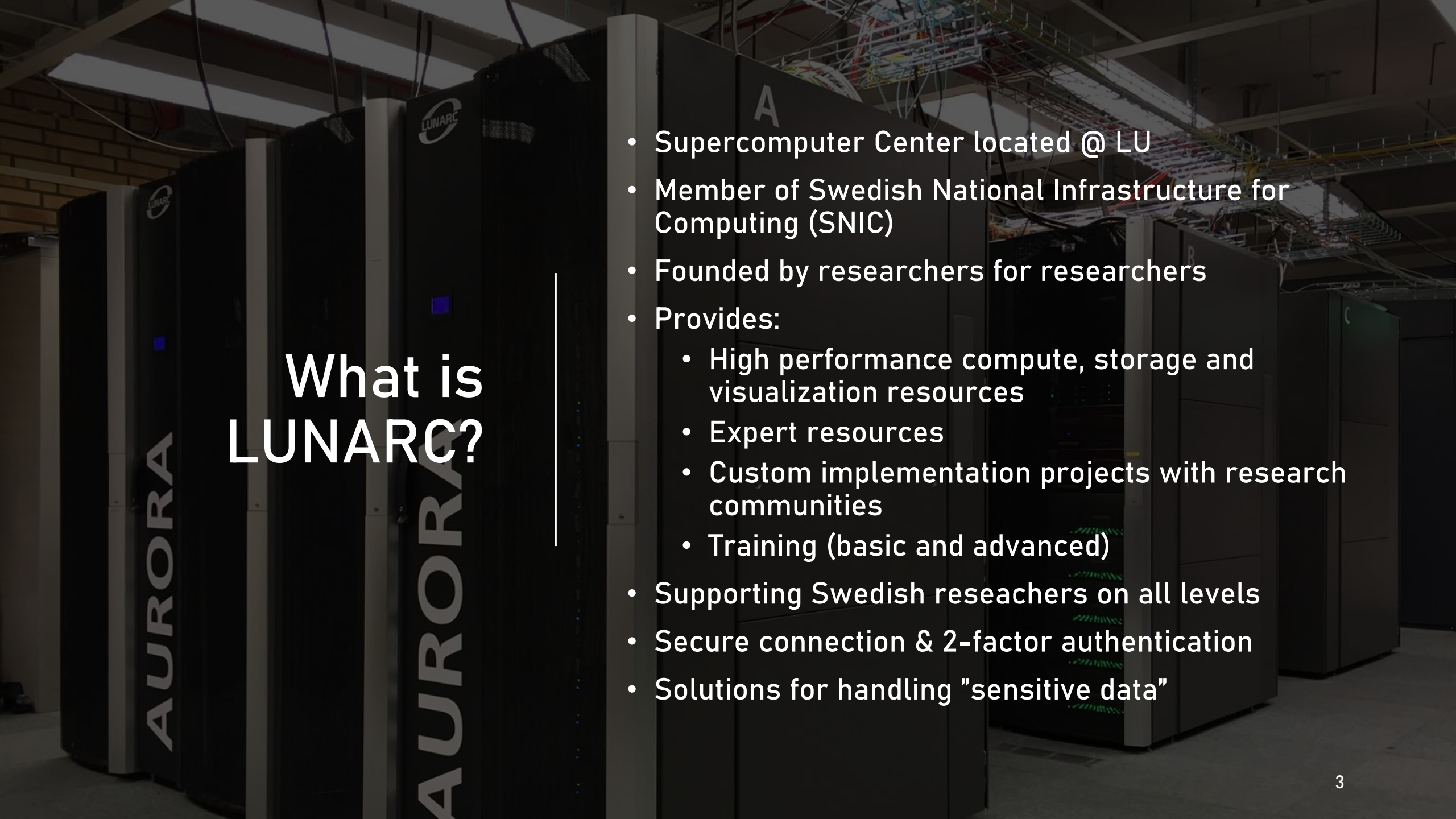
Jonas Lindemann
Anders Follin

Providing a user friendly and scalable desktop environment for HPC and visualisation

Visualisation and interactive HPC at LUNARC

About LUNARC



What is LUNARC?

- Supercomputer Center located @ LU
- Member of Swedish National Infrastructure for Computing (SNIC)
- Founded by researchers for researchers
- Provides:
  - High performance compute, storage and visualization resources
  - Expert resources
  - Custom implementation projects with research communities
  - Training (basic and advanced)
- Supporting Swedish reseachers on all levels
- Secure connection & 2-factor authentication
- Solutions for handling ”sensitive data”

Remote Visualisation @ LUNARC

LUNARC and Remote Visualisation

Our remote visualisation journey started back in 2010

We early envisioned an increased need for user friendly interactive remote access to HPC systems. The two of us had many years of experience in architecting, developing and implementing graphic sw solutions and rviz environments in both academic and industrial environments.

Two major reasons:

LUNARC and Remote Visualisation

1 : Remote (hw accelerated) visualisation.

- Keep large data sets in the datacenter – don't stress network BW & shorten lead times
- Enable parellel compute and remote post processing of huge datasets that won't fit in local WS
- Secure management of sensitive data
- License consolidation
- And many other well known reasons why remote viz is beneficial...

