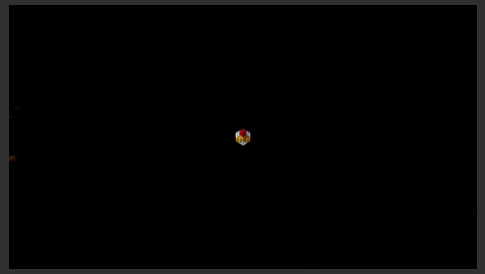


EOS for Users

How to use the CERN physics storage solution most effectively

Roberto Valverde Cameselle, Luca Mascetti, Dr. Andreas J. Peters, Manuel Reis, Elvin Alin Sindrilaru

For the CERN IT Storage Group

24 April 2023

Overview (1)

- What is EOS?
- EOS Services at CERN
  - Structure
  - Performance to expect
  - Reporting problems, troubleshooting and getting help
- Using EOS
  - Installing EOS
  - Getting access to EOS
  - Authentication to EOS
  - The EOS Command Line Interface
  - The CERNBox Web Interface
  - EOS as a filesystem
    - on Linux, Windows, Mac
  - root://, https:// access
- Data Durability & Safety
  - Backup
  - Recycle Bin & Undo Deletion
  - File Versioning

eos.web.cern.ch

Overview (2)

- Sharing data with others
  - EOS permission system
  - Sharing files or subtrees using CERNBox
- Synchronisation & Backup
  - Synchronize from your device to EOS using CERNBox
  - Generic synchronization tools
    - Rsync
    - Rclone
    - Restic
- Running Workflows on EOS
  - Efficient usage from laptops, desktops
  - Efficient usage on lxplus
  - Efficient usage from batch jobs

What is EOS?

- Structure
- Performance to expect
- Reporting problems, troubleshooting and getting help

What is EOS?

EOS Open Storage provides a **service for storing large amounts of physics data and user files**, with a focus on interactive and batch analysis.

EOS provides a **filesystem-like hierarchical namespace** with a feature-rich permission and quota system.

It is designed to support **several thousand users** (clients) at the same time providing secure Data storage access.

EOS is developed since 2010 by the IT Storage Group at CERN.

EOS is developed using the XRootD framework and the main protocol to interact with EOS is called `root://`

EOS is a very cost effective solution for large scale storage reducing costs for CERN by an order of magnitude when compared to cloud storage offered by Big Data companies.

EOS is also used by dozens of external institutions and is the core of additional data services like

- CERNBox - Sync & Share platform
- CTA - CERN tape archive

cernbox.web.cern.ch

What is EOS?

Service Architecture

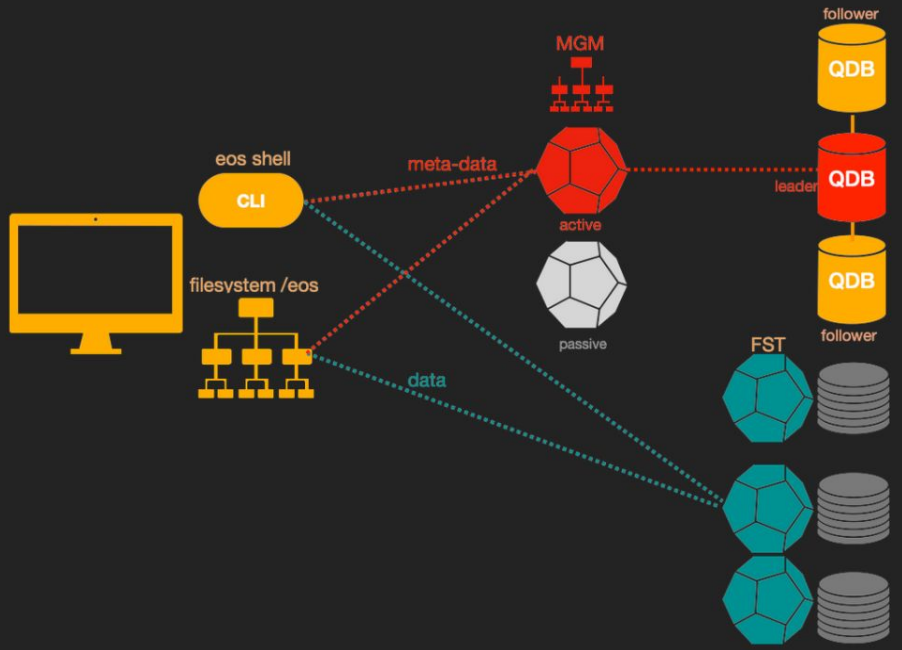
EOS splits into client and server side components

Clients

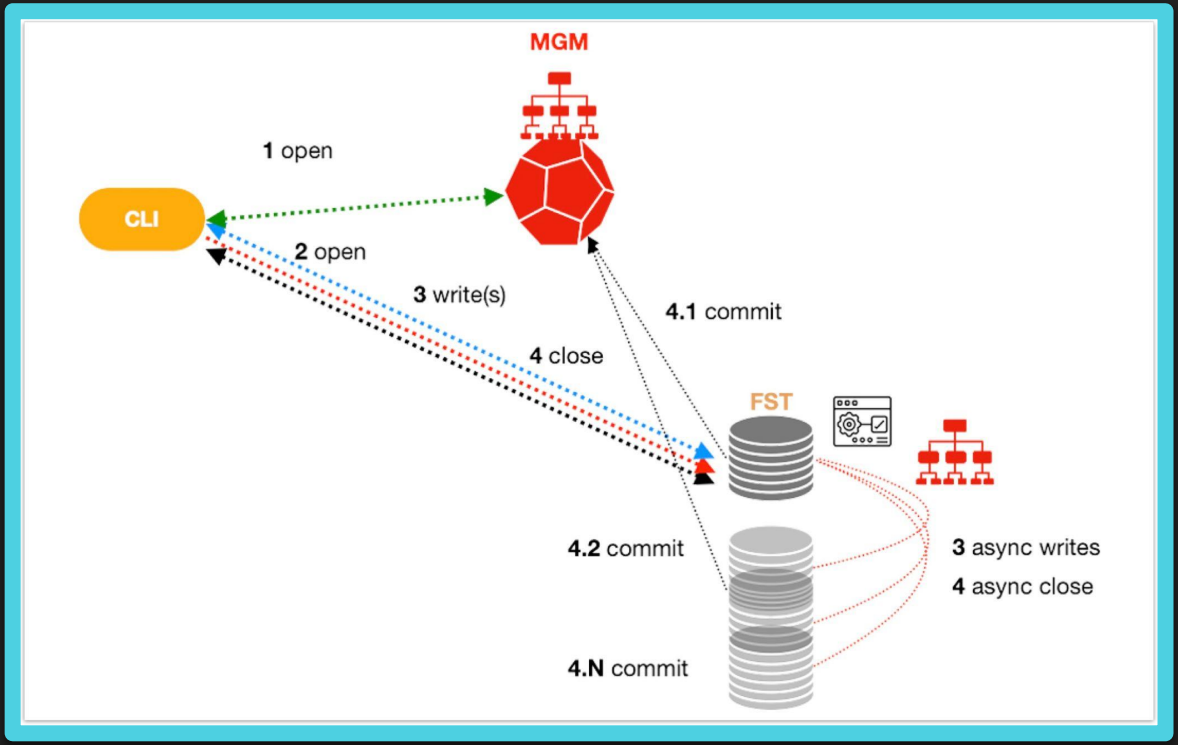
The EOS client provides a command line interface and a mounted filesystem interface.

Server

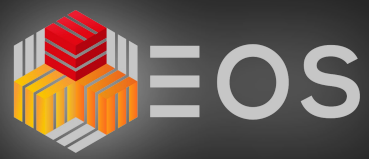
The EOS server is divided into meta-data and data storage components and persistency back-ends.



File Transactions



- No need to understand every detail here just
  - every file open in EOS requires to talk to at least two machines in the data center!

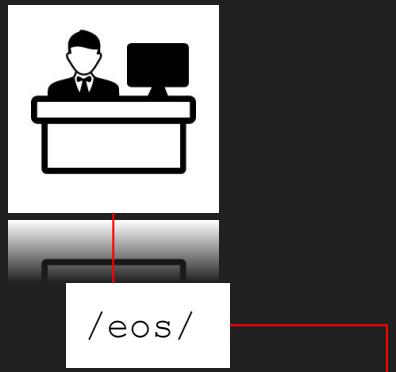


EOS Services at CERN

Is EOS one thing? What is the difference between EOS for physics and CERNBox?

- EOS Service Model
- EOS Instance Scale-Out
- EOS in Numbers
- EOS Usage at CERN

EOS Service Model - EOS as a ‘Single Thing’



EOS services are unified by namespace under **/eos/**

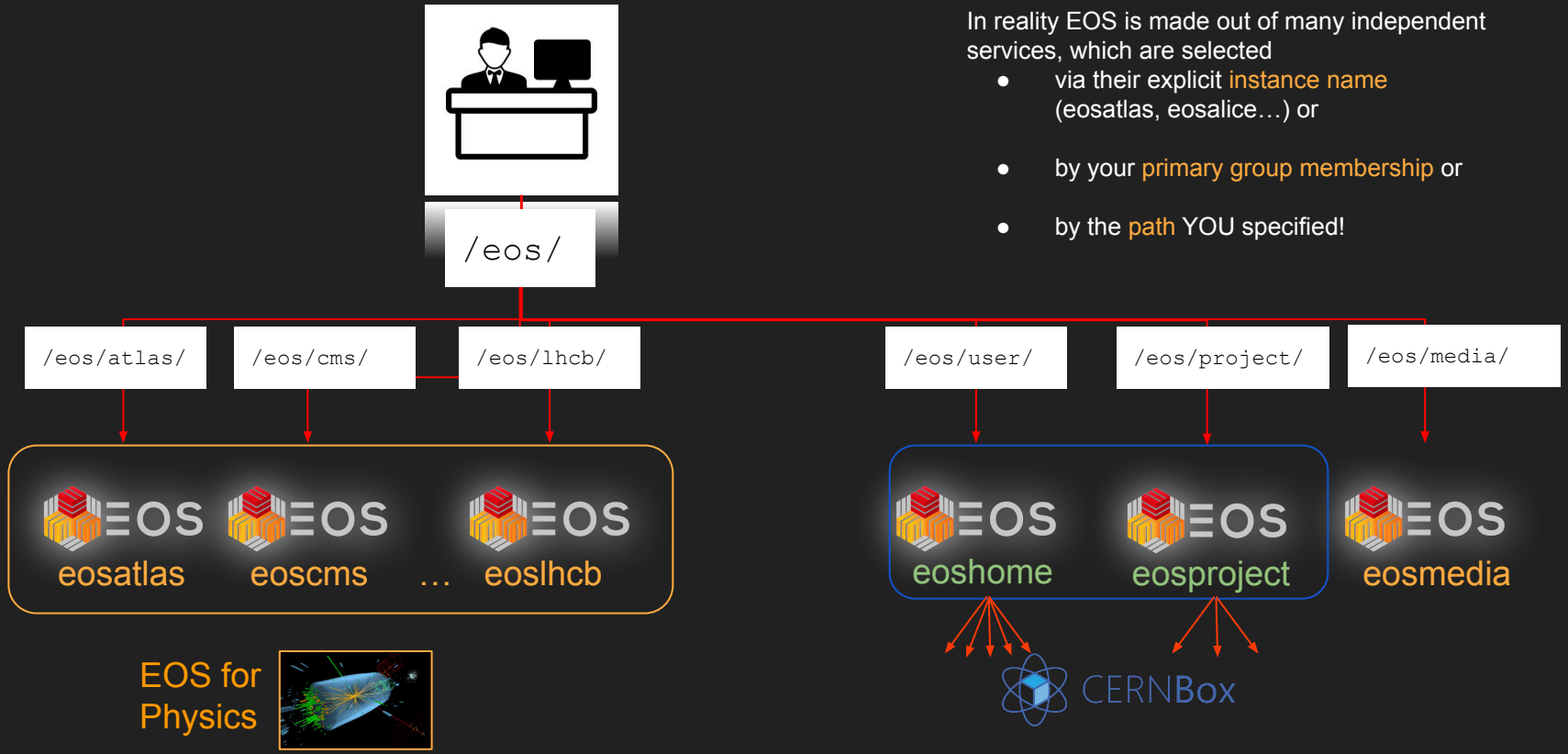
What does this mean?

- It might look like a single service to you
- Every path in EOS starts with **/eos/**…
- But: subtrees of the namespace can point to individual EOS instances

EOS Service Model - EOS Service Scale-out

- To scale the namespace performance EOS is split for various user communities into independent EOS installations
  - Activity of ATLAS users should not impact CMS, ALICE or LHCb users
  - An upgrade of the CMS instance should not impact other communities
- Each LHC experiment has its dedicated service
  EOSALICE, EOSALICEO2, EOSATLAS, EOSCMS, EOSLHCB
- AMS has a dedicated service EOSAMS
- Many smaller experiments are hosted by the EOSPUBLIC service
- CERNBox is split into
  - Instances for private user directories EOSHOME
  - Instances for shared project directories EOSPROJECT

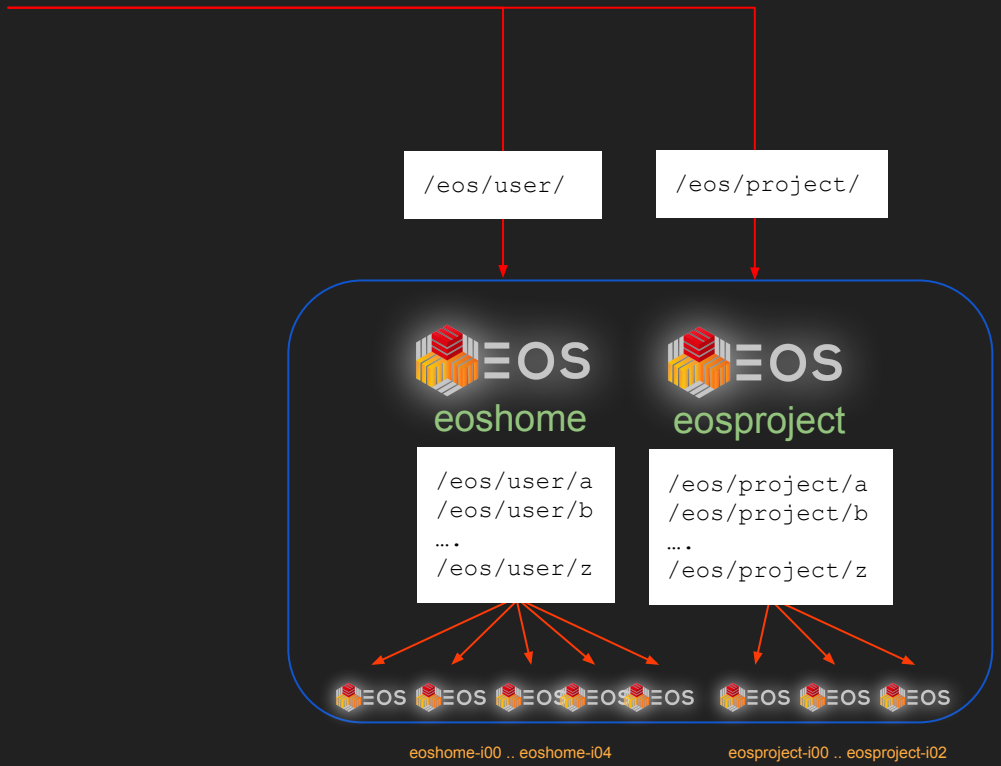
EOS Service Model - EOS Service Scale-out



In reality EOS is made out of many independent services, which are selected

- via their explicit instance name (eosatlas, eosalice…) or
- by your primary group membership or
- by the path YOU specified!

