

# Introduction to Multiuser Cluster Systems at LRZ

Panorama of Systems at LRZ & User perspective


April, 8<sup>th</sup> 2026

# HPC & BDAI Systems for Bavarian Universities



<https://doku.lrz.de/linux-cluster-10745672.html>

LRZ Linux Cluster



CoolMUC-4    Teramem-2

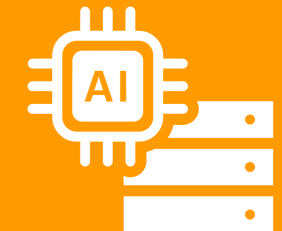
[cool.hpc.lrz.de](http://cool.hpc.lrz.de)

<https://ood.hpc.lrz.de>: R Studio etc.

<https://doku.lrz.de/lrz-ai-systems-11484278.html>

LRZ AI Systems


- “Big Data” CPU nodes
- V100 nodes
- DGX-1 P100, DGX-1 V100
- DGX/HGX A100
- HGX H100



<https://login.ai.lrz.de>  
ssh [login.ai.lrz.de](https://login.ai.lrz.de)


<https://doku.lrz.de/display/PUBLIC/Compute+Cloud>

LRZ Compute Cloud



LRZ Compute Cloud  
(w/ some GPUs)

<https://cc.lrz.de>



Data Science Archive (DSA)    Archive and Backup (ABS)

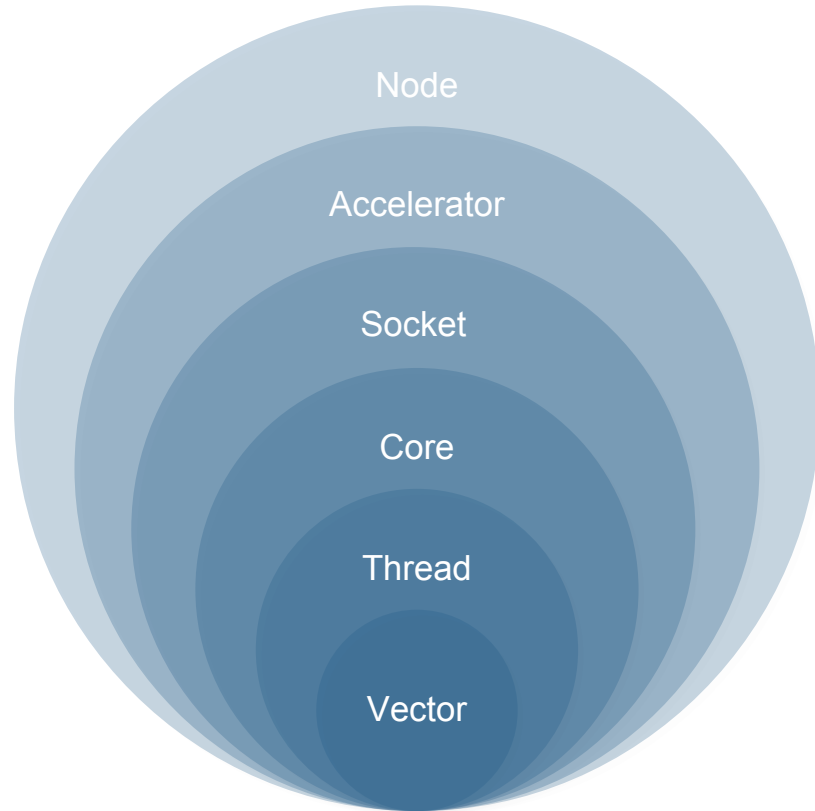
Data Science Storage (DSS)



A long row of black server racks in a data center. The racks are filled with server hardware, and blue fiber optic cables are visible through the mesh doors. Yellow cable management trays are mounted on top of the racks. The floor is light-colored with blue ventilation grates. A semi-transparent grey box with a white and blue geometric logo is overlaid on the left side of the image.

# SuperMUC-NG

SUPERMUC-  
NG



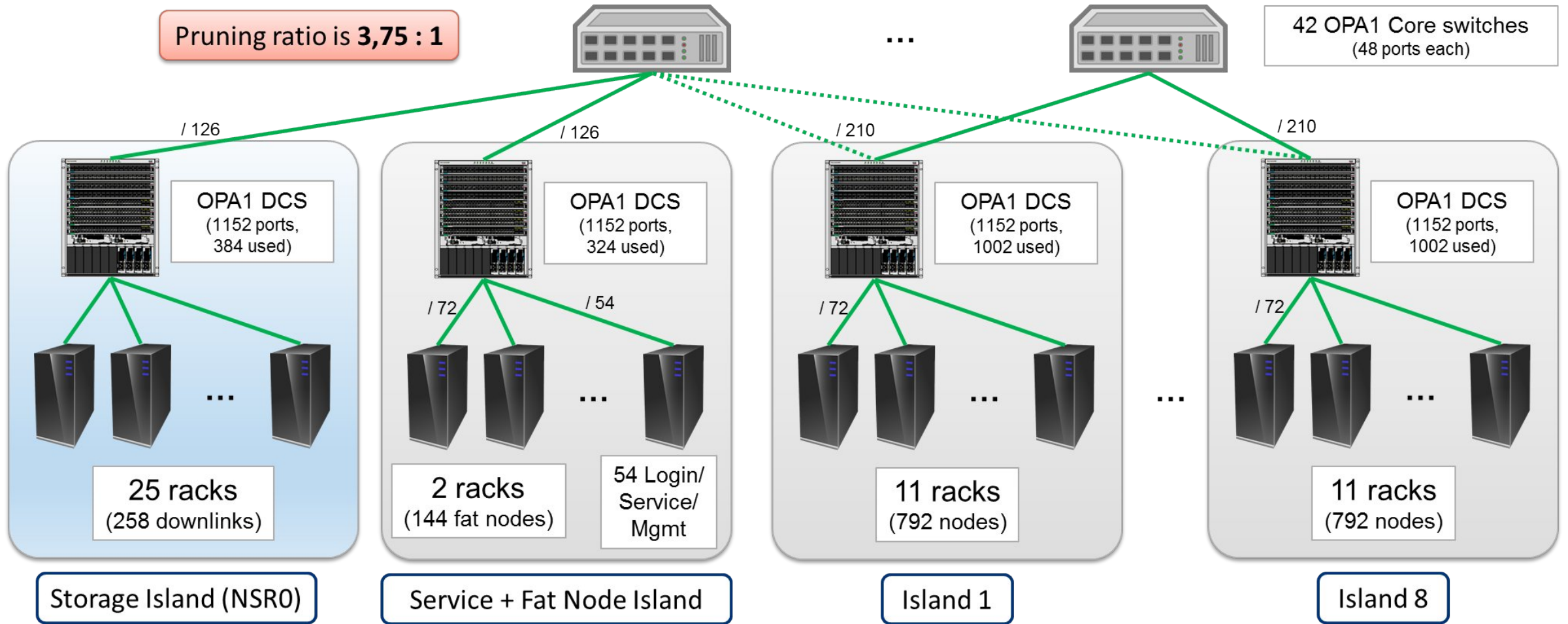
- **Node Level** (e.g., SuperMUC-NG has 6480 nodes)
- **Accelerator Level** (e.g., a Nvidia DGX A100 has 8 GPUs)
- **Socket Level** (e.g., Linux Cluster Teramem has 4 sockets [with 24 cores each])
- **Core Level** (e.g., Linux Cluster CoolMUC-3 nodes have 64 cores [on a single socket])
- **Thread Level** (e.g., Linux Cluster CoolMUC-2 nodes allow 2 threads per core)
- **Vector Level** (e.g., AVX-512 has 32 512-bit vector registers)

