SWAN: a Service for web-based analysis at CERN

Diogo Castro

On behalf of the SWAN team

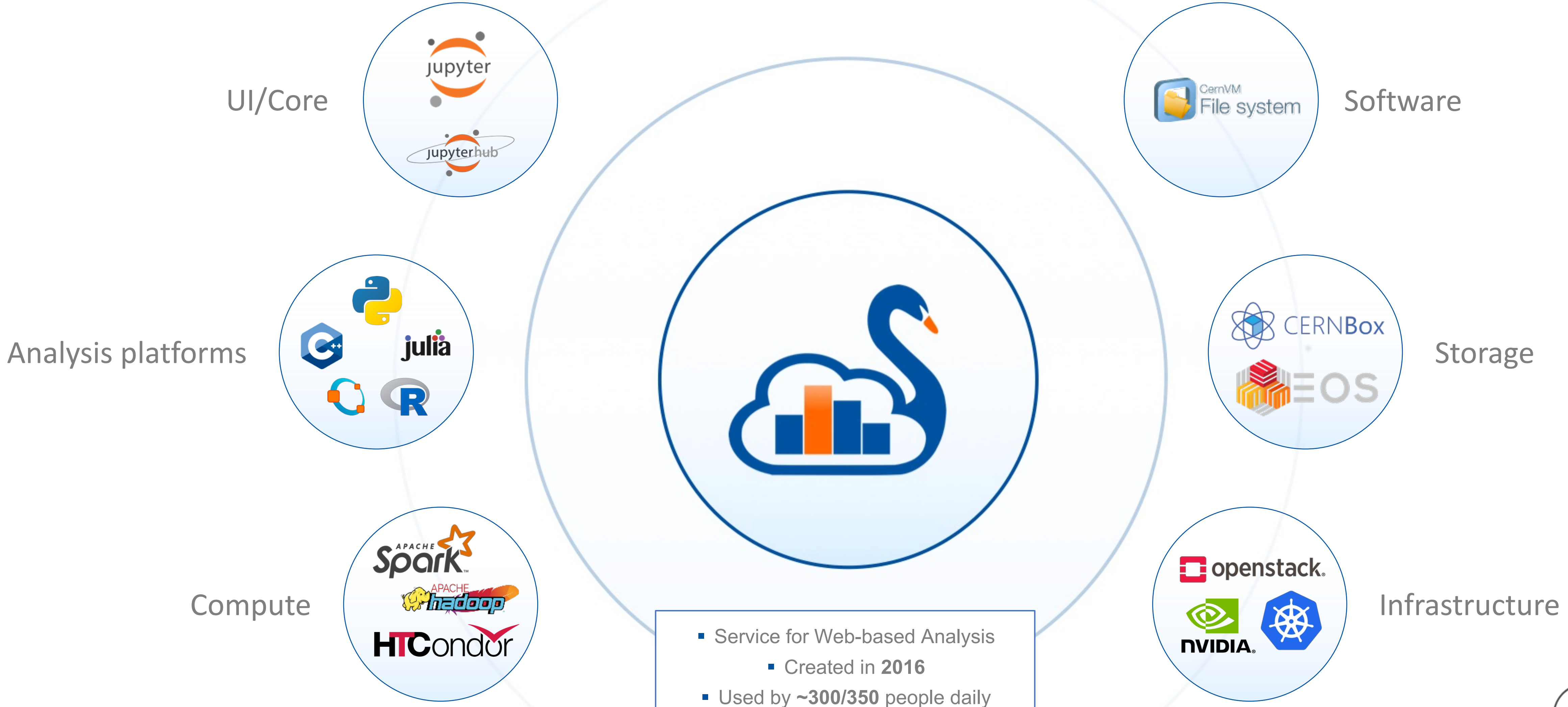
https://cern.ch/swan

May 15th, 2024

CS3 JupyterHub Community Technical Workshop 2024

Introduction

SWAN’s building blocks



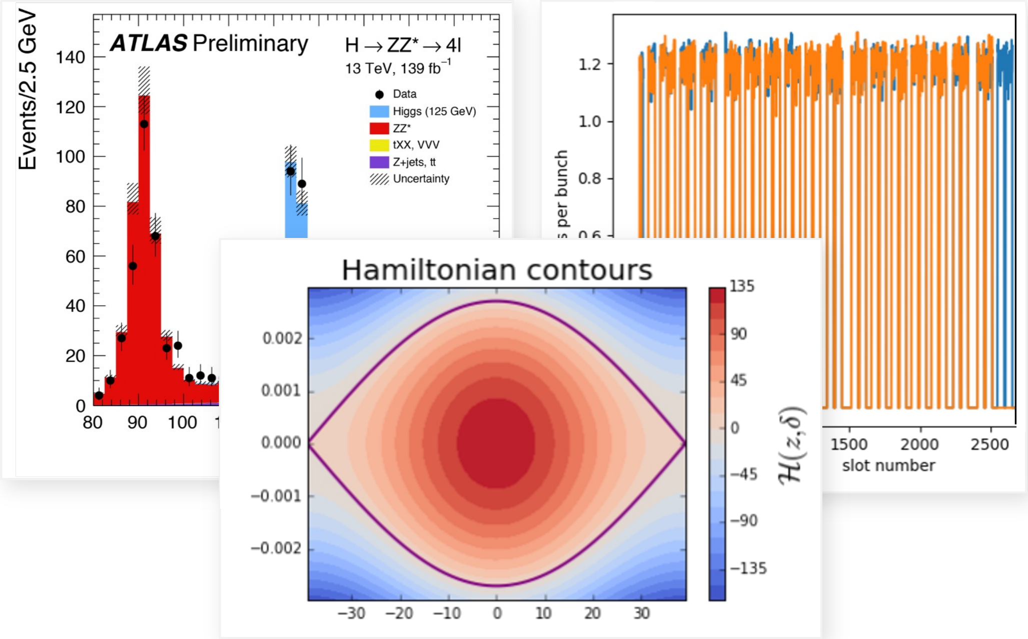
- Service for Web-based Analysis
- Created in **2016**
- Used by **~300/350** people daily
- ~1500 people in the last 2 months

Main user communities

- Physics analysis
  - Usually last stages of analysis
  - Interactive, exploratory
  - Collision event data, ntuple-like, columnar
  - More and more with Machine Learning

