



Kubernetes Overview

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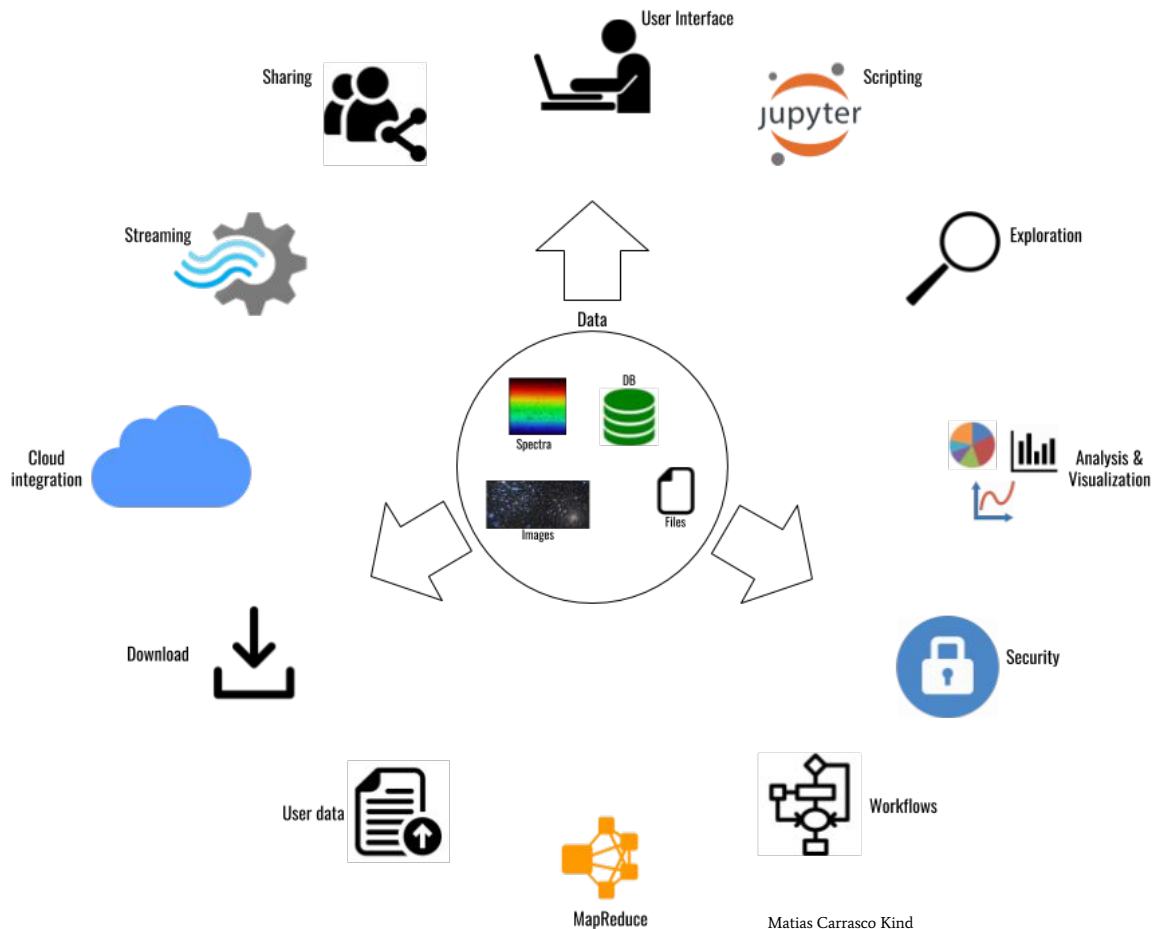
Assistant Research Professor, Astronomy

Data Release Scientist, Dark Energy Survey

University of Illinois at Urbana-Champaign

Linea Webinar, Oct 10th, 2019

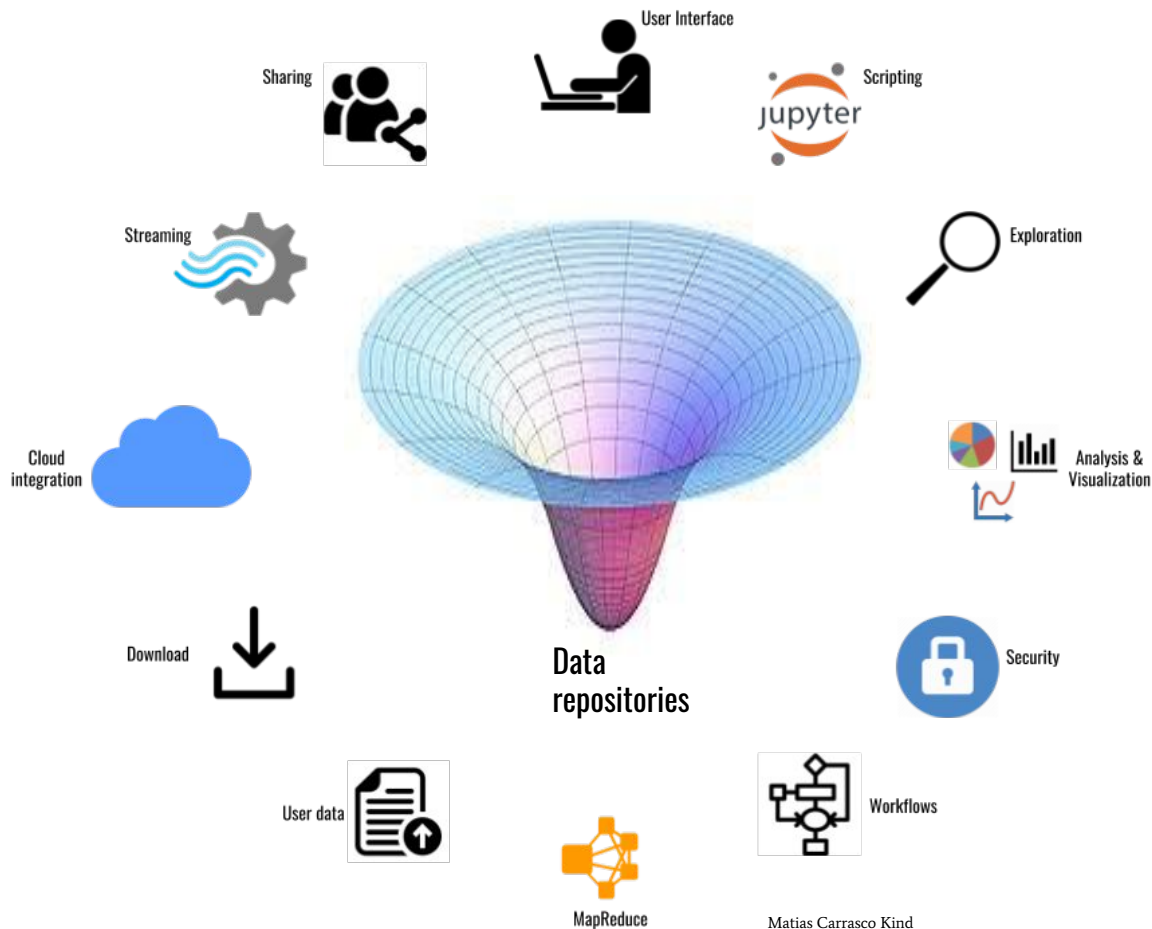
What is Data Access?



Several meanings around a central data archive, a.k.a “data lake”, “data gravity” repository with common components

- Storage
- Security
- Retrieving
- Interacting
- Modifying
- Understanding

What is Data Access?

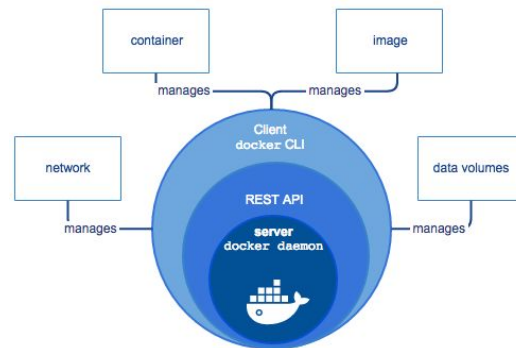


Several meanings around a central data archive, a.k.a “data lake”, **“data gravity”** repository with common components

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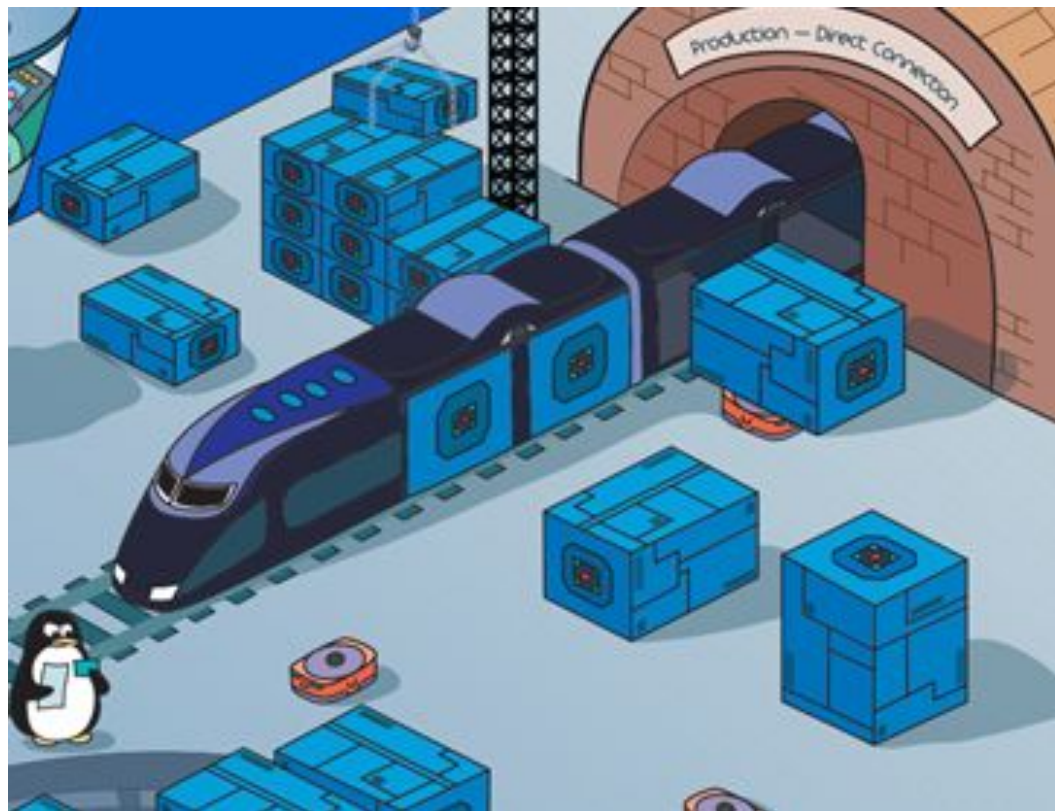
Containerization to the rescue