SuperMUC-NG theoretical peak performance:

$$\begin{aligned} & \mathbf{6480} \text{ Nodes} \times \mathbf{2} \text{ Sockets} \times \mathbf{24} \text{ Cores} \times \mathbf{32} \text{ Vectors} \times \mathbf{2,7} \text{ GHz} \\ & = 26\,873\,856\,000\,000\,000 \text{ Flop/s} \end{aligned}$$

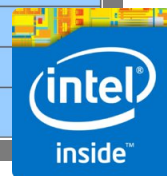


# High-Level System Architecture



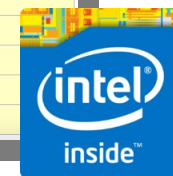
## Phase 1

Compute Nodes	Thin Nodes	Fat Nodes	Total (Thin + Fat)
Processor Type	Intel Skylake Xeon Platinum 8174	Intel Skylake Xeon Platinum 8174	Intel Skylake Xeon Platinum 8174
Cores per Node	48	48	48
Memory per Node [GByte]	96	768	N/A
Number of Nodes	6,336	144	6,480
Number of Cores	304,128	6,912	311,040
Peak Performance @ nominal [PFlop/s]	26.3	0.6	26.9
Linpack [PFlop/s]	-	-	19.476
Memory [TByte]	608	111	719
Number of Islands	8	1	9
Nodes per Island	792	144	N/A
<b>Filesystems</b>			
High Performance Parallel Filesystem	50 PiB @ 500 GB/s		
Data Science Storage	20 PiB @ 70 GB/s		
Home Filesystem	256 TiB		
<b>Infrastructure</b>			
Cooling	Direct warm water cooling		
Waste Heat Reuse	For producing cold water with adsorption coolers		
<b>Software</b>			
Operating System	Suse Linux Enterprise Server (SLES)		
Batch Scheduling System	SLURM		
High Performance Parallel Filesystem	IBM Spectrum Scale (GPFS)		
Programming Environment	Intel Parallel Studio XE, GNU compilers		
Message Passing	Intel MPI, (OpenMPI)		



