



LUXEMBOURG
LET'S MAKE IT HAPPEN

Uni.lu HPC School 2021

Keynote: User environment and data management

Uni.lu High Performance Computing (HPC) Team

S. Peter

University of Luxembourg (UL), Luxembourg

<http://hpc.uni.lu>



Latest versions available on Github:



UL HPC tutorials:

<https://github.com/ULHPC/tutorials>

UL HPC School:

hpc.uni.lu/education/hpcschool

Keynote tutorial sources:

ulhpc-tutorials.rtfd.io/en/latest/data



Summary

1 Session Objectives

2 Data storage

- [Big] Data components in HPC
- Shared Storage on UL HPC
- User environment
- Quotas
- Backup

3 Data organisation and management

- File organisation and naming
- Version control with Git

4 Data security

- GDPR and data security
- Encryption
- Passwords

Motivation

- **HPC** = high performance **computing**

Motivation

- **HPC** = high performance **computing**
- But computing needs **input** and produces **output**
 - ↪ Both input and output might be very valuable

Motivation

- **HPC** = high performance **computing**
- But computing needs **input** and produces **output**
 - ↪ Both input and output might be very valuable
- There is also **code** that describes how to get from input to output

Motivation

- **HPC** = high performance **computing**
- But computing needs **input** and produces **output**
 - ↪ Both input and output might be very valuable
- There is also **code** that describes how to get from input to output
- Data and code need to be kept save and protected from unauthorized access

Motivation

- **HPC** = high performance **computing**
- But computing needs **input** and produces **output**
 - ↪ Both input and output might be very valuable
- There is also **code** that describes how to get from input to output
- Data and code need to be kept save and protected from unauthorized access
- Additional requirement: **reproducibility**

Data management definition

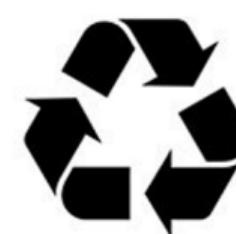
Definition

“Research data management (RDM) concerns the organisation of data, from its entry to the research cycle through to the dissemination and archiving of valuable results. It aims to ensure reliable verification of results, and permits new and innovative research built on existing information.”

Whyte, A., Tedds, J. (2011). 'Making the Case for Research Data Management'. DCC Briefing Papers.

FAIR data

Findable Accessible Interoperable Reusable



Wilkinson M, Dumontier M et al. Nature Scientific Data 2016. "The FAIR Guiding Principles for scientific data management and stewardship"

Questions

- **Data storage:**

- Where can I store my data on the HPC?
- What are the differences between the storage options?
- How safe is my data?
- What restrictions do I have in terms of storage?

Questions

- **Data storage:**

- Where can I store my data on the HPC?
- What are the differences between the storage options?
- How safe is my data?
- What restrictions do I have in terms of storage?

- **Data organisation/management:**

- How can I keep my files organised?
- How can I keep my code organised?

Questions

- **Data storage:**

- Where can I store my data on the HPC?
- What are the differences between the storage options?
- How safe is my data?
- What restrictions do I have in terms of storage?

- **Data organisation/management:**

- How can I keep my files organised?
- How can I keep my code organised?

- **Data security:**

- How should I deal with sensitive/personal data on the HPC?
- How can I protect my data from unauthorized access?
- How can I encrypt data on the HPC?
- What passwords should I use and how should I store them?

Session objectives

- Provide an overview of the **storage** options at UL HPC.
- Explain **quotas**, how to check them and what the default settings are.
- Provide information on what data is backed up
 - ↪ where and how long **backups** are retained.
- Give guidance on **data management**, file organisation and naming.
- Briefly introduce **version control** with git and it's benefits.
- Provide information on where **personal or sensitive data** is handled on the UL HPC
 - ↪ give recommendations how it can be secured.
- Introduce different file **encryption** options available on the UL HPC clusters.
- Explain which **passwords** are secure and how they can be stored.