EOS Service Model - Split of the CERNBox Service

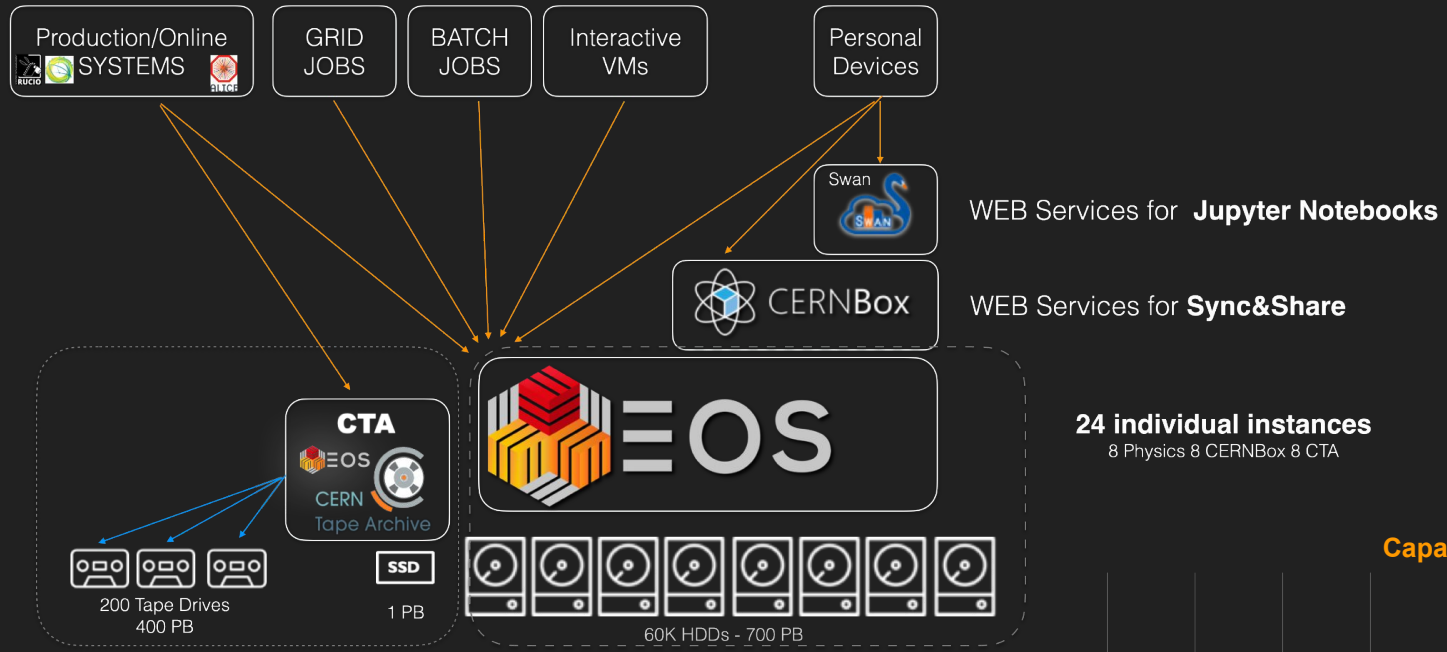


CERNBox

CERNBox service is made out of

- **5 instances for `/eos/user/..`**
- **3 instances for `/eos/project/..`**
- **groups of letters of user and project names are mapped to 5+3 instances**

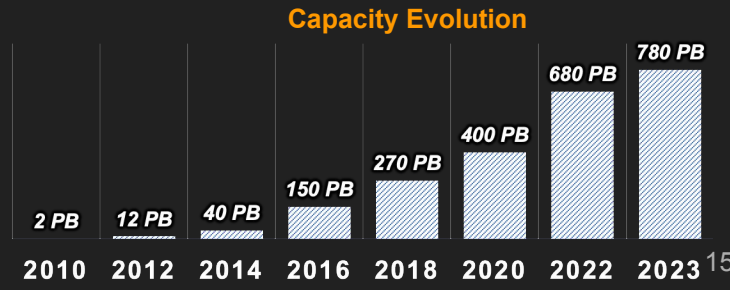
EOS Service in Numbers



2023 Targets

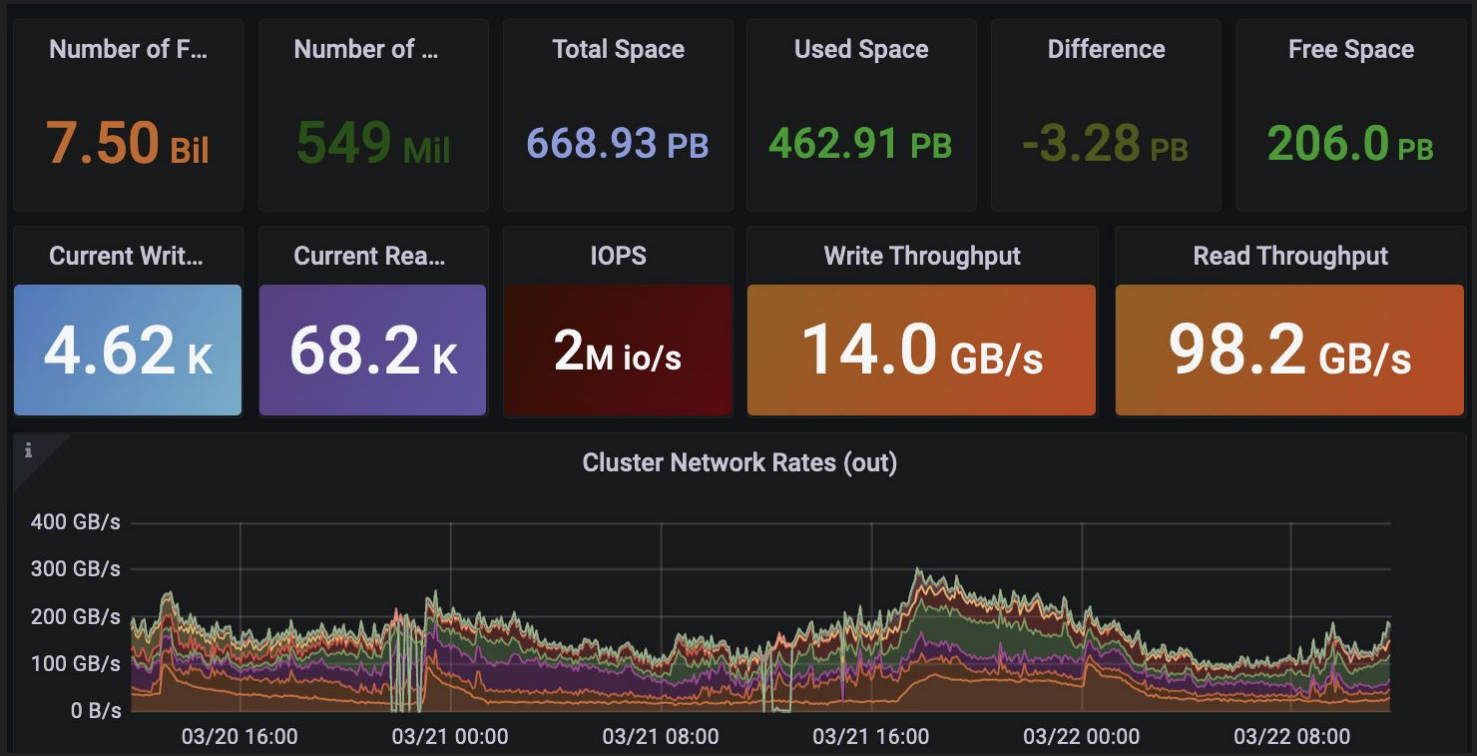
Total Space	780 PB
Files Stored	~8 Bil
# Storage Nodes	~1300
# Disks	~60000

How is EOS used?



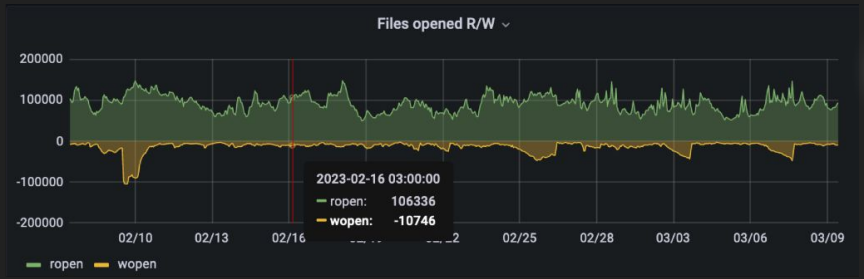
EOS Service Usage in Numbers

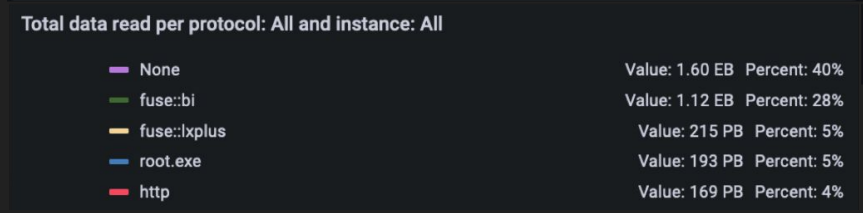
8 Physics, 8 User/Project (CERNBox), 8 CTA EOS Instances at CERN + various pre-production installations

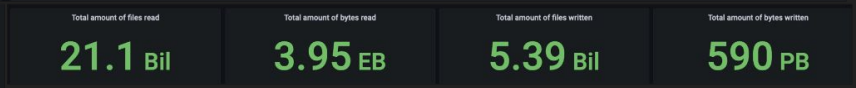


EOS Usage at CERN

IO Statistics of the last 12 month







Reading 2020: **2.5 EB** => [last 12mo]: **3.95 EB**

+58%

EOS Service - what can you expect?

- EOS is optimized for massive parallel usage
  - The initial goal is not to make a single client extremely fast !
  - The goal is to optimize the overall performance for thousands of clients !

- For a single client stream EOS as storage is not faster than using a local SSD!
  - Single file stream performance in most cases 50-250 MB/s
    e.g. copy a file from local to /eos/ or copy a file from /eos/ to local
  - You benefit once you start using parallelism! EOS instances can deliver up to 500 GB/s when using thousand of streams

- Meta-data operations like opening a file are much slower than on your local disk
  - You can open 250 files/s in EOS from 1 client sequentially!
  - You can open 100.000 files/s on your local SSD!
  - Not the ideal place for GIT checkouts and software compilation!

- But EOS has much more space than your local disks!
  - Hundreds of PB for physics
  - 1 TB for each CERNBOX user by default
  - It provides massive performance if used in the right way!

Reporting Problems - Troubleshooting - Getting help

The standard way to report problems or get help is to use the CERN Service portal
SNOW ticket

- You can type some keywords in the search bar and check if any of the knowledge base articles matches your problem

- If not, Click on “Need help” and fill the form:
  - Mention the word EOS in the subject
  - Please specify
    - from which client you access or which OS you have a problem
    - which instance you access or which EOS path you access
    - the time of your trial
    - the authentication method and username you are using
    - any other detail which might be relevant
      - see the next slide for detailing problems with XRootD protocol issues

  - This is procedure is what is called “submit a SNOW (Service Now) ticket

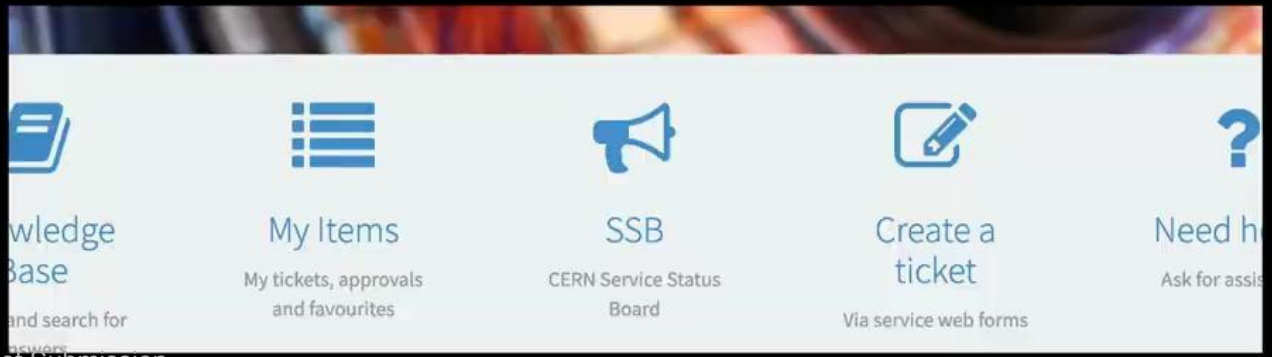
    to help us finding a solution

Main entry points in the CERN Service Portal

- EOS
- CERNBox

Efficiently reporting issue - Help us to help you!

- Issues/reports should always contain a few pieces of basic information
  - What OS you are using?
    - `uname -a`
  - What version of the software are you running?
    - `rpm -qa | grep "eos\|xrootd"`
  - Debug logs from the XRootD client interaction that trigger the issue if your are not using an EOS mount
    - `XRD_LOGLEVEL=Dump xrdcp root://eos1…. /other/path`
  - The same also works for any eos CLI command
    - `XRD_LOGLEVEL=Dump eos whoami`
  - Output from the XRootD client can be redirected to a file by using the following env. variable
    - `XRD_LOGFILE=/var/tmp/log XRD_LOGLEVEL=Dump xrdcp root://eos1… …`
  - Debug logs in highest verbosity for authentication issues
    - `XrdSecDEBUG=3 xrdcp root://eos1… …`
    -
- Provide as much context as possible about the problems you are facing
  - Provide a snapshot of the environment - `env`
  - Is is something reproducible or only transient?
  - Does it happen only when interacting with a certain EOS instance?
  - Do you have a reproducer?


wledge
Base
and search for
My Items
My tickets, approvals
and favourites
SSB
CERN Service Status
Board
Create a
ticket
Via service web forms
Need h
Ask for assis

Using EOS

- Installing the EOS client
- Getting access to EOS
- Authentication to EOS
- The EOS Command Line Interface
- The CERNBox Web Interface
- EOS as a filesystem
  - on Linux, Windows, Mac
- root://, https:// access

Using EOS - How to install the EOS client

EOS clients are readily available on shared infrastructure. There is no need for installation on these services:

- **lxplus** - interactive login nodes
- **lxbatch** - batch queue nodes
- **kubernetes** - container service cluster
- **Swan** - notebook service

When you use your own laptop, an Openstack VM or desktop, you need to install the EOS client software.