- It's been around for over 10 years, but popular since 2014 thanks to Docker
- Many other alternatives (rkt, kata, shifter, singularity, etc...)
- Lightweight, stand-alone, executable package of a piece of software that includes everything to run it
- Not just applications
- Software designed storage
- Software designed network



Container organization and orchestration

- We can create a container with an application inside, now what?
- Need to consider:
 - Resource needs
 - Fault tolerant
 - Load balancing
 - Storage management
 - Lifecycle
 - Service Discovery
 - Scalability



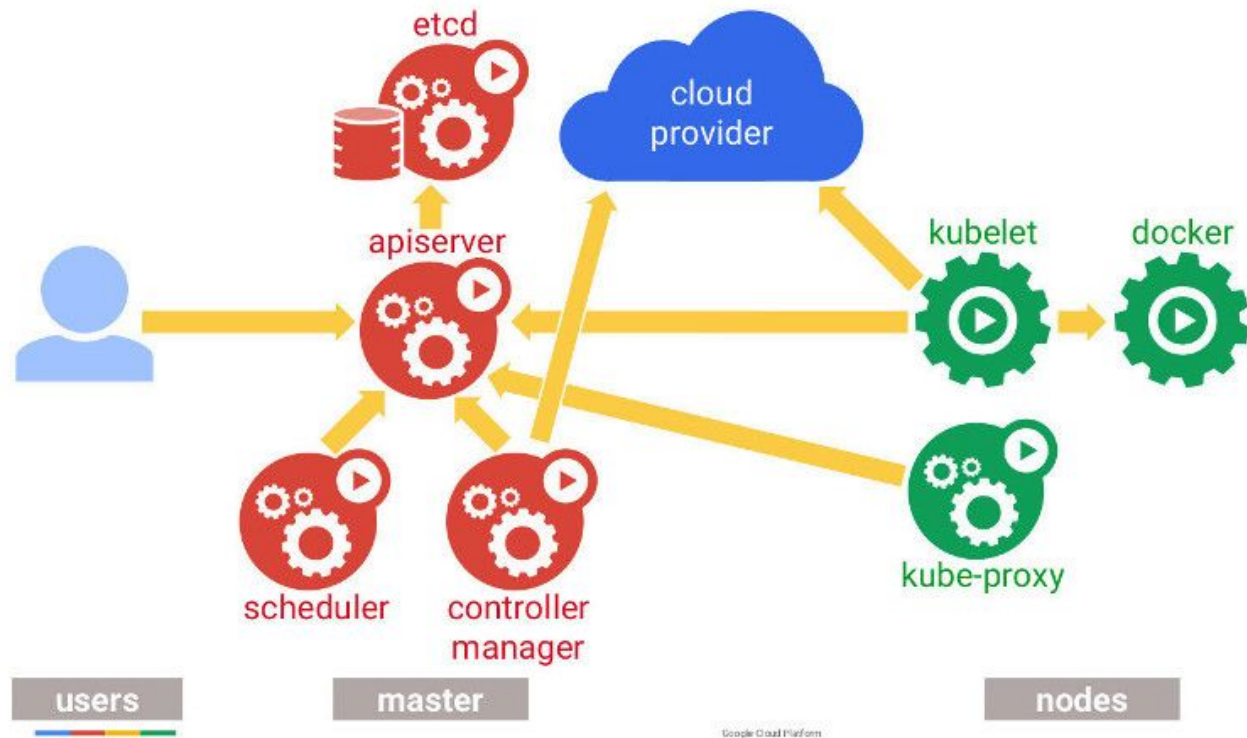
The Kubernetes Factor

- It solves all previous issues and more (not the only one but most popular)
- Open source container management and orchestration platform
- Developed by Google, made open sourced
- One of top 5 most commented open source repositories and #2 in number of pull request
- Standard within all cloud platforms
- Flexible and extensible, customize schedulers
- Is changing the cloud computing paradigm



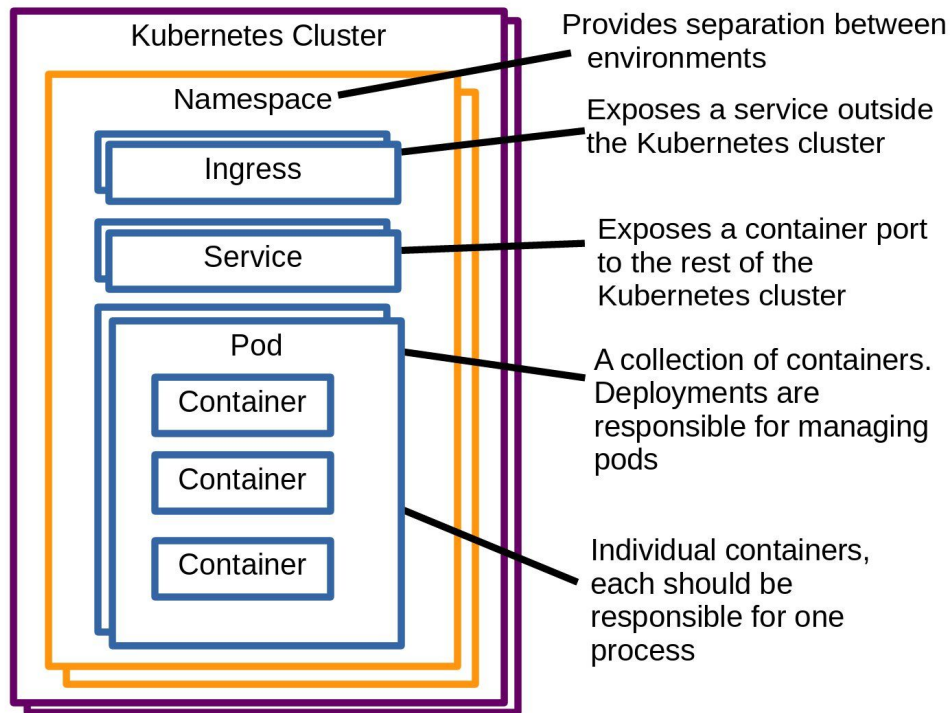
Kubernetes Overview

- Cloud democratization
- Easy deployment
- Controls most of the aspects
- Adopted at NCSA, CERN, LSST, NASA
- Edge Computing
- Scalability
- Federation
- Resource Manager