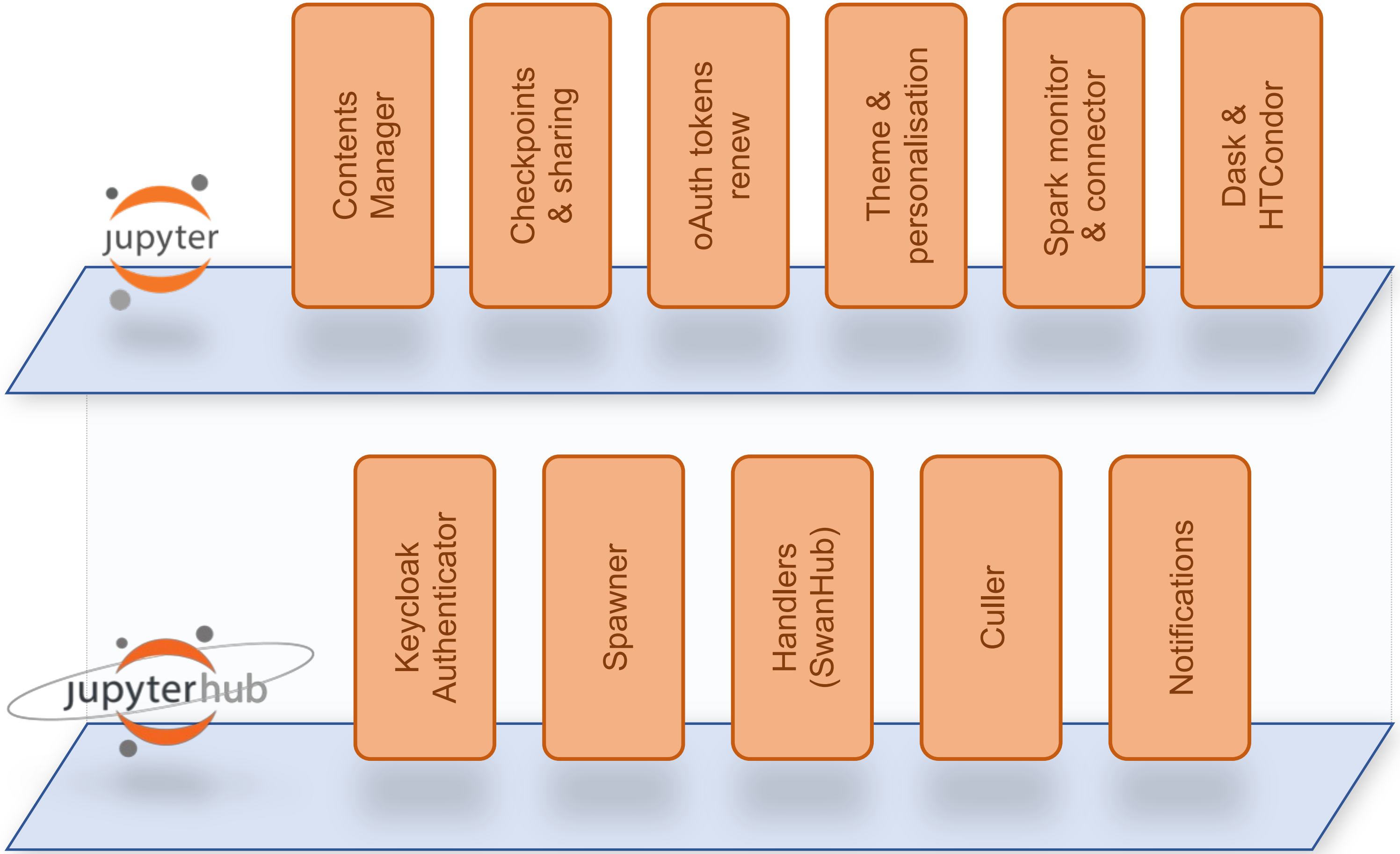
- Non-physics analysis (e.g. ATS)
  - LHC studies: extract machine measurements, query machine settings
  - Beam dynamics simulation
  - Query and process LHC logs distributedly via Spark
  - Query and plot monitoring data in experiment DAQ systems

- Education
  - Many schools/workshops use SWAN for teaching



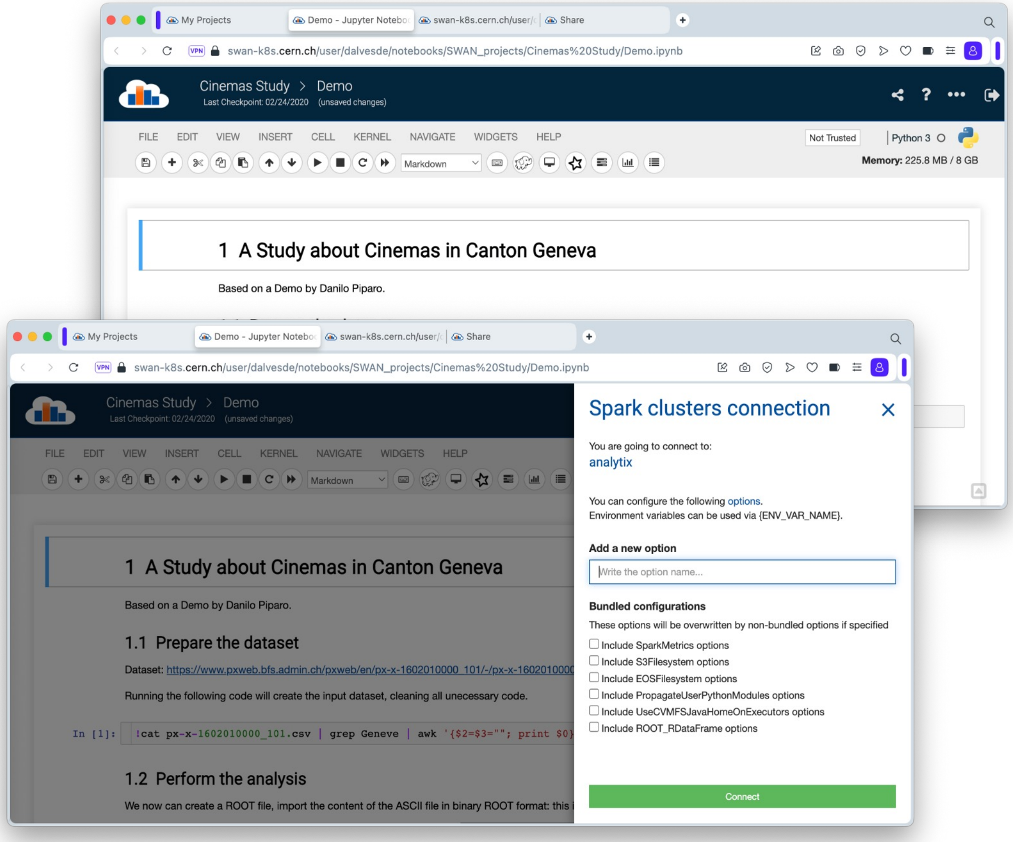
SWAN personalisations

- SWAN re-uses as much as possible from upstream projects
- We maintain modules created for Jupyter and JupyterHub
  - Thin layers to integrate with CERN resources and services
- These modules are released as open-source
  - e.g. Spark Monitor and Authenticator



https://github.com/swan-cern/jupyter-extensions
https://github.com/swan-cern/jupyterhub-extensions

Classic UI (Notebook 6)



1 A Study about Cinemas in Canton Geneva

Based on a Demo by Danilo Piparo.

1.1 Prepare the dataset

Dataset: https://www.pxweb.bfs.admin.ch/pxweb/en/px-x-1602010000_101/-/px-x-1602010000

Running the following code will create the input dataset, cleaning all unecessary code.

```
In [1]:  !cat px-x-1602010000_101.csv | grep Geneve | awk '{$2=$3=""; print $0}
```

1.2 Perform the analysis

We now can create a ROOT file, import the content of the ASCII file in binary ROOT format: this i

Spark clusters connection

You are going to connect to:
analytix

You can configure the following options.
Environment variables can be used via {ENV_VAR_NAME}.