LUNARC and Remote Visualisation

2: Improved usability and workflow

- Adaption of our HPC services to new users familiar with modern desktop environments
- Provide graphical user interfaces to the HPC backend. Both build in DT applications (fm, etc) as well as custom developed tools (module browser, ARC storage explorer, etc)
- Disconnect / reconnect – a massive improvement in usability

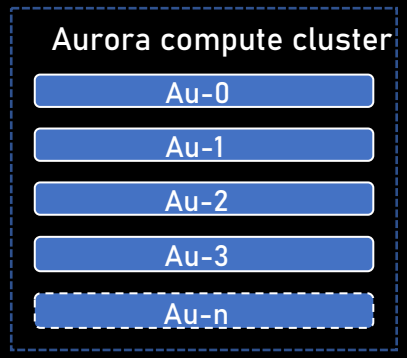
LUNARC HPC Desktop 2021

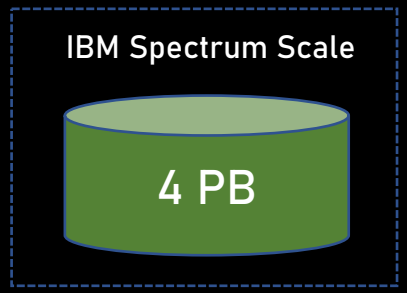
- Remote Desktop solution in production since 2013
- Accessible from all client platforms (Mac, Windows, Linux and iOS)
- Custom architected scalable backend providing both 2D and 3D applications with hardware graphics acceleration
- Custom developed Desktop On-Demand service for requesting dedicated nodes for interactive use managed by queuing system (SLURM)
- Operating system independent solution with hardware accellerated graphics (CentOS, MS Windows, Ubuntu, etc)
- A constantly increasing amount of graphical software available. Both open source and commercial packages installed upon user request

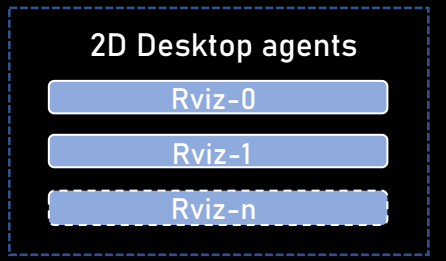
LUNARC High level architectuire

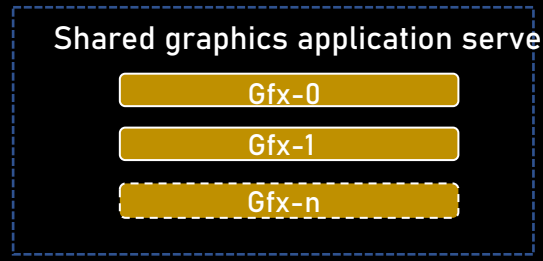
Nb: Only major components included

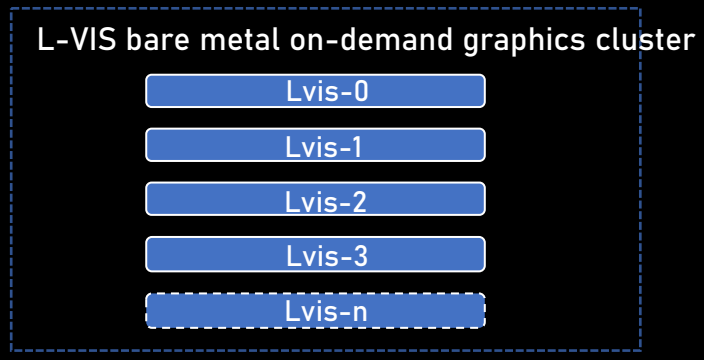
LUNARC Datacenter – High level architecture