We support:
CentOS, RHEL, Fedora, ALMA, Ubuntu, (older OSX)
We don't support:
Latest OSX, Windows

Installing EOS for CentOS

```
# Install repos for extra packages:
yum install epel-release -y
FLAVOUR=$(rpm  --eval '%{?fedora:fc}%{!?fedora:el}')

# Setup EOS repo(s):
echo '''[eos]
name=EOS repo
baseurl=https://storage-ci.web.cern.ch/storage-ci/eos/diopside/tag/testing/'''${FLAVOUR}'''-$releasever/x86_64/
enabled=1
gpgcheck=0

[eos-deps]
name=EOS Dependencies repo
baseurl=https://storage-ci.web.cern.ch/storage-ci/eos/diopside-depend/'''${FLAVOUR}'''-$releasever/x86_64/
enabled=1
gpgcheck=0''' > /etc/yum.repos.d/eos.repo

# Install EOS client RPMs
yum install eos-client eos-fusex -y
```

Installing EOS for ubuntu

```
# Install tools to configure EOS repos
apt update && apt install gpg curl -y

# Install EOS's GPG public key
curl -sL http://storage-ci.web.cern.ch/storage-ci/storageci.key | gpg --dearmor -o
/etc/apt/trusted.gpg.d/storage-ci.gpg

# Setup environment
source /etc/lsb-release

# Configure EOS repo(s):
echo """deb [arch=$(dpkg --print-architecture)]
http://storage-ci.web.cern.ch/storage-ci/debian/xrootd/ ${DISTRIB_CODENAME} release
deb [arch=$(dpkg --print-architecture)]
http://storage-ci.web.cern.ch/storage-ci/debian/eos/diopside/ ${DISTRIB_CODENAME} tag""" >
/etc/apt/sources.list.d/cerneos-client.list

# Install EOS client packages
apt update && apt install eos-client eos-fusex -y
```

Installing EOS on CERN desktop's (EL only)

Checkout the complete documentation from Linux @ CERN

```
yum install locmap-release -y
yum install locmap -y
locmap --enable eosclient
locmap --configure eosclient
```

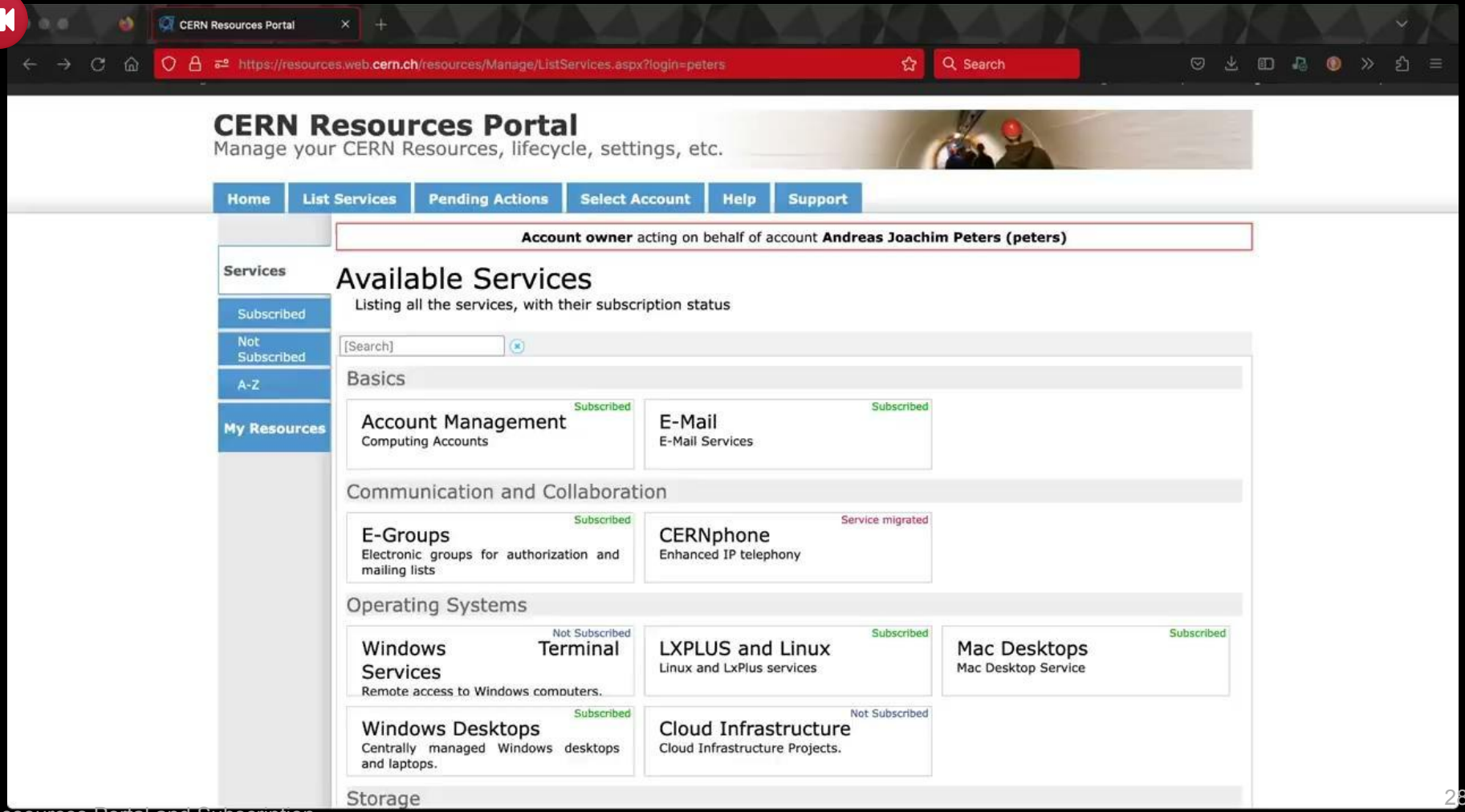
Using EOS - Getting access to EOS

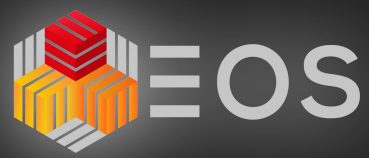
- Access to physics instances is automatically possible once your computing account has its primary group assigned to an experiment
  - If you require dedicated directories for your work to be created/configured, this is handled via experiment assigned managers
    - Straightforward way is to submit a SNOW ticket
  - Access to ALICE instances is with few exceptions not directly possible, only using the **jALIEN** middleware

- Access for users to CERNBox requires that you are subscribed to the EOS/CERNBox service in the Service Portal and open once in a browser https://cernbox.cern.ch and authenticate using the CERN SSO (single sign-on) page
  - This will automatically create a USER directory for you e.g. for the user `foo` : `/eos/user/f/foo/`
  - Your username is then automatically whitelisted in CERNBox to allow access the instance

- Creating a project space in CERNBox is done via this Service Portal Form

- Access to all other instances (MEDIA…) is also handled via SNOW ticket


CERN Resources Portal
https://resources.web.cern.ch/resources/Manage/ListServices.aspx?login=peters
Search
CERN Resources Portal
Manage your CERN Resources, lifecycle, settings, etc.
Home
List Services
Pending Actions
Select Account
Help
Support
Account owner acting on behalf of account Andreas Joachim Peters (peters)
Services
Subscribed
Not Subscribed
A-Z
My Resources
Available Services
Listing all the services, with their subscription status
[Search]
Basics
Account Management
Computing Accounts
Subscribed
E-Mail
E-Mail Services
Subscribed
Communication and Collaboration
E-Groups
Electronic groups for authorization and mailing lists
Subscribed
CERNphone
Enhanced IP telephony
Service migrated
Operating Systems
Windows Terminal Services
Remote access to Windows computers.
Not Subscribed
LXPLUS and Linux
Linux and LxPlus services
Subscribed
Mac Desktops
Mac Desktop Service
Subscribed
Windows Desktops
Centrally managed Windows desktops and laptops.
Subscribed
Cloud Infrastructure
Cloud Infrastructure Projects.
Not Subscribed
Storage



Using EOS - Authentication to EOS

EOS provides various ways to authenticate.

The most important are:

1. Kerberos V
2. X509 Certificates
3. Tokens

Using EOS - Authentication to EOS - Kerberos V

- The default and preferred authentication mechanism at CERN for users is Kerberos V authentication - as you use when you login to lxplus
  - It is available once you have a computing account at CERN

    ```
    bash> kinit foo # create a kerberos credential for user foo
    bash> Password for foo@CERN.CH:
    bash> klist
    ```
  - When using kerberos authentication, files in EOS are by default stored with the user and group ID assigned to your account e.g. after `kinit cmsprod`

    ```
    bash> id cmsprod
    uid=5410(cmsprod) gid=1399(zh) groups=1399(zh)
    ```
    - Files created in EOS will be owned by cmsprod/zh = 5410/1399
    - BUT: in CERNBox they are owned by the pre-defined owner of a directory!

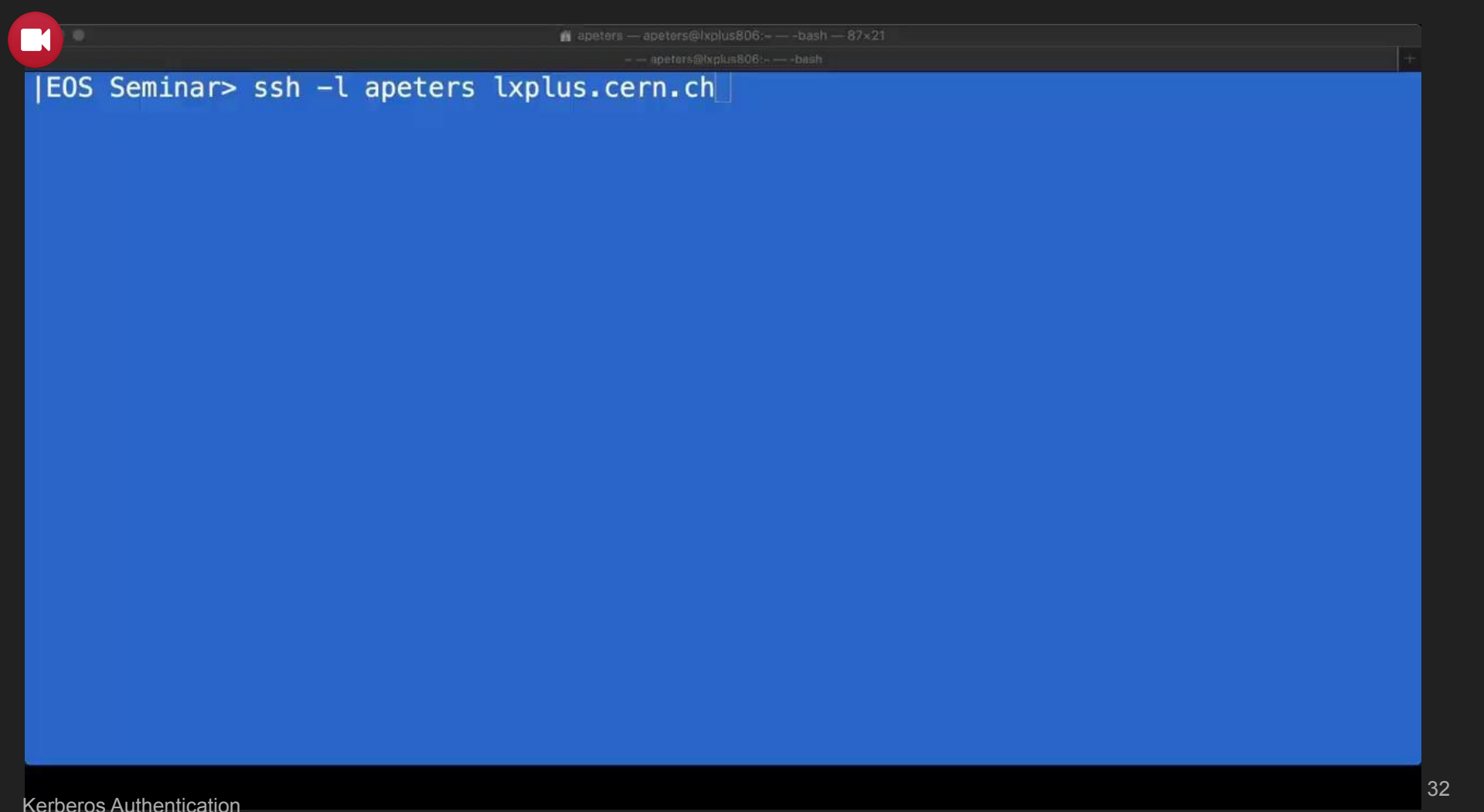
Using EOS - Authentication to EOS - X509 Certificates

- Experiments instances allow X509 authentication for access from the GRID using certificates
  - You can request a GRID user certificate under `https://ca.cern.ch`
  - Certificates are not automatically mapped to your CERN user name in EOS
    - To map certificates service manager deploy GRID map files, which translate the distinguished name (DN) from you certificate to a CERN account
      - Often many DNs are mapped to the same account e.g. `atlas001` and files are then owned by the mapped account e.g. `atlas001`
      - If you require a certificate to be mapped to a specific account talk to experiment representatives or submit a SNOW ticket
  - Before you use a certificate you typically create a short-lived PROXY certificate doing:

    ```
    bash> grid-proxy-init
    ```

    or

    ```
    bash> voms-proxy-init
    ```
  - certificates will be replace by tokens in the coming years


apeters — apeters@lxplus806:~ — -bash — 87×21
apeters@lxplus806:~ — -bash
EOS Seminar> ssh -l apeters lxplus.cern.ch

Using EOS - Authentication to EOS - Token

- EOS supports the creation of EOS tokens to provide access authorization to others
  - A token has to be provided to each interaction with an EOS service
  - Tokens are easier to use in automatic services for example in GITLAB pipelines than kerberos or certificates
  - Tokens have a limited lifetime (max. 1 year)
  - Tokens have a limited scope
    - Access to a single file
    - Access to a single directory
    - Access to a directory tree
  - Tokens carry an identity
    - Files are created and accessed with the identity embedded in a token
  - Token usage can be restricted to certain client machines
- You will see token authorization in an example later
  (EOS token documentation)

- There are also GRID tokens coming, but you should not get exposed directly!

Using EOS

EOS Interfaces
What do I do with it?