Add a new option

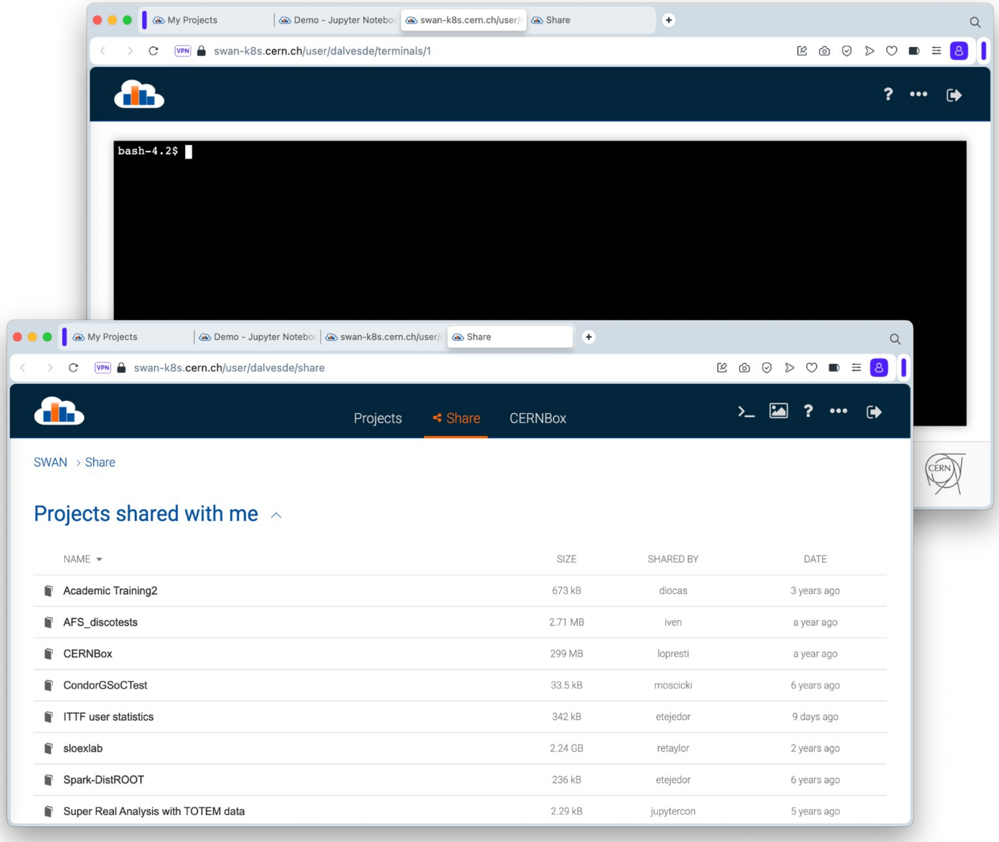
Write the option name...

Bundled configurations

These options will be overwritten by non-bundled options if specified

- □ Include SparkMetrics options
- □ Include S3Filesystem options
- □ Include EOSFilesystem options
- □ Include PropagateUserPythonModules options
- □ Include UseCVMFSJavaHomeOnExecutors options
- □ Include ROOT_RDataFrame options

Connect



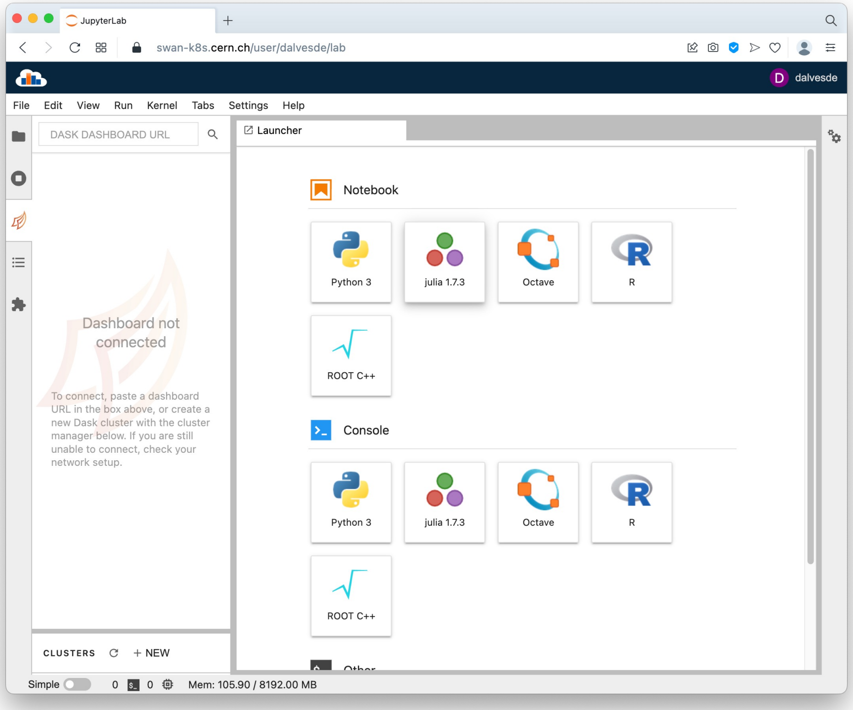
```
bash-4.2$
```

Projects shared with me

NAME	SIZE	SHARED BY	DATE
Academic Training2	673 kB	diocas	3 years ago
AFS_discotests	2.71 MB	iven	a year ago
CERNBox	299 MB	lopresti	a year ago
CondorGSoCTest	33.5 kB	moscicki	6 years ago
ITTF user statistics	342 kB	etejedor	9 days ago
sloexlab	2.24 GB	retaylor	2 years ago
Spark-DistROOT	236 kB	etejedor	6 years ago
Super Real Analysis with TOTEM data	2.29 kB	jupytercon	5 years ago

Migration to JupyterLab

- Deployed Jupyterlab v4
  - Extensions migrated to the new version
- Available as beta UI
  - Collection of user feedback underway
  - Users can use the classic UI in parallel
- Missing further integration with CERNBox
  - See next slide



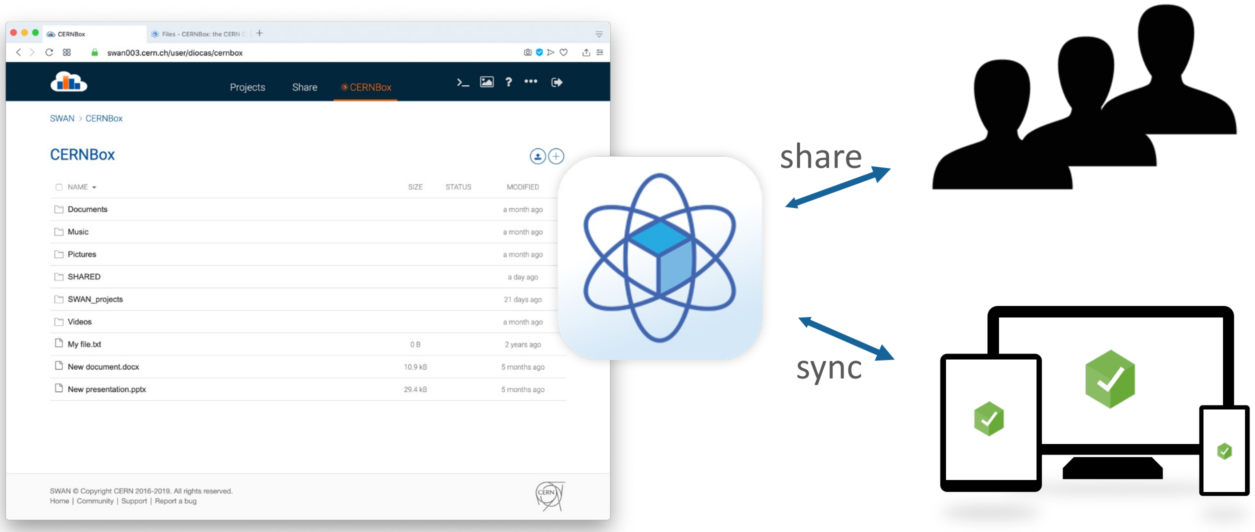
Dashboard not connected

To connect, paste a dashboard URL in the box above, or create a new Dask cluster with the cluster manager below. If you are still unable to connect, check your network setup.