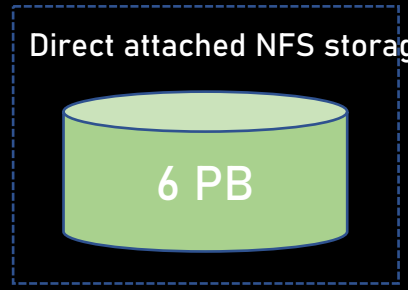












Nb: Only major components shows

LUNARC Datacenter – High level architecture

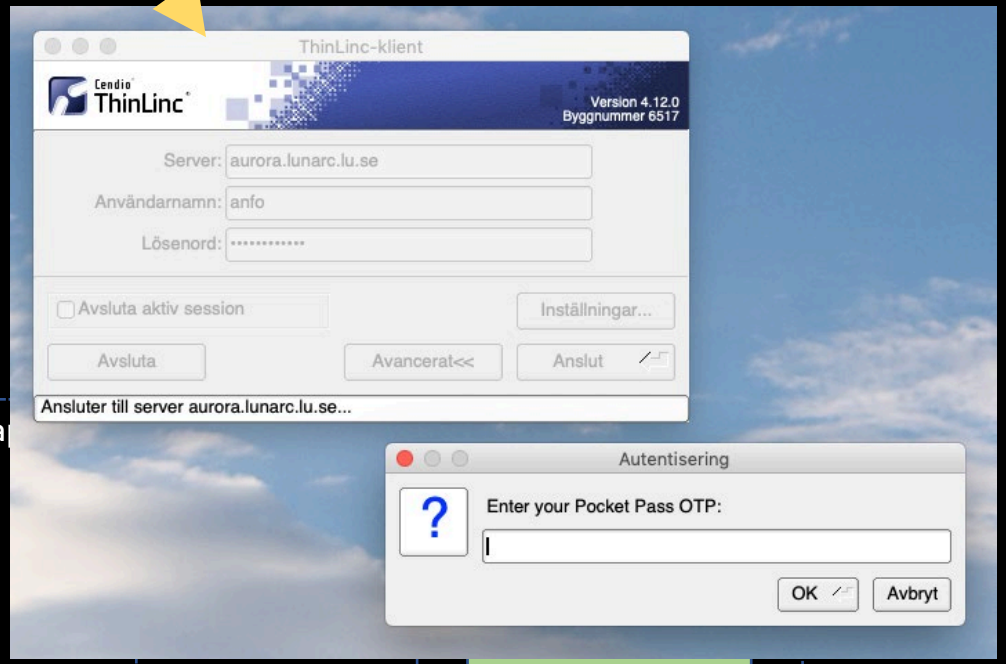
Phenix ID 2-factor authentication

Red Hat IDM Directory Service

Microsoft Active Directory

Aurora compute cluster

- Au-0
- Au-1
- Au-2
- Au-3
- Au-n



2D Desktop agents

- Rviz-0
- Rviz-1
- Rviz-n