The most important EOS interfaces are:

- Command Line Interface
  EOS shell
- Filesystem Interface
  POSIX-like *open,read,write.close*
- CERNBox Web UI
- Remote access protocols:
  - ROOT protocol root://
  - HTTP protocol http(s)://

Using EOS - the EOS command line interface CLI

The EOS shell has two modes of operation:

- **Interactive mode** - supporting a current working directory, relative paths and an input terminal
- **Batch mode** - requiring absolute path names and one shot commands
- **Script mode** - a set of commands is read line by line from a file and executed

Invoking the interactive shell:

```
bash> eos
EOS Console [root://eoscms] |/> whoami

Virtual Identity: uid=100755 (99,100755) gid=1338 (99,1338) [authz:krb5]
host=lxplus717.cern.ch domain=cern.ch
EOS Console [root://eoscms] |/>
```

Invoking a batch shell command:

```
bash> eos whoami
Virtual Identity: uid=100755 (99,100755) gid=1338 (99,1338) [authz:krb5]
host=lxplus717.cern.ch domain=cern.ch
bash>
```

Using EOS - the EOS command line interface CLI

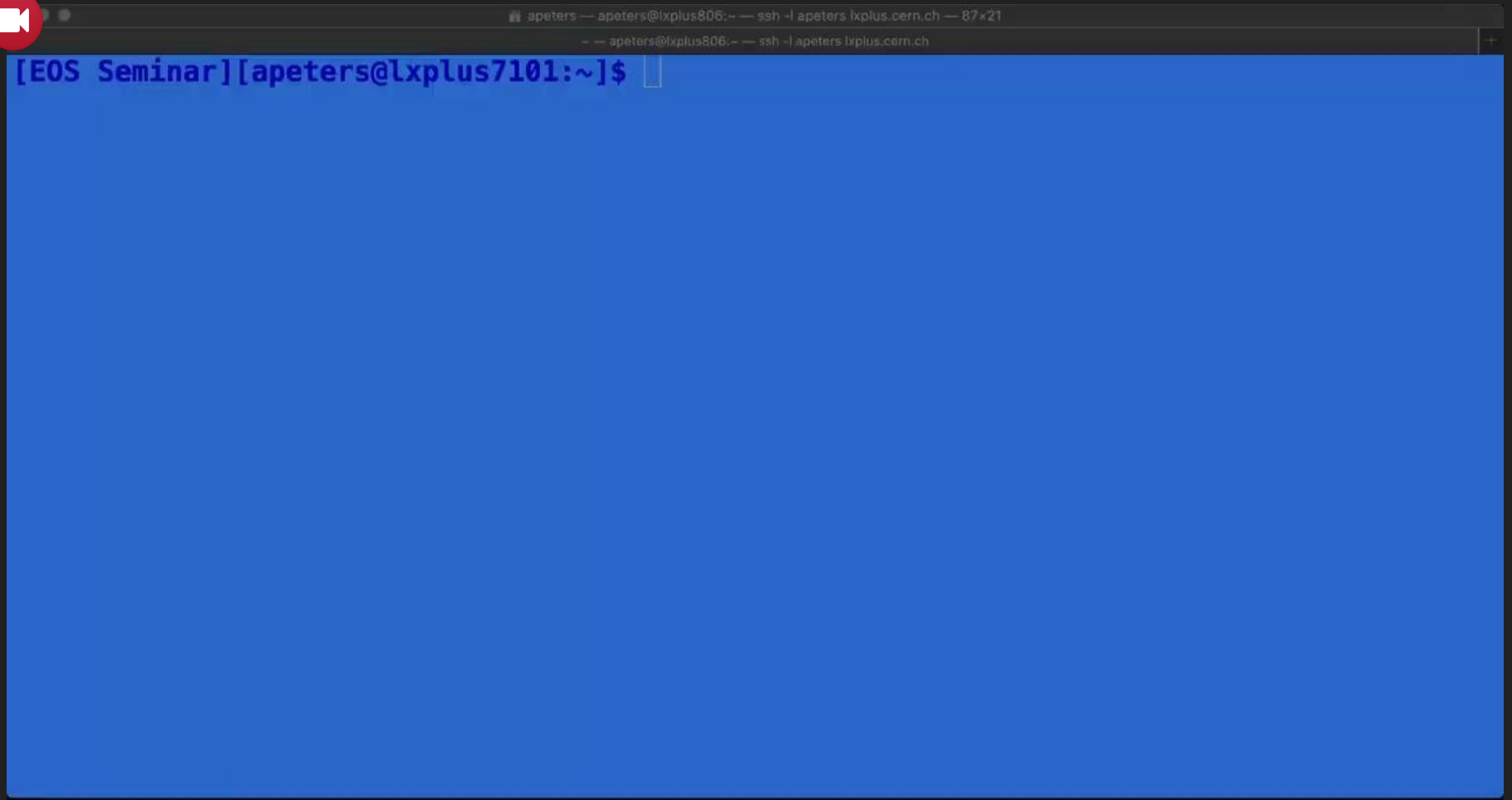
Invoking a shell script command:

```
bash> eos commandlist.eosh
```

commandlist.eosh:

```
version
whoami
ls -la /eos/
cp file:/data/file1 /eos/user/f/foo/file.1
cp file:/data/file2 /eos/user/f/foo/file.2
```

Good to know: If you need to run many commands in a row, this way is much faster, because you connect and authenticate only once to the EOS instance, while something like `loop( eos <cmd>)` has to connect and authenticate for each command!


apeters — apeters@lxplus806:~ — ssh -l apeters lxplus.cern.ch — 87×21
apeters@lxplus806:~ — ssh -l apeters lxplus.cern.ch
[EOS Seminar][apeters@lxplus7101:~]$

Using EOS - the EOS command line interface CLI

How to select the default instance you want to talk to:

- If you are not on a shared infrastructure like **lxplus** or **lxbatch** you should define a default instance using the environment variable EOS_MGM_URL which you can store in your shell profile e.g.:

```
bash> export EOS_MGM_URL=root://eosatlas.cern.ch
bash> export EOS_MGM_URL=root://eospublic.cern.ch
```

- For CERNBOX if your user name starts with letter ‘a’ you do

```
bash> export EOS_MGM_URL=root://eoshome-a.cern.ch
```

- For CERNBOX if your project name starts with letter ‘b’ you do

```
bash> export EOS_MGM_URL=root://eosproject-b.cern.ch
```

The **eos** command will use this variable to connect to the respective instance!

Using EOS - the EOS command line interface CLI

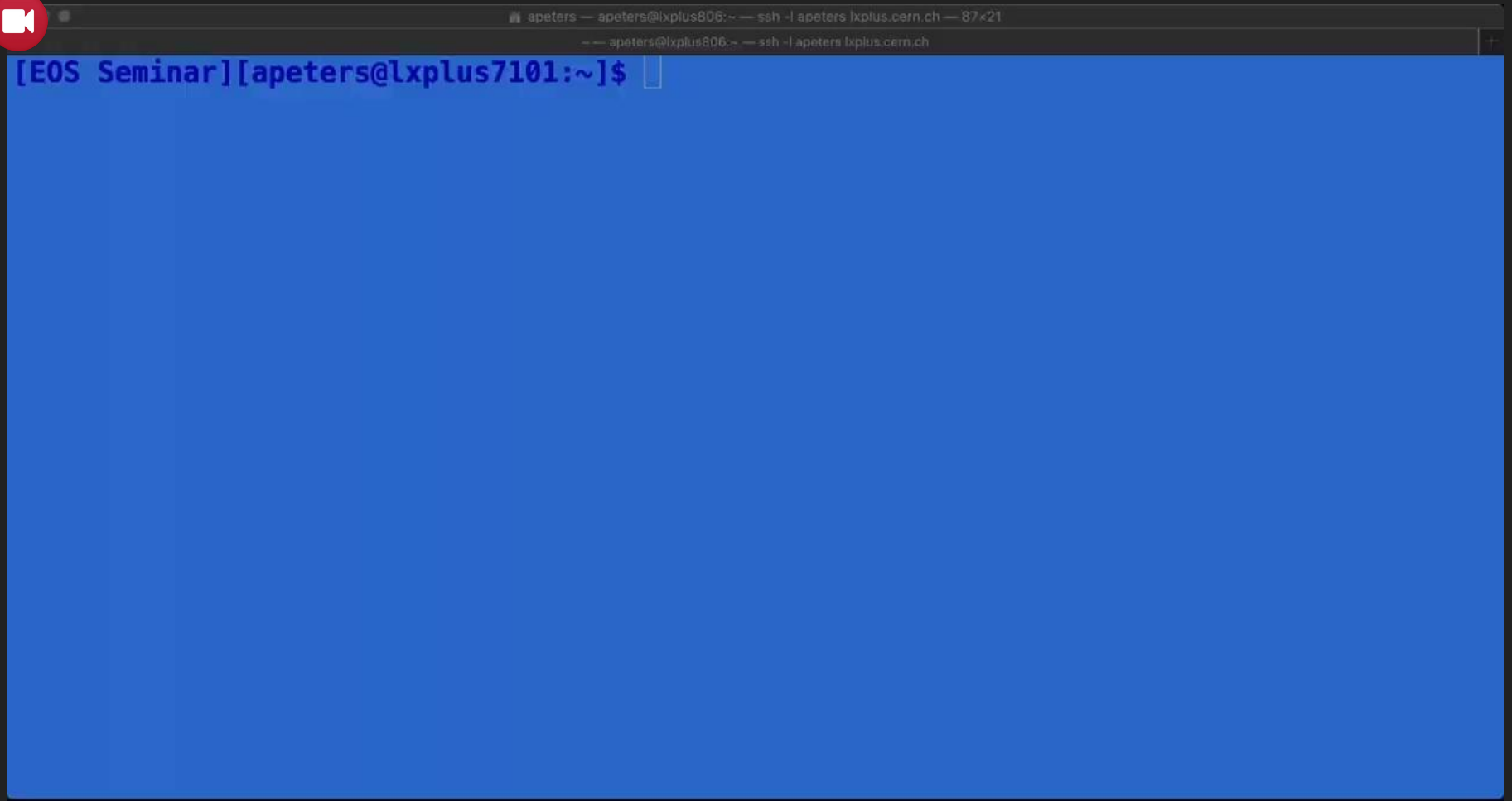
How to specify the instance you want to talk to for individual commands:

- One can add the instance to the eos command itself like:

```
bash> eos root://eosatlas.cern.ch whoami
bash> eos root://eospublic.cern.ch whoami
```

- One can add the environment variable to a single command like:

```
bash> env EOS_MGM_URL=root://eosatlas.cern.ch eos whoami
```


apeters — apeters@lxplus806:~ — ssh -l apeters lxplus.cern.ch — 87×21
apeters@lxplus806:~ — ssh -l apeters lxplus.cern.ch
[EOS Seminar][apeters@lxplus7101:~]$

Using EOS - the EOS command line interface CLI

The EOS service provides a front-end service, which is able to route any path based command to the right instance.

- To use it, you can configure

```
bash> env EOS_MGM_URL=root://eoshome.cern.ch
bash> # alternative: env EOS_MGM_URL=root://eosuser.cern.ch
bash> env EOSHOME=/eos/user/f/foo/
```

- E.g. if user `foo` queries the current quota, he will talk to eoshome-f

```
bash> eos quota
```

- If you provide a path, it will route your command to the responsible instance e.g. to eosatlas

```
bash> eos ls /eos/atlas/
```

  - however if you execute a pathless command it might execute on the front-end since there is no routing e.g. `eos whoami`

Recommendation: the clearest solution is to define your default instance using EOS_MGM_URL and in case specify another instance for individual commands, where needed!

Using EOS - the EOS command line interface CLI

Most useful commands:

eos **whoami**	Shows how you are authenticated
eos **version**	Shows the EOS version and the instance you currently talk to
eos **find, cp, ls, mkdir, rmdir, rm, pwd, df***	Equivalent to shell commands
eos **cp**	Copy command
eos **quota** [<path>]	Without path, shows all your quotas With path, shows quota for <path>

*not available on CERNBox instances (yet)

Using EOS - the EOS command line interface CLI

Good to know:

- **Recursive accounting**
  - If you type

```
bash-4.2$ eos ls -lah /eos/cms/
drwxr-xr-x   1 root   root         31.30 P Mar 18  2022 .
```

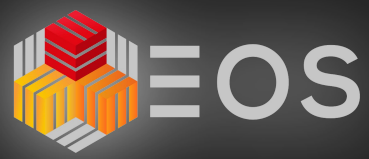
…

the directory size shows the size of all children under this directory

Using EOS - the EOS command line interface CLI

Good to know:

- EOS shows by default all units in base 1000 e.g. 1 MB = 1.000.0000 bytes
  - A common mistake: people comparing file system output which is by default in base 1024 (MiB !)
- You can get available shell commands by typing: `eos [tab]`
  - Some commands are only available to users with administrator roles
  - Some commands may require a confirmation code and cannot be executed in a script e.g. deep recursive deletion
- You can get help for a specific command by typing: `eos <cmd-name> -h`
  - EOS shell commands are not 100% identical to their UNIX sibling, in particular `eos find`
  - If you need some standard UNIX tools you can use filesystem access to EOS
- Be aware, that wildcards might be expanded locally by your shell if not escaped
  - EOS CLI supports only simple wildcards like `eos rm f*.root`
  - EOS CLI does not support regular expressions for pattern matching or ? replacements



Using EOS - EOS as a filesystem (drive)

/eos/

EOS can be mounted natively on most LINUX systems using **eosxd** or **sshfs**

EOS is accessible on Windows using the SAMBA service or sshfs

EOS is mountable on MacOS and most other platforms using sshfs

Using EOS - EOS as a LINUX filesystem

EOS can be mounted as a filesystem using a FUSE filesystem implementation on LINUX based systems.

There are two ways to mount EOS:

- As a shared mount (executed under root)
  - available to all users on a machine - each one uses his private credentials to authenticate
- As a private mount (executed under a user)
  - available only to the user who did the mount

Common infrastructure at CERN like lxplus, lxbatch, SWAN have all EOS instances mounted as shared mounts and you can immediately use them!

EOS provides the same authentication methods for filesystem access as for the EOS shell.
The implementation is POSIX-like and not completely POSIX conform e.g. there is no root access to EOS using a mount! Some specific applications might not work due to variations in ownership/permission handling!

Important to know:

Accessing the same files from several clients at the same time can create unexpected results/race-conditions. open/creations/renames are consistent between clients, stat and deletions are asynchronous and might not see the latest state of a file/directory when racing between several clients!