Architecture

Storage

- > All the data our users need for their analysis
  - CERNBox as home directory
  - EOS (storage backend of CERNBox) Fuse mounted
  - Also experiments data available
- > Sync&Share
  - Files synced across devices and the Cloud
  - Simple collaborative analysis
  - Users can share directly from SWAN's UI
- > Lab Extension with full CERNBox capabilities under development

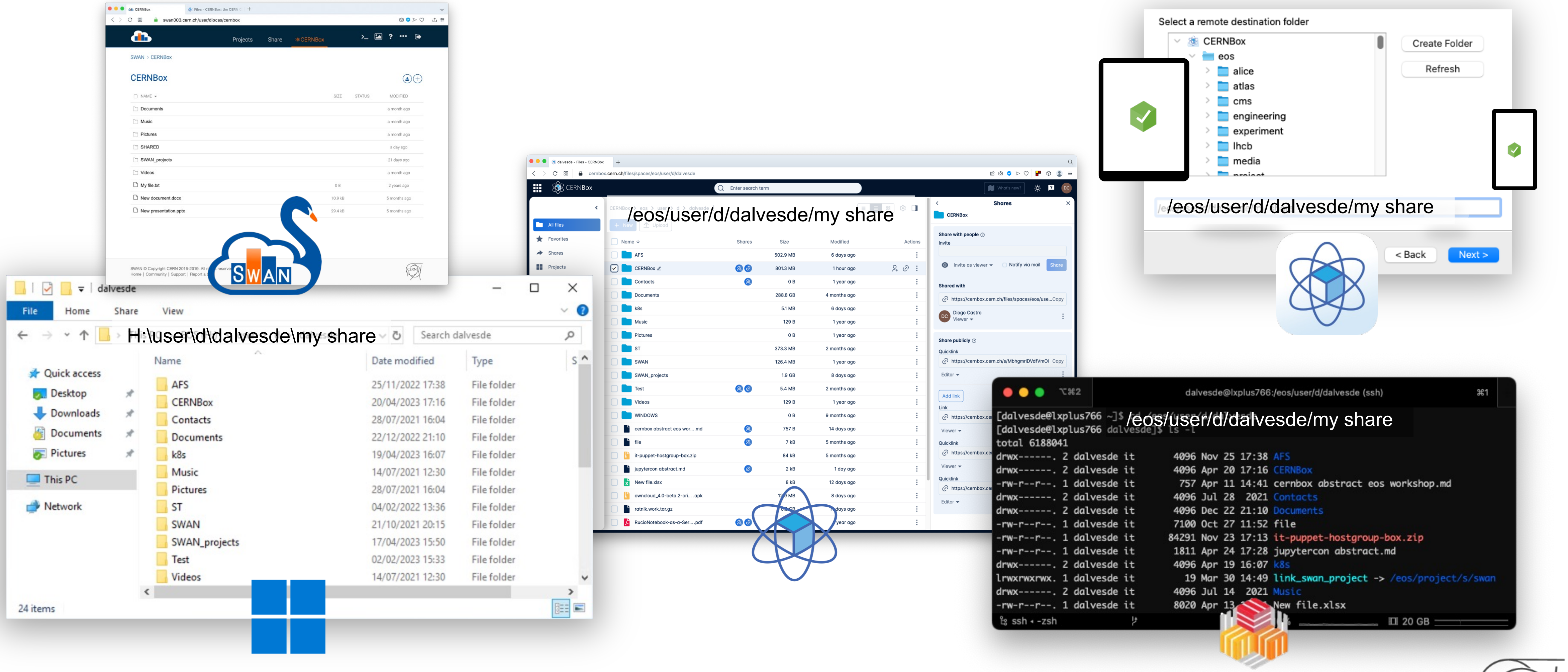

CERNBox
Files - CERNBox: the CERN
swan003.cern.ch/user/diocas/cernbox
Projects
Share
CERNBox
SWAN > CERNBox
share
sync

CERNBox

NAME	SIZE	STATUS	MODIFIED
Documents			a month ago
Music			a month ago
Pictures			a month ago
SHARED			a day ago
SWAN_projects			21 days ago
Videos			a month ago
My file.txt	0 B		2 years ago
New document.docx	10.9 kB		5 months ago
New presentation.pptx	29.4 kB		5 months ago

SWAN © Copyright CERN 2016-2019. All rights reserved.
Home | Community | Support | Report a bug

Consistent view across protocol boundaries



swan003.cern.ch/user/diocas/cernbox

SWAN › CERNBox

CERNBox

NAME	SIZE	STATUS	MODIFIED
Documents			a month ago
Music			a month ago
Pictures			a month ago
SHARED			a day ago
SWAN_projects			21 days ago
Videos			a month ago
My file.txt	0 B		2 years ago
New document.docx	10.9 kB		5 months ago
New presentation.pptx	29.4 kB		5 months ago

SWAN © Copyright CERN 2016-2019. All rights reserved

/eos/user/d/dalvesde/my share

cernbox.cern.ch/files/spaces/eos/user/d/dalvesde

Name	Shares	Size	Modified	Actions
AFS		502.9 MB	6 days ago	⋮
☑ CERNBox		801.3 MB	1 hour ago	⋮
Contacts		0 B	1 year ago	⋮
Documents		288.8 GB	4 months ago	⋮
k8s		5.1 MB	6 days ago	⋮
Music		129 B	1 year ago	⋮
Pictures		0 B	1 year ago	⋮
ST		373.3 MB	2 months ago	⋮
SWAN		126.4 MB	1 year ago	⋮
SWAN_projects		1.9 GB	8 days ago	⋮
Test		5.4 MB	2 months ago	⋮
Videos		129 B	1 year ago	⋮
WINDOWS		0 B	9 months ago	⋮
cernbox abstract eos wor....md		757 B	14 days ago	⋮
file		7 kB	5 months ago	⋮
it-puppet-hostgroup-box.zip		84 kB	5 months ago	⋮
jupytercon abstract.md		2 kB	1 day ago	⋮
New file.xlsx		8 kB	12 days ago	⋮
owncloud_4.0-beta.2-ori... .apk		12[illegible] MB	8 days ago	⋮
ratnik.work.tar.gz		[illegible] GB	[illegible] days ago	⋮
RucioNotebook-as-a-Ser... .pdf		[illegible]	[illegible] year ago	⋮

Shares

CERNBox

Share with people

Invite

Shared with

https://cernbox.cern.ch/files/spaces/eos/use... Copy

Diogo Castro Viewer

Share publicly

Quicklink https://cernbox.cern.ch/s/MbhgmrIDVdfVmOI Copy

H:\user\d\dalvesde\my share

Name	Date modified	Type
AFS	25/11/2022 17:38	File folder
CERNBox	20/04/2023 17:16	File folder
Contacts	28/07/2021 16:04	File folder
Documents	22/12/2022 21:10	File folder
k8s	19/04/2023 16:07	File folder
Music	14/07/2021 12:30	File folder
Pictures	28/07/2021 16:04	File folder
ST	04/02/2022 13:36	File folder
SWAN	21/10/2021 20:15	File folder
SWAN_projects	17/04/2023 15:50	File folder
Test	02/02/2023 15:33	File folder
Videos	14/07/2021 12:30	File folder

24 items

Select a remote destination folder

- CERNBox
  - eos
    - alice
    - atlas
    - cms
    - engineering
    - experiment
    - lhcb
    - media

/eos/user/d/dalvesde/my share

dalvesde@lxplus766:/eos/user/d/dalvesde (ssh)