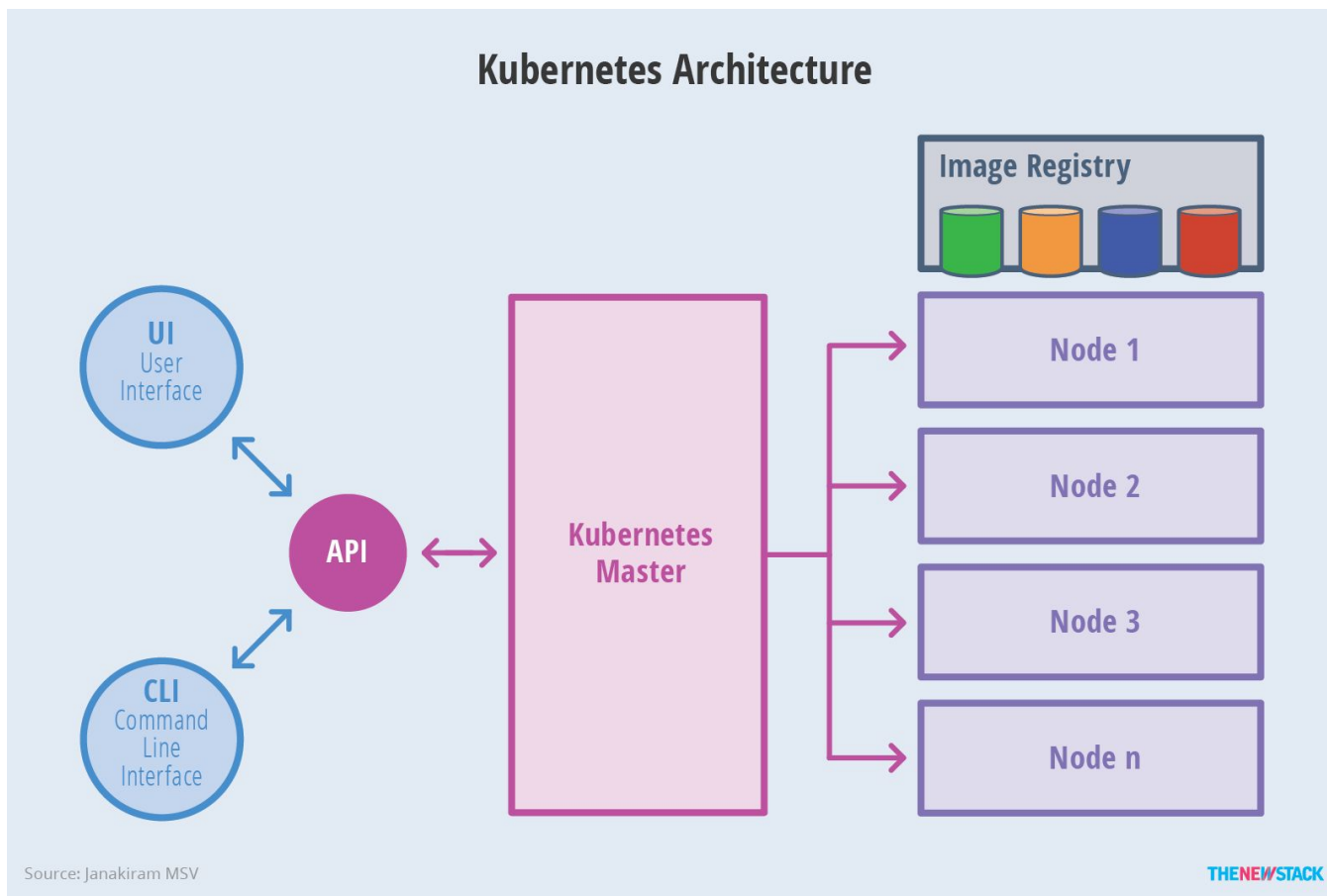


Kubernetes Key Concepts

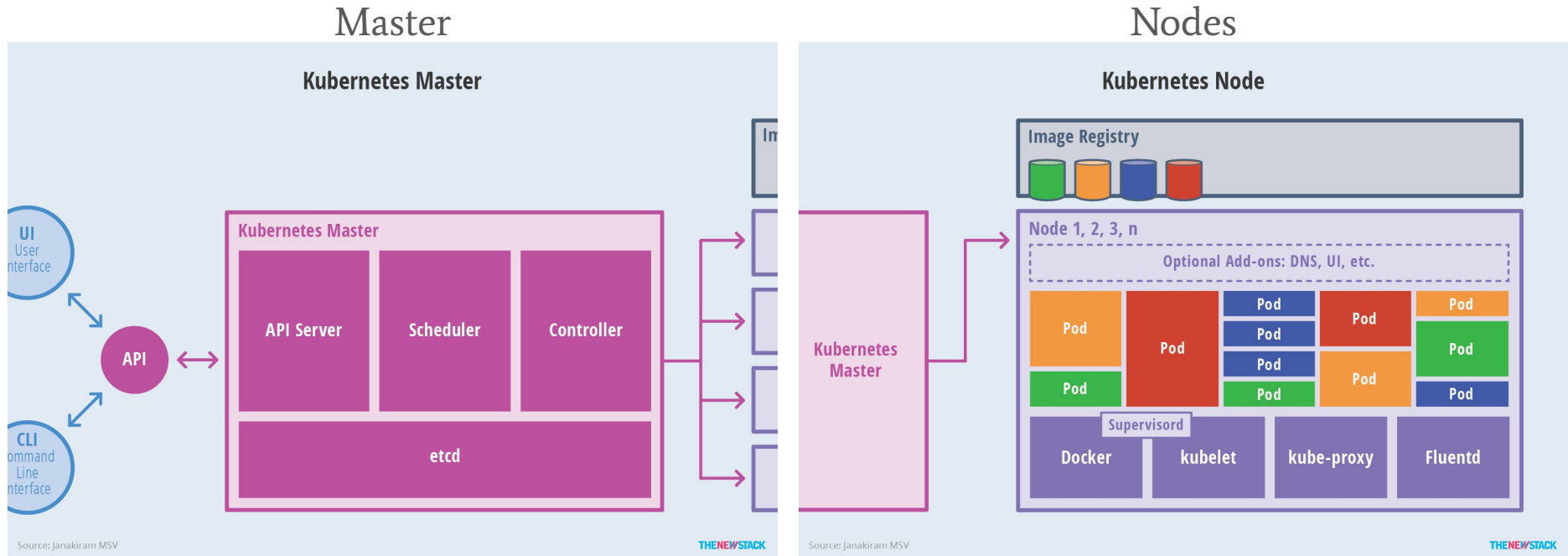
- **Pod** - A group of Containers
- **Labels** - Labels for identifying pods
- **Kubelet** - Container Agent
- **Proxy** - A load balancer for Pods
- **etcd** - A metadata service
- **cAdvisor** - Container Advisor provides resource usage/performance statistics
- **Replication Controller** - Manages replication of pods
- **Scheduler** - Schedules pods in worker nodes
- **API Server** - Kubernetes API server



The Kubernetes Architecture



The Kubernetes Architecture



The Kubernetes Architecture

Namespaces/Labels

- Namespaces; can partition cluster in resources, users, etc. Different namespaces for different environments (prod vs devel)
- Labels: Used to select resources within the cluster or namespace, to select pods, nodes, deployments,

Users/Groups/Service Accounts

- User and Groups refer to humans running and using resources. Permissions/Roles are applied at these levels . Cluster scoped
- Service Accounts are for processes, permissions/Roles can be applied to allow a running pod to schedule another pod, etc... Namespace scoped

The Kubernetes Architecture

Roles/Cluster Roles

- Roles are namespace scoped
 - CRUD resources namespace
 - Pods, deployments, PVC, service
 - Roles are bind to users/groups/sa
- Cluster Roles are cluster scoped
 - CRUD resources at cluster level
 - Nodes, namespaces, secrets, policy

Policies

- Pod Policy: at Cluster level to control how the pods/containers are run
 - Disabled running as root or a particular group, allow certain volumes to be mounted, limit access to port in host machine
- Network policy: how groups of pods are allowed to communicate with each other and other network endpoints. Namespaced scope, traffic control, use labels

The Kubernetes Architecture

Resource Quotas

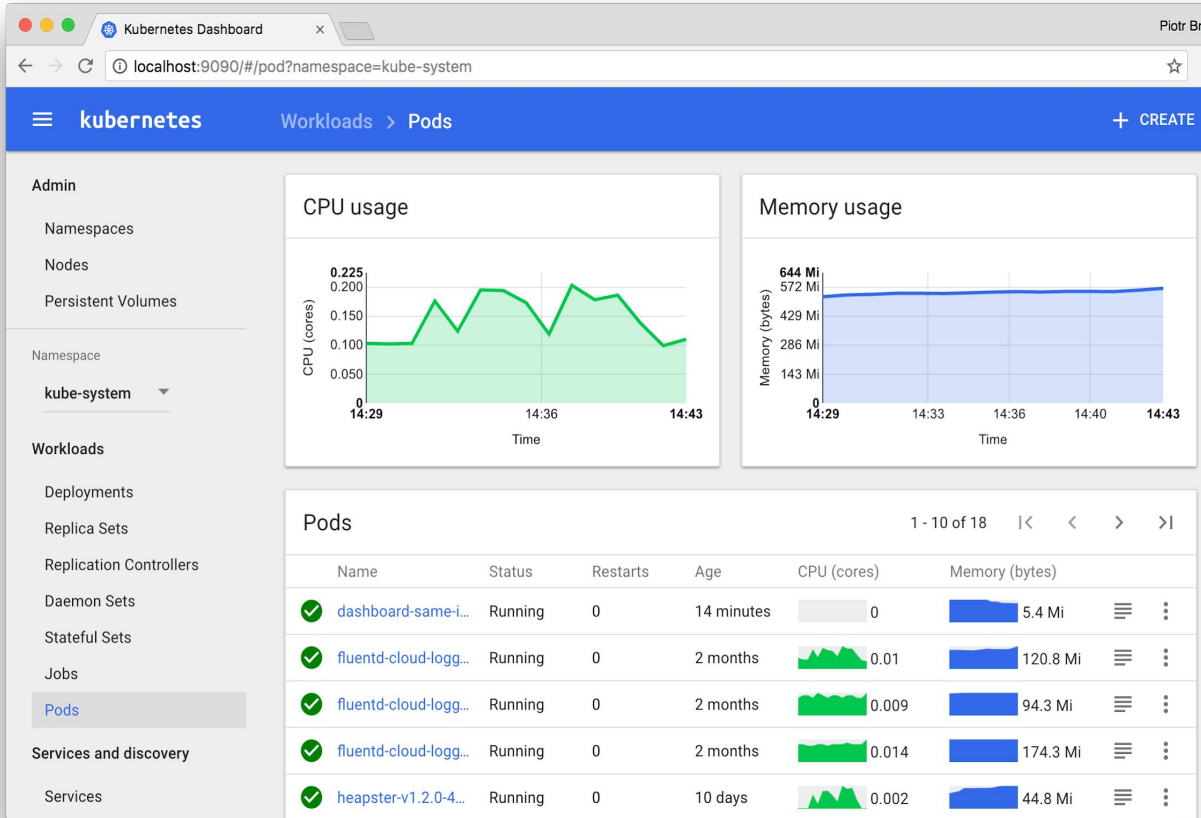
- Namespace scoped
- Limit cpu, memory, storage, etc
- Limit count of pods, deployments, claims, services, pods, etc.
- Doesn't work on nodes
- Can be updated dynamically