Summary

1 Session Objectives

2 Data storage

- [Big] Data components in HPC
- Shared Storage on UL HPC
- User environment
- Quotas
- Backup

3 Data organisation and management

- File organisation and naming
- Version control with Git

4 Data security

- GDPR and data security
- Encryption
- Passwords

[Big]Data Management: FS Summary

- **File System (FS)**: Logical manner to *store, organize & access* data

- ↪ (local) **Disk FS** : FAT32, NTFS, HFS+, ext4, {x,z,btr}fs...
- ↪ **Networked FS** : NFS, CIFS/SMB, AFP
- ↪ **Parallel/Distributed FS**: SpectrumScale/GPFS, Lustre
 - ✓ typical FS for HPC / HTC (High Throughput Computing)

[Big]Data Management: FS Summary

- **File System (FS)**: Logical manner to *store, organize & access* data
 - (local) **Disk FS** : FAT32, NTFS, HFS+, ext4, {x,z,btr}fs...
 - **Networked FS**: NFS, CIFS/SMB, AFP
 - **Parallel/Distributed FS**: SpectrumScale/GPFS, Lustre
 - ✓ typical FS for HPC / HTC (High Throughput Computing)

Main Characteristic of Parallel/Distributed File Systems

Capacity and Performance increase with #servers

[Big]Data Management: FS Summary

- **File System (FS)**: Logical manner to *store, organize & access* data

- (local) **Disk FS** : FAT32, NTFS, HFS+, ext4, {x,z,btr}fs...
- **Networked FS**: NFS, CIFS/SMB, AFP
- **Parallel/Distributed FS**: SpectrumScale/GPFS, Lustre
 - ✓ typical FS for HPC / HTC (High Throughput Computing)

Main Characteristic of Parallel/Distributed File Systems

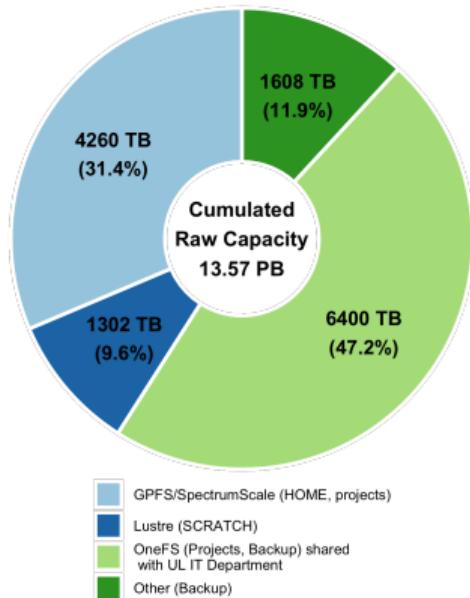
Capacity and Performance increase with #servers

Name	Type	Read* [GB/s]	Write* [GB/s]
ext4	Disk FS	0.426	0.212
nfs	Networked FS	0.381	0.090
gpfs (iris/aion)	Parallel/Distributed FS	22.58	19.02
lustre (iris/aion)	Parallel/Distributed FS	12.97	16,15

* maximum **random** read/write, per IOZone or IOR measures, using concurrent nodes for networked FS.

UL HPC Storage Systems

UL HPC Storage FileSystems (2021)



Understanding Your Storage Options

Where can I store and manipulate my data?

- **Shared storage**

- ↪ NFS - **not scalable** $\sim \simeq 1.5$ GB/s (R) $\mathcal{O}(100 \text{ TB})$
- ↪ GPFS - **scalable** $\sim \simeq 10$ GB/s (R) $\mathcal{O}(1 \text{ PB})$
- ↪ Lustre - **scalable** $\sim \simeq 5$ GB/s (R) $\mathcal{O}(0.5 \text{ PB})$