/eos/user/d/dalvesde/my share

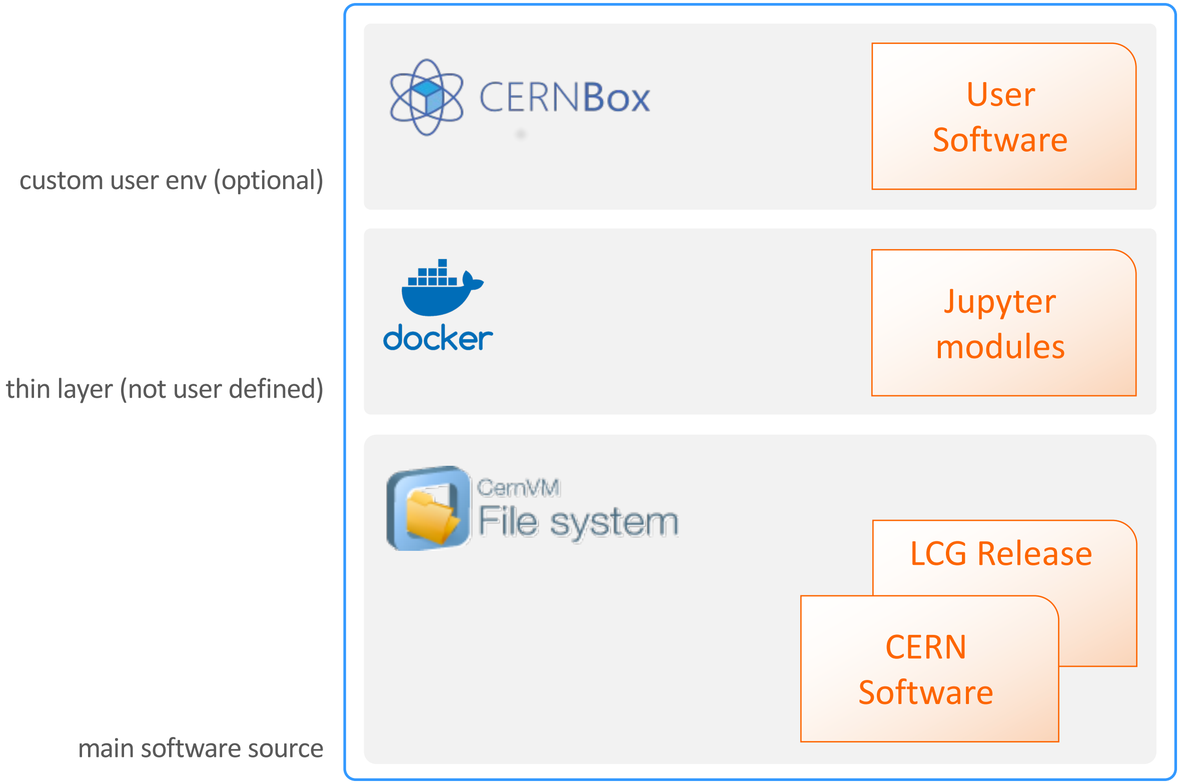
```
[dalvesde@lxplus766 ~]$
[dalvesde@lxplus766 dalvesde]$ ls -l
total 6188041
drwx------. 2 dalvesde it      4096 Nov 25 17:38 AFS
drwx------. 2 dalvesde it      4096 Apr 20 17:16 CERNBox
-rw-r--r--. 1 dalvesde it       757 Apr 11 14:41 cernbox abstract eos workshop.md
drwx------. 2 dalvesde it      4096 Jul 28  2021 Contacts
drwx------. 2 dalvesde it      4096 Dec 22 21:10 Documents
-rw-r--r--. 1 dalvesde it      7100 Oct 27 11:52 file
-rw-r--r--. 1 dalvesde it     84291 Nov 23 17:13 it-puppet-hostgroup-box.zip
-rw-r--r--. 1 dalvesde it      1811 Apr 24 17:28 jupytercon abstract.md
drwx------. 2 dalvesde it      4096 Apr 19 16:07 k8s
lrwxrwxrwx. 1 dalvesde it        19 Mar 30 14:49 link_swan_project -> /eos/project/s/swan
drwx------. 2 dalvesde it      4096 Jul 14  2021 Music
-rw-r--r--. 1 dalvesde it      8020 Apr 13       New file.xlsx
```

Software

> Software distributed through CVMFS
  - Distributed RO filesystem
  - Immutable software “stacks” maintained by librarians (called LCG Releases)
  - Lazy fetching of software

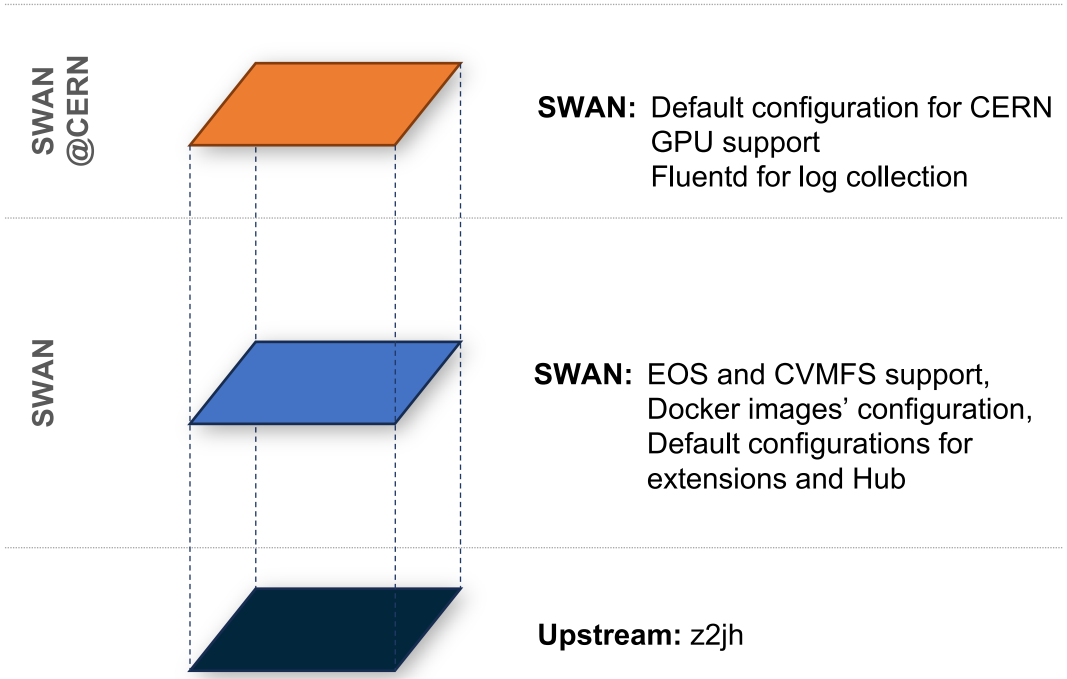
> Possibility to install additional packages on top of an LCG release
  - Stored on EOS/CERNBox

> WIP: custom software environments
  - Python environment independent of any LCG release
  - Picked during session startup
  - No plans for Binder integration due to security concerns



Infrastructure

- Fully running in k8s since this year
  - Initially, it ran in bare metal machines and later in a mix of bare metal + k8s cluster
- Helm charts based on *z2jh*
  - Before z2jh it ran on CERN-developed k8s yaml's
- 2 flavour of charts: *swan* and *swan@cern*
  - Allows deploying SWAN outside of CERN (ScienceBox)
  - Integrate the Python personalisations, EOS and CVMF
- JH 4.0.2