Using EOS - EOS as a LINUX filesystem

How to mount a specific EOS instances on a private node or VM e.g. a CERNBox user directory:

```
# create a directory and mount an instance
mkdir -p /eos/user/f/foo/
mount -t fuse eosxd -ofsname=eoshome-f.cern.ch:/eos/user/f/foo/ /eos/user/f/foo/ # as root
#             eosxd -ofsname=eoshome-f.cern.ch:/eos/user/f/foo/ /eos/user/f/foo/ # as user
kinit foo
ls -la /eos/user/f/foo/

# in case of problem, stop the mount
umount -fl /eos/user/f/foo/
# fusermount -u /eos/user/f/foo/ # as user LINUX/MAC

# start from top …
```

Using EOS - EOS as a LINUX filesystem

How to mount a specific EOS instances on a private node or VM e.g. EOSATLAS

```
# create a directory and mount an instance
mkdir -p /eos/atlas/
mount -t fuse eosxd -ofsname=eosatlas.cern.ch:/eos/atlas/ /eos/atlas/ # as root
# eosxd -ofsname=eosatlas.cern.ch:/eos/atlas/ /eos/atlas/ /eos/atlas/ # as user

kinit foo
ls -la /eos/atlas/

# in case of problem, stop the mount
umount -fl /eos/user/f/foo/ # as root
# fusermount -u /eos/atlas/ # as user LINUX/MAC
# start from top …
```

Using EOS - EOS as a LINUX filesystem

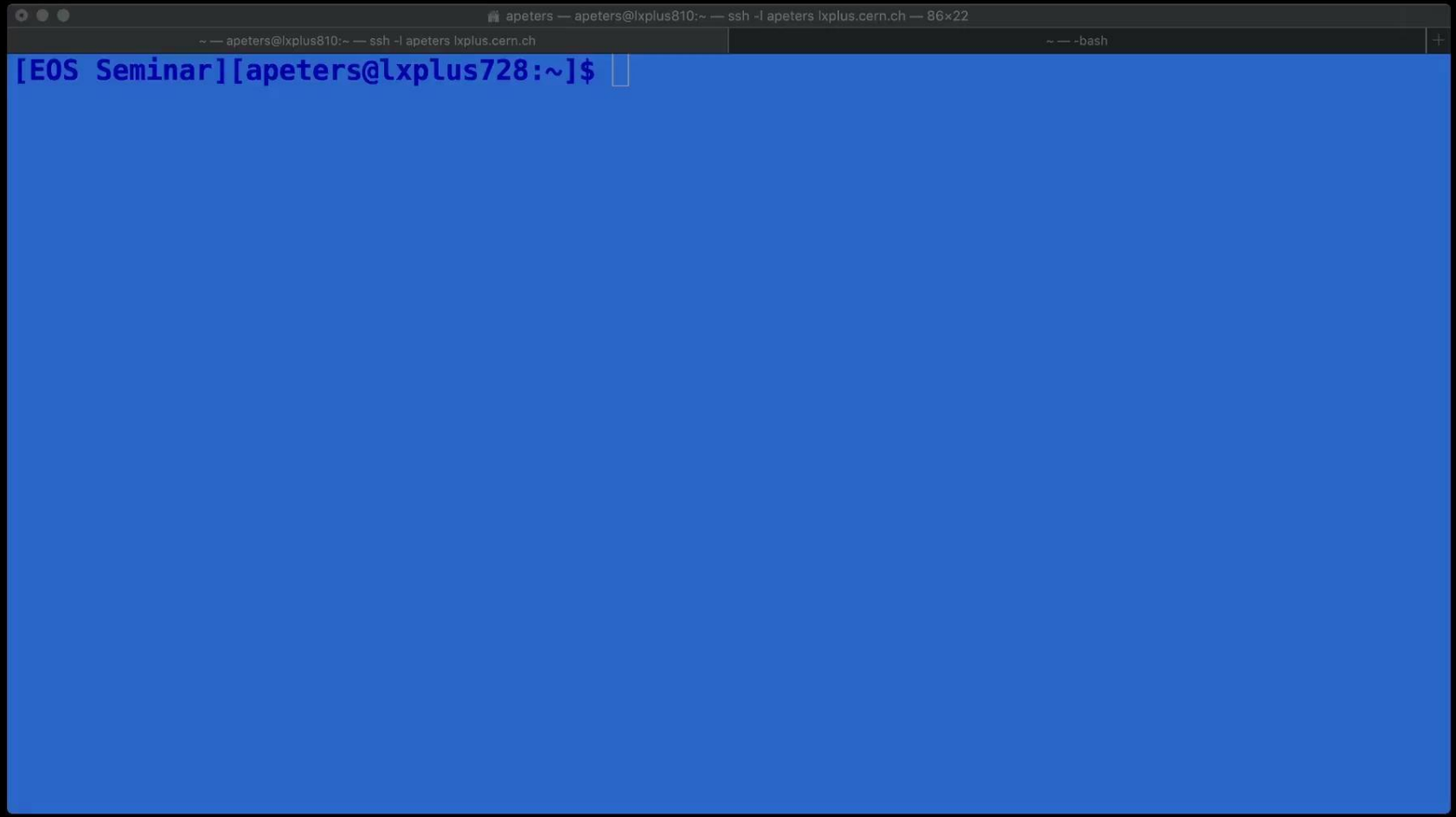
How to deal with authentication problems:

- If you use Kerberos V on your own machine, make sure, that your kerberos cache is stored as a file
  KRB5CCNAME := FILE:/tmp/krb5cc_$UID
  or as a type KEYRING: not with type KCM: !!! This is shown when typing `klist`

- You can see, how your `/eos` mount authenticates by issuing against any EOS path you want to use
  e.g. `/eos/user/f/foo/`
  `eosxd get eos.reconnect /eos/user/f/foo/`

  If the output does not give you a clue, you can submit a ticket attaching the output to get assistance

Good to know: if you change an environment variable like KRB5CCNAME it is only visible to child commands of your shell. F.e. if you use cd in this shell, it will not use the new KRB5CCNAME yet since `cd` is not a new process! The solution is to create a new shell and continue to work!


apeters — apeters@lxplus810:~ — ssh -l apeters lxplus.cern.ch — 86×22
~ — apeters@lxplus810:~ — ssh -l apeters lxplus.cern.ch
~ — -bash
[EOS Seminar][apeters@lxplus728:~]$

Using EOS - EOS as a filesystem using **sshfs**

The simplest way to get all EOS instances available doing one mount on almost any platform is to install sshfs.

To install on LINUX:

```
sudo yum install -y sshfs  # Redhat flavor

sudo apt-get install sshfs # Ubuntu flavor
```

For Windows follow https://github.com/winfsp/sshfs-win
For MacOSX follow https://osxfuse.github.io/

Using EOS - EOS as a filesystem using **sshfs**

After installation one can issue a mount command. By default your CERN password will be asked. An alternative is to deploy SSH keys to avoid password input during mounting!

Good to know: the default performance on OSX is not that great without tuning of the blocksize!

```
# create a directory and mount an instance on Linux/OSX
mkdir -p $HOME/eos/
sshfs foo@lxplus.cern.ch:/eos/ $HOME/eos/
ls -la $HOME/eos/

# in case of problem, stop the mount
# linux: fusermount -u $HOME/eos
# mac osx: diskutil umount force $HOME/eos/
# start from top …
```

Mounting EOS with autofs on LINUX

- The procedure to mount all EOS instances on an unmanaged machine as adminstrator is described in this knowledge base article
  - it is inconvenient

- A simpler RPM based procedure using the KOJI repository is

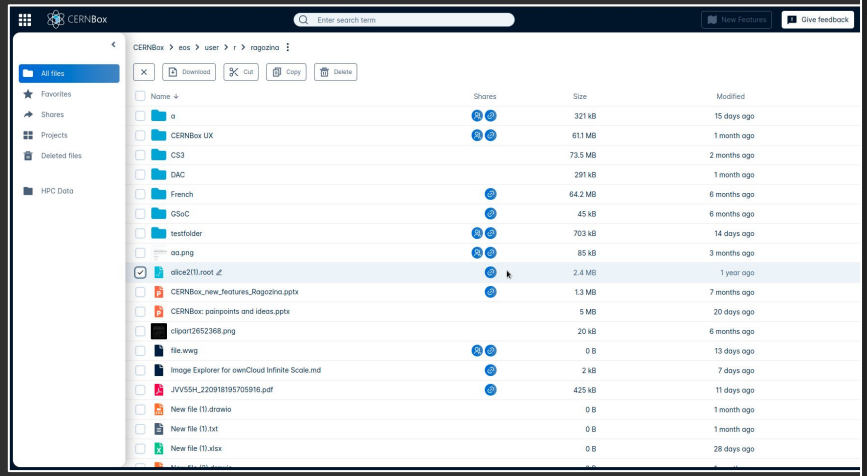
```
yum install -y cern-eos-autofs
systemctl start autofs
```

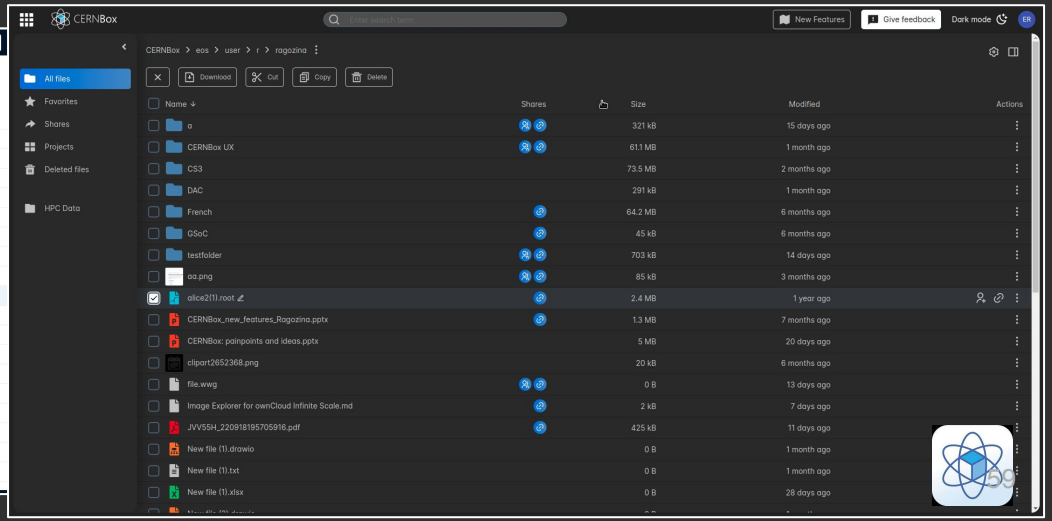
Using EOS - CERNBox

- CERNBox provides:
  - Web UI access to EOS storage:
    - File management (upload, download, view)
    - Share management (public links, direct sharing)
    - Online collaboration tools (MS Office, codimd, etc)
  - Sync clients for desktops (Windows, macOS, linux)
    - Allows have a full/partial local sync of data stored on EOS for offline access.
  - SMB (SAMBA) online access from Windows hosts as a mounted network drive.
  - Mobile device access (iOS/Android)
  - SWAN, Indico integrations

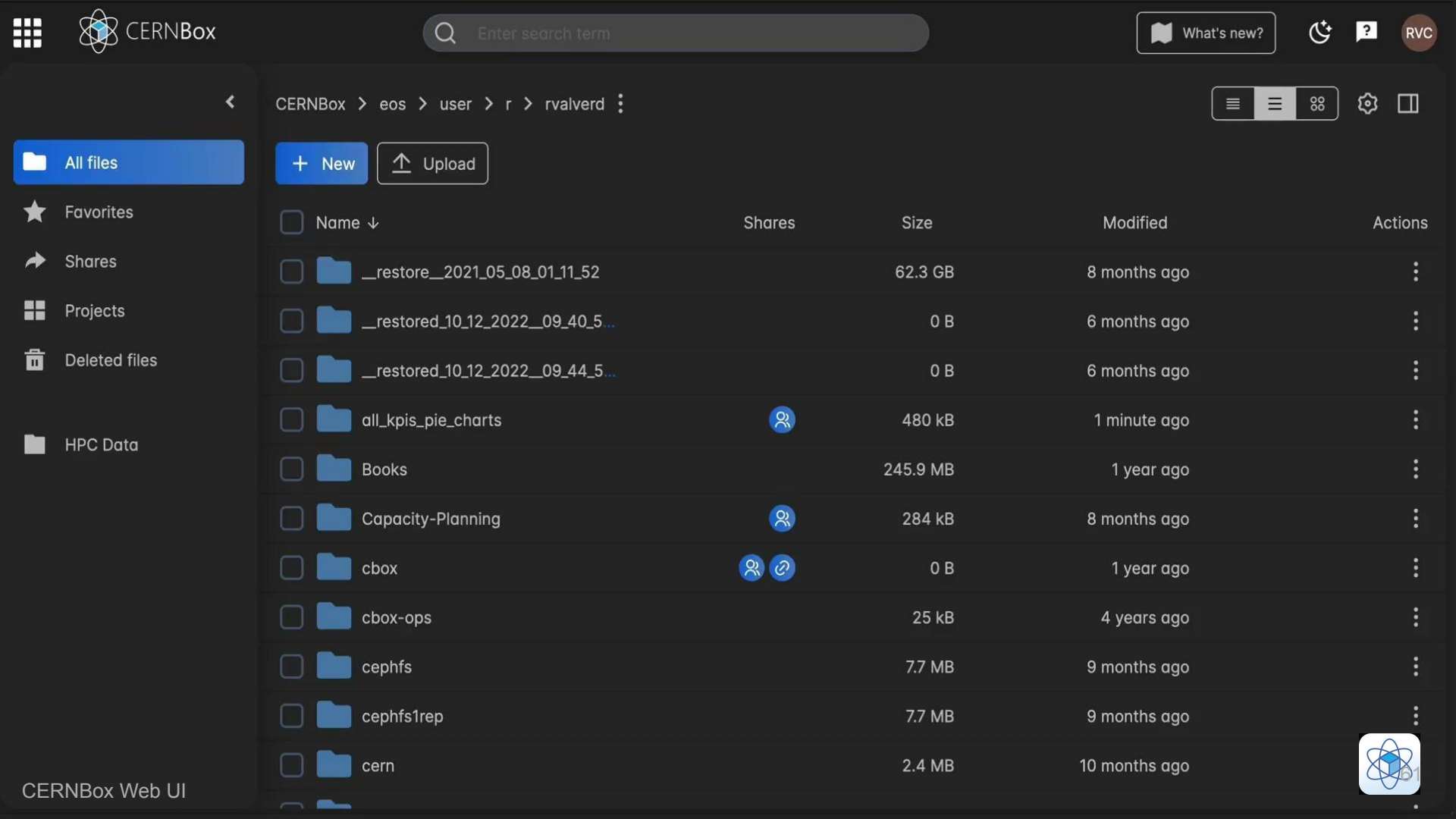
Using EOS - CERNBox: Web Interface

- Accessible via: https://cernbox.cern.ch for all CERN users.
  - First access to the interface will create and configure the EOS area automatically.
  - Enabled for /eos/user and /eos/project areas.
  - In pre-production for access to EOS physics storage.