- **Local storage**

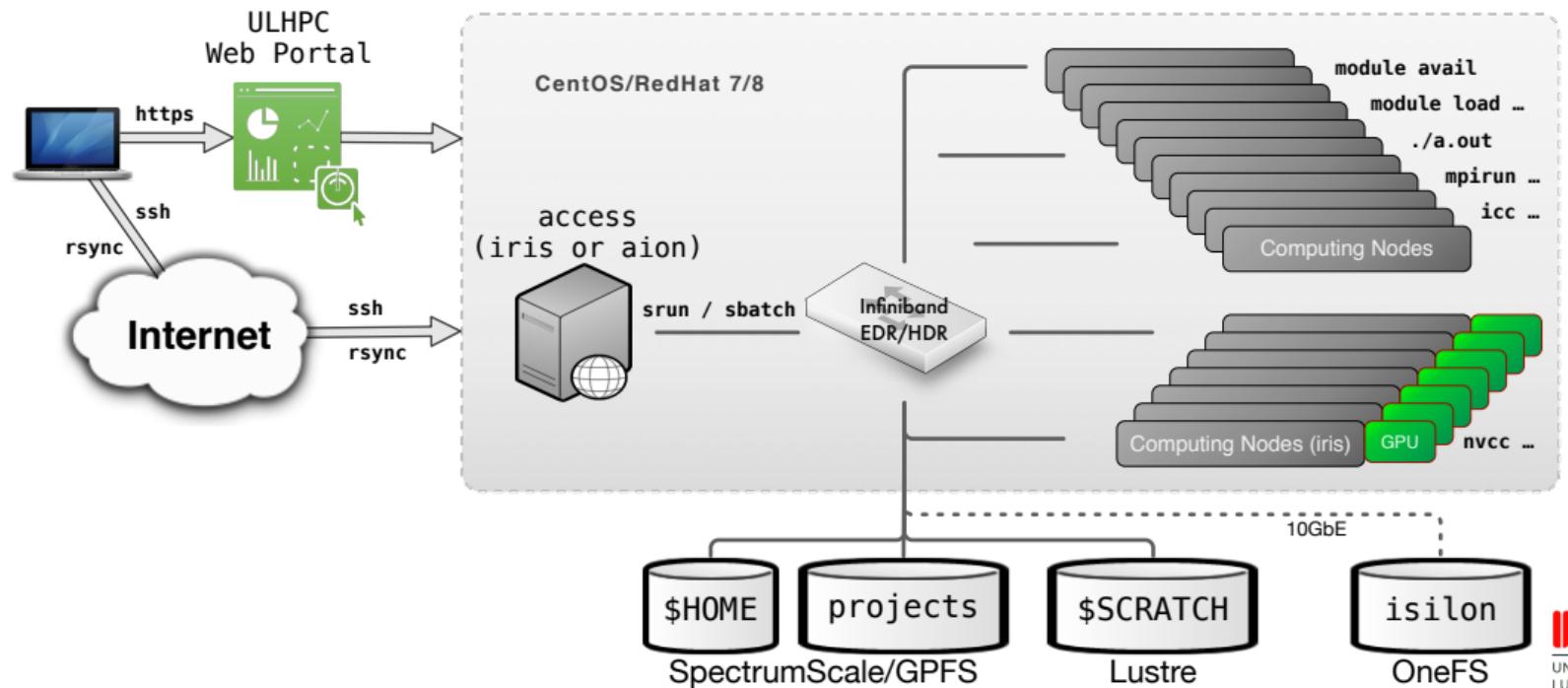
- ↪ local file system (/tmp) $\mathcal{O}(200 \text{ GB})$
 - ✓ over HDD $\simeq 100$ MB/s, over SDD $\simeq 400$ MB/s
- ↪ RAM (/dev/shm) $\simeq 30$ GB/s (R) $\mathcal{O}(20 \text{ GB})$

- **Distributed storage**

- ↪ HDFS, Ceph, GlusterFS - **scalable** $\sim \simeq 1$ GB/s

⇒ In all cases: small I/Os really **kill** storage performances

Compute Nodes Environment



Where is what

Directory	Env variable	Filesystem
/home/users	\$HOME	SpectrumScale
/work/projects	-	SpectrumScale
/scratch/users	\$SCRATCH	Lustre
/mnt/isilon/projects	-	OneFS