Shared graphics application servers

- Gfx-0
- Gfx-1
- Gfx-n

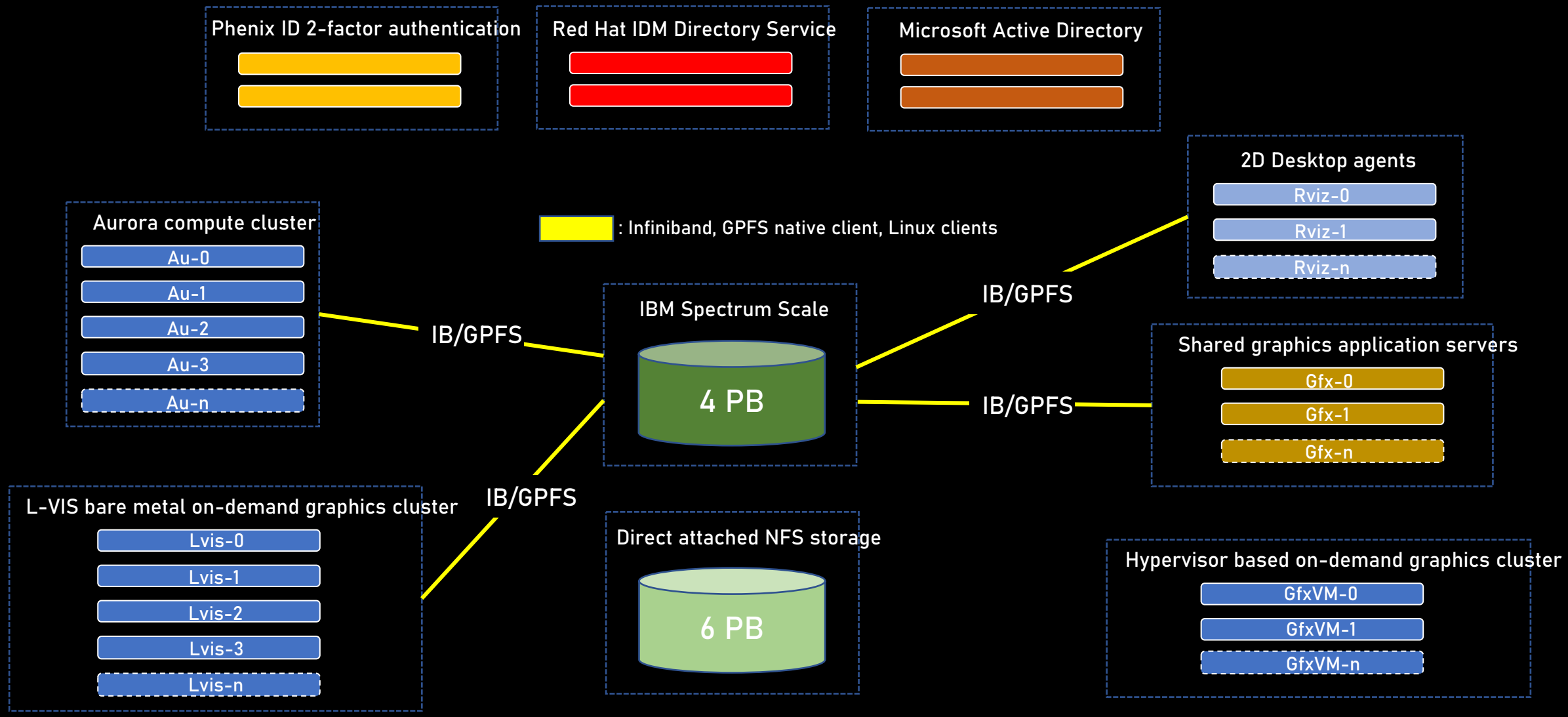
L-VIS bare metal on-demand gra

- Lvis-0
- Lvis-1
- Lvis-2
- Lvis-3
- Lvis-n

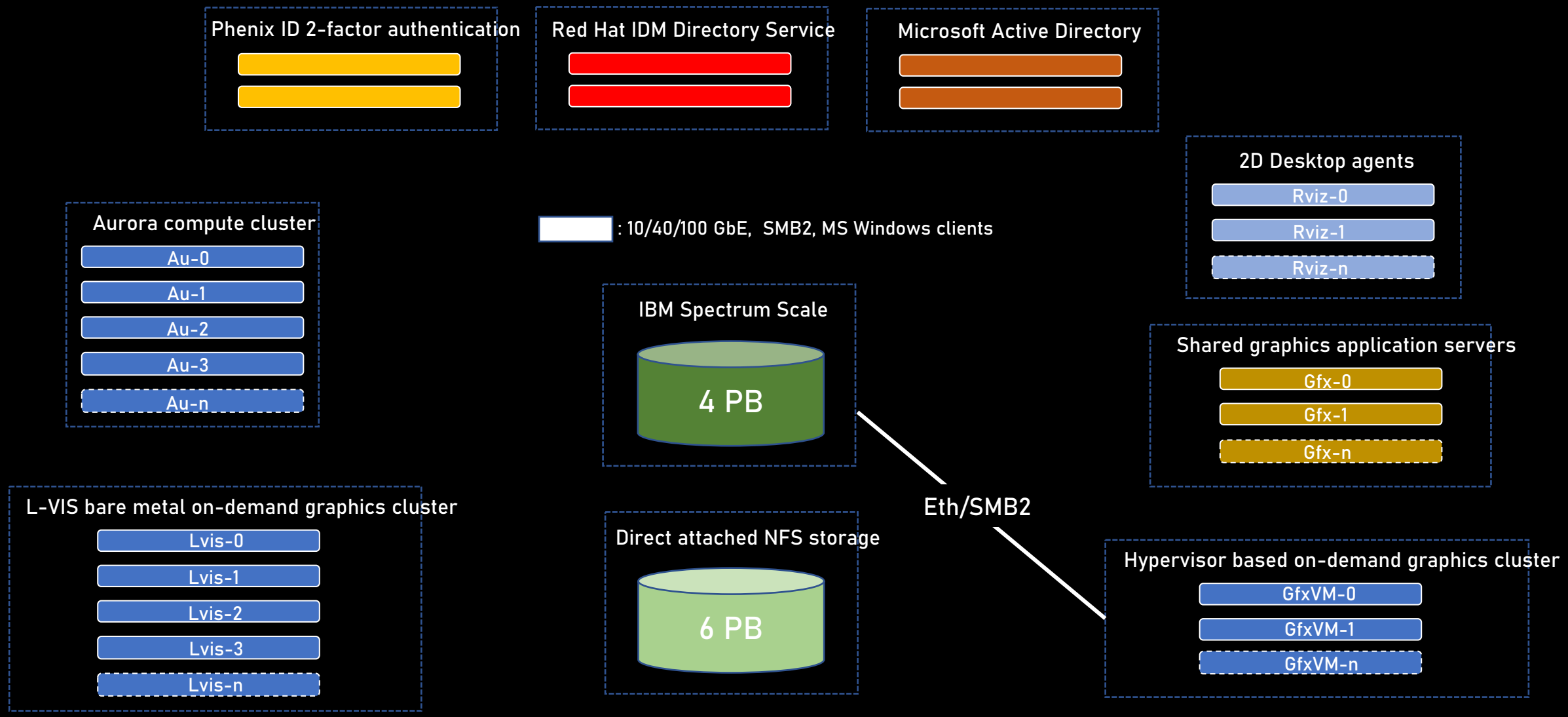
Hypervisor based on-demand graphics cluster

- GfxVM-0
- GfxVM-1
- GfxVM-n

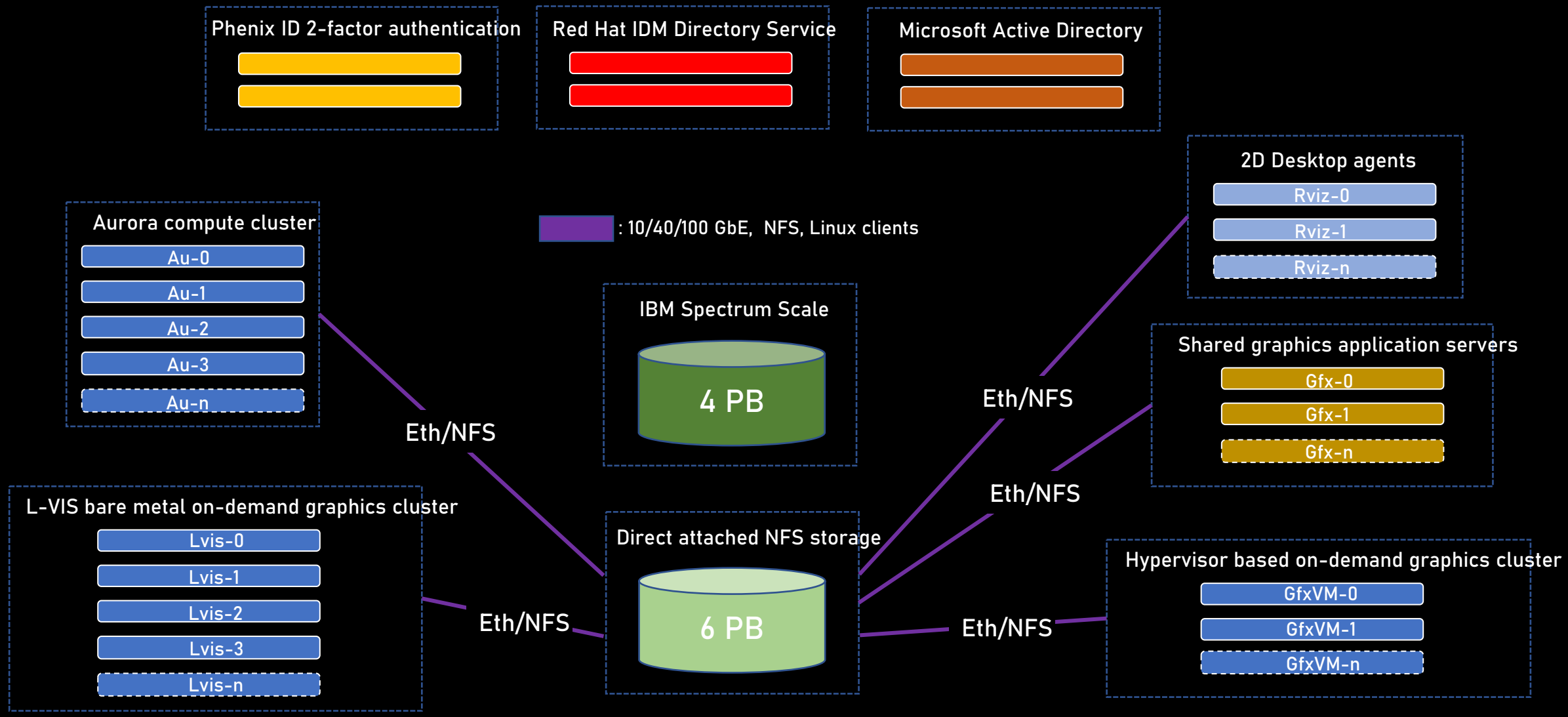
LUNARC Datacenter – High level architecture