Node Selectors/Admission Control

- By labeling nodes, nodes can be tainted, reserved or specifically selected for scheduling
- Can enforce a set of dedicated nodes for a namespace using Admission Control
- Need to restart api server (not cluster)

Monitor

- Daemons sets can monitor nodes health, volumes
- Etcd @ master monitor use of resources, status of resources
- Controller manager monitors the status of the deployments and other resources
- Dashboard



Applications

DES Labs: Collection of containerized tools for DES access

- Launched in March 2015
- Used by the Collaboration
- Running using Kubernetes at NCSA (hybrid model) since 2016
- Used for DR1 infrastructure
- Customizable



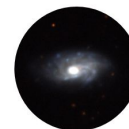
DES Labs

- [Home](#)
- [People](#)
- [Projects](#)
- [? Help](#)

DESAccess web



DES cutouts



DESDM Services status



External Links

Science Server




NOAO Data Lab



CosmoHub



easyaccess: DES command line tool



```

DARK ENERGY SURVEY
DATA MANAGEMENT

easyaccess 1.4.0. The DESDM Database shell.
Connected as mcarras2 to desdct.
** Type 'help' or '?' to list commands. **

*General Commands* (type help <command>):
=====
clear edit help      history prefetch version
config exit help_function import shell

*DB Commands*      (type help <command>):
=====
add_comment      find_tables      myquota          show_index
append_table     find_tables_with_column mytables         user_tables
change_db        find_user        refresh_metadata_cache whoami
describe_table   load_table       set_password
execproc         loadsql          show_db

*Default Input*
=====
* To run SQL queries just add ; at the end of query
* To write to a file : select ... from ... where ... ; > filename
* Supported file formats (.csv, .tab., .fits, .h5)
* To check SQL syntax : select ... from ... where ... ; < check
* To see the Oracle execution plan : select ... from ... where ... ; < explain

* To access an online tutorial type: online_tutorial

DESDB ~>

```

- DES DB in Oracle
- Specifically designed for DES (internal and public)
- Enhanced SQL command line interpreter in Python
- Astronomer friendly
- Python API, web interface
- There are many other CLI and GUI clients.
- Needed a simple tool, easy to use and install
- Autocompletion
- Load/Save to hdf5, fits, csv

easyaccess: DES command line tool

```
matias@XPS:~$ e
```

- DES DB in Oracle
- Specifically designed for DES (internal and public)
- Enhanced SQL command line interpreter in Python
- Astronomer friendly
- Python API, web interface
- There are many other CLI and GUI clients.
- Needed a simple tool, easy to use and install
- Autocompletion
- Load/Save to hdf5, fits, csv

Services options for user (independent containers)

DARK ENERGY SURVEY desaccess



mcarras2
mcarras2@ncsa.illinois.edu

Welcome to dessci, Matias!

Home

DB access

DES Table Schema

Example Queries

Cutouts Service

DES JupyterLab

Finding Chart

DES Footprint

Data Analysis

My Jobs

Help



DB ACCESS

Oracle SQL web-client

[More...](#)



DES TABLE SCHEMA

Browse all tables

[More...](#)

```
SELECT dr1.RA,dr1.DEC,dr1.COADD_OBJECT_ID
FROM dr1_main sample(0.01) dr1
WHERE
dr1.MAG_AUTO_G < 18 and
dr1.WAVG_SPREAD_MODEL_I + 3.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I + 1.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I > -1 and
dr1.IMAFLAGS_ISO_G = 0 and
dr1.IMAFLAGS_ISO_R = 0 and
dr1.IMAFLAGS_ISO_I = 0 and
```

EXAMPLE QUERIES

See some example queries as a start

[More...](#)



CUTOOUTS SERVICE

Generate cutouts for positions or ids

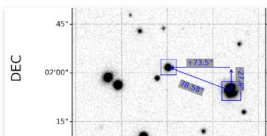
[More...](#)



DES JupyterLabs

(Beta) Jupyter Labs

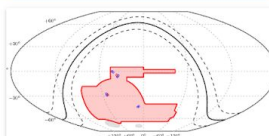
[More...](#)



FINDING CHART

Find your object

[More...](#)



DES FOOTPRINT

Interactive globe

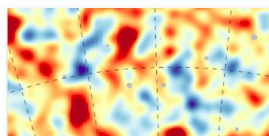
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DATA ANALYSIS

SEDs and color-color diagrams

[More...](#)



MY JOBS

List of submitted jobs

[More...](#)



HELP

Help form

[More...](#)

DB access: SQL Interface, quick and job submission

DARK ENERGY SURVEY desaccess



mck

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Home

DB access

DR1 Table Schema

Example Queries

Cutout Service

DR1 Footprint

My Jobs

DES JupyterLab

Help

Query box

Insert your query in the box below. Data results for "Quick" Jobs (30 sec.) will be displayed at the bottom.

```

1 --
2 -- Example Query --
3 -- This query selects stars around the center of globular cluster M2
4 SELECT
5 COADD_OBJECT_ID,RA,DEC,
6 MAG_AUTO_G,G,
7 MAG_AUTO_R,R,
8 WAVG_MAG_PSF_G_PSF,
9 WAVG_MAG_PSF_R_PSF
10 FROM DR1_MAIN
11 WHERE
12 RA between 323.36-0.12 and 323.36+0.12 and
13 DEC between -0.82-0.12 and -0.82+0.12 and
14 WAVG_SPREAD_MODEL_I + 3.0*WAVG_SPREADERR_MODEL_I < 0.005 and
15 WAVG_SPREAD_MODEL_I > -1 and
16 IMAFLAGS_ISO_G = 0 and
17 IMAFLAGS_ISO_R = 0 and
18 FLAGS_G < 4 and
19 FLAGS_R < 4
20

```

Submit Job

Clear

Check

Quick

See Examples

Output file (.csv, .fits or .h5). Enable in order to submit.

Output file

Options:

Compressed files (csv and h5 files). Slightly longer jobs but smaller files

Job Name (optional)

Send email after completion

Email

Cutouts Service: Get image cutouts from given positions

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Bulk Cutouts Form



Upload csv file (with header).
Or enter values manually (with header).

Upload File

Enter Values



Generate color png or just FITS cutouts **required**

Stiff_RGB ↗

Lupton_RGB ↗

Just FITS ↗



Xsize (in arcminutes): 1.0



Ysize (in arcminutes): 1.0



Release Tag: Y6A1

Y6A1



Job Name

Job Name



Email Options

Send email on completion

Email



Return Options

Include CSV of tiles matched to objects



Clear Form



Submit Job

Cutouts Service: Get image cutouts from given positions

DARK ENERGY SURVEY desaccess

Job [mini82]: 50728451_4c33_4e62_bb97_204eb5fc1798 (9 images)

See Log Download All(tar file) See Files Close

DESJ011905.1746-064767.4184_lrg_lupton.png
DESJ012854.4067-003133.0680_lrg_lupton.png
DESJ011837.2917-005924.8972_lrg_lupton.png
DESJ012105.9195-002980.8340_lrg_lupton.png
DESJ012023.2054-002188.5686_lrg_lupton.png
DESJ011854.4625-004859.4300_lrg_lupton.png

DESJ005008.4414-010611.2752_lrg_lupton.png
DESJ010351.5086-002131.0096_lrg_lupton.png
DESJ010322.5785-002741.9228_lrg_lupton.png

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Asynchronous Jobs: Job status, jobs name

DARK ENERGY SURVEY desaccess



mck
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My Jobs

#	Status	Job Name	Job type	Execution time (s)	Cancel Job	Queries	Results	Files
0	●	Name: Job id: 6b4cac2b-b544-44e1-96bf-58cd4968a338 6 days and 0 hours ago (Expired)	query	0		Query	Cutouts	Files
1	●	Name: Job id: daf5e3c-461e-42ed-8efb-5fcbf684047 6 days and 0 hours ago (Expired)	cutout	1		Query	Cutouts	Files
2	●	Name: testapi Job id: 0dfc5a58-b00a-4798-834f-9816c6fa98e5 7 days and 4 hours ago (Expired)	cutout	3		Query	Cutouts	Files
3	●	Name: testapi Job id: 12961656-8075-4629-8e4f-fd4378013634 7 days and 4 hours ago (Expired)	cutout	3		Query	Cutouts	Files
4	●	Name: testapi Job id: 09a37f69-2096-4296-b87d-c6567cde0649 7 days and 4 hours ago (Expired)	cutout	1		Query	Cutouts	Files
5	●	Name: Job id: fd10cf32-3cc6-4090-bb90-344268dd615e 7 days and 5 hours ago (Expired)	cutout	1		Query	Cutouts	Files
6	●	Name: testapi Job id: b85ea747-5201-4e49-a0eb-f2b667f266de 7 days and 5 hours ago (Expired)	cutout	-1		Query	Cutouts	Files
7	●	Name: Job id: 8f8fa56a-4685-49f9-b7be-603310ccdde8 8 days and 16 hours ago (Expired)	query	577		Query	Cutouts	Files
8	●	Name: Job id: df8a57c4-b1d5-4332-80d5-a08a27b537d9 8 days and 16 hours ago (Expired)	query	1042		Query	Cutouts	Files
9	●	Name: Job id: 7f1fd550-4d38-441f-a037-ed659b3b79c9 8 days and 16 hours ago (Expired)	query	-1		Query	Cutouts	Files
10	●	Name: Job id: fcaacde-9d63-45a4-92f2-4f847b9b415c 8 days and 16 hours ago (Expired)	query	9		Query	Cutouts	Files
11	●	Name: Job id: a88b79cc-fd71-4ee0-a33d-92b5be98106f 8 days and 17 hours ago (Expired)	query	9		Query	Cutouts	Files
	●	Name: demo1						

REFRESH

DELETE

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- DB access
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- Cutout Service
- DR1 Footprint
- My Jobs**
- DES JupyterLab
- Help

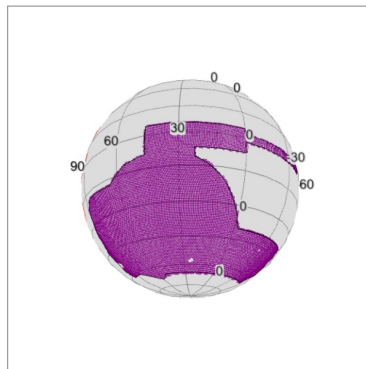
Footprint and Jupyter Labs: Exploring the data



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mcarras2@ncsa.illinois.edu

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- DES JupyterLab
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- DES Footprint**
- Data Analysis
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DES Footprint



Use the footprint tool to search a tile by position or name.
Double click to select a tile.