How to use

Directory	Usage
/home/users	personal space, software & packages
/work/projects	shared project storage
/scratch/users	intermediate fast storage, work here
/mnt/isilon/projects	archival storage, do not use for processing

Checking quota

Check file size quota with

```
df -ulhpc
```

Check inode quota with

```
df -ulhpc -i
```

Checking disk usage

Check free space on all file systems with

```
df -h
```

Check free space on current file system with

```
df -h .
```

To see what directories are using your disk space:

```
ncdu
```

Soft quota, hard quota and grace period

- Once you reach the **soft quota** you can still write data until the **grace period** expires (7 days) or you reach the **hard quota**.
- After you reach the end of the grace period or the hard quota, you have to reduce your usage to below the soft quota to be able to write data again.

Default quotas

Directory	size quota	inode quota
\$HOME	500 GB	1,000,000
\$SCRATCH	10 TB	1,000,000
/work/projects/...	16 MB	-
/mnt/isilon/projects/...	2 PB globally	-

Remarks

Quota for clusterusers group in project directories is 0

- Make sure the *setgid* bit is set on all folders in the project directories
- Transfer files without preserving group

`chmod g+s`

`rsync --no-p --no-g`

Backup: Iris and Aion

- \$HOME
 - ↪ weekly backup to another server in the same data center
 - ↪ retention: last 7 backups, at least one per month for the last 2 months
 - ↪ Example: if today is Tuesday, November 9, and backups are done on Fridays, there will be backups for Nov 5, Oct 29, Oct 22, Oct 15, Oct 8, Oct 1, Sep 24 and Sep 17
- /work/projects
 - ↪ daily backup to another server in the same data center
 - ↪ retention: one backup per week of the backup directory (\$PROJECT/backup/) for at least 1 week
 - ↪ Example: if today is Tuesday, November 9, and Saturday's backups are kept, there will be backups for yesterday and Nov 6

Backup: Isilon (HPC share)

- /mnt/isilon/projects
- weekly snapshot
- retention: snapshots are kept for 10 days
- no true backup, because it's on the same system
- Example: if today is Tuesday, November 9 and snapshots are done on Sundays, there will be snapshots for Nov 7 and Oct 31

Backup: Warning

- **NO** off-site backups
- best-effort, frequency and retention may change depending on backup duration and available space
- **NO** backup in \$SCRATCH (/scratch or /tmp) directories
- **Clean-up:** files in \$SCRATCH older than 60 days are removed every month (you will be notified by email before any deletion happens)
- **Clean-up:** files in /tmp on compute nodes are removed at the end of the job