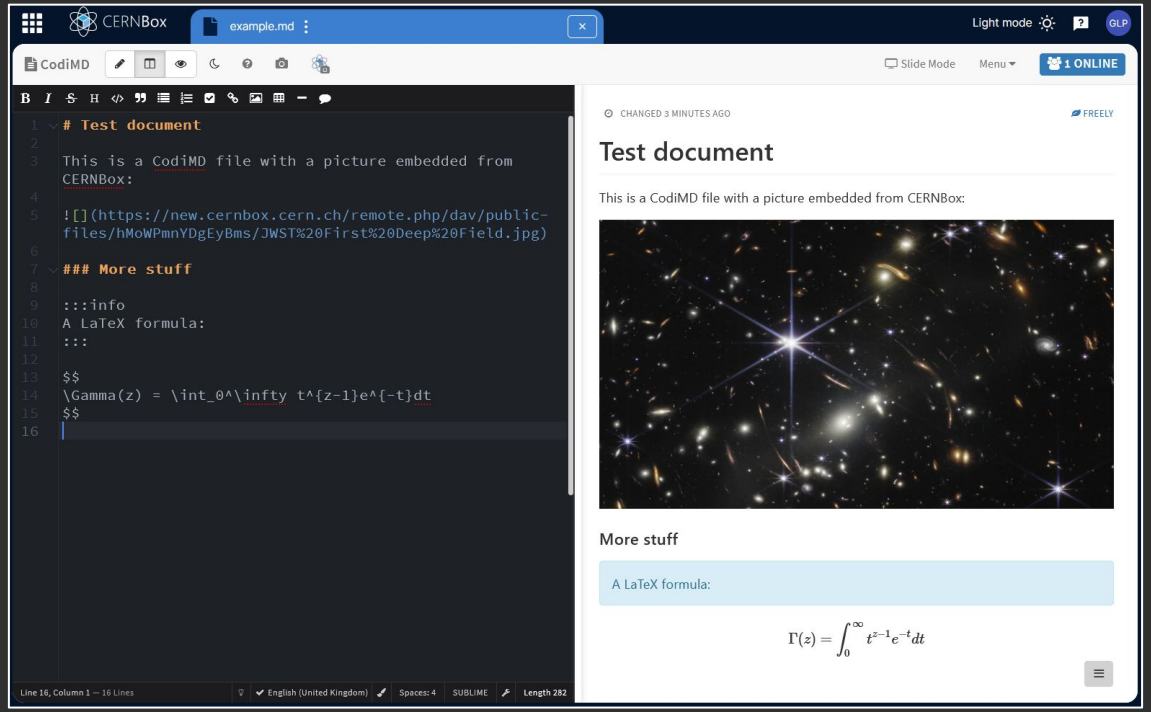


CERNBox Web Interface


CERNBox
Enter search term
What's new?
RVC
CERNBox > eos > user > r > rvalverd
All files
Favorites
Shares
Projects
Deleted files
HPC Data
New
Upload
Name
Shares
Size
Modified
Actions
__restore__2021_05_08_01_11_52 62.3 GB 8 months ago
__restored_10_12_2022__09_40_5... 0 B 6 months ago
__restored_10_12_2022__09_44_5... 0 B 6 months ago
all_kpis_pie_charts 480 kB 1 minute ago
Books 245.9 MB 1 year ago
Capacity-Planning 284 kB 8 months ago
cbox 0 B 1 year ago
cbox-ops 25 kB 4 years ago
cephfs 7.7 MB 9 months ago
cephfs1rep 7.7 MB 9 months ago
cern 2.4 MB 10 months ago
CERNBox Web UI

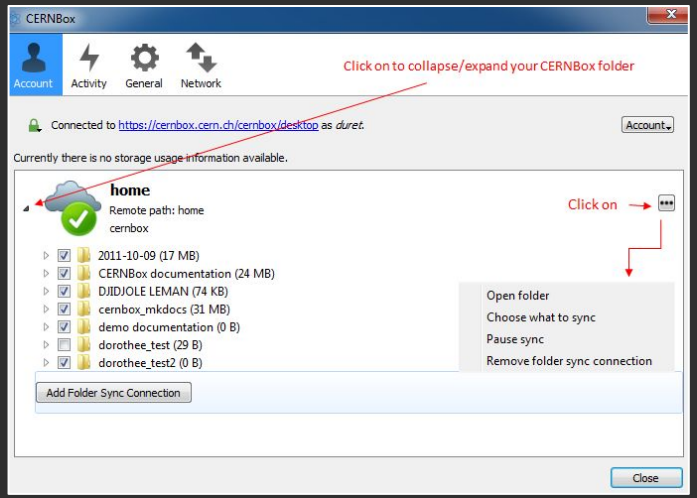
Using EOS - CERNBox Online Apps

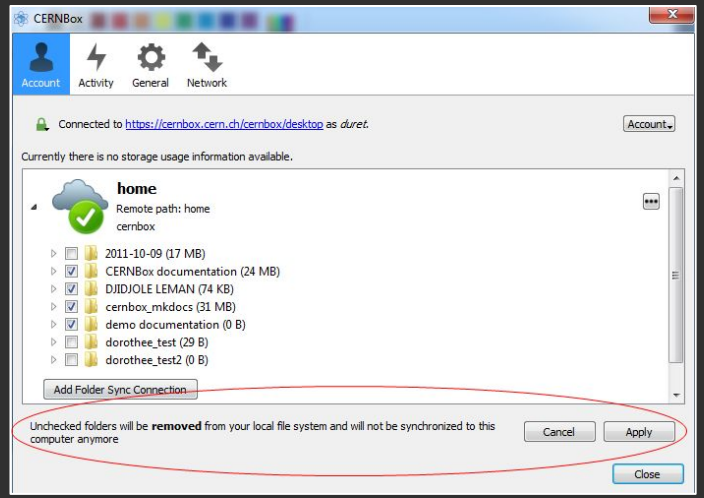
Application	Opens	Creates	Allows editing
Microsoft Office 365	Office files	.docx, .pptx, .xlsx	✓
CodiMD	Markdown files (.md, .zmd)	.md, .zmd	✓
Draw.io	diagrams (.drawio, .vsdx)	.drawio	✓
Text editor	text files (.txt) and .js, .json, .xml, .py, .php, .yaml	.txt	✓
PDF viewer	.pdf		×
Jupyter viewer	.ipynb		×
Open in SWAN	.ipynb		✓
IFC viewer	.ifc		×
ROOT viewer	.root		×
Media viewer	photos and videos (.png, .jpg, .jpeg, .gif, .mp4, .webm, .ogg)		×



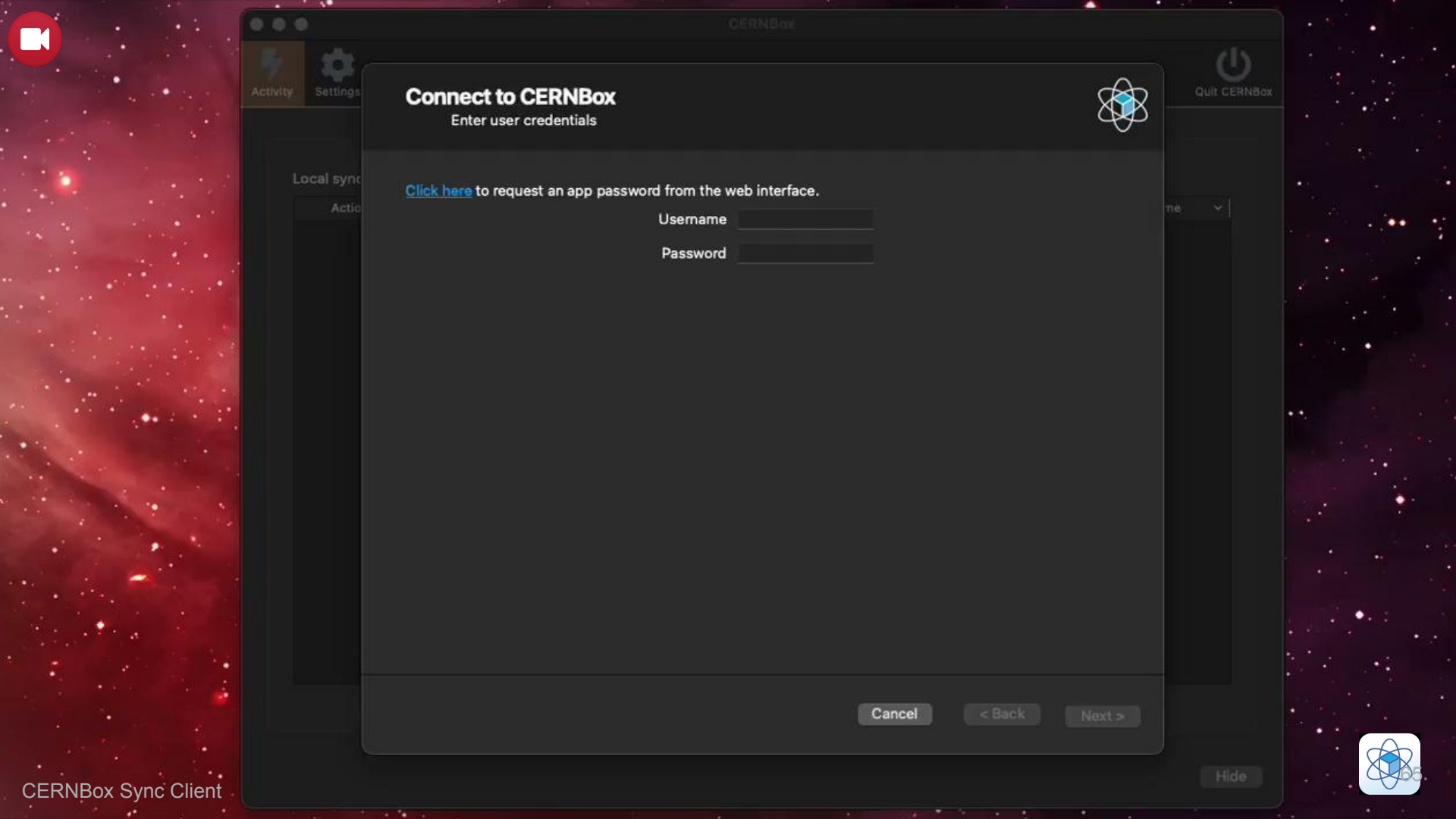
Using EOS - CERNBox: Clients

- Desktop sync client allows to synchronize EOS data to local device for offline access.
  - Available for Windows, Mac and Linux
  - Latest clients available here: https://cernbox.web.cern.ch/cernbox/downloads/





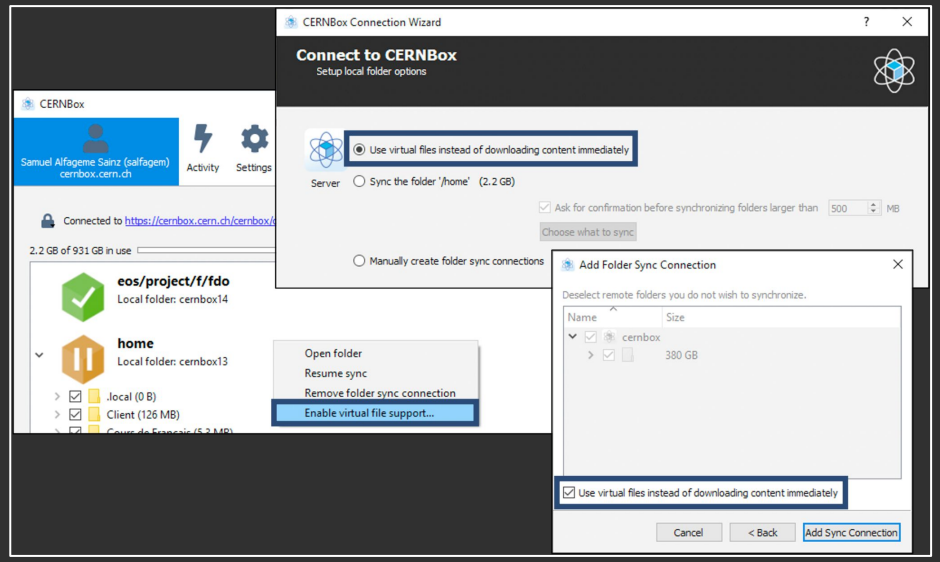
CERNBox Sync client

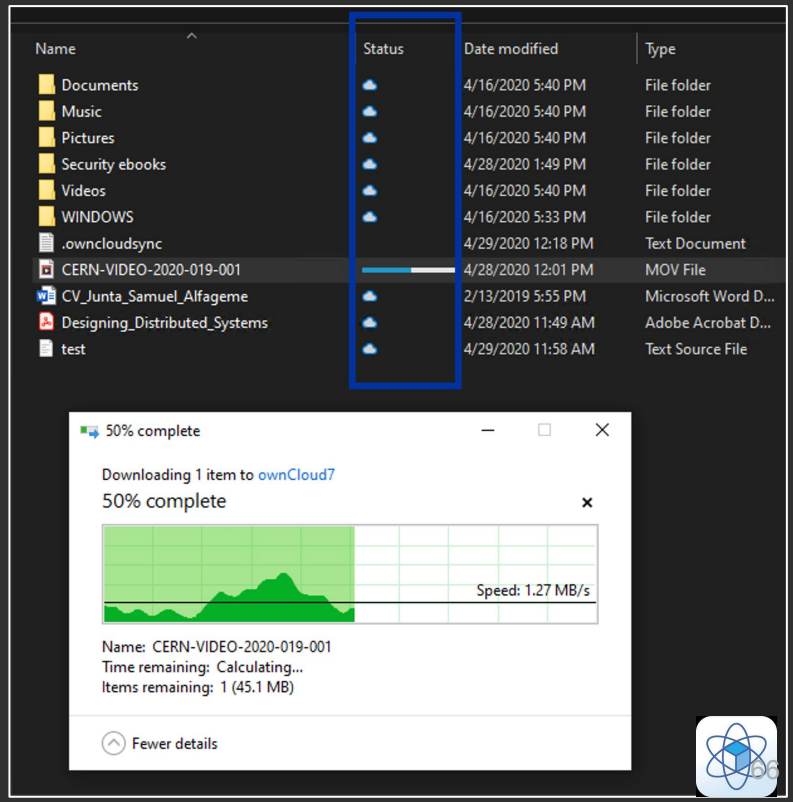


CERNBox Sync Client

Using EOS - CERNBox: Clients (II)

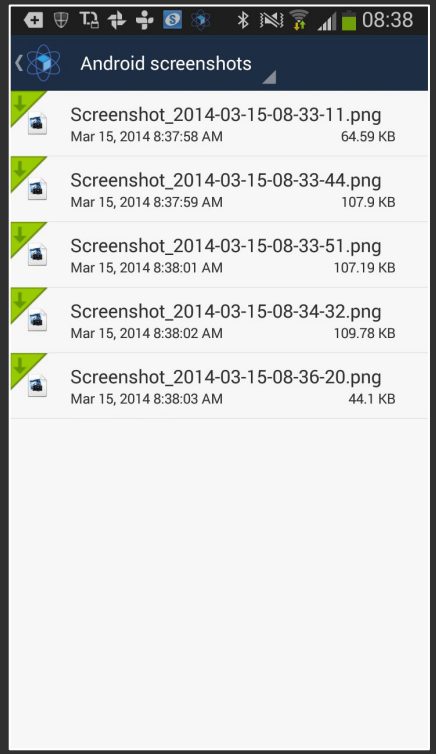
- Virtual files support (Windows)
  - Available since version 2.9.2
  - Local view of all EOS storage but only downloads files on demand.