SWAN: Default configuration for CERN
GPU support
Fluentd for log collection

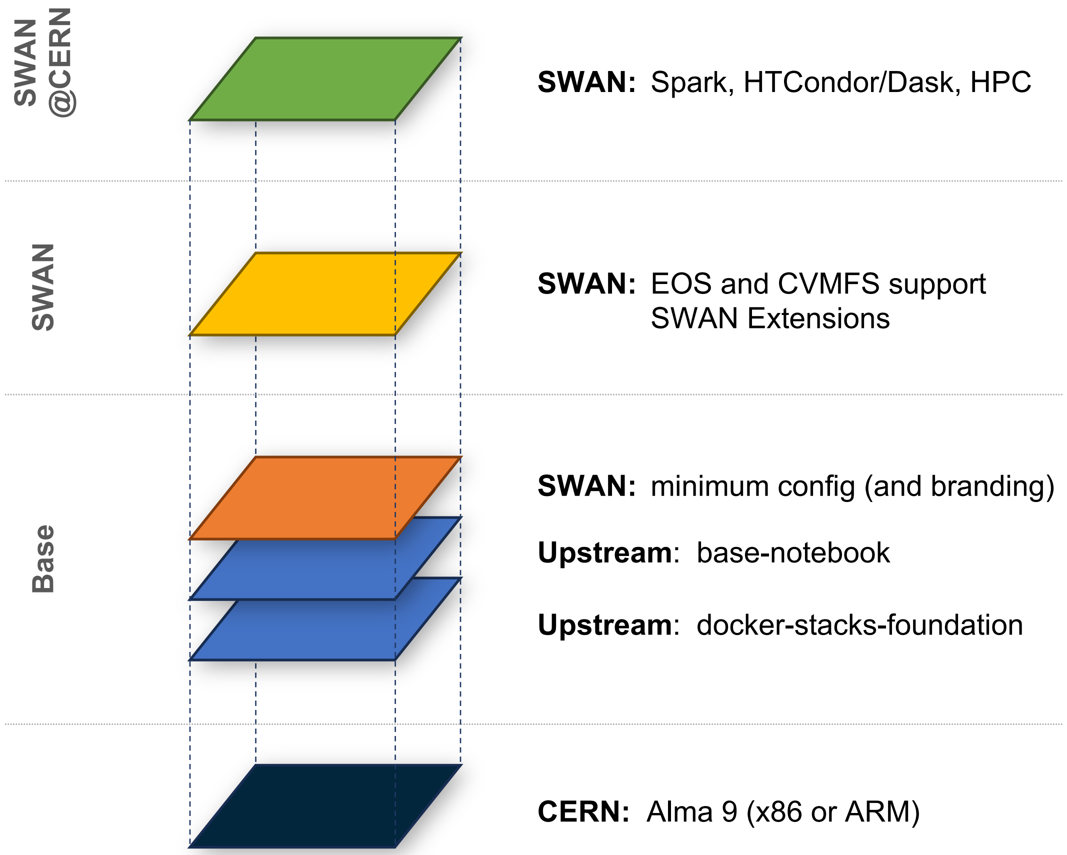
SWAN: EOS and CVMFS support,
Docker images' configuration,
Default configurations for
extensions and Hub

Upstream: z2jh

https://github.com/swan-cern/swan-charts

Container images: migration to Alma 9

- Key SWAN container images migrated
  - i.e. user session and JupyterHub images
- User images rewritten from scratch
  - Like upstream images, but Alma, not Ubuntu
  - Same entry points and configuration options
- Modular components' configuration
  - Independently configured on separate scripts
  - Easy to disable or add new components
- More runtime freedom
  - Opens the possibility to use the images in other contexts (e.g. CI)



SWAN: Spark, HTCondor/Dask, HPC

SWAN: EOS and CVMFS support
SWAN Extensions

SWAN: minimum config (and branding)

Upstream: base-notebook

Upstream: docker-stacks-foundation

CERN: Alma 9 (x86 or ARM)

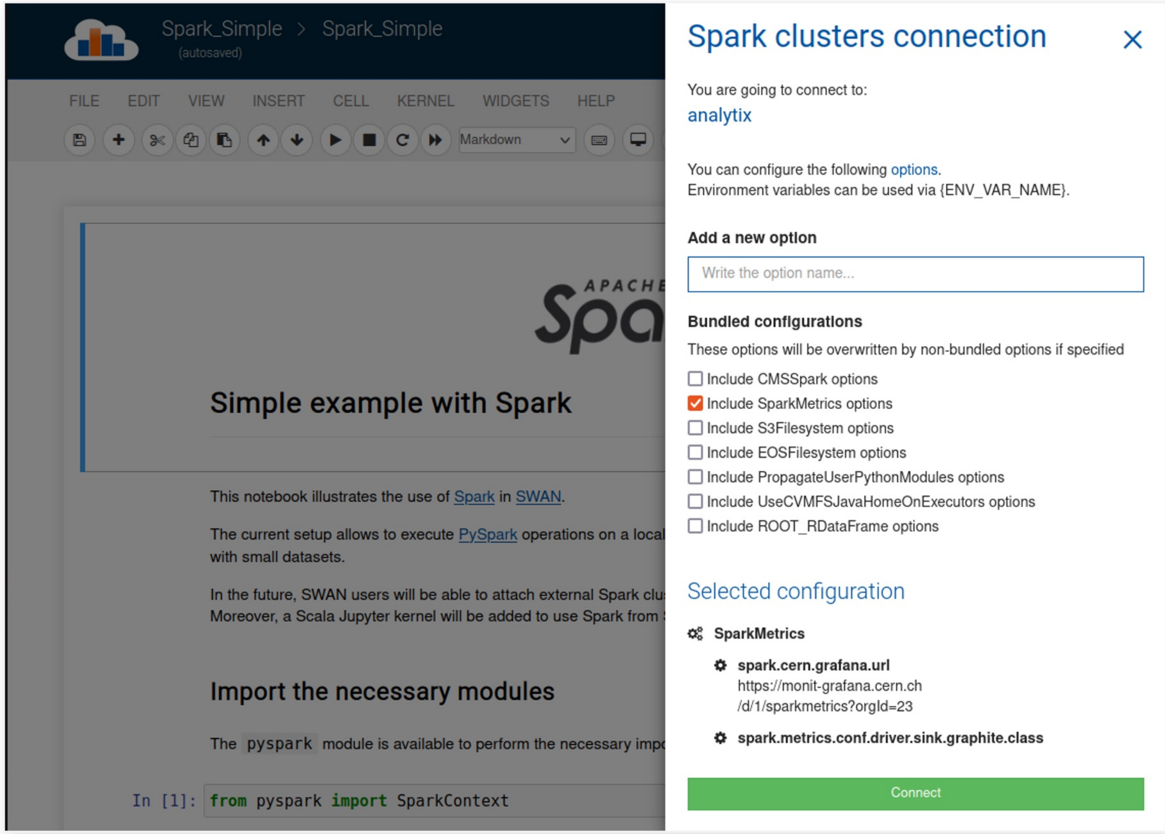
https://github.com/swan-cern/jupyter-images
https://github.com/swan-cern/jupyterhub-image

External computing resources

SWAN as entry point to computing resources

- A user SWAN session gets some resources (cores, memory) for running its notebook / terminal processes
  - 2 cores and 8 GB are the current defaults
- Additionally, SWAN can be used as an interface to access larger computing resources
  - Users launch computations elsewhere and inspect their results in the notebook
  - UI Extensions are provided to make it easy to connect to the external resources
- Current integrations
  - Batch/HTCondor pools
  - Spark/Hadoop clusters
  - HPC/Slurm clusters (work in progress, integration with CEPH FS)
  - GPUs (18 T4s, partitionable A100s for events, in the future access to a shared pool in CERN-IT)

Spark Connector and Monitor



Spark_Simple > Spark_Simple
(autosaved)
FILE EDIT VIEW INSERT CELL KERNEL WIDGETS HELP
Markdown
APACHE Spa

Simple example with Spark

This notebook illustrates the use of Spark in SWAN.

The current setup allows to execute PySpark operations on a local
with small datasets.