Summary

1 Session Objectives

2 Data storage

[Big] Data components in HPC

Shared Storage on UL HPC

User environment

Quotas

Backup

3 Data organisation and management

File organisation and naming

Version control with Git

4 Data security

GDPR and data security

Encryption

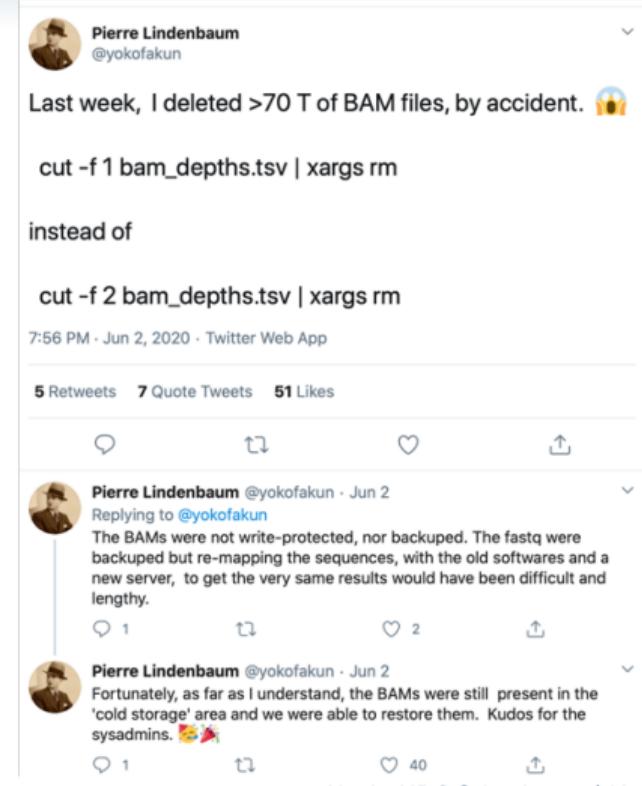
Passwords

Guidelines for raw data

- Collect and store **metadata**, e.g. in README files that accompany data
 - ↪ Minimal metadata describing what is the data and how it got there:
 - ✓ Title
 - ✓ Date of creation/receipt
 - ✓ Data origin
 - ✓ Version of the data
 - ✓ Data owner/responsible
 - ✓ Data structure
 - ✓ How was the data downloaded
- Generate checksums for raw/source data, e.g. with sha256sum
 - ↪ Before and after data transfer
 - ↪ Before archival

Guidelines for raw data

Make raw data read-only!



Pierre Lindenbaum
@yokofakun

Last week, I deleted >70 T of BAM files, by accident. 🙀

```
cut -f 1 bam_depths.tsv | xargs rm
```

instead of

```
cut -f 2 bam_depths.tsv | xargs rm
```

7:56 PM · Jun 2, 2020 · Twitter Web App

5 Retweets 7 Quote Tweets 51 Likes

Pierre Lindenbaum @yokofakun · Jun 2
Replying to @yokofakun

The BAMs were not write-protected, nor backuped. The fastq were backuped but re-mapping the sequences, with the old softwares and a new server, to get the very same results would have been difficult and lengthy.

Pierre Lindenbaum @yokofakun · Jun 2
Fortunately, as far as I understand, the BAMs were still present in the 'cold storage' area and we were able to restore them. Kudos for the sysadmins. 🎉

Uni.lu HPC School 2021/ Keynote

File naming

3 main principles

- Machine readable
- Human readable
- Plays well with default ordering

Good examples:

- `fig01_scatterplot-talk-length-vs-interest.png`
- `2013-06-26_BRAFWTNEGASSAY_Plasmid-Cellline-100-1MutantFractions_B03.csv`

Sources and further reading:

- Jenny Bryan's talk on “Naming things” from Reproducible Science Workshop, Duke, 2015
- Kristin Briney's file naming convention worksheet. Caltech Library, 2020

Date format

Use date in standard format
ISO8601 (YYYY-MM-DD)

PUBLIC SERVICE ANNOUNCEMENT:

OUR DIFFERENT WAYS OF WRITING DATES AS NUMBERS CAN LEAD TO ONLINE CONFUSION. THAT'S WHY IN 1988 ISO SET A GLOBAL STANDARD NUMERIC DATE FORMAT.

THIS IS THE CORRECT WAY TO WRITE NUMERIC DATES:

2013-02-27

THE FOLLOWING FORMATS ARE THEREFORE DISCOURAGED:

02/27/2013 02/27/13 27/02/2013 27/02/13

20130227 2013.02.27 27.02.13 27-02-13

27.2.13 2013. II. 27. 2^{1/2}-13 2013.158904109

MMXIII-II-XXVII MMXIII ^{LVI}_{CCCLXV} 1330300800

((3+3)×(111+1)-1)×3/3-1/3³ 2013 Mississ

10/11011/1101 02/27/20/13 01237 27/02/13

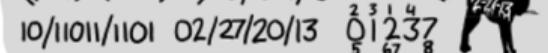


image source: XKCD

Version control

- “**Backup**” for your code
- Keep track of your processing / analysis history
- Benefits (from [Atlassian](#)):
 - ↪ complete long-term change history of every file
 - ↪ branching and merging
 - ↪ traceability
- **Important for reproducibility and GDPR compliance**