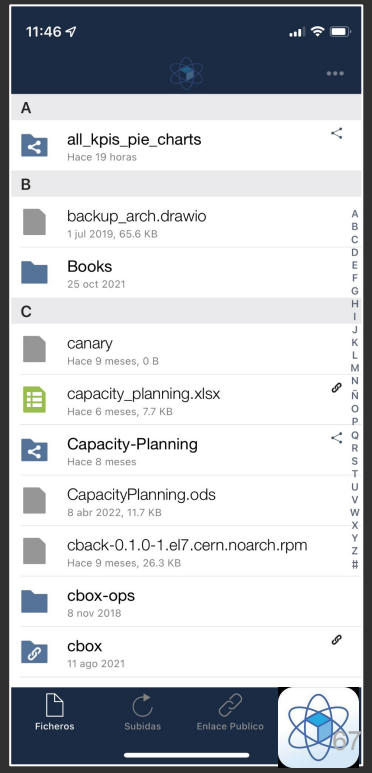




Using EOS - CERNBox: Mobile clients

- Mobile clients allow access to EOS storage on the go
- Android and iOS supported
- Automatic file upload





CERNBox Sharing

CERNBox Sharing

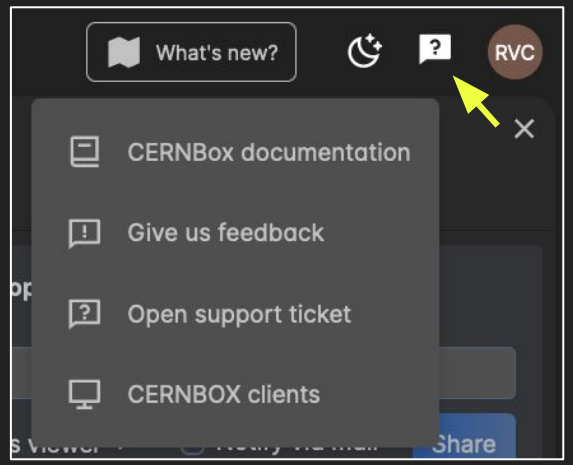
Using EOS - CERNBox: Windows Clients

- You can mount EOS/CERNBox on Windows as an external drive or access it directly in the explorer
  - The procedure is explained here
  - The windows path you have to use looks like:
    `\\cernbox-smb.cern.ch\eos\user\f\foo`

- The exported EOS paths are for the time being
  - `/eos/engineering`
  - `/eos/experiment`
  - `/eos/geant4`
  - `/eos/media`
  - `/eos/opendata`
  - `/eos/project`
  - `/eos/theory`
  - `/eos/user`
  - `/eos/web`

Using EOS: CERNBox Training

- There are two training courses available
  - CERNBox: Synchronisation, Sharing and Collaboration
  - CERNBox: Project Space
- A lot of useful information can be found in the CERNBox Manual
  - EOS/CERNBox documentation



Using EOS - application access using remote protocols

- The native protocol of EOS is XRootD protocol, which is referenced in URLs as `root://eosatlas.cern.ch//eos/atlas/…`
  - note the double slash after the host name !

- XRootD protocol is natively supported by **ROOT** - it provides also a very useful copy command line tool **xrdcp**

  - xrdcp is a recommended option to do recursive copies of directory tree
    - xrdcp supports a parallel mode, where several files of a recursive copy a copied in parallel

      `xrdcp --parallel 16 -R root://eosatlas.cern.ch//eos/atlas/higgs/ /data/higgs/`
  - xrdcp allows to copy from local to remote, from remote to local, local to local and from remote to remote (EOS to EOS instance)

    `xrdcp root://eosatlas.cern.ch//eos/atlas/file1 root://eoscms.cern.ch//eos/cms/file2`

- **ROOT** can open files on EOS using this syntax:

  ```
  TFile::Open("root://eoscms.cern.ch//eos/cms/higgs/all.root");
  ```

  PyROOT

  ```
  import ROOT
  ROOT.TFile.Open("root://eoscms.cern.ch//eos/cms/higgs/all.root","READ");
  ```

Using EOS - application access using remote protocols

- EOS provides additionally access using the HTTP(S) protocol
  - Namespace access is done using HTTPS for security reasons
  - Data transfers are done using HTTP protocol for performance reasons
  - The port number for HTTP access is 8444 on physics instances
    - Good to know: CERNBox is to be migrated to the same schema, not yet available in the same way, currently there is WebDAV access through CERNBox gateways
  - There is no Kerberos V authentication configured for HTTP(S)
  - However HTTP(S) can be used with EOS tokens easily
    - See example:


```
TOKEN=`eos token --path /eos/atlas/ --tree -permission
rx`
curl -H "Authorization: Bearer $ TOKEN" -L
https://eosatlas.cern.ch//eos/atlas/group/file.root
```

*you can only get a token for the access permission you posses!

Using EOS - Webpages in EOS wwweos

You can deploy websites in EOS using the webEOS service

- All the information to get a personal or project site up and running is explained in the Web Service Portal and in even more detail in the CERNBox Documentation
- The web directory for a personal page of user foo is hosted on EOS/CERNBox under the folder
  `/eos/user/f/foo/www`
- The recommended web directory for a project foo hosted on EOS/CERNBox should be stored under the folder
  `/eos/project/f/foo/www/`
- Once your site is configured you can update it using any kind of tool using the EOS mount or via remote access protocols from you private machine or shared infrastructure nodes

Data Durability & Safety

Preventing accidental deletions, unwanted modifications, etc.

- Data Redundancy
- Backup of your data
- Recycle Bin & Undo Deletion
- File Versioning

EOS Redundancy & Backups

- How do we make sure, no data / meta data gets lost?
  - The namespaces in EOS are secured with threefold replication and nightly backups
  - Your data in physics instances is stored with redundancy
    - **D2** (equivalent of two copies) - most data of today uses two replicas per file
    - **D3** (equivalent of three copies) - newer setups use s.c. erasure coding with 2 parities
    - GRID data is replicated often also outside of CERN by experiment GRID middleware tools
    - RAW data is typically stored also on two tapes

      Good to know: There is no automatic backup on physics instances!

  - Your data in CERNBox is stored with redundancy
    - **D2** (equivalent of two copies)
    - All data in CERNBox is backed up daily to a storage system with different technology **S3**
      - Backups are not point-in-time snapshots

Important to know: It is not possible to rollback a directory to a given state at an exact time

EOS Recycle Bin to UNDO deletions

- All CERNBox directories *(and physics instance directories on demand)* are configured in a way, that a deletion does not physically delete data when you issue a deletion command using the EOS shell or **`rm`** on the /eos/ mount
  - Data is kept at least for 6 month in the EOS recycle bin and can be restored using the CERNBox Web UI or the EOS shell
  - You can check if a directory has the recycle bin configured issuing a command like this receiving a not empty variable:

```
bash> eos root://eoshome-f.cern.ch attr get sys.recycle
/eos/user/f/foo/
sys.recycle="/eos/home-i04/proc/recycle/"
```

EOS Recycle Bin to UNDO deletions

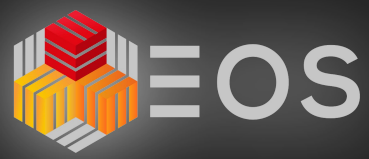
- You can list files attributed to your user name using:
  `bash> eos recycle ls`
  - Good to know: file end up always in the recycle bin of the owner of a file, not in the recycle bin of the user executing the deletion!
  - There are two types of entries in the listing
    - entries for each individual file deletion
      - each file has to be restored one by one
    - entries for subtree deletions via the EOS shell e.g. eos rm -rf /eos/tree/
      - one can restore the whole tree with a single command!
- You can restore a file using the displayed key from the listing command:
  `bash> eos recycle restore fxid:00000000012345678`
    - The restore directory has to exist, if not one can add the **-p** flag to re-create the needed parent directories

- If you deleted (too) many files by mistake and don't manage to restore them, you can submit a SNOW ticket and ask for help!

- The recycle bin is also available in the CERNBox UI, which is good to get single files back!

EOS File Versioning

- All CERNBox directories *(and physics instance directories on demand)* are configured in a way, that a file replacement creates a new version of an existing file - up to 20 versions are kept in time bins enlarged by age (see documentation)
  - Example how two versions of file.1 are created on EOS:
    ```
    xrdcp /tmp/file.1 root://eoshome-f.cern.ch//eos/user/f/foo/file.1
    xrdcp /tmp/file.1 root://eoshome-f.cern.ch//eos/user/f/foo/file.1
    ```
  - Inspect existing versions:
    ```
    eos file versions /eos/user/f/foo/file.1
    ```
  - Put back a specific version
    ```
    eos file versions /eos/user/f/foo/file.1 1681757784.0014ede7
    ```
  - Create a new version manually
    ```
    eos file version /eos/user/f/foo/file.1
    ```
  - Create a new version and keep only N (e.g. 5)
    ```
    eos file version /eos/user/f/foo/file.1 5
    ```



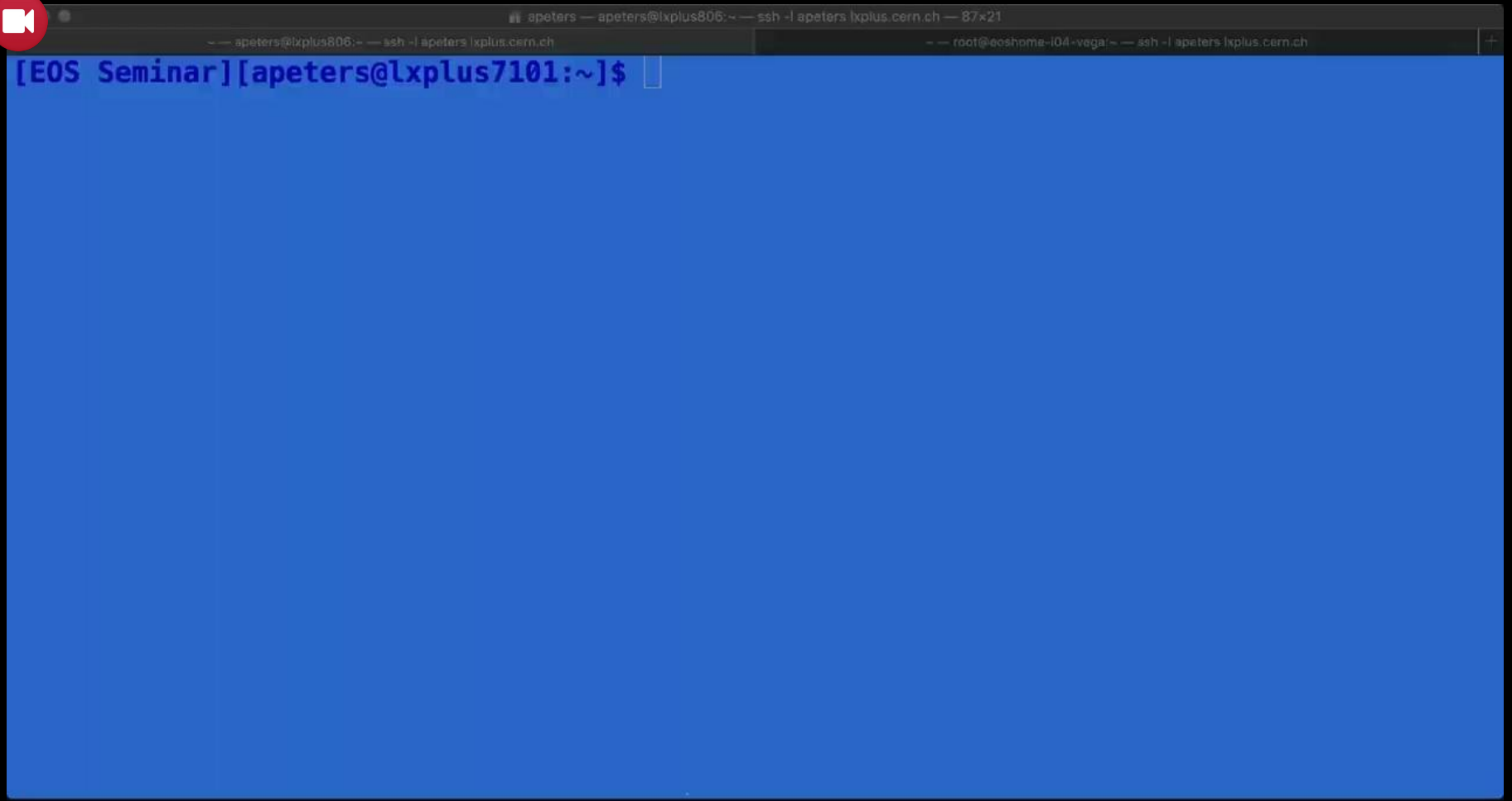
Sharing Data

“I cannot chmod 777 on EOS 😢”

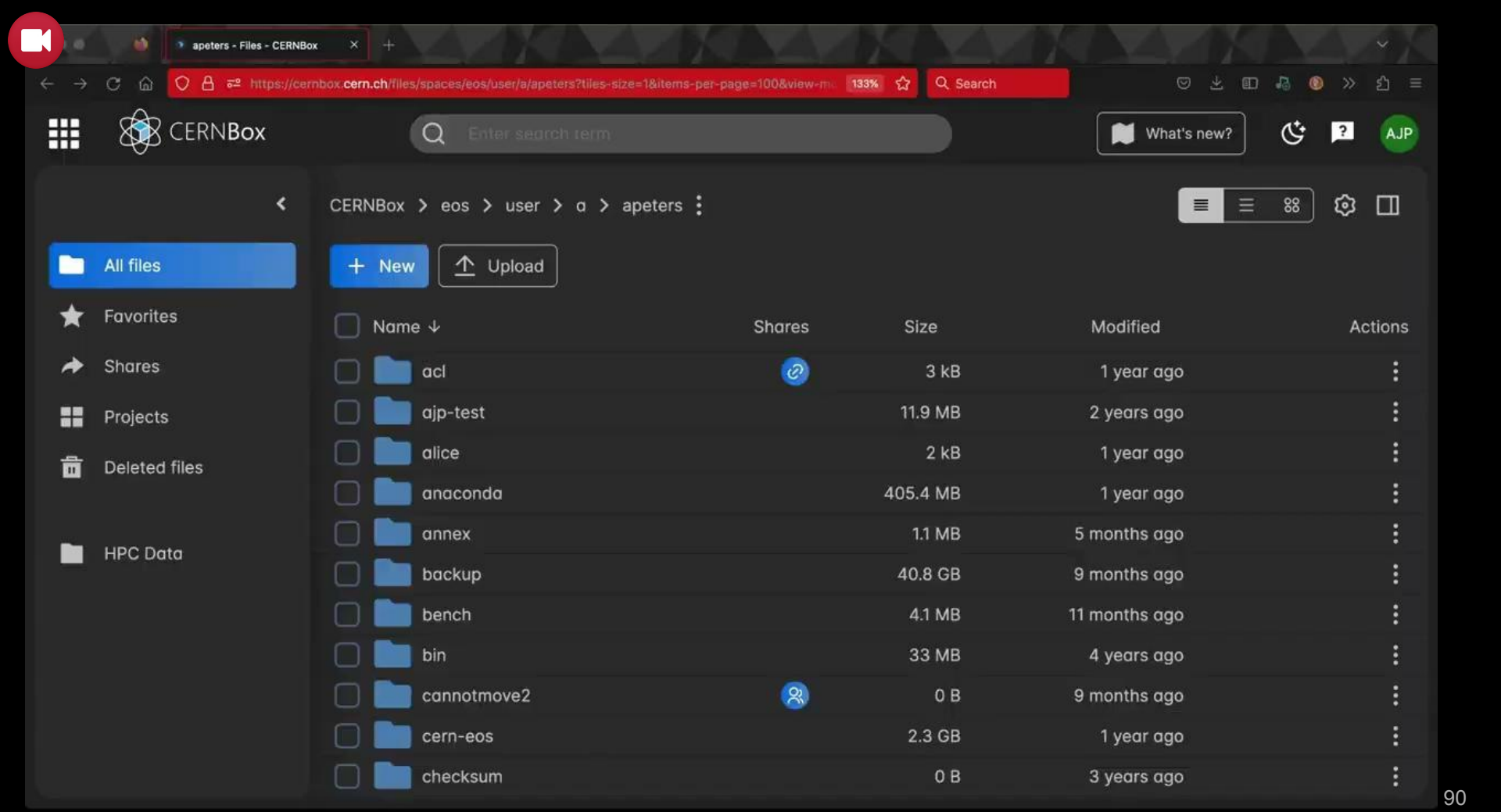
- EOS permission system
- Sharing files or subtrees using CERNBox