In the future, SWAN users will be able to attach external Spark clu
Moreover, a Scala Jupyter kernel will be added to use Spark from

Import the necessary modules

The `pyspark` module is available to perform the necessary impo

```
In [1]: from pyspark import SparkContext
```

Spark clusters connection

You are going to connect to:
analytix

You can configure the following options.
Environment variables can be used via {ENV_VAR_NAME}.

Add a new option

Write the option name...

Bundled configurations

These options will be overwritten by non-bundled options if specified

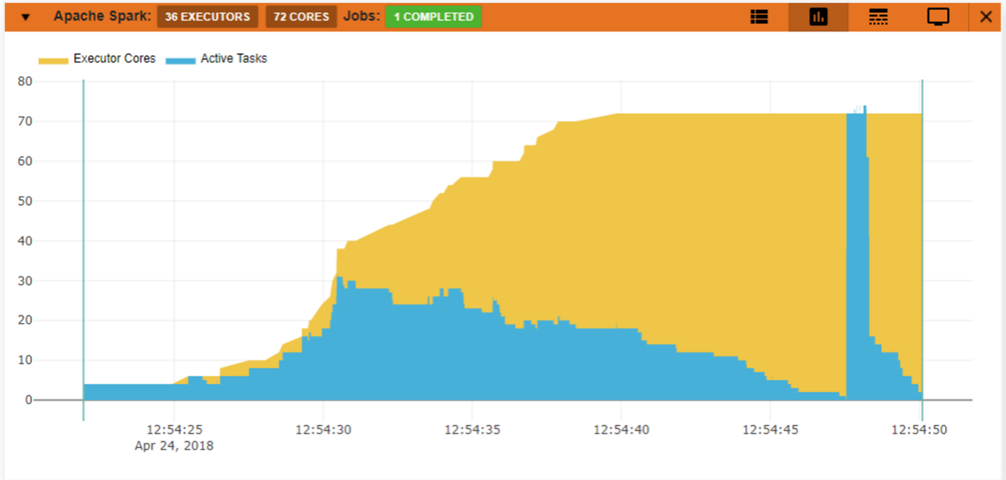
- ☐ Include CMSSpark options
- ☑ Include SparkMetrics options
- ☐ Include S3Filesystem options
- ☐ Include EOSFilesystem options
- ☐ Include PropagateUserPythonModules options
- ☐ Include UseCVMFSJavaHomeOnExecutors options
- ☐ Include ROOT_RDataFrame options

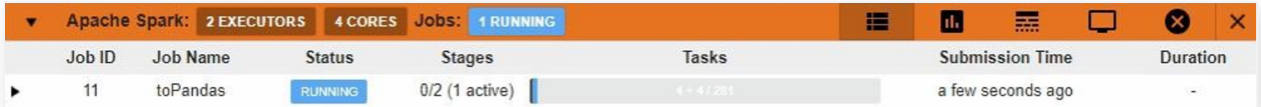
Selected configuration

SparkMetrics

- **spark.cern.grafana.url**
  https://monit-grafana.cern.ch
  /d/1/sparkmetrics?orgId=23
- **spark.metrics.conf.driver.sink.graphite.class**

Connect





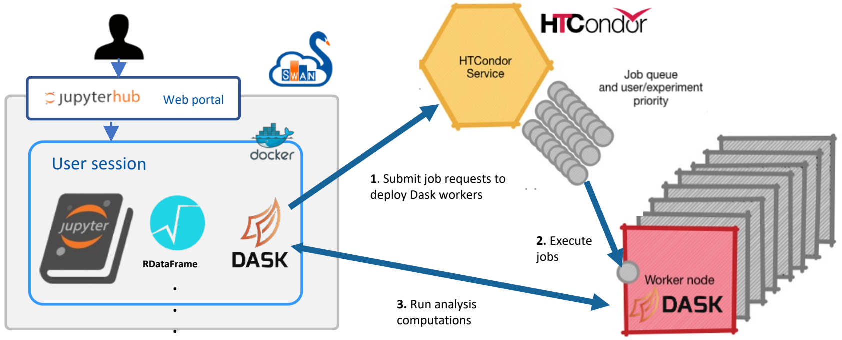
Job ID	Job Name	Status	Stages	Tasks	Submission Time	Duration
11	toPandas	RUNNING	0/2 (1 active)		a few seconds ago	-

Analysis facility pilot

- Support interactive distributed analysis for High Energy Physics
  - Address the future analysis needs due to foreseen increase in data volumes.

- Dask as the connector to batch resources
  - The two main HEP analysis frameworks, ROOT and coffea, rely on Dask for running analysis distributedly

- For now, it uses overcommitted "static" slots on HTCondor
  - Optimizes usage of batch resources
  - A well-stacked batch farm with a good job mix can get to 80% CPU utilization
  - Known analysis jobs potential to stack nicely with other workloads to drive up utilization



What next?

What next?

- SWAN in the TN (CERN’s restricted Technical Network)
  - Includes work in custom software environments
- Finish Jupyterlab migration
- Deploy HPC integration and Rucio Lab extension
- Simplify operations
  - B/G deployment, GitOps, etc
- Investigate the world beyond notebooks
  - IDE

Contacts

Where to find us

> Contacts
- swan-contact@cern.ch
- http://cern.ch/swan
- https://swan-community.web.cern.ch/

> Repository
- https://github.com/swan-cern/

> Documentation
- https://swan.docs.cern.ch

> ScienceBox
- Install SWAN on-premises
- https://sciencebox.web.cern.ch

Have you heard about REVA?

- https://reva.link
- CERNBox backend
  - Exposes APIs for the new ownCloud OCIS Web UI and sync/mobile clients
- Can have CEPH as storage backend (WIP)
  - Could add sync&share to your Jupyter CEPH FS mounted storage?

