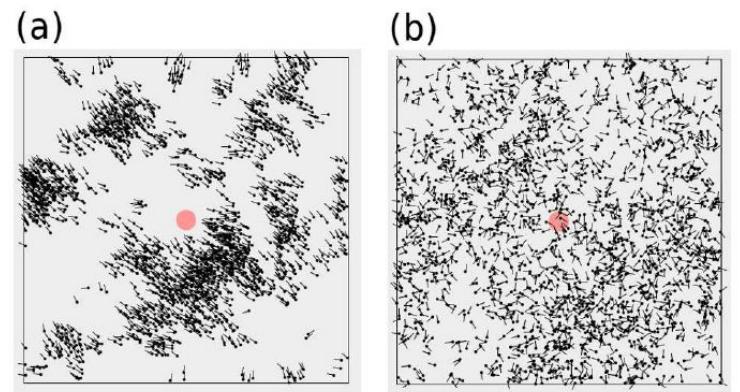
Where

- X = Quantity of vehicles
- vehicleType = <drone, rover>
- simTime = Simulation time in seconds
- telemetryFolder = Shared folder in the HPRC cluster

Finally the rankfile is used to execute a single MPI process per vehicle (HPRC node). An example is the following:

```
rank 0=<hostname_vehicle_1> slot=0
rank 1=<hostname_vehicle_2> slot=0
rank 2=<hostname_vehicle_3> slot=0
rank 3=<hostname_vehicle_4> slot=0
rank 4=<hostname_vehicle_5> slot=0
```

Desarrollo de software para cluster de UAVs



Modelo Vicsek

1. Cada entidad (por ejemplo, pájaro, UAV) vuela con velocidad constante y dirección (rumbo) igual al promedio de las direcciones de sus vecinos. Una entidad i se considera vecina de la entidad j si en el tiempo t , i y j están a una distancia menor o igual que un radio seleccionado.
2. El ruido en el sistema. Se consideran dos tipos de ruido: *extrínseco* e *intrínseco*.
 - a. Extrínseco: Se refiere al ruido causado por el medio ambiente. En los sistemas biológicos, podría relacionarse con las entidades, a las que les podría suceder, que en determinado momento, no pudieren determinar correctamente si otra entidad es un vecino. En sistemas artificiales, el ruido extrínseco puede estar relacionado con problemas de precisión del GPS.
 - b. Intrínseco: Se refiere a la decisión de las entidades de moverse en cierta dirección incluso si comprenden completamente la dirección de sus vecinos. En sistemas artificiales, esto podría relacionarse con errores de cómputo en tiempo de ejecución.

Desarrollo de software para cluster de UAVs

Ingresar al maestro usando el usuario (<usuario_cluster>) que crearon para el despliegue del cluster

1. Clonar el repositorio intro_to_smart_uavs:

```
cd  
git clone https://github.com/<usuario_git>/intro_to_smart_uavs.git  
cd intro_to_smart_uavs/session3
```

2. Crear directorio para almacenar el código fuente:

```
mkdir -p code  
cd code  
touch __init__.py  
mkdir instructor_code my_code  
touch instructor_code/__init__.py my_code/__init__.py
```

3. Clonar código multi-robot-vicsek

```
cd instructor_code  
git clone https://github.com/leonardocfor/multi-robot-vicsek
```

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4. Crear .gitignore

```
cd $HOME/intro_to_smart_uavs  
nano .gitignore → session3/code/instructor_code
```

5. Configurar PATH y PYTHON_PATH

```
cd  
nano .bashrc  
Al final del archivo  
export PYTHONPATH=$PYTHONPATH:$HOME/intro_to_smart_uavs/session3/code/my_code  
export PATH=$PATH:/home/<usuario_sudo>/ardupilot/Tools/autotest  
Cerrar archivo  
source .bashrc
```

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6. A little hack

```
sudo chown -R <usuario_cluster> /home/<usuario_sudo>/ardupilot
```

Partir terminator en dos ventanas

Ventana 1:

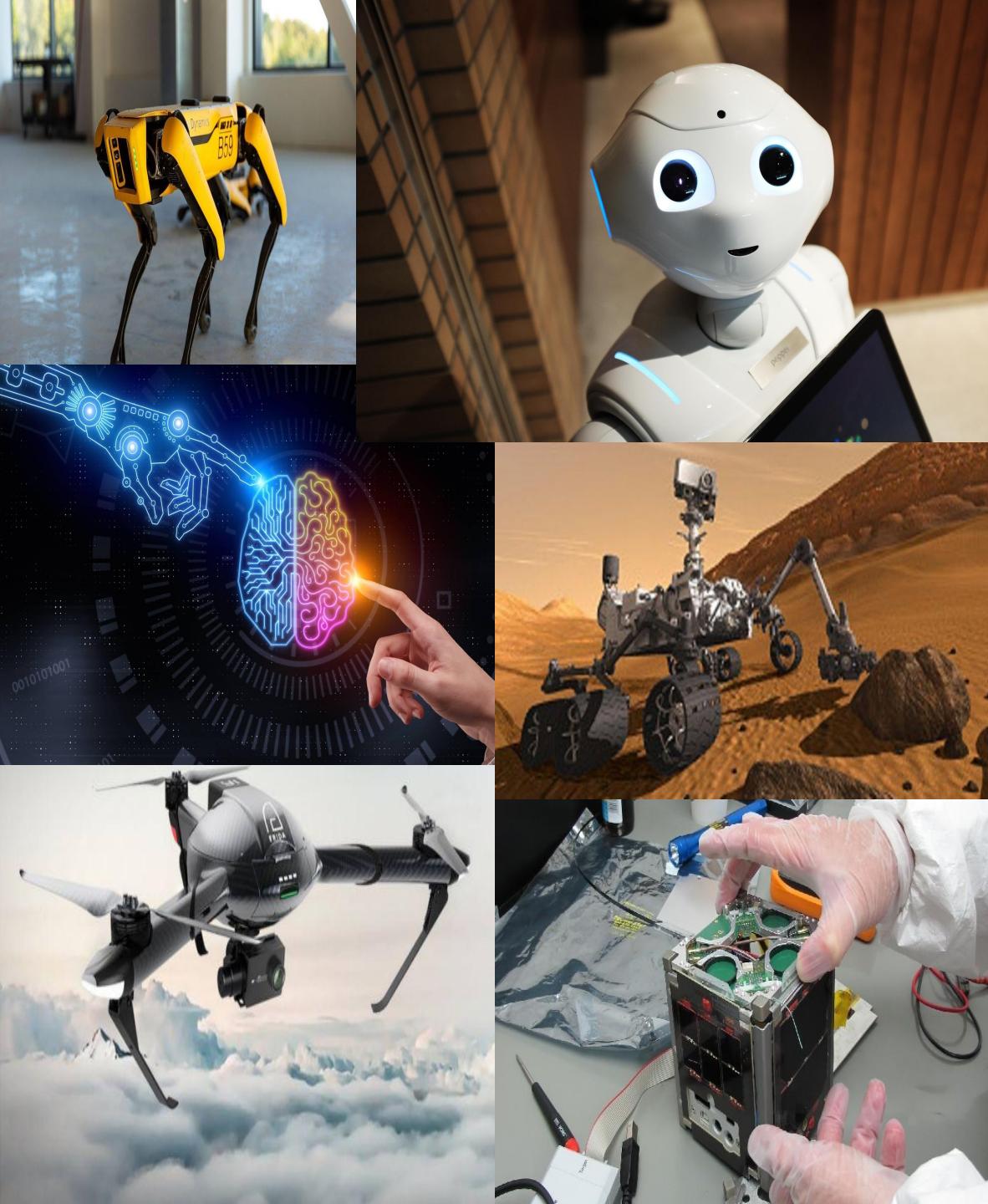
```
sim_vehicle.py -v ArduCopter --map --console --out 127.0.0.1:14551 --out 127.0.0.1:14552
```

Ventana 2:

```
python3
>>> from dronekit import connect, VehicleMode
>>> vehicle = connect('127.0.0.1:14550', wait_ready=True)
>>> vehicle.mode = VehicleMode('GUIDED')
>>> vehicle.armed = True; vehicle.simple_takeoff(30)
```

7. Code Along

```
cd $HOME/intro_to_smart_uavs/session3/code
atom .
```



Para la siguiente sección

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Instalar Jupyter notebook Windows: <https://test-jupyter.readthedocs.io/en/latest/install.html>

Instalar OpenCV python Windows: https://docs.opencv.org/master/d5/de5/tutorial_py_setup_in_windows.html

Gracias

Leonardo Camargo Forero, Ph.D

✉ leonardo@ubihpc.com
🌐 www.ubihpc.com