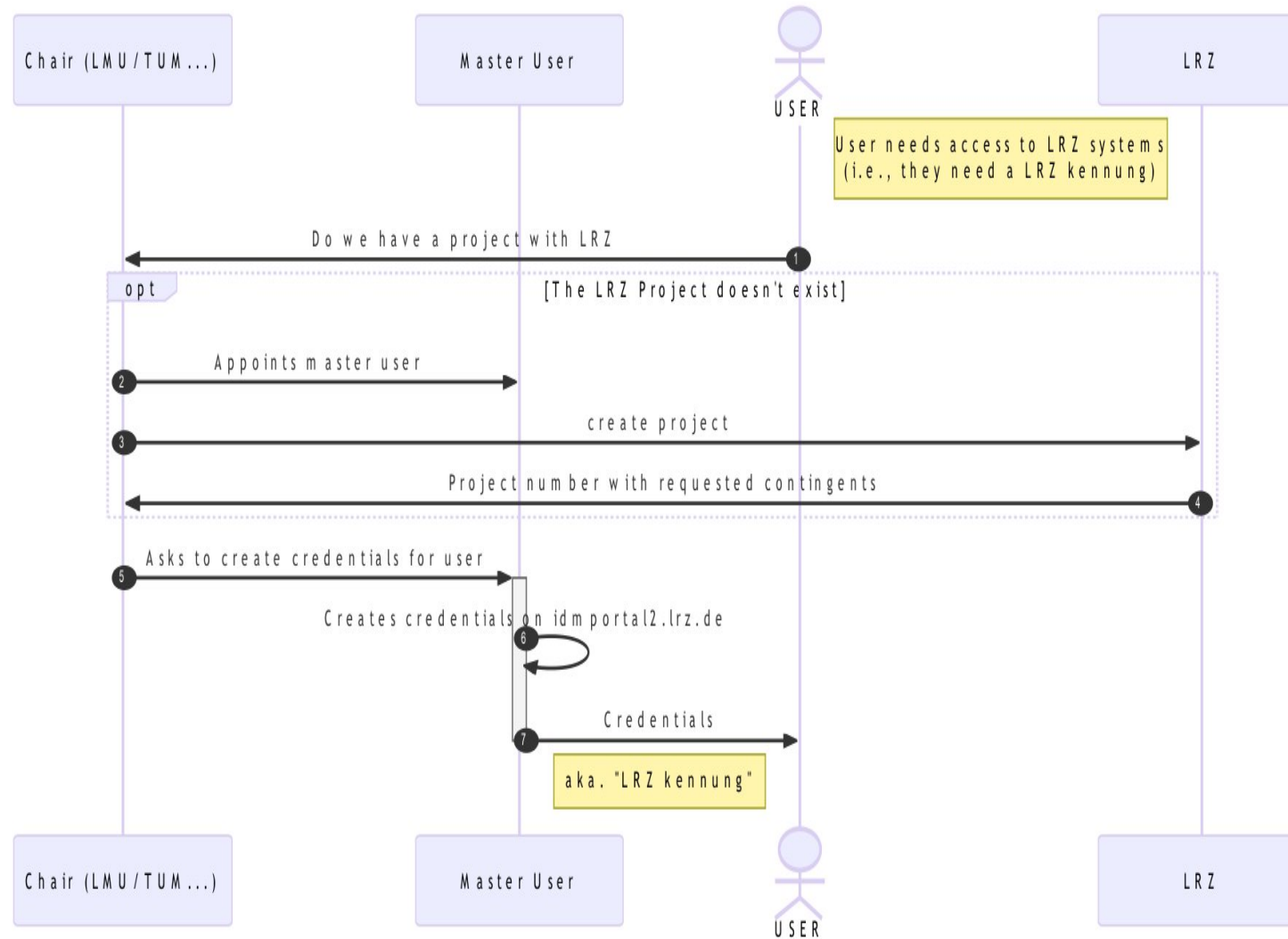
## Phase 2

Nodes	
Processor	Intel Sapphire Rapids Intel Xeon Platinum 8480+
CPUs per Node	2
Cores per Node	112
Memory per Node	512 GByte DDR5
GPUs	Intel Ponte Vecchio Intel Data Center GPU Max 1550
GPUs per Node	4
Memory per GPU	128 GByte HBM2e
Number of Nodes	240 (incl. 4 login nodes)
Total CPU Cores	26,880
Total Memory	122.88 TByte DDR5
Total GPUs	960
Total GPU Memory	122.88 TByte HBM2e
PEAK (fp64; PFlop/s)	27.96 PFlop/s
Linpack (fp64; PFlop/s)	17.19 PFlop/s
<b>Compute network</b>	
Fabric	NVIDIA/Mellanox HDR Infiniband (200 GBit/s)
Topology	fat tree
Interconnects per Node	2
Number of Islands	1
<b>Filesystems</b>	
HPPFS (same as Phase 1)	50 PB @ 500 GByte/s
DSS (same as Phase 1)	20 PB @ 70 GByte/s
Home Filesystem	256 TByte
DAOS	1 PB @ 750 GByte/s
<b>Infrastructure</b>	
Cooling	Direct warm water cooling
<b>Software</b>	
Operating System	Suse Linux (SLES)
Batch Scheduling System	SLURM
High Performance Parallel Filesystem (HPPFS)	IBM Spectrum Scale (GPFS)
Programming Environment	Intel OneAPI
Message Passing	Intel MPI, (OpenMPI)



# LRZ User Management System

## The complete Perspective



# Linux Cluster

# Linux Cluster: Hardware Overview



## Login Nodes

Architecture	Number of login nodes	Number of physical cores	Memory	Operating system
Intel(R) Xeon(R) Platinum 8380 CPU (Ice Lake)	2	80	1 TB	SLES 15 SP6

## Compute Nodes

Architecture	Number of nodes	Number of cores per node	Total number of cores	Memory per node	Operating system	local temporary file system (attached to the node)	temporary file system (across all nodes)	Remarks
Intel(R) Xeon(R) Platinum 8380 CPU (Ice Lake)	12	80	480	1 TB	SLES 15 SP6	1.7 TB via "/tmp" (SSD)	\$SCRATCH_DSS	New CoolMUC-4
Intel(R) Xeon(R) Platinum 8480+ (Sapphire Rapids)	106	112	11872	512 GB				Usage: <a href="#">Job Processing on the Linux-Cluster</a>
Intel(R) Xeon(R) Platinum 8360HL CPU (Cooper Lake)	1	96	96	6 TB				Already existing <a href="#">Large Memory Teramem System</a> Usage: <a href="#">Job Processing on the Linux-Cluster</a>