Position (ra,dec) 🔍 Tile name 🔍

Coordinates Y6A1 Y3A2 Y5A1 Y1A1 SVA1


Tile properties

Name :
Tile Center :
No Objects (Y3) :
RA Corners :
DEC Corners :

Click below to get the files for this tile (if available)

Click [here](#) to get access to all campaign tiles

DARK ENERGY SURVEY desaccess



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DES Jupyter Labs (Beta)

This feature is experimental only. Please use with caution.
You can launch, access and delete your Jupyter Notebook. This Notebook will run with 1 CPU and 2GB of RAM.

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- DES JupyterLab**
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Deploy Lab +
Delete Lab

Status

● Ready
Status: Running

Go To Lab

REFRESH ↻

Labs with access to jobs, easyaccess, api

The screenshot displays a JupyterLab environment with three main components:

- File Browser (Left):** Shows a directory structure under 'jobs' with various files and folders, including their names and last modified dates.
- Plot Window (Center):** Titled 'basics_plotting', it shows a scatter plot of 'MAG_AUTO_I' vs 'MAG_AUTO_R' with a density heatmap overlay. The plot is titled '<Figure size 720x720 with 0 Axes>'.
- Terminal (Right):** Titled 'Terminal 4', it shows the 'easyaccess 1.4.4' shell interface. It displays the 'DARK ENERGY SURVEY DATA MANAGEMENT' logo and lists available commands and options.

Below the plot window, the following code is shown in the JupyterLab console:

```
In [9]: import holoviews as hv
        hv.extension('bokeh')

In [10]: hextiles = hv.HexTiles(df, [('MAG_AUTO_R', 'R'), ('MAG_AUTO_I', 'I')], [], extents=(20,26,20

In [11]: hextiles.options(width=500, height=500, min_count=0, tools=['hover'], colorbar=True, ) * hv.

Out[11]:
```

The output of the last cell shows a zoomed-in view of the heatmap from the plot window, with a color scale ranging from 0 to 800.

Services can be customized (limited user view)



DARK ENERGY SURVEY desaccess



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diwen2@illinois.edu

Welcome to dessci, Di!



DB ACCESS

Oracle SQL web-client

[More...](#)



DES TABLE SCHEMA

Browse all tables

[More...](#)

```
SELECT dr1.RA,dr1.DEC,dr1.COADD_OBJECT_ID
FROM dr1_main_sample(0,0) dr1
WHERE
dr1.MAG_AUTO_G < 18 and
dr1.WAVG_SPREAD_MODEL_I + 3.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I + 1.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I - 1.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I > -1 and
dr1.IMAFLAGS_ISO_G = 0 and
dr1.IMAFLAGS_ISO_R = 0 and
dr1.IMAFLAGS_ISO_I = 0 and
```

EXAMPLE QUERIES

See some example queries as a start

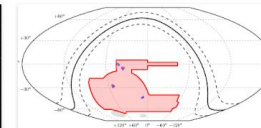
[More...](#)



CUTOUTS SERVICE

Generate cutouts for positions or ids

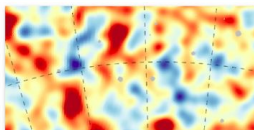
[More...](#)



DES FOOTPRINT

Interactive globe

[More...](#)



MY JOBS

List of submitted jobs

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Services can be customized (advanced user view)

DARK ENERGY SURVEY desaccess



mcarras2
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Welcome to dessci, Matias!



DB ACCESS

Oracle SQL web- client

[More...](#)



DES TABLE SCHEMA

Browse all tables

[More...](#)

```
SELECT dr1.RA, dr1.DEC, dr1.COADD_OBJECT_ID
FROM dr1_main sample(0.01) dr1
WHERE
dr1.MAG_AUTO_G < 18 and
dr1.WAVG_SPREAD_MODEL_I + 3.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I + 1.0*dr1.WAVG_SPREADERR_M
dr1.WAVG_SPREAD_MODEL_I > -1 and
dr1.IMAFLAGS_150_G = 0 and
dr1.IMAFLAGS_150_R = 0 and
dr1.IMAFLAGS_150_I = 0 and
```

EXAMPLE QUERIES

See some example queries as a start

[More...](#)



CUTOUTS SERVICE

Generate cutouts for positions or ids

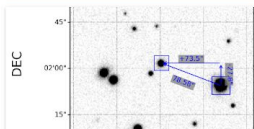
[More...](#)



DES JupyterLabs

(Beta) Jupyter Labs

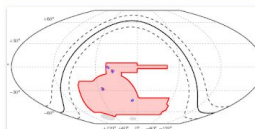
[More...](#)



FINDING CHART

Find your object

[More...](#)



DES FOOTPRINT

Interactive globe

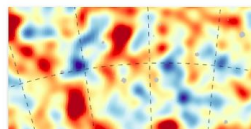
[More...](#)



DATA ANALYSIS

SEDs and color-color diagrams

[More...](#)



MY JOBS

List of submitted jobs

[More...](#)



HELP

Help form

[More...](#)



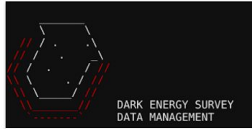
Services can be customized (default user view)

DARK ENERGY SURVEY desaccess



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Welcome to dessci, Ruiqi!



DB ACCESS

Oracle SQL web-client

[More...](#)