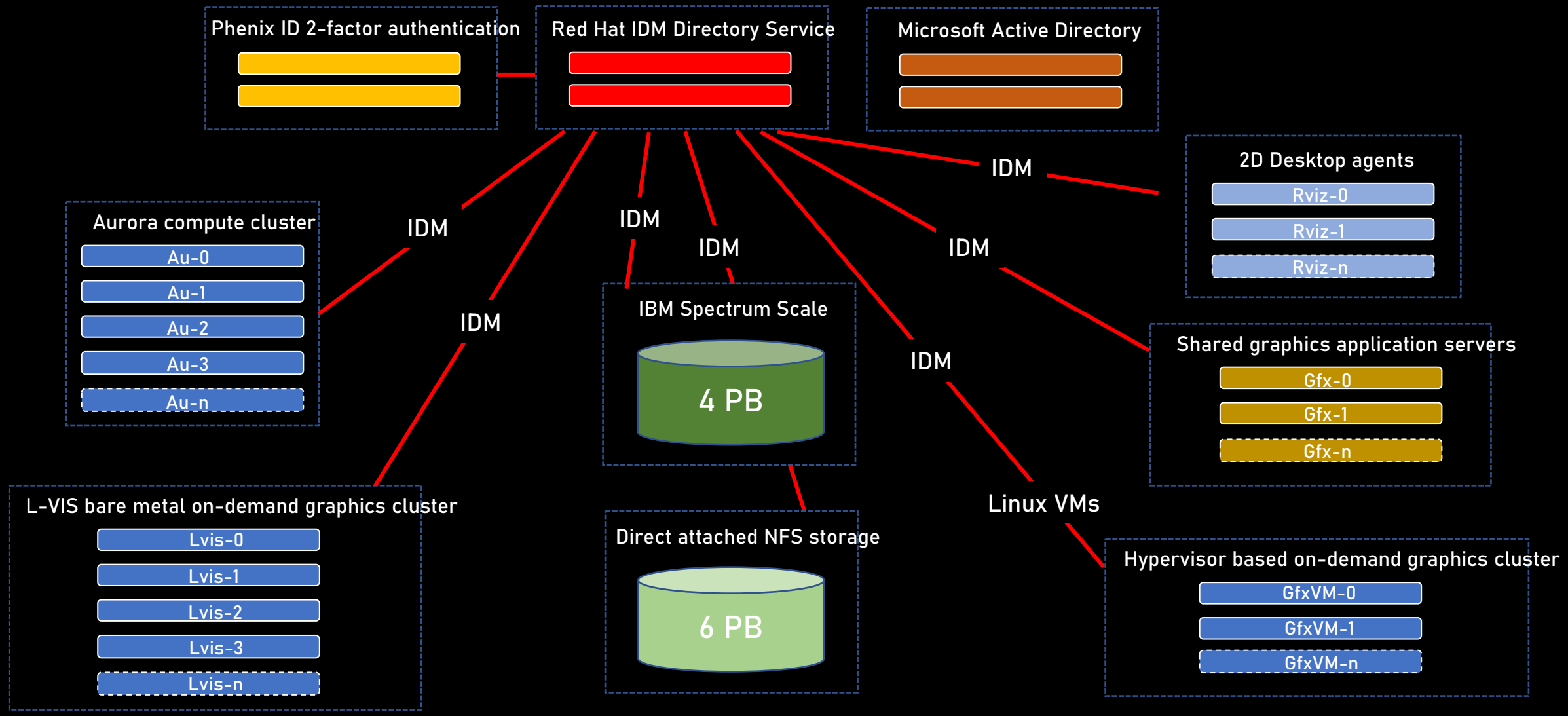
LUNARC Datacenter – High level architecture