<https://doku.lrz.de/coolmuc-4-1082337877.html>



# User Perspective: Environment & Workspace

- These are systems shared by many users, i.e. other people will be working on the same (login) node at the same time.
- Be aware of your surroundings and considerate of your fellow colleagues!

```

ssh lxlogin1.lrz.de ~
└─ ssh -fish 09.10., 6:50 PM
di67pif@cm2login1:/dss/dsshhome1/lxc00> w
18:50:22 up 27 days, 8:55, 46 users, load average: 4.51, 5.31, 5.81
USER      TTY      FROM          LOGIN@   IDLE   JCPU   PCPU   WHAT
ra35fud   pts/6    th-ws-7010m59.th Thu15   10:38m 2:00m 23:23 /dss/ds
ra35fud   pts/13   th-ws-7010m59.th Thu15   10:40m 1:45m 21:15 /dss/ds
di57ril   pts/14   dynamic-002-215- Sun10   51:02  5.90s  5.90s -bash
ra78wan2  pts/19   244-152-163-10.l Sat23   43:46m 0.27s  0.27s -bash
ra35fud   pts/28   th-ws-7010m59.th 020ct23 4days  1:41m  0.36s /dss/ds
ga26kes2  pts/33   10.152.188.171 26Sep23 3days  60.96s  2.35s -tcsh
t388110   pts/36   f166.tum.vpn.lrz 18:22  59.00s  0.11s  0.11s -bash
ge72xes2  pts/38   10.162.92.110   Fri17   2:45m  1.38s  0.26s bash
t388110   pts/41   f166.tum.vpn.lrz 18:22  14:24  0.32s  0.32s -bash
ge49hid2  pts/42   onat.frm2.tum.de 18Sep23 20days 0.14s  0.14s -bash
ra68mop   pts/44   10.163.213.247  Sun11   4:02m  1.04s  1.04s -bash
ga38qon3  pts/47   129.187.45.149  Fri12   2:48m  42:20  42:03 /dss/ds
ge52wid2  pts/58   ip139188.forst.w 26Sep23 25:24m  2.15s  2.15s -bash
ga92ziv3  pts/17   hirusako.aer.ed. Wed14   1:30m  0.31s  0.31s -bash
di68miy   pts/8    pd9Fe2ea2.dip0.t 28Sep23 4:49m  0.85s  0.85s -bash
ga84qec2  pts/10   10.162.204.183  22Sep23 6:23m  1.24s  1.24s -bash
ga26kes2  pts/54   10.152.188.171  020ct23 7days  0.66s  0.66s -tcsh
di98mug2  pts/66   p4fca8d79.dip0.t 18:24  19:34  0.16s  0.16s -bash
di67kah   pts/68   10.153.163.46   09:20m  0.14s  0.14s -bash
di67pif   pts/73   i59f7e60d.versan 18:35  3.00s  0.13s  0.02s w
ga38qon3  pts/74   129.187.45.149  Fri13   2:44m  44:27  44:26 /dss/ds
di93xej   pts/75   10.156.37.219   13:48  5:01m  4.56s  4.43s /usr/bi
ga26kes2  pts/80   10.152.188.171  26Sep23 3days  8.30s  1.94s -tcsh
ga38qon3  pts/82   129.187.45.149  Fri13   2:47m  39:39  39:39 /dss/ds
ra57dut   pts/84   lmb1dp1-wxrob08. 25Sep23 9:17m  0.18s  0.18s -bash
ra98fif   pts/77   10.153.191.141  16:38  3:50  0.30s  0.30s -bash
di67kah   pts/88   10.153.163.46   09:07  4:33m  0.79s  0.79s -bash
ka641oh   pts/89   gw-acgd1.net.fh- 22Sep23 12days 0.51s  0.51s -bash
di39dux   pts/90   10.153.163.218  09:09  6:01m  2.80s  2.80s -bash
di67kah   pts/92   10.153.163.46   09:19  7:08m  0.58s  0.58s -bash

```

```

ssh lxlogin1.lrz.de ~
└─ ssh -fish 09.10., 6:50 PM
di67pif@cm2login1:/dss/dsshhome1/lxc00> ls
di2832ba di39yol di82sos ga84coc2 gu92dot2 ra43cob ru47qah
atlas001 di46jof di82tun ga84coc3 gu92vih2 ra46jim ru48fak2
atlas051 di46puy di98tap ga84wug2 gu95lun2 ra52fef2 ru54vax2
di46sap dteam007 ga86ket2 h039uaa ra52hen ru57maj
atlas066 di46taf ga26buq2 ga92wes2 h039uac ra52mer ru58guj2
atlas096 di49jat ga27rug2 ga92wof2 h039y36 ra52wos ru62guf
atlas037 di49mir ga34hed2 ga92yuh2 h039y45 ra56dut ru64nib
atlas104 di49qap ga34kat2 ga95nik2 ka85bup ra56yol ru64waf2
atlas107 di49suf ga34nox2 ga95xaf2 ka97kuk ra57biv ru67ban
atlas115 di49tom ga35hiw2 ga98dig2 lmu29425 ra57laj2 ru67yuf
atlas130 di52doh ga35piw2 ge23jiq2 lu26mur2 ra57lon ru68quw
atlas135 di52doz2 ga38coq2 ge24por2 lu28fam ra75kuw ru73jas
atlas137 di52mit ga38lix2 ge25don2 lu28tej ra75pan ru74jac
atlas139 di52qaw ga39dig2 ge29xac2 lu43fup2 ra78wuh ru74mon
atlas175 di67hal ga42jol2 ge29yig2 lu57gup9 ra66buy ru76qiq
atlas192 di67pif ga46luh2 ge34ket3 lu65cug ra98cit ru76tap
atlasprd di68tek ga48zoj2 ge35pom2 lu79hip3 ri32bet ru78zob
biokurs102 di68vad ga49cen2 ge37tiq2 lu79hun2 ri32bor ru83pey2
biokurs110 di69heg ga53vuj2 ge38aqx2 lu96mah6 ri35xob ru84xox
biokurs125 di69pun ga54ger2 ge39dww2 mmda009 ri42bof2 ru85kil2
biokurs157 di72mer ga58qes2 ge45cix2 mmda012 ri47pih ru86wed
biokurs197 di72run ga58roj3 ge45set2 mnmq011 ri58huc ru87cir4
biokurs220 di72zuy2 ga58sur2 ge46tov2 ne53qez2 ri58mey ru94puk
biokurs257 di73gov ga58yec2 ge47wus2 ne65nib2 ri65cal ru95mof
biokurs283 di73wor3 ga58zer2 ge69sid2 ne85lif2 ri83xep t388110
di25mpq2 di73wux ga59mer2 ge73woy2 ngscourse03 ri85voq t5112ae
di25qeq di73yux ga62kuy2 ge86gis2 ge47wus2 ri96kit t5431ad
di25wuw di75gem ga62sed2 ge89sih2 ge89sih2 ngscourse14 ru23qir2 t7846ac
di29wad di75nef ga62tan2 ge98bej2 ngscourse15 ru27qod uh101ai
di29waj di76dan ga63yep2 ge98hun2 ngscourse26 ru23kel2 uh341ae
di34god di76dax ga67dij2 ge98sig2 ra35pim ru32yiv uh351bp
di34jag di76ral ga68jov6 genomics06 ra36jip ru36mij uj311ci