Gitlab.uni.lu

- Local [GitLab](#) instance hosted by HPC
 - ↪ Alternative to (reference) [GitHub/BitBucket](#) for **self-hosted private/public** projects
 - ↪ Manage groups, users, SSH keys and (*of course*) Git repositories
 - ↪ Project management (issue tracker, milestones, documentation)
 - ↪ Continuous Integration
 - ↪ **As many private repositories as you want!**
- **Data stays within UL**
- Access for **external** collaborators with [GitHub](#) accounts
 - ↪ Blocked by default → provide us details to unblock
 - ↪ **Hint:** use professional logins for your professional usage on GitHub

Getting started with git

- Many IDEs have git integration
- **Learning git:**
 - ↳ tutorial: Software Carpentry: Version Control with Git
 - ↳ <https://git-scm.com/>
- **Additional resources**
 - ↳ tutorial: IT/Dev[op]s Army Knives Tools for the Researcher
 - ↳ tutorial: Reproducible Research at the Cloud Era

Summary

1 Session Objectives

2 Data storage

[Big] Data components in HPC

Shared Storage on UL HPC

User environment

Quotas

Backup

3 Data organisation and management

File organisation and naming

Version control with Git

4 Data security

GDPR and data security

Encryption

Passwords

GDPR and UL HPC



www.eugdpr.org



- EU General Data Protection Regulation (**GDPR**)
 - ↪ replaces the Data Protection Directive 95/46/EC
 - ↪ legislation came into effect May 25th 2018

- The UL HPC facility handles both:
 - ↪ **data about people** (facility users identification details)
 - ✓ ULHPC Identity Management (IdM) system
 - ✓ Account request form results
 - ↪ **large scale data** that may contain Personally Identifiable Info
 - ✓ stored by facility users in networked, parallel & distributed filesystems used across the HPC infrastructure
 - ✓ can be considered as falling under GDPR regulations.

GDPR and UL HPC

- Personal data is/may be visible, accessible or handled:

- ↪ directly on the HPC clusters
- ↪ through *Resource and Job Management System* (RJMS) tools
 - ✓ glue for a parallel computer to execute parallel jobs
 - ✓ Goal: satisfy users demands for computation
 - ✓ comes with web interfaces
- ↪ through service portals
- ↪ on code management portals
- ↪ on secondary storage systems

Monika, Ganttchart
Open OnDemand
GitLab, GitHub
DropIT, OwnCloud

Best practices for you

General

- Data (pseudo-) anonymisation
- Data minimisation
- Data partitioning

Best practices for you

General (continued)

- Secure laptop
 - Enable FileVault / disk encryption
 - Lock your screen when you leave your place
 - Apply security updates
 - Anti-virus / anti-malware software
 - (Encrypted) backup of your laptop
- Secure access credentials
 - Consider using a password manager
 - Use 2FA when possible (authenticator better than SMS)
- **Follow policies of your institute and the UL!**

Best practices for you

On ULHPC

- Double-check permissions on your \$HOME and \$SCRATCH folders
- Secure your SSH key with a passphrase
- Empty /tmp at the end of the job
- Reserve a full node
- Mind backups
- Encrypt your files

Data encryption

- Basic approach: **GPG**
 - ↪ Encrypt single files
 - ↪ Files need to be completely decrypted for processing
- More convenient: **gocryptfs**
 - ↪ Encrypt all files within a folder
 - ↪ Can be mounted in a *view* folder where you can read and write the unencrypted files
 - ↪ Automatically unmounted upon job termination
- For LCSB: **PetaSuite Protect**
 - ↪ Encrypt and compress genomic data
 - ↪ Encryption keys and access managed centrally
 - ↪ Decryption and decompression on-the-fly using a library that intercepts all FS access
 - ↪ Commercial software
 - ↪ Contact lcsb.software@uni.lu if you would like to use it
- In git repositories: **git-crypt**
- In Dropbox, Owncloud and other cloud storage: **Boxcryptor**

GPG encryption

Encrypt a single file (will ask for a passphrase):

```
gpg -c file_to_be_encrypted
```

Decrypt the file:

```
gpg encrypted_file
```

Instead of using a passphrase, you can also encrypt files using an encryption key.