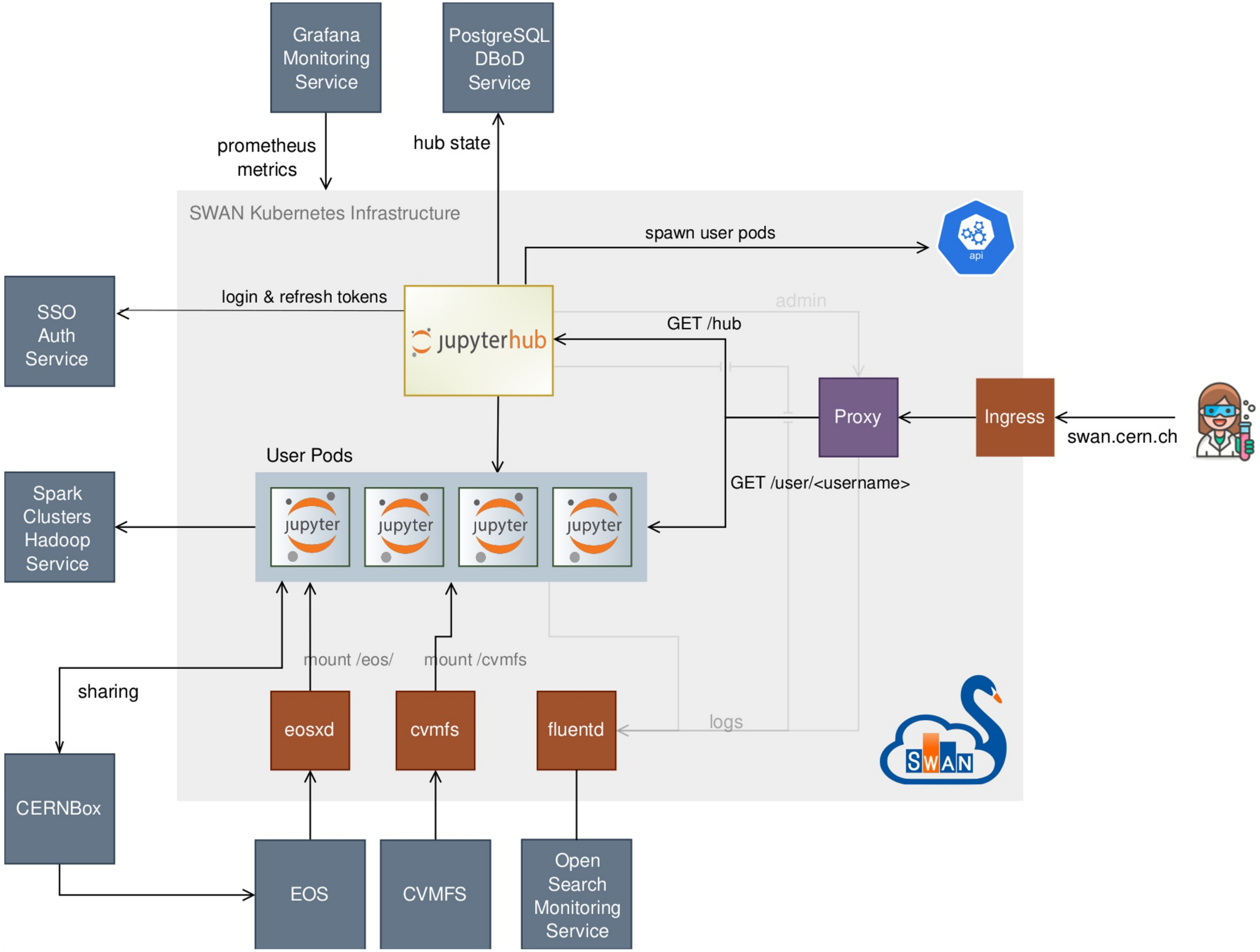
SWAN: a Service for web-based analysis at CERN

Thank you

Diogo Castro
diogo.castro@cern.ch

Backup slides

Architecture based on Kubernetes

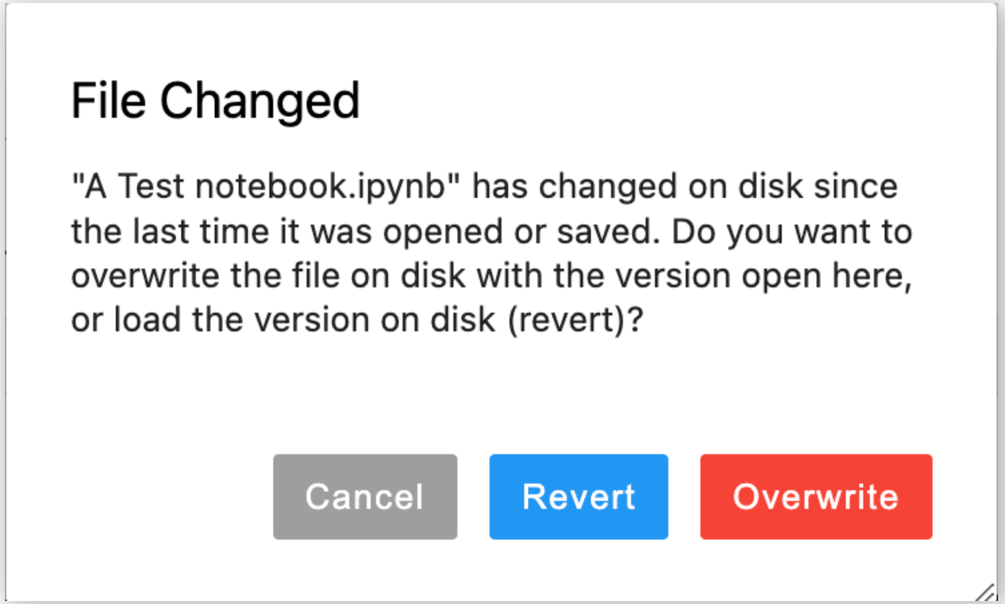


SWAN's Kubernetes setup
Based on Zero-to-JupyterHub

A note on collaboration

Current collaboration model for Jupyterlab

- In the beginning, notebooks could not be open in parallel
  - Conflicts would happen, especially on shared filesystems
- Now they can, and their data structures are synchronized
  - This looks awesome!
  - But optimal usage requires sharing the same Jupyter server and kernel (?)
- Jupyterhub proposes “collaboration accounts” instead
  - “Real-time collaboration without impersonation"



File Changed

"A Test notebook.ipynb" has changed on disk since the last time it was opened or saved. Do you want to overwrite the file on disk with the version open here, or load the version on disk (revert)?

The problems of the current collaboration model

> A shared filesystem might mean access from different Jupyter servers
- Or even other applications altogether
- The concurrent editing does not work fully

> Collaboration requires coordination
- This might not always be easy, especially if we don’t know who is editing on the other side…

> Sharing the same server + kernel is risky
- Full access to another user’s account, storage, and permissions on many resources
- Collaboration accounts help, but might be harder to coordinate or integrate with deployment

> We’re not aware of use cases that would benefit from true concurrent editing

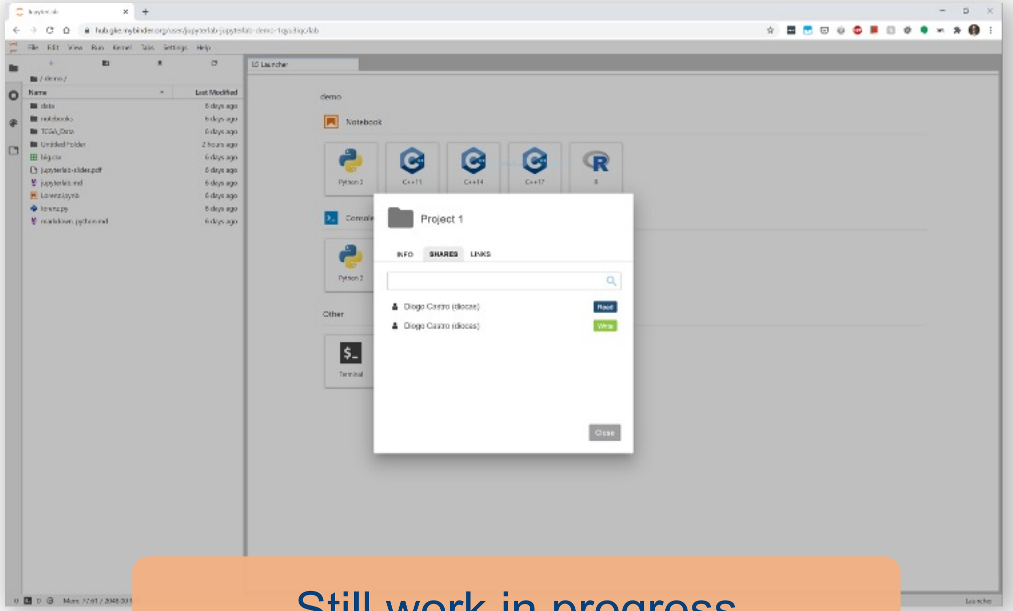
We proposed a complementary model better suited for large scale distributed environments

Collaboration model of the CS3Mesh project

> Same view as EFSS inside Jupyter
  - Access files, different mounts, shares, versions, etc.

> Sharing functionality
  - Share with users or public links
  - Same permissions everywhere

> Parallel access to notebooks
  - As alternative to concurrent editing
  - Opening the same notebook without creating conflicts (both locally or remote)
  - Execution environment independence



Still work in progress

https://github.com/sciencemesh/cs3api4lab