```

```

ssh lxlogin1.lrz.de ~
└─ ssh -fish 8% 9.4 GB
root 27591 0.0 0.0 0 0 ? S Sep28 0:00 [kworker/10:0]
di93qiz 27648 0.0 0.0 22688 2436 ? Ss Oct06 0:00 tmux
root 52566 0.0 0.0 0 0 ? S Oct07 0:03 [kworker/23:0]
di93sig 52918 0.0 0.0 23116 672 ? Ss Sep12 0:00 tmux
di93sig 52919 0.0 0.0 30908 8 pts/39 Ss+ Sep12 0:00 -bash
root 53091 0.0 0.0 127464 8332 ? Ss 18:35 0:00 sshd: di67pif [priv]
di67pif 53105 0.0 0.0 127464 5124 ? R 18:35 0:00 sshd: di67pif@pts/73
di67pif 53107 0.0 0.0 31844 10812 pts/73 Ss 18:35 0:00 -bash
root 53656 0.0 0.0 0 0 ? S 18:37 0:00 [kworker/29:0]
di93xej 53747 0.0 0.0 68700 3592 ? S 11:24 0:00 dbus-daemon --nofork --print-address 4 --session
root 53995 0.0 0.0 0 0 ? S Sep14 0:00 [kworker/19:2]
ga26kes2 53997 0.0 0.0 59296 0 pts/80 S Sep27 0:00 dbus-launch --autolaunch 473632f0f9e04159814ae522ae309b5
ga26kes2 53998 0.0 0.0 68712 80 ? Ss Sep27 0:00 /usr/bin/dbus-daemon --syslog-only --fork --print-pid 6
di93qiz 54001 0.0 0.0 8340 4 pts/70 T Sep27 0:00 less run_norm.slurm
root 54254 0.0 0.0 0 0 ? S 11:26 0:00 [mmkproc]
di39tel 54554 0.0 0.0 31952 8 ? Ss Sep20 0:00 SCREEN -S Tim
di39tel 54555 0.0 0.0 32100 8 pts/46 Ss+ Sep20 0:00 /bin/bash
ga26kes2 54650 0.0 0.0 298400 13048 pts/99 S+ Oct06 0:00 emacs -nw PPP.PCF
root 54765 0.0 0.0 127472 0 ? Ss Sep26 0:00 sshd: ge52wid2 [priv]
root 54944 0.0 0.0 127472 3508 ? Ss Oct06 0:00 sshd: ga38qon3 [priv]
ga38qon3 54951 0.0 0.0 129296 3508 ? S Oct06 0:00 sshd: ga38qon3@notty
ga38qon3 54952 0.0 0.0 35220 2020 ? S Oct06 0:00 /usr/lib/ssh/sftp-server
ge52wid2 54955 0.0 0.0 128784 1912 ? S Sep26 0:20 sshd: ge52wid2@pts/58
ge52wid2 54956 0.0 0.0 34212 2760 pts/58 Ss+ Sep26 0:02 -bash
di93sig 55169 0.0 0.0 15912 0 ? Ss Sep12 0:00 ssh-agent
di93xej 55253 0.0 0.0 68700 0 ? S Oct04 0:00 dbus-daemon --nofork --print-address 4 --session
di93qiz 55305 0.0 0.0 8340 4 pts/70 T Sep27 0:00 less run_norm.slurm
di93qiz 55512 0.0 0.0 102064 0 pts/69 TL Sep27 0:00 salloc --clusters=serial --partition=serial_std --mem=55
root 55602 0.0 0.0 0 0 ? S Sep21 0:20 [kworker/54:2]
root 56155 0.0 0.0 0 0 ? S Oct02 0:43 [mmkproc]
root 56536 0.0 0.0 0 0 ? S Sep29 0:14 [kworker/20:1]
root 56585 0.0 0.0 0 0 ? S Sep28 3:07 [mmkproc]
di93xej 57065 0.0 0.0 68700 3536 ? S 15:05 0:00 dbus-daemon --nofork --print-address 4 --session

```

## User Perspective: Environment & Workspace

You don't have administrative rights on these systems, i.e. no root access.

- × You will not be able to use the `sudo` command
- × You're prohibited from making system-wide modifications
- × Disk access is restricted to your home directory (and possibly other storage areas accessible to your account, e.g., your DSS containers)

→ That said, your home (directory) is your castle – there, anything goes!