Gocryptfs

```
module load tools/gocryptfs
mkdir dir.crypt dir
gocryptfs -init dir.crypt
gocryptfs dir.crypt dir
echo "Happy secure computing!" > dir/message.txt
fusermount -u dir
```

Details: <https://hpc.uni.lu/blog/2018/sensitive-data-encryption-using-gocryptfs/>

Warnings

- Encryption **keys and passphrases need to be kept safe** and **protected from unauthorised access**.
- **Loosing** your encryption **key means loosing your data**.
- Ensure **off-site backup** of critical data stored on the platform under encryption.
- **(Disaster) recovery** of encrypted data is **NOT** guaranteed to be viable
 - depending on internal consistency when the recovery snapshot is taken

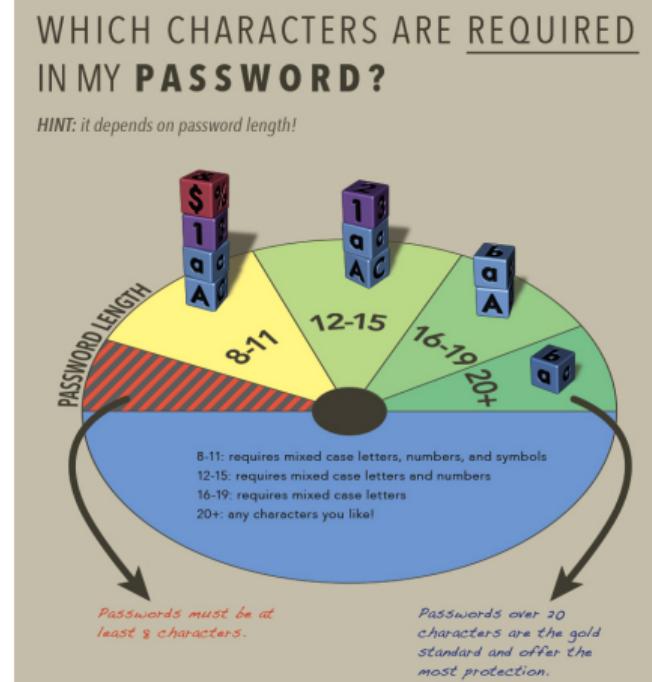
Password Management

Traditional [Strong] Password policy

- ≥ 15 characters, including digits, special chars (#,&,@,\$ etc.)
 - ↪ mix upper/lower case
 - ↪ length is more important than complexity
 - avoid matching dictionary/personal/company/dates info
 - not recommended anymore to renew periodically ([NIST - Digital Identity Guidelines](#))
-
- Build by selecting words / sentence easy to remember
 - ↪ combine them to respect the above rules

Stanford Password Policy

<https://itservices.stanford.edu/service/accounts/passwords/quickguide>



Password Manager

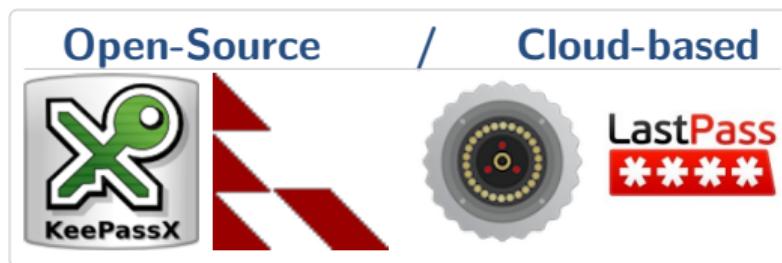
Password Manager

- Ensure a safe and **secure** way to store/organize passwords
 - ↪ privilege **random & unique** passwords **everywhere**
 - ↪ ideally: cross-platform applications, with browser integration
- encrypted back-end/vault, eventually shared over Cloud storage
 - ↪ Dropbox, iCloud, S3, OneDrive...

Password Manager

Password Manager

- Ensure a safe and **secure** way to store/organize passwords
 - ↪ privilege **random & unique** passwords **everywhere**
 - ↪ ideally: cross-platform applications, with browser integration
- encrypted back-end/vault, eventually shared over Cloud storage
 - ↪ Dropbox, iCloud, S3, OneDrive...