DES TABLE SCHEMA

Browse all tables

[More...](#)

```
SELECT dr1_RA,dr1_DEC,dr1_COADD_OBJECT_ID
FROM dr1_main_sample(9,0) dr1
WHERE
dr1_MAG_AUTO_G < 18 and
dr1_WAVG_SPREAD_MODEL_I + 3.0*dr1_WAVG_SPREADERR_M
dr1_WAVG_SPREAD_MODEL_I + 1.0*dr1_WAVG_SPREADERR_M
dr1_WAVG_SPREAD_MODEL_I - 1.0*dr1_WAVG_SPREADERR_M
dr1_WAVG_SPREAD_MODEL_I > -1 and
dr1_IMAFLAGS_150_G = 0 and
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```

EXAMPLE QUERIES

See some example queries as a start

[More...](#)



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DES JupyterLabs

(Beta) Jupyter Labs

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DB access

DES Table Schema

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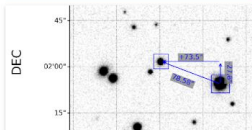
DES JupyterLab

Finding Chart

DES Footprint

My Jobs

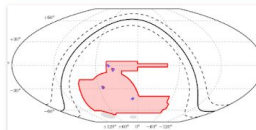
Help



FINDING CHART

Find your object

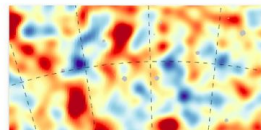
[More...](#)



DES FOOTPRINT

Interactive globe

[More...](#)



MY JOBS

List of submitted jobs

[More...](#)



HELP

Help form

[More...](#)

Special options for Jupyter Labs: Deploy on GPU Nodes

DARK ENERGY SURVEY desaccess



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DES Jupyter Labs (Beta)

This feature is still under development. Please use with caution. You can launch, access and delete your Jupyter Lab from here. This Lab will run with 1 CPU and 2GB of RAM.