# User Perspective: Package Managers and Binaries

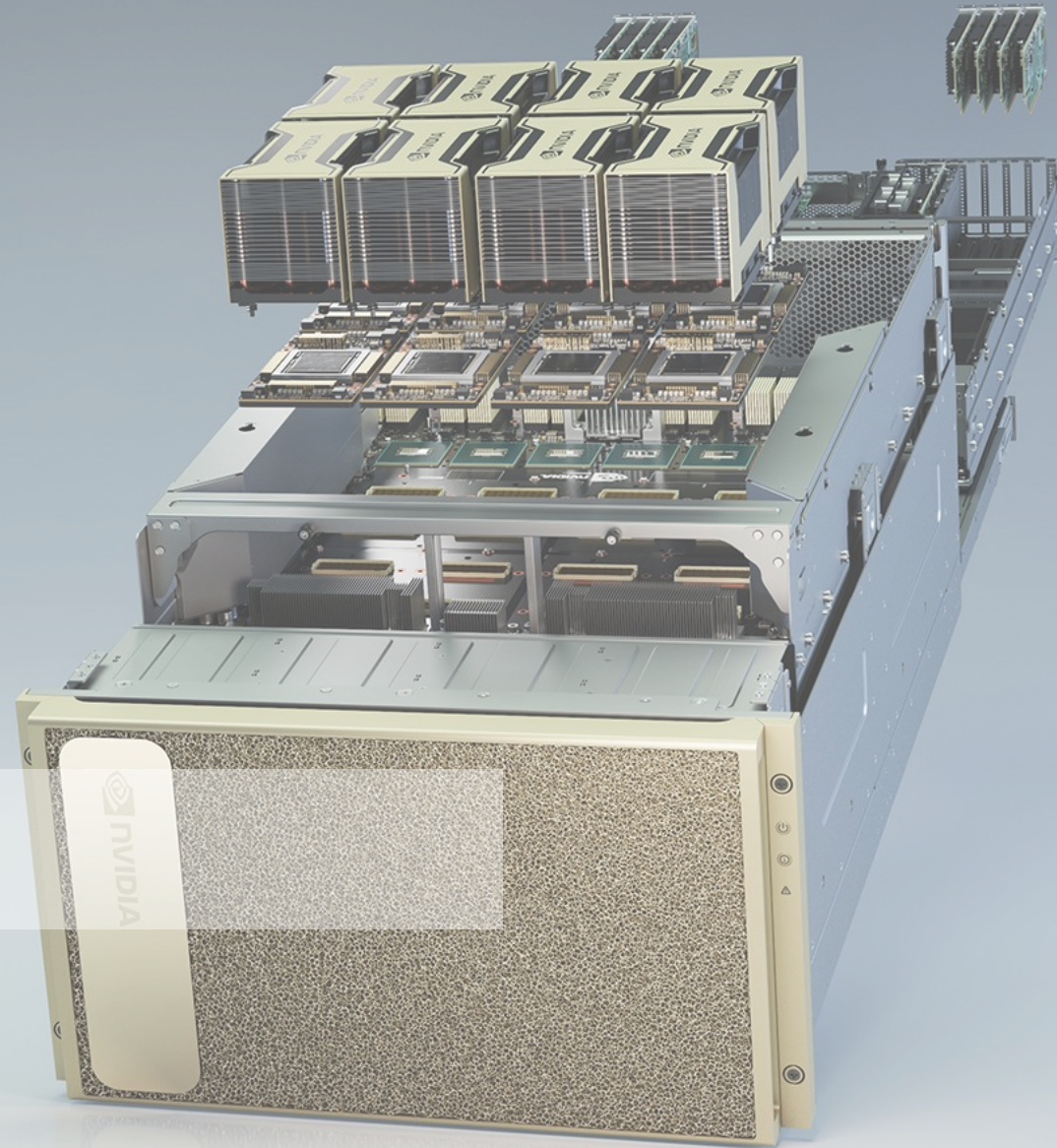
- **pip** (<https://pip.pypa.io>) is “the package installer for Python. You can use it to install packages from the Python Package Index and other indexes”.  
Make sure to install packages to the home directory instead of the system-wide default location:  
~\$ `pip install --user <package>`
- **wget** a binary from the internet (be careful!)  
~\$ `wget http://free-software.ru/download/not-malware.bin`
- **Compile** yourself  
~\$ `git clone https://github.com/ggerganov/whisper.cpp`  
~\$ `cd whisper.cpp`  
~\$ `make`



## User Perspective: Environment & Workspace

- If available on the system, modules allow for the dynamic modification of environment variables, e.g., they provide a flexible way to access various applications and libraries available on the system
- List the currently active modules (loaded by default):  
~\$ `module list`
- Search for available modules:  
~\$ `module available <module>` or  
~\$ `module av <module>`
- Get more information about a specific module:  
~\$ `module show <module>`
- Use `$ module load <module>` to apply the changes of a module to the environment

# LRZ AI Systems



# (BD)AI Systems: Hardware Overview



## Partitions

Architecture	Slurm Partition	Number of nodes	CPUs per node	Memory per node	GPUs per node	Memory per GPU
HGX H100 (BayernKI)	lrz-hgx-h100-94x4	30	96	768 GB	4 NVIDIA H100	94 GB HBM2
HGX A100	lrz-hgx-a100-80x4	5	96	1 TB	4 NVIDIA A100	80 GB HBM2
DGX A100	lrz-dgx-a100-80x8	4	252	2 TB	8 NVIDIA A100	80 GB HBM2
	lrz-dgx-a100-40x8-mig	1	252	1 TB	8 NVIDIA A100	40 GB HBM2
DGX-1 V100	lrz-dgx-1-v100x8	1	76	512 GB	8 NVIDIA Tesla V100	16 GB HBM2
DGX-1 P100	lrz-dgx-1-p100x8	1	76	512 GB	8 NVIDIA Tesla P100	16 GB HBM2
HPE Intel Skylake + P100	lrz-hpe-p100x4	1	28	256 GB	4 NVIDIA Tesla P100	16 GB HBM2
V100 GPU Nodes	lrz-v100x2 (default)	4	19	368 GB	2 NVIDIA Tesla V100	16 GB HBM2
CPU Nodes	lrz-cpu	12	18 / 28 / 38 / 94	min. 360 GB	--	--

### Quick note on the partition names:

The naming convention (e.g. lrz-hgx-h100-94x4) can be roughly interpreted as:  
**<housing>-<platform>-<GPU model>-<VRAM per GPU>-<number of GPUs>**.

MIG stands for **Multi-Instance GPU**.

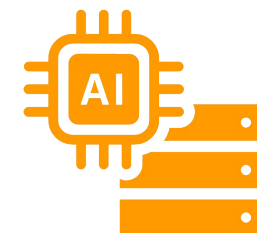
Developed by NVIDIA to be partition a GPU into smaller GPU instances, with its own dedicated resources.