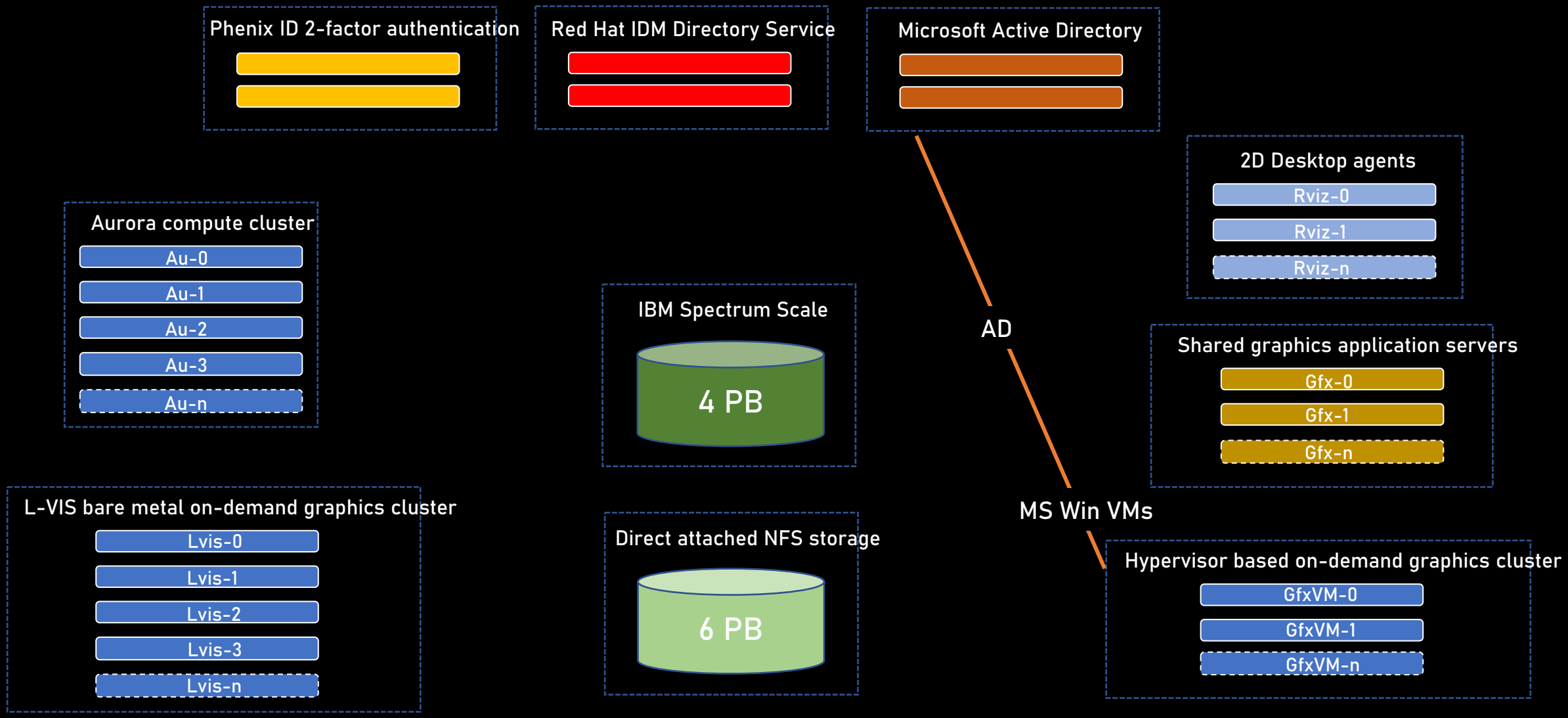
LUNARC Datacenter – High level architecture



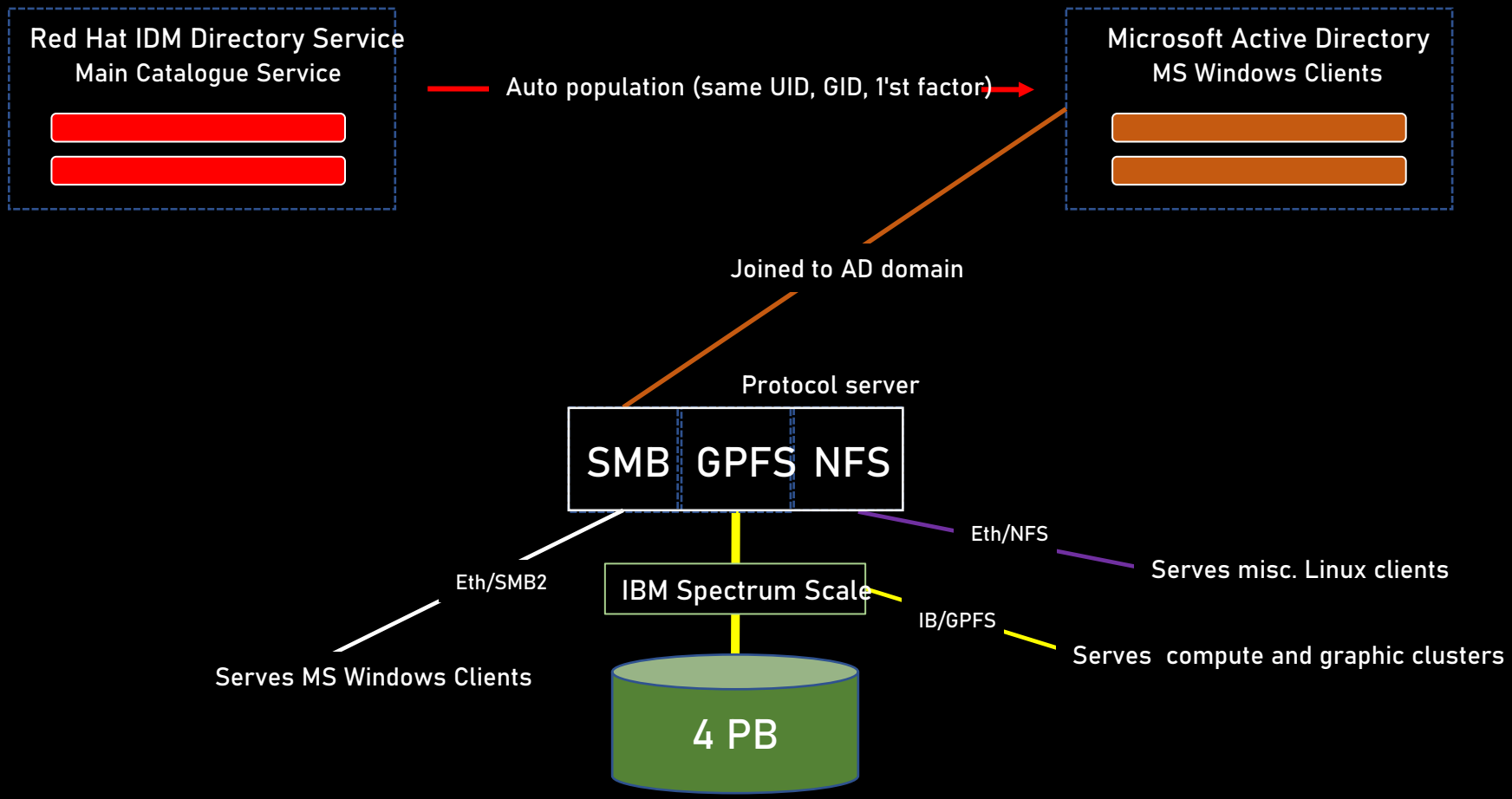
LUNARC Datacenter – High level architecture