The EOS Permission system

- EOS supports a rich custom **A**ccess **C**ontrol **L**anguage to express permissions and user/group ownership
  - EOS displays ownership and POSIX modes as any filesystem, but permissions might be masked or denied by ACL entries
    - in most instances public permissions like 755 allowing anyone to read and browse are masked automatically as 750, which you can also summarize as "If you are not member of the my group, you cannot read or browse here"
  - By default permission and ACL modifications **are not allowed** due to security considerations
    - CERNBox allows to share files or directory trees specifying permissions
    - Only few managers have the power to change ownership, change mode or ACL entries
- It is not too important for you to know how to define permissions, this is entirely up to experiment responsibles, service administrators - you cannot change them!
  - But, you can grant permissions to others using the CERNBox UI
  - If you own on a project, the people with access are defined by an EGROUP and you can add and remove access to your project by modifying the EGROUP


apeters — apeters@lxplus806:~ — ssh -l apeters lxplus.cern.ch — 87×21
~ — apeters@lxplus806:~ — ssh -l apeters lxplus.cern.ch
~ — root@eoshome-i04-vega:~ — ssh -l apeters lxplus.cern.ch
[EOS Seminar][apeters@lxplus7101:~]$

CERNBox Sharing


apeters - Files - CERNBox
https://cernbox.cern.ch/files/spaces/eos/user/a/apeters?tiles-size=1&items-per-page=100&view-m
133%
Search
CERNBox
Enter search term
What's new?
AJP
CERNBox > eos > user > a > apeters
All files
Favorites
Shares
Projects
Deleted files
HPC Data
New
Upload
Name
Shares
Size
Modified
Actions
acl 3 kB 1 year ago
ajp-test 11.9 MB 2 years ago
alice 2 kB 1 year ago
anaconda 405.4 MB 1 year ago
annex 1.1 MB 5 months ago
backup 40.8 GB 9 months ago
bench 4.1 MB 11 months ago
bin 33 MB 4 years ago
cannotmove2 0 B 9 months ago
cern-eos 2.3 GB 1 year ago
checksum 0 B 3 years ago

Synchronisation & Backup Tools

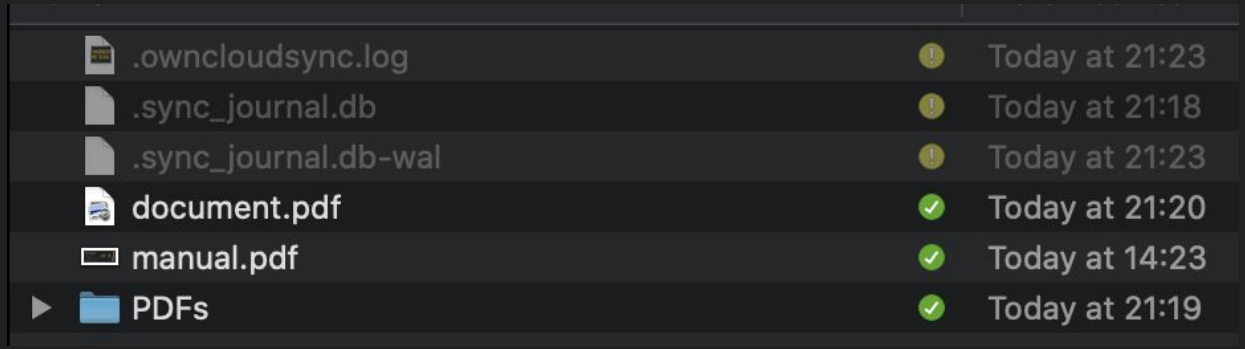
Benefit from tools for offline access to part of your data, folder synchronisation etc.

- Synchronize from your device to EOS using CERNBox
- Generic synchronization tools
  - rsync
  - rclone
  - restic

Synchronisation/Backup Tools

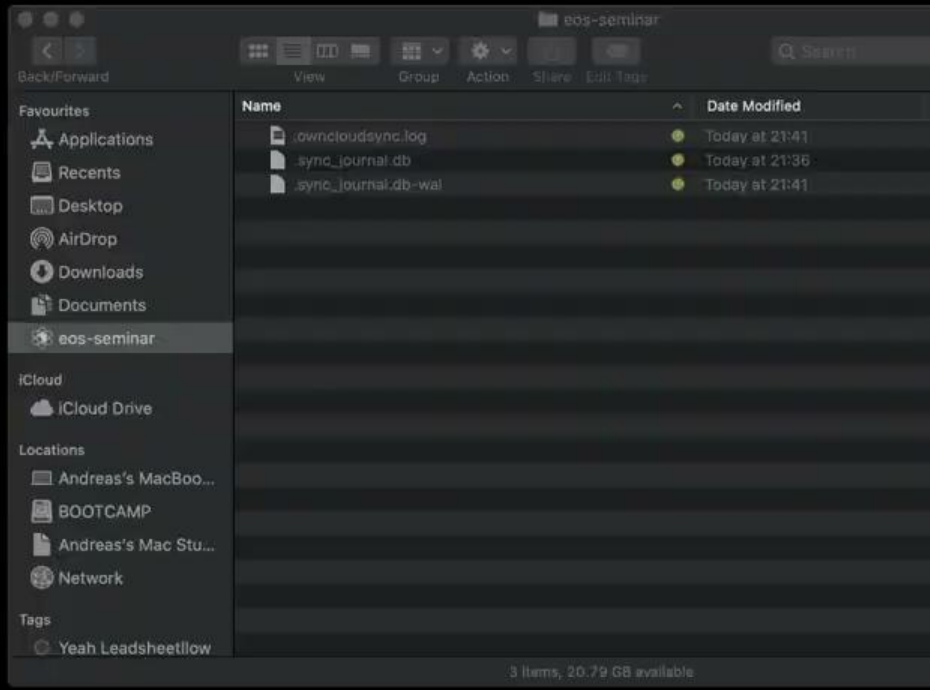
CERNBox Synchronisation

- The video will demonstrate how you create a sync folder connection between your local machine and EOS
  - CERNBox is nicely integrated into the OSX Finder and the synchronisation status of files is colour coded




Downloads
Today
PDF


[EOS Seminar][apeters@lxplus810:/eos/user/a/apeters/eos-seminar]$


eos-seminar
Back/Forward
View
Group
Action
Share
Edit Tags
Favourites
Applications
Recents
Desktop
AirDrop
Downloads
Documents
eos-seminar
iCloud
iCloud Drive
Locations
Andreas's MacBoo...
BOOTCAMP
Andreas's Mac Stu...
Network
Tags
Yeah Leadsheetllow
Name
Date Modified
.owncloudsync.log
Today at 21:41
.sync_journal.db
Today at 21:36
.sync_journal.db-wal
Today at 21:41
3 items, 20.79 GB available

Synchronisation/Backup Tools

CERNBox Synchronisation

- **Some Shortcomings …**
  - CERNBox cannot sync symbolic links
  - CERNBox cannot sync hardlinks
  - CERNBox does not preserve ownership
  - CERNBox does not preserve modes
  - So do not …
    - sync GIT repositories
    - sync your OS installation
    - …
- **Some Great Features …**
  - Every file transfer is checksummed, files a retransfered in case of corruption
  - Interrupted transfers resume and don’t start again from scratch

So, in some cases we still need other tools …

Synchronisation/Backup Tools

Rsync

- rsync is a standard linux tool
- It allows you to synchronize data from external file systems to/from `/eos/`
  - when writing to EOS ownership is not preserved, in physics instances you will create files with the owner associated to your credentials, in CERNBox ownership is hardcoded by the target directory - if you can write in a directory the ownership will be the same as the directory where you write to
  - POSIX ACLs are not supported on EOS, so don't use the **-A** option
  - You are only allowed to write extended attributes with a `user.*` prefix, so it is not possible to preserve all system attributes using -X
  - You are not allowed to change ownership
  - rsync can also be used over SSH(lxplus) to synchronize from external machines without local /eos/ mount
- Please: don't synchronize large directory trees with millions of entries continuously due to the repetitive load on the EOS instance involved

Synchronisation/Backup Tools

Rclone

- rclone is a very powerful tool to bridge between various storage systems
  - You can synchronize/backup/copy your GOOGLE drive to/with EOS
  - You can synchronize/backup/copy your ONEDRIVE to/with EOS
  - … Amazon S3 to/with EOS
  - … and many more

- We will demonstrate how to use EOS tokens, HTTPS and rclone to synchronize data from EOS to the local disk
  - Unfortunately rclone does not support a crucial HTTP feature (100-CONTINUE), so one cannot upload data to EOS using HTTPS protocol, but we can download
  - via a FUSE mount or SFTP protocol (via lxplus!) this is no problem

Synchronisation/Backup Tools

Restic

- restic is a modern backup program, which we also use to backup CERNBox itself to S3
  - The IT-SD group is also working to interface it with the CERN Tape Archive to allow backups to tape
- restic implements very efficiently full and incremental backups
  - backups can be mounted like a hard drive using FUSE and you can just get backup files back using standard tools
- restic can use EOS as a backend when a /eos/ local mount is available on client side or using SFTP remote protocol via lxplus nodes!

Synchronisation/Backup Summary

- There is no “one fits all” solution
  - For laptops and desktops CERNBox is the most comfortable synchronisation solution with a lot of advanced features and graphical configuration
  - The CERNBox team is adding currently a self-service feature to get access to your backups!
- For workflows synchronising small/medium-sized subtrees rsync is a good solution
- To synchronise cloud services rclone is a good choice with SFTP over lxplus to EOS
- Restic can be used to store a private encrypted backup on EOS (or S3 or many other …)
  - a CERN service with backup on tapes is currently worked on!
- We have a proposal to provide storage gateway nodes for all kinds of protocols and tools to route IO activities not anymore via lxplus.cern.ch but via dedicated nodes

Running Workflows Using EOS

How to best use EOS from applications?

- Efficient usage from laptops, desktops
- Efficient usage on lxplus
- Efficient usage from batch jobs

Running Workflows with EOS

Best practices

- Whenever you can avoid mounting, use remote access protocols e.g. access files in ROOT, PyROOT etc. using URLs `root://eoscms.cern.ch//eos/cms/...` instead of `/eos/cms/…`
  - Good to know: since ROOT release 6.28 ROOT automatically switches from `/eos/…` to `root://eosxyz//eos/…` automatically when using TFile::Open()
- Don’t use `/eos/` to synchronize/define your batch jobs on many clients
  - A bad example: you submit 1000 jobs and each job picks from a directory with 100k files the next file to work on - by listing always 100k files and rename one by one after processing. Often this might end up with your account being blocked until your jobs are killed!

Running Workflows with EOS

Best practices

- Batch Job Submission
  - As of today it is not allowed to submit batch jobs directly from job files stored on EOS - read the batch documentation

- Batch Job Output
  - If your batch job result output is not extremely large
    - avoid writing files from your application directly to EOS which will keep files possibly opened for hours or days (in /eos/ or via root://)
    - write files into the local working directory (spool directory) of your batch job and use the XRootD HTCondor output file upload plug-in as documented here

Running Workflows with EOS

Best practices

- Don’t start large software frameworks from `/eos/`
  - Use a CVMFS installation or your AFS home directory
  - Software often creates very high meta-data load when done from 1000 batch jobs in parallel - in particular to point **LD_LIBRARY_PATH** to `/eos/` is bad for performance

- As comfortable as it might seem, don’t use `/eos/` to host your only copy of a very large GIT repository

  - GIT operations create very heavy meta-data workloads on EOS.
    The idea of GIT is, that you can checkout locally and synchronize your repository to the GITLAB or GITHUB service, not to host it on a shared filesystem!

  - If you really need, you can reduce the repository size using `git shallow clone`
    Or just install an archive repository on EOS (tarball)

Running Workflows with EOS

Best practices

- Avoid to write too many files into a single directory and list them
  - When you write more than 128k files into a single directory, `/eos/` will not show them anymore! You can even write many more, but you can see them only using the EOS shell
  - When 1000 jobs list once a directory with 100k files, the meta-data service has to provide 1000x100k = 100M entries !!!
- Avoid to create and append to log files stored on `/eos/`
  - Continuously open log files are a problem for operating the service
  - Ever-growing log files are a problem for operating the service
  - Appending to the same log file from 1000 of concurrent jobs should also be avoided

Running Workflows with EOS

Best practices

- Keep your files at reasonable size recom. < 50 GB
  - There is a 50GB file size limit on CERNBox for operational reasons
    - We have to shuffle files around e.g. to re-create redundancy and the time to copy very large files puts them at risk
- Avoid very small files in processing as input and output recom. > 10 MB
  - The minimum size for effective IO is few MBs
    - IO is effective when the time to open a file is small compared to the time of reading/writing bytes
    - If you read or write 1kb files, you get data rates of 250 kb/s from a single client
- Don’t create too many file open/s from many clients
  - Every user has a file open/s limit at 500/s defined, which enforces this rate
  - In the case you hit this limit more parallel jobs do not make the processing faster

Running Workflows on EOS

Best practices

- Don’t use EOS if you need data available only on a single VM or machine
  - Use local storage
  - Use Openstack Block Storage
  - Use Openstack Manila Shares

- Don’t use EOS if you have a low-latency use-case with data shared between few machines for a single user
  - Use Openstack Manila Shares

Running Workflows on EOS

EOS access from GITLAB

- The easiest way to get access to an EOS instances is to create an access token and use this in combination with remote protocols `root://` or `https://`
  (token usage documentation)
- Second alternative is to create a service account and use a Kerberos keytab file to create Kerberos token (knowledge base article)
- Third alternative is to use a GRID certificate and request to map its DN to your account
- In all cases all of them expire and might need to be recreated - moreover these credentials have to be handled in a secure way e.g. don't store them in a public GIT repository

Accessing EOS from outside CERN

- EOS services are accessible from the internet
  - You can run applications from outside CERN using remote access protocols (root:// https://)
  - You can mount EOS from external institutions or your desktop at home
    - network latency might give you a different user experience than at CERN
  - You have to authenticate in the same way you do at CERN (Kerberos, X509, Token)
    - `kinit foo@CERN.CH`

- CERNBox services are also accessible from the internet for synchronisation

Summary

- Our goal and intention is to make your work efficient with intuitive tools
- We do our best to consider your requirements and wishes
  - If you have proposals for improvements, let us know … e.g. via a SNOW ticket 😀
  - We know, not everything is perfect
- With this seminar we tried to connect you with information, which is sometimes not always easy to find!
- We hope it was useful for you!
- We will inject useful information from this seminar into new Knowledge Base articles (KB)
- Outlook: “EOS for advanced users”

Thank you! Questions? Comments?

EOS 2023 Workshop

24–27 Apr 2023
CERN
Europe/Zurich timezone

Enter your search term

- Overview
- Scientific Programme
- Call for Abstracts
- Timetable
- Contribution List
- My Conference
  - My Contributions
- Book of Abstracts
- Registration
- Participant List
- Privacy Information
- Videoconference

You are welcome to join the 7th EOS workshop tomorrow at CERN IT

https://indico.cern.ch/event/1227241/