Password Manager

Password Manager

- Ensure a safe and **secure** way to store/organize passwords
 - ↪ privilege **random & unique** passwords **everywhere**
 - ↪ ideally: cross-platform applications, with browser integration
- encrypted back-end/vault, eventually shared over Cloud storage
 - ↪ Dropbox, iCloud, S3, OneDrive...

Open-Source



Cloud-based



LastPass

Commercial

1Password



DASHLANE

GPG+Git Password Management: pass

- **pass**: the standard Unix password manager
 - ↪ stores passwords as encrypted files – default: `~/.password-store/`
 - ↪ cross-platform GUI clients, incl. iOS/Android / [Pass4Win](#)
 - ↪ multiple recipient can share a sub-directory
- Installation: { `brew` | `yum` | `apt-get` } install `pass`

```
$> pass init <ID> && pass git init
```

Create the store over git

GPG+Git Password Management: pass

- **pass**: the standard Unix password manager
 - ↪ stores passwords as encrypted files – default: `~/.password-store/`
 - ↪ cross-platform GUI clients, incl. iOS/Android / [Pass4Win](#)
 - ↪ multiple recipient can share a sub-directory
- Installation: { `brew` | `yum` | `apt-get` } install `pass`

```
$> pass init <ID> && pass git init                                # Create the store over git
```

```
$> pass insert <domain>/<name>                                         # store <domain>/<name>.gpg
```

GPG+Git Password Management: pass

- **pass**: the standard Unix password manager
 - ↪ stores passwords as encrypted files – default: `~/.password-store/`
 - ↪ cross-platform GUI clients, incl. iOS/Android / [Pass4Win](#)
 - ↪ multiple recipient can share a sub-directory
- Installation: { `brew` | `yum` | `apt-get` } install `pass`

```
$> pass init <ID> && pass git init                                # Create the store over git
```

```
$> pass insert <domain>/<name>                                         # store <domain>/<name>.gpg
```

```
$> pass [<domain>/<name>]                                              # list / retrieve password <name>
```

Data Management in Practice

Your Turn!

Hands-on Data Management

▶ url ◀ | [github](#) | [src](#)

- Access to ULHPC facility
- Check [inodes] quotas
- Compute and verify data checksum
- Encrypt and decrypt files or directories
 - ↪ using GPG
 - ↪ using [Gocryptfs](#)

ssh

df-ulhpc [-i]

sha256sum

gpg

gocryptfs

Thank you for your attention...

Questions?

High Performance Computing @ Uni.lu

University of Luxembourg, Belval Campus
Maison du Nombre, 4th floor
2, avenue de l'Université
L-4365 Esch-sur-Alzette
mail: hpc@uni.lu

1 Session Objectives

2 Data storage

[Big] Data components in HPC
Shared Storage on UL HPC
User environment
Quotas
Backup

3 Data organisation and management

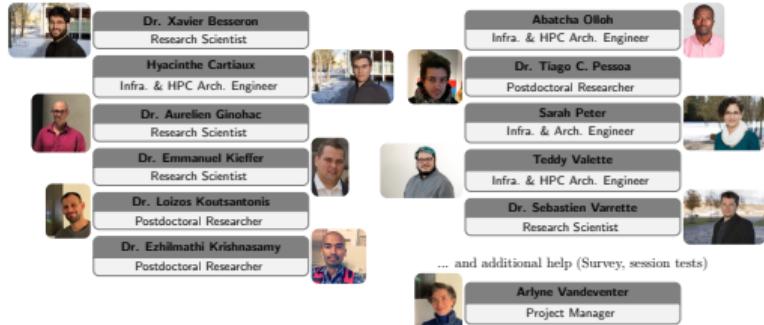
File organisation and naming
Version control with Git

4 Data security

GDPR and data security
Encryption
Passwords

ulhpc-tutorials.rtfd.io/en/latest/data

Uni.lu HPC School 2021 Contributors



hpc.uni.lu