## GPUs

GPU	Brand	Arch.	Year	FP32 TFLOPS	Tensor Cores FP16 TFLOPS	Memory (GB)
P100	NVDA	Pascal	2016	~9.3	-	16
V100	NVDA	Volta	2017	~15.7	~125 (1st Gen)	16
A100	NVDA	Ampere	2020	~19.5	~312 (3rd Gen)	40/80
H100	NVDA	Hopper	2022	~51	~1000 (4th Gen)	94

## Server

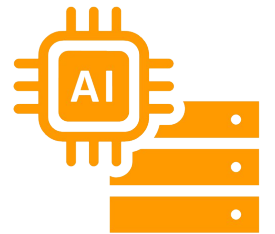
	What it is	Build by	Usage
HGX	GPU baseboard & platform design	OEMs + NVIDIA	Used by partners to build servers
DGX	Complete, ready-to-use AI system	NVIDIA	Turnkey AI/HPC server from NVIDIA



# (BD)AI Systems: Hardware Overview



- 3 NVIDIA A100 rack mounted at the Argonne National Lab
- 143kg / node
- 8 GPUs / node
- 400 W / GPU
- (not actually made of gold)



LRZ AI Systems Web UI (TEST INSTANCE) Files Jobs Clusters Interactive Apps My Interactive Sessions Help Logged in as di67pif

Very important notice: The previous home directories have been superseded by the default Linux Cluster home directories. Please see <https://doku.lrz.de/display/PUBLIC/LRZ+AI+Systems>

Home / My Interactive Sessions / Jupyter Notebook

Interactive Apps

- Servers
- Jupyter Notebook
- RStudio Server

### Jupyter Notebook

Jupyter Notebook Access.

Choose the partition where the job will run

lrz-dgx-1-v100x8

Check available partitions <https://doku.lrz.de/x/sQCuAw>

Choose an Nvidia NGC container image or "Custom" to provide the container info in the next field

Tensorflow v2

Check <https://tinyurl.com/3uscc23c> to configure your Nvidia NGC access

Number of hours

6

Desired number of GPUs for your job

8

Comma separated list of mounts to perform from the host inside the container in the format <path-in-home><:><path-in-container>

Make it Jupyter Lab!

If selected a Jupyter Lab will be started; otherwise a Jupyter Notebook will start

Launch

```
ssh datalab2 ~ (ssh) %2 +
~ (-fish) %1
Welcome to Ubuntu 20.04.5 LTS (GNU/Linux 5.4.0-122-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/advantage

System information as of Mon 10 Oct 2022 11:04:31 PM CEST

System load: 0.25          Processes:           1243
Usage of /:  90.2% of 39.99GB    Users logged in:    29
Memory usage: 69%          IPv4 address for eth0: 10.156.116.8
Swap usage:  0%

=> / is using 90.2% of 39.99GB

#####
#
#      *** VERY IMPORTANT NOTICE ***:
#
# The previous home directories have been superseded by the default Linux
# Cluster home directories. Please see:
#
#      https://doku.lrz.de/display/PUBLIC/LRZ+AI+Systems
#
#####

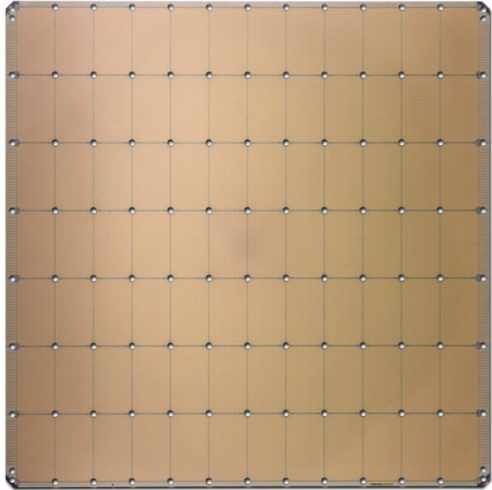
# LRZ AI System
# For Help/Support please see:
#   https://doku.lrz.de/display/PUBLIC/LRZ+AI+Systems
#
# Some notes:
# - Please stop calling the 'sudo' command, it will never work.
# - When submitting a job, you must specify the number of GPUs
#   you are planing to use, i.e. --gres=gpu:XX .
# Otherwise the job will stay in the state pending, look for
#   ST = (PD) and REASON = (QOSMinGRES) when calling 'squeue'.
#
#####

Last login: Fri Oct  7 15:51:46 2022 from 129.187.49.87
di67pif@datalab2:~$ sinfo
PARTITION      AVAIL  TIMELIMIT  NODES  STATE MODELIST
lrz-v100x2*    up 14-00:00:0  2    mix gpu-[002-003]
lrz-v100x2*    up 14-00:00:0  2    alloc gpu-[001,005]
lrz-hpe-p100x4 up 14-00:00:0  1    idle p100-001
lrz-dgx-1-p100x8 up 14-00:00:0  1    alloc dgx-001
lrz-dgx-1-v100x8 up 14-00:00:0  1    alloc dgx-002
lrz-dgx-a100-80x8 up 14-00:00:0  4    mix lrz-dgx-a100-[001-002,004-005]
lrz-dgx-a100-40x8-mig up 14-00:00:0  1    idle lrz-dgx-a100-003
lrz-cpu        up 14-00:00:0  2    mix cpu-[005,007]
lrz-cpu        up 14-00:00:0  5    alloc cpu-[001-004,006]
mcml-dgx-a100-40x8 up 14-00:00:0  5    mix mcml-dgx-[001-003,006-007]
mcml-dgx-a100-40x8 up 14-00:00:0  3    alloc mcml-dgx-[004-005,008]
test-v100x2    up 14-00:00:0  1    idle gpu-004
test-amd-mi50x8 up 14-00:00:0  5    idle mankai[01-05]
di67pif@datalab2:~$
```



# Next Generation AI System(s)

## Cerebras CS-2 Wafer Scale Engine (WSE2) in



**Cerebras WSE-2**  
2.6 Trillion Transistors  
46,225 mm<sup>2</sup> Silicon



**Largest GPU**  
54.2 Billion Transistors  
826 mm<sup>2</sup> Silicon

**A Systems Approach to Deep Learning**  
**“Cluster-scale acceleration on a single chip”**

	Cerebras WSE-2	NVIDIA A100	WSE 2 Advantage
<b>Chip Size</b>	46,225 mm <sup>2</sup>	826 mm <sup>2</sup>	56 X
<b>Cores</b>	850,000	6,912 + 432	123 X
<b>On Chip memory</b>	40 Gigabytes	40 Megabytes	1,000 X
<b>Memory B/W</b>	20 Petabytes/sec	1,555 Gigabytes/sec	12,862 X
<b>Fabric B/W</b>	220 Petabits/sec	4.8 Terabytes/sec	45,833 X

Data Source: <https://www.cerebras.net/whitepapers/>

The background of the slide is a grayscale photograph of a server room. Several rows of server racks are visible, each with a 'Lenovo' logo on its top edge. The racks are filled with server units, and some have indicator lights glowing. The perspective is from a low angle, looking down the length of the server aisle.