[Deploy Lab +](#)
[Delete Lab 🗑️](#)

Lab status

● No Lab running
Status: Not Running

[Go To Lab ↻](#)
[See Token 🔍](#)

REFRESH ↻

- Home
- DB access
- DES Table Schema
- Example Queries
- Cutouts Service
- DES JupyterLab**
- Finding Chart
- DES Footprint
- My Jobs
- Help

DARK ENERGY SURVEY desaccess



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DES Jupyter Labs (Beta)

This feature is still under development. Please use with caution. You can launch, access and delete your Jupyter Lab from here. This Lab will run with 1 CPU and 2GB of RAM. GPU Labs are only allowed for 24 hours

[Deploy Lab +](#)
[Delete Lab 🗑️](#)
 GPU

Lab status

● Ready
Status: Running

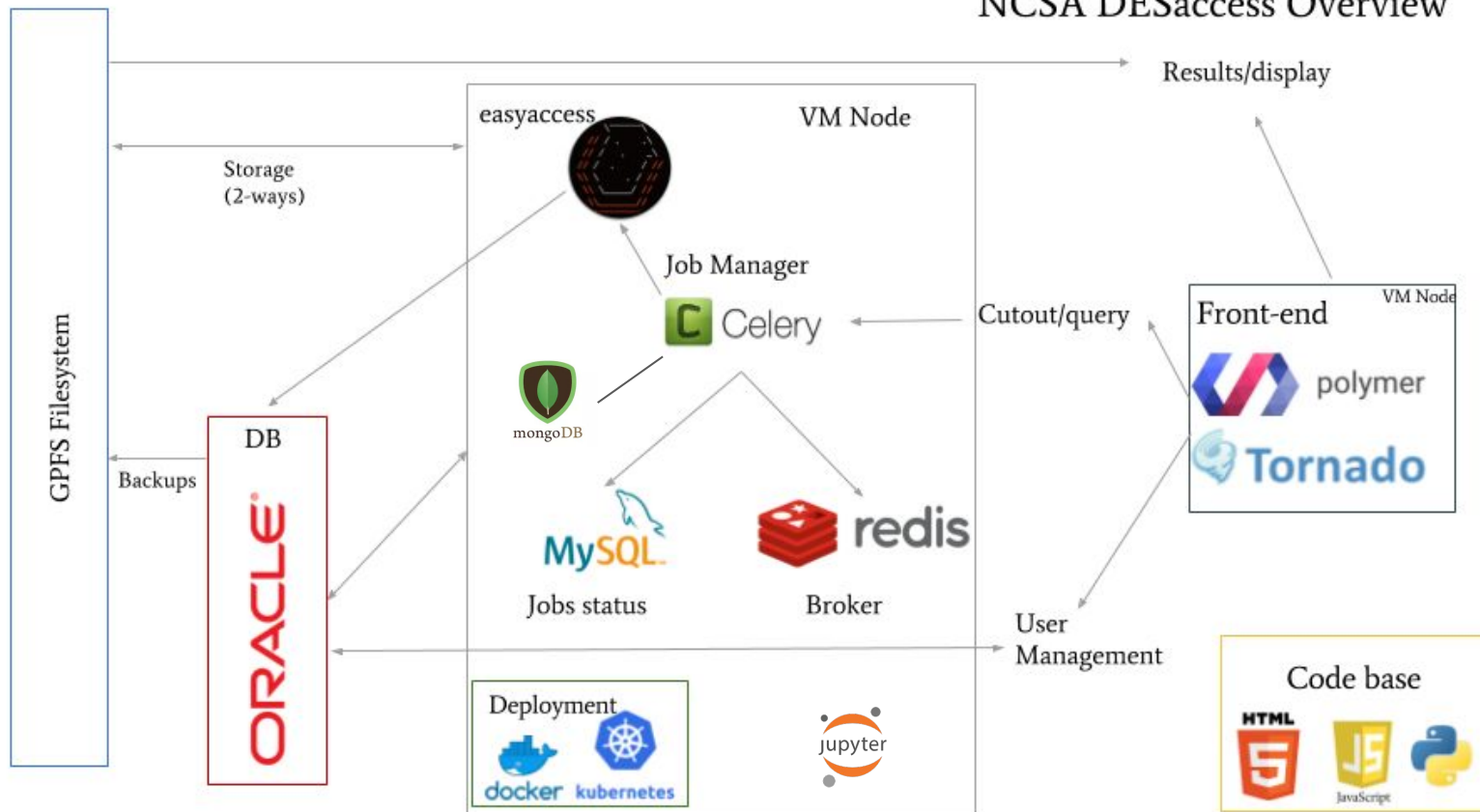
[Go To Lab ↻](#)
[See Token 🔍](#)

REFRESH ↻

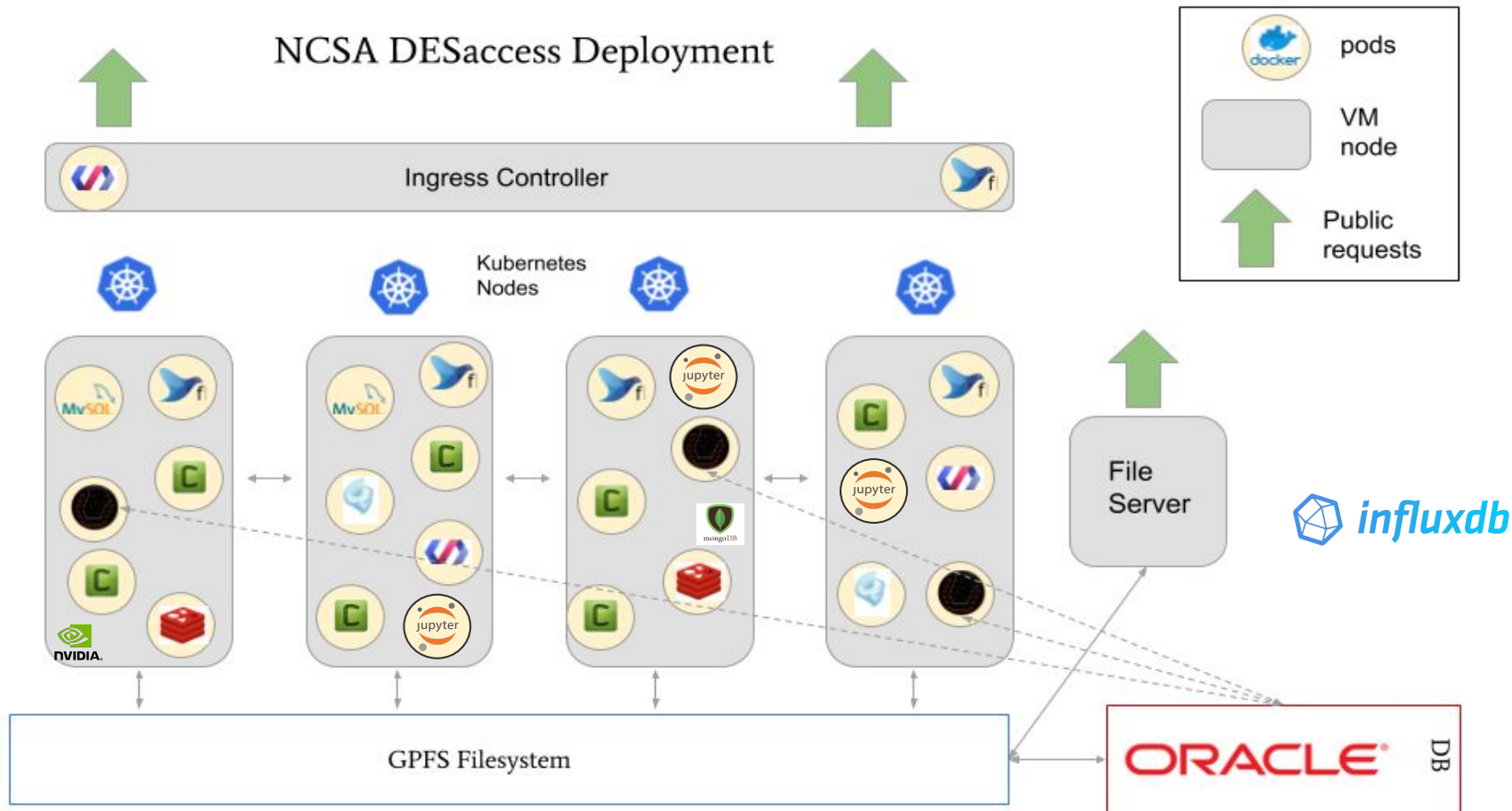
- Home
- DB access
- DES Table Schema
- Example Queries
- Cutouts Service
- DES JupyterLab**
- Finding Chart
- DES Footprint
- Data Analysis
- My Jobs
- Help

NCSA DESaccess: Technology Overview

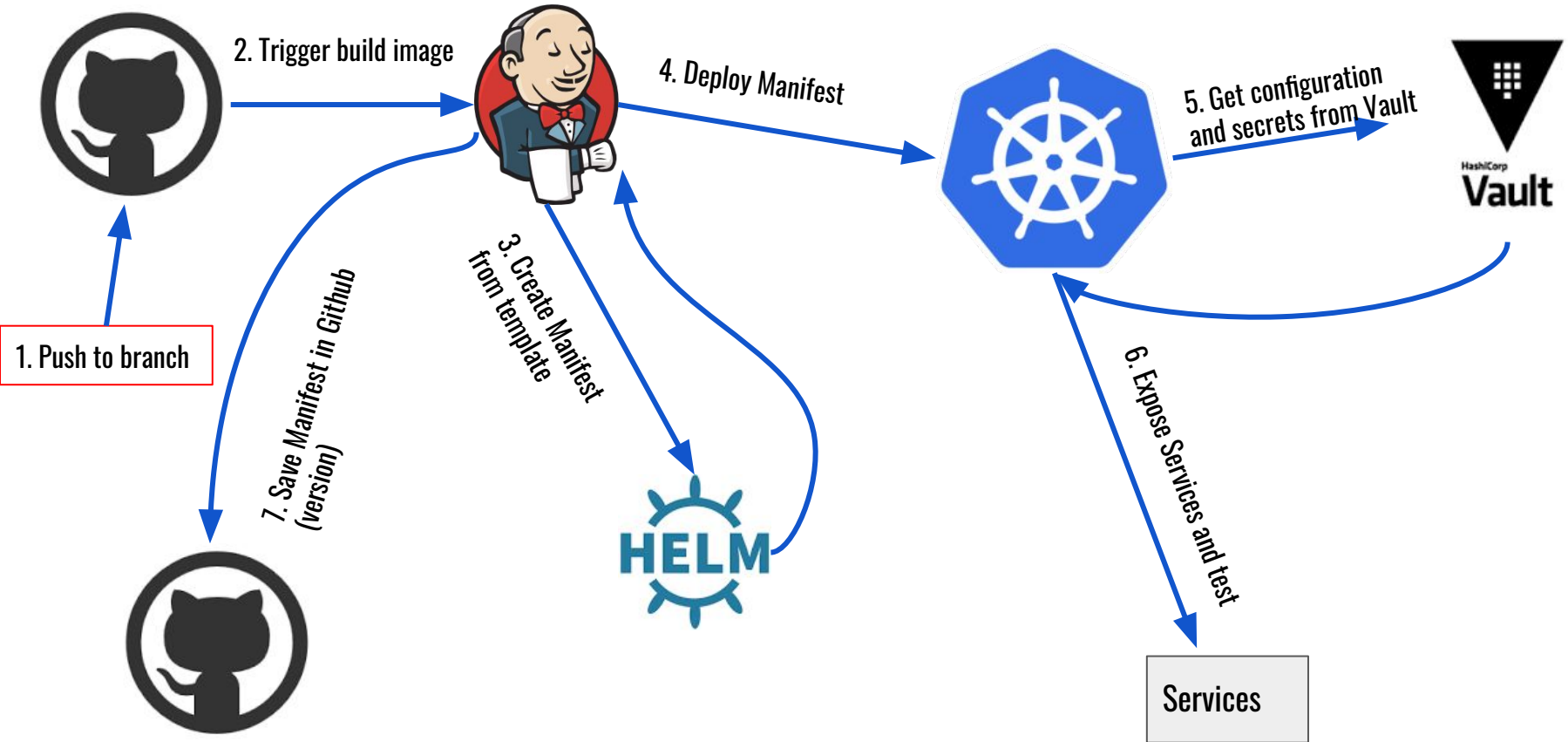
NCSA DESaccess Overview



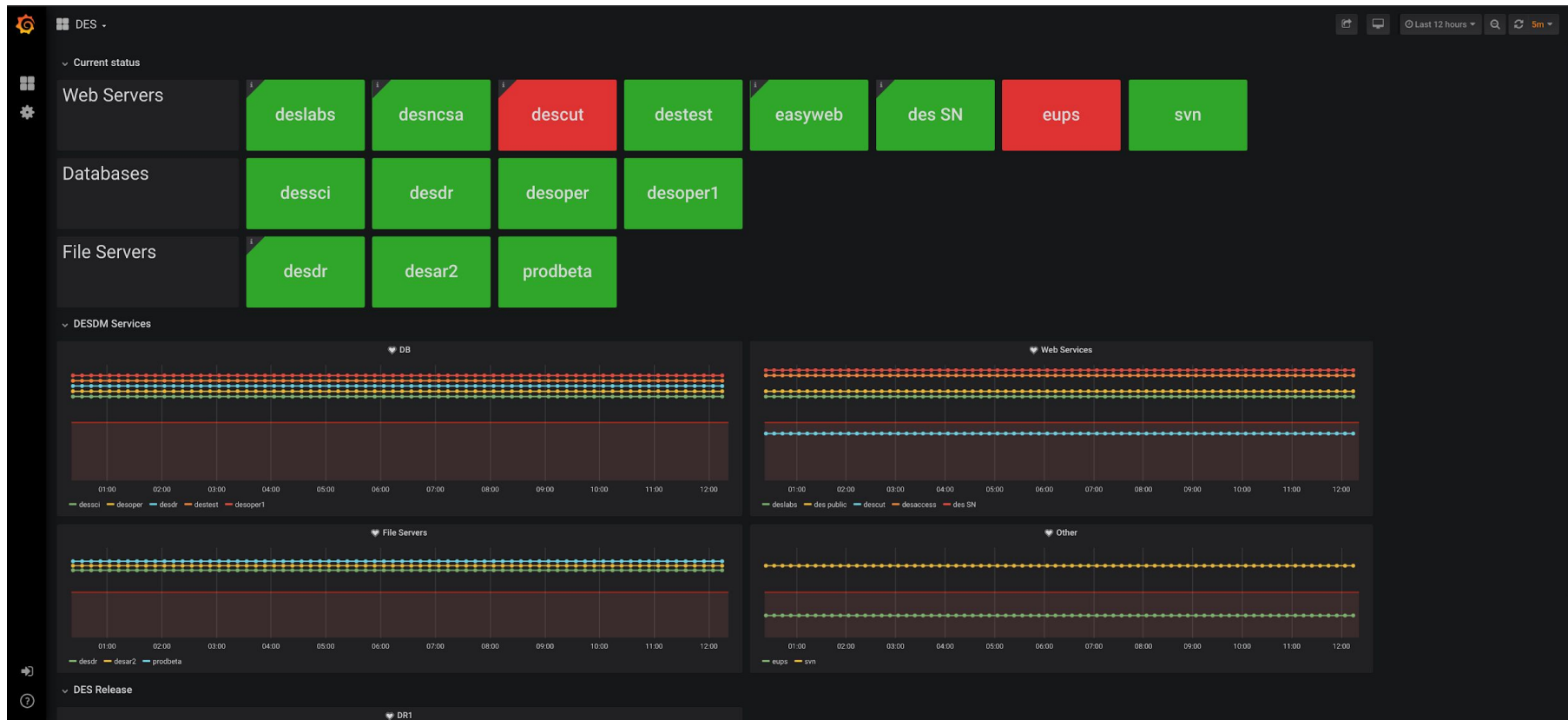
NCSA DESaccess: Deployment (Hybrid)



NCSA DESaccess: CI/CD



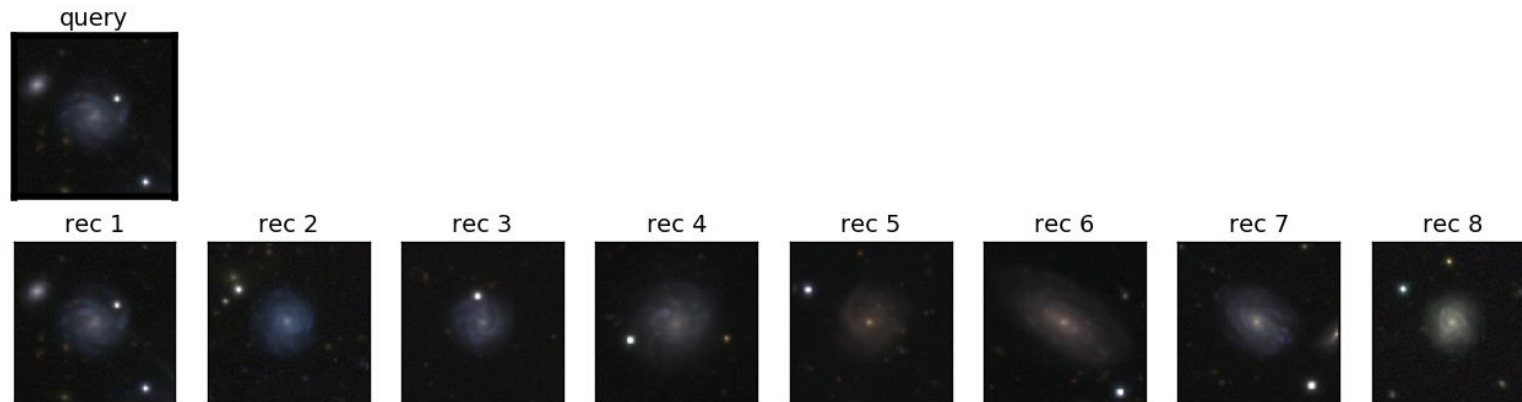
NCSA DESaccess: Monitoring



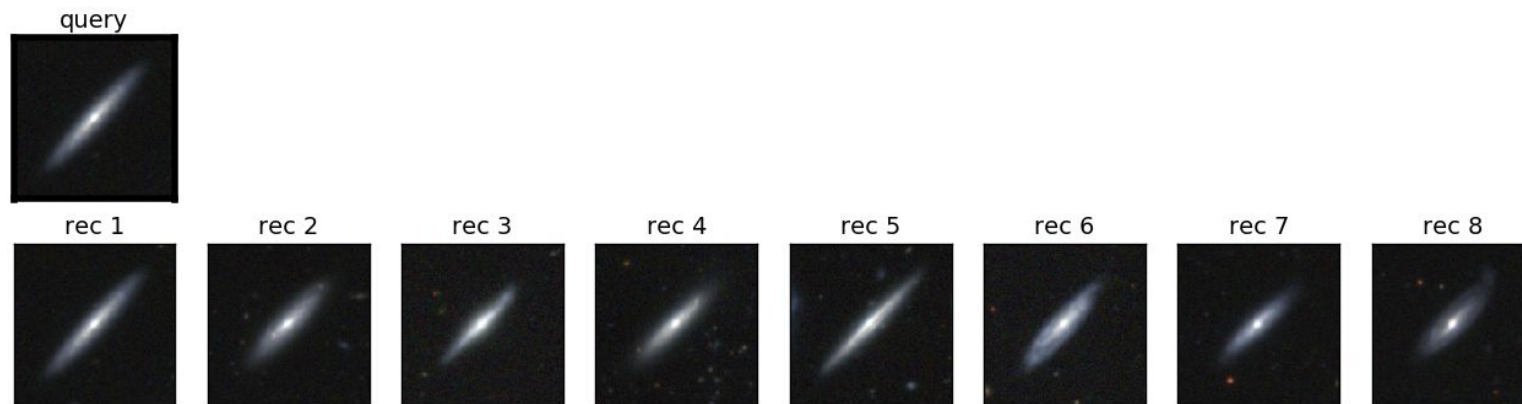
Other Services

- **Other Services being integrated, easy to configure and to expand**