LUNARC Datacenter – High level architecture

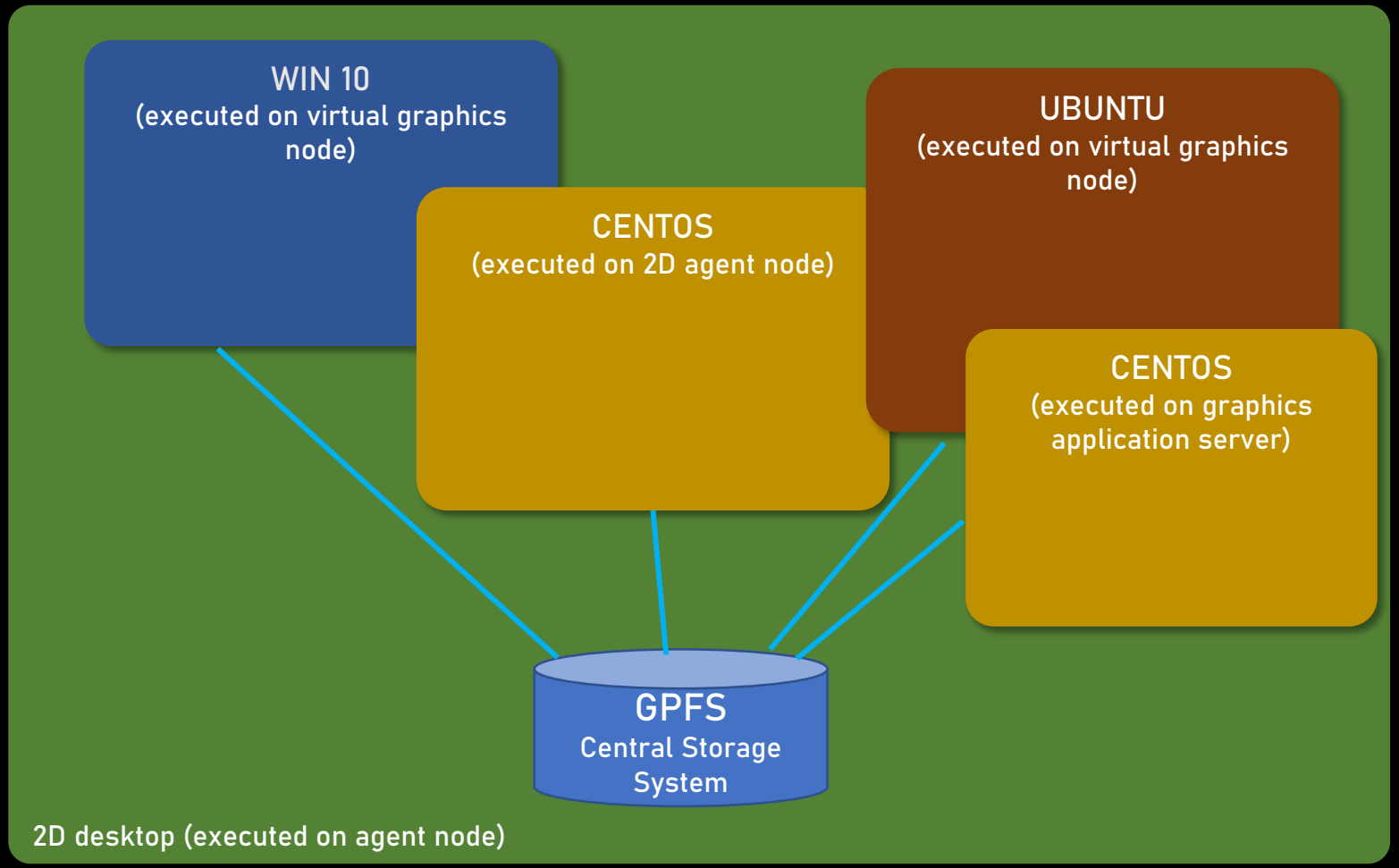


LUNARC Datacenter – High level architecture



LUNARC Datacenter – High level architecture

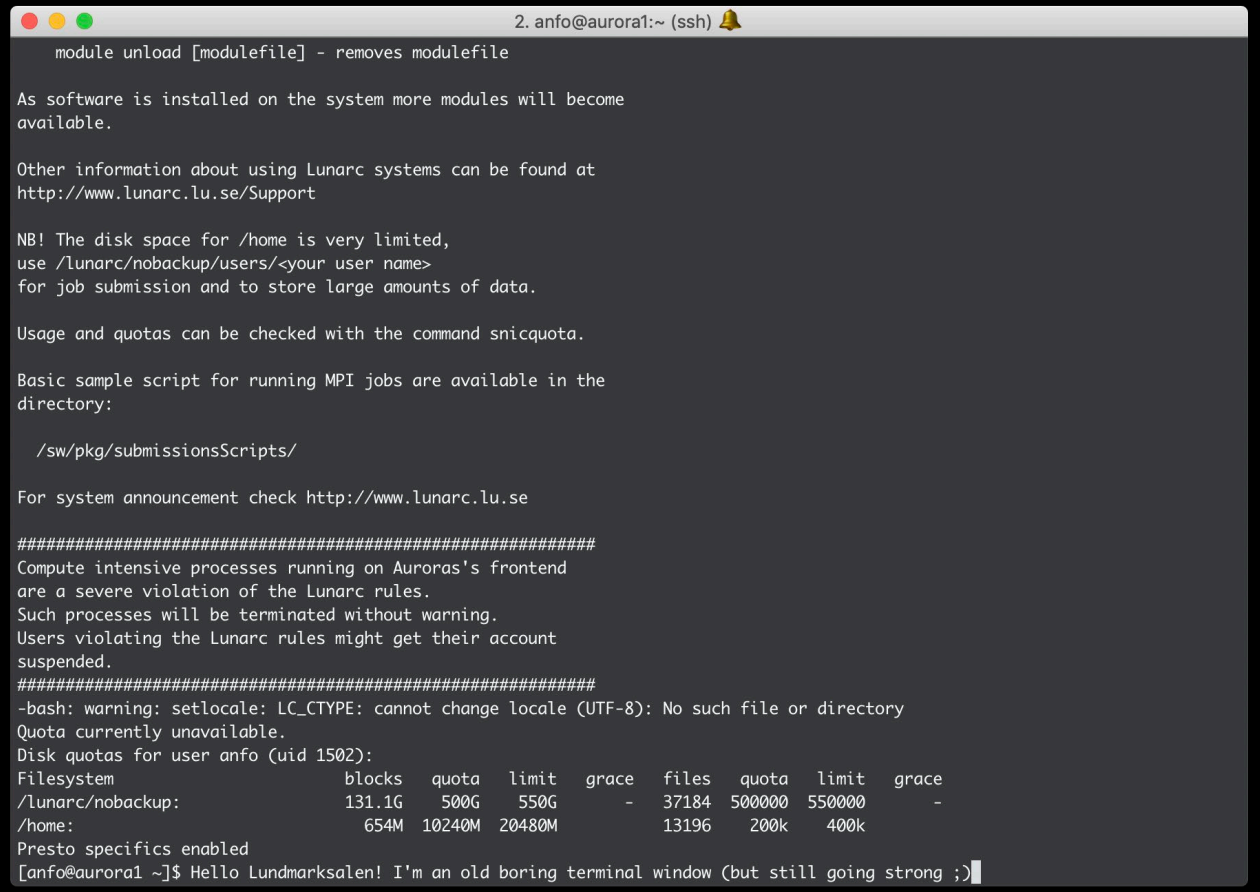
Final integated solution. Application windows ingested and assembled into TL desktop

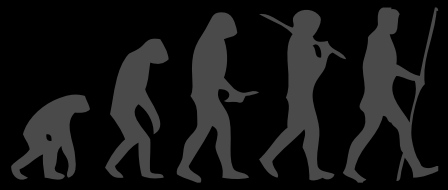


Evolution of interactive HPC and visualisation

Evolution of interactive HPC and visualisation

1. Terminal session (classic ssh, no DT)





Evolution of interactive HPC and visualisation

1. Terminal session (classic ssh, no DT)

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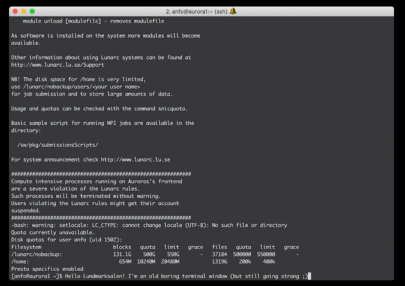
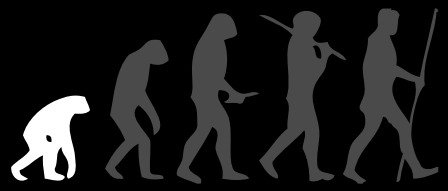
Aurora frontend