# LRZ Compute Cloud

# LRZ Compute cloud: Hardware Overview



Compute	200 Nodes 192 GB to 1024 GB RAM Intel® Xeon® ~2.40 GHz
	32 x 2 GPUs Nodes 2x Nvidia Tesla V100 16 GB/node 768GB RAM/node
Storage	15 nodes 2 PB Raw Storage
Networking	100G Intel OmniPath
Software	OpenStack & Ceph

Access to more than 10 vCPUs and/or other restricted resources can be requested by contacting the cloud support team: <https://servicedesk.lrz.de/ql/create/105>

40000 vCPU capacity with overcommitment  
2000 users and 1500 active VMs



# Compute Cloud: Hardware Overview



**Limit Summary**

Resource	Used	Limit
Instances	2 of 10	10
VCPUs	8 of 20	20
RAM	38GB of 50GB	50GB
Floating IP	0 of 10	10

**Usage Summary**

Select a period of time to query its usage:  
The date should be in YYYY-MM-DD format.

2019-01-30 to 2019-01-31

Active Instances:	2
Active RAM:	38GB
This Period's VCPU-Hours:	55.63
This Period's GB-Hours:	278.16
This Period's RAM-Hours:	270597.39

```
root@course-node: /home/ubuntu
master ssh -f -fish 6% 9.6 GB 09.10., 2:48 PM
~/g/du4 (master|) $ ssh 138.246.237.83 -l ubuntu
Welcome to Ubuntu 20.04.5 LTS (GNU/Linux 5.4.0-126-generic x86_64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:       https://ubuntu.com/advantage

System information as of Sun Oct  9 12:47:32 UTC 2022

System load:          0.0
Usage of /:           19.3% of 28.89GB
Memory usage:        11%
Swap usage:          0%
Processes:           132
Users logged in:     0
IPv4 address for br-1a868af01643: 172.19.0.1
IPv4 address for docker0: 172.17.0.1
IPv4 address for ens3: 192.168.130.80

=> There are 9 zombie processes.

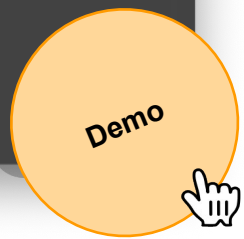
* Super-optimized for small spaces - read how we shrank the memory
  footprint of MicroK8s to make it the smallest full K8s around.

https://ubuntu.com/blog/microk8s-memory-optimisation

12 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

New release '22.04.1 LTS' available.
Run 'do-release-upgrade' to upgrade to it.

Last login: Thu Oct  6 08:07:28 2022 from 10.183.34.140
ubuntu@course-node:~$ sudo su
root@course-node:/home/ubuntu# whoami; uname -a
root
Linux course-node 5.4.0-126-generic #142-Ubuntu SMP Fri Aug 26 12:12:57 UTC 2022 x86_64 x86_64 x86_64 GNU/Linux
root@course-node:/home/ubuntu#
```



Get access: <https://doku.lrz.de/display/PUBLIC/FAQ#FAQ-HowtogetaccesstotheComputeCloud?>

# LRZ Data Storage

## Data Storage: Overview

- The LRZ HPC/HPDA/HPAI Infrastructure is backed by the Data Science Storage (DSS)
  - Long-term storage solution for potentially vast amounts of data
  - Directly connected to the LRZ computing ecosystem
  - Flexible data sharing among LRZ users
  - Web interface for world-wide access and transfer
  - Data sharing with external users (invite per e-mail, access per web interface)
- Additionally, we also provide a new type of Data Archive, based on the DSS Solution stack, called Data Science Archive (DSA) (this basically relates to DSS like AWS Glacier relates to AWS S3).
- Disk space and access is managed (as DSS projects and containers) by data curators. This can be LRZ personnel (e.g., Linux Cluster \$HOME directories) or PIs/master users/dedicated data curators (e.g., project storage).



# Data Storage: Linux Cluster & AI Systems

- **\$HOME** (DSS-backed home directory, managed by LRZ)
  - 100GB per user
  - Access: `/dss/dsshome1/lxc###/<user>`
  - Automatic tape backup and file system snapshots (see `"/dss/dsshome1/.snapshots/"` directory)
  - All your important files/anything you invested a lot of work into should be here
  - BUT Not suitable for heavy and/or high-frequency I/O operations, i.e. most machine learning applications. Use the AI Systems DSS instead.



## Data Storage: Linux Cluster

- `$SCRATCH`

- 3.1 PB, shared among all users
- Access: `/dss/lxclscratch/###/<user>`
- No backup (!) and sliding window file deletion, i.e. old files will eventually be deleted (!!)  
– a data retention time of approx. 30 days may be assumed, but is not guaranteed
- This is the place for e.g., very large, temporary files or intermediate results, directly feeding into additional analyses
- Data integrity is not guaranteed. Do not save any important data exclusively on these file systems! Seriously, don't do it!



# Data Storage: AI Systems

- AI DSS

- Up to 5 TB per project **upon request**, shared among project members
- Access: `$ dssusrinfo all`
- Configuration (e.g., exports, quota) to be managed by data curator
- Use this for e.g., high bandwidth, low latency I/O
- Can not (yet) be accessed from Linux Cluster



# Data Storage: Linux Cluster

- DSS [project storage](#)
  - Up to 10 TB per project **upon request**, shared among project members
  - Access: `$ dssusrinfo all`
  - Configuration (e.g., exports, backup, quota) to be managed by data curator
  - Use this for e.g., large raw data (and consider backup options)
  - Can be accessed from the AI systems