- **Can expand to the cloud when needed**
- **Each service is an independent application**
- **Working on: Automatic registration and service discovery**
- **Image exploration tool to visualize and classify thousands of images**
- **Similarity and anomaly searches**
- **Others...**

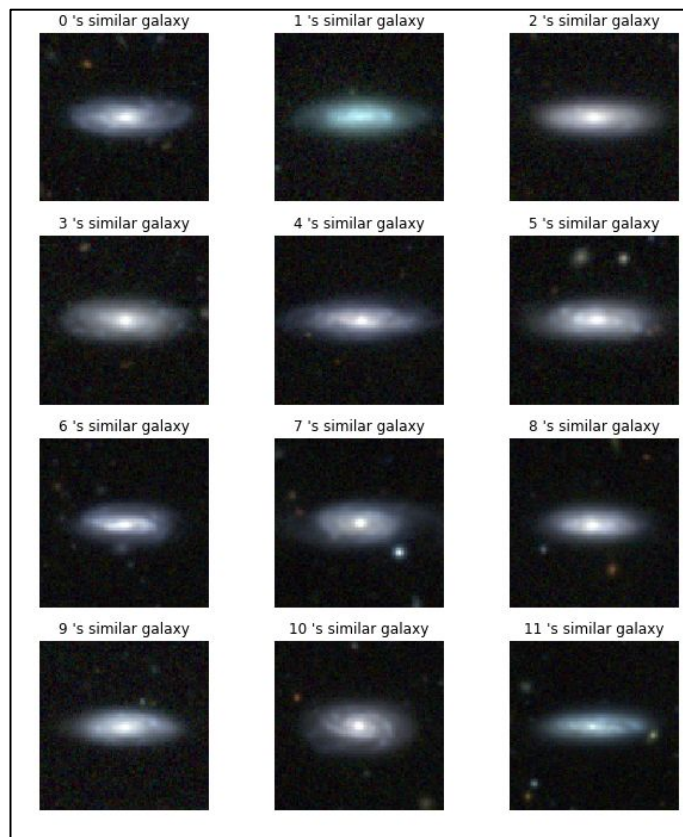
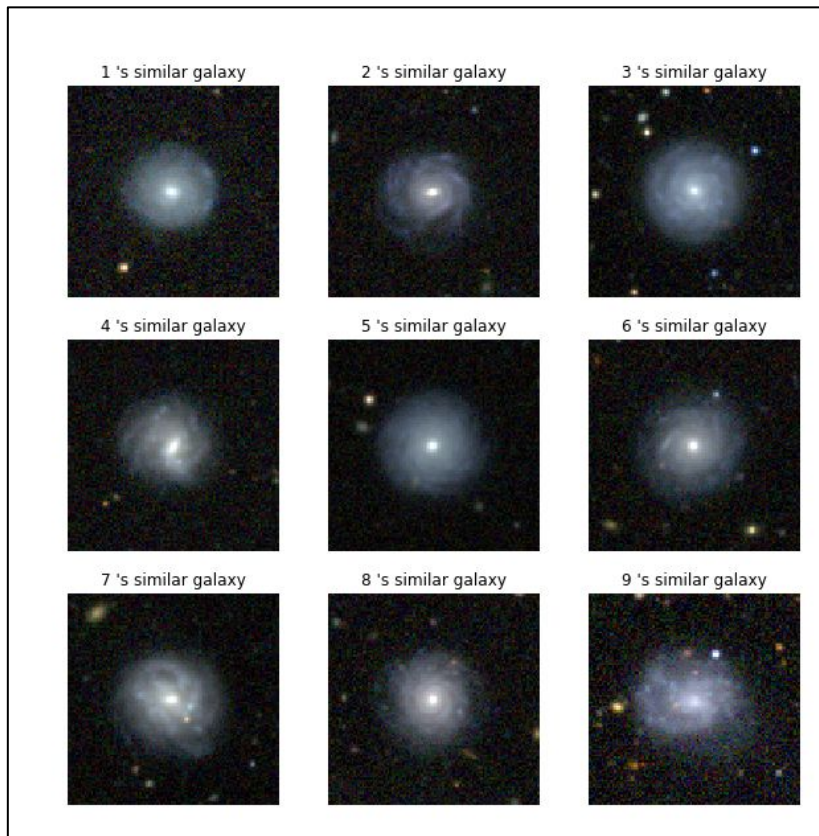
Galaxy selection and similarity search



Compress images
from 200x200 to
50 or less, for
fast search



Galaxy selection and similarity search

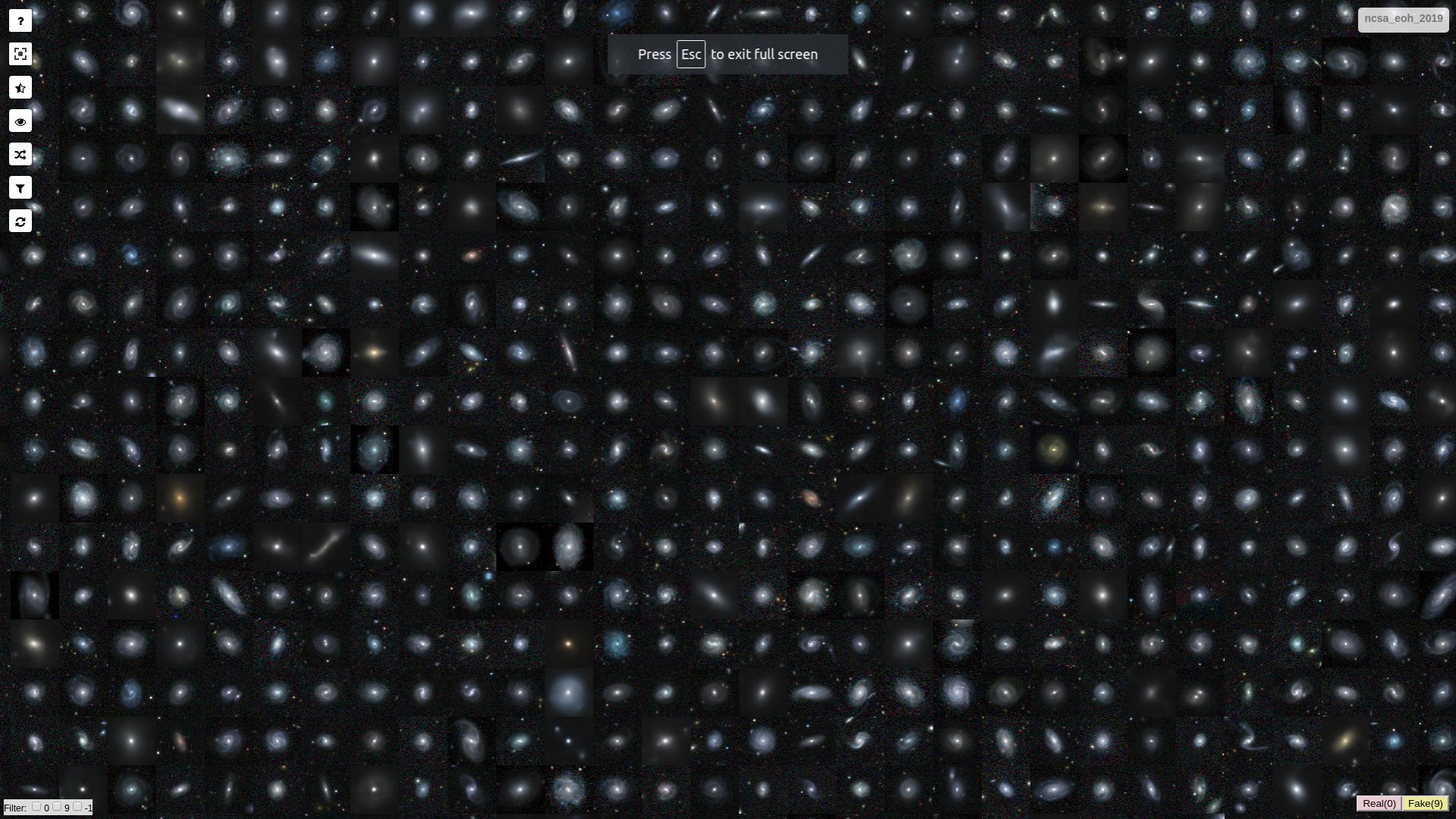


Galaxy Image Exploration and Classification

- Image Exploration
- Resize is done dynamically
- Quick Classification/Label
- Works fine with 10,000 images
- Individual classifications are saved and aggregated
- Keyboard control

<https://github.com/mgckind/cutouts-explorer>

Press **Esc** to exit full screen



- ? Help
- 🏠 Home
- ★ Favorites
- 👁️ Full Screen
- 🔍 Search
- 🔼 Previous
- 🔽 Next
- 🔄 Refresh

Demo!

Hello from: demo-app-6869c67458-bhdcg

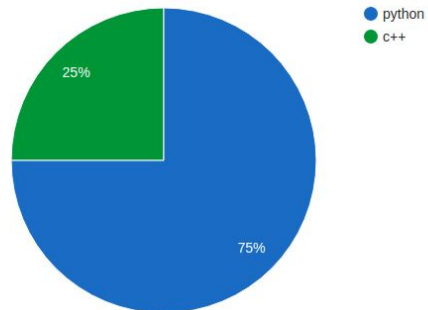
What is my favorite language?:

Python IDL Fortran C++ Go

Other?

Submit

Best Programming Language



Simple app with MySQL Back end

- Service
- 2 Deployments
- Ingress Rule
- PVC and PV
- Secrets

https://github.com/mgckind/container_demo

Thank you!

Questions?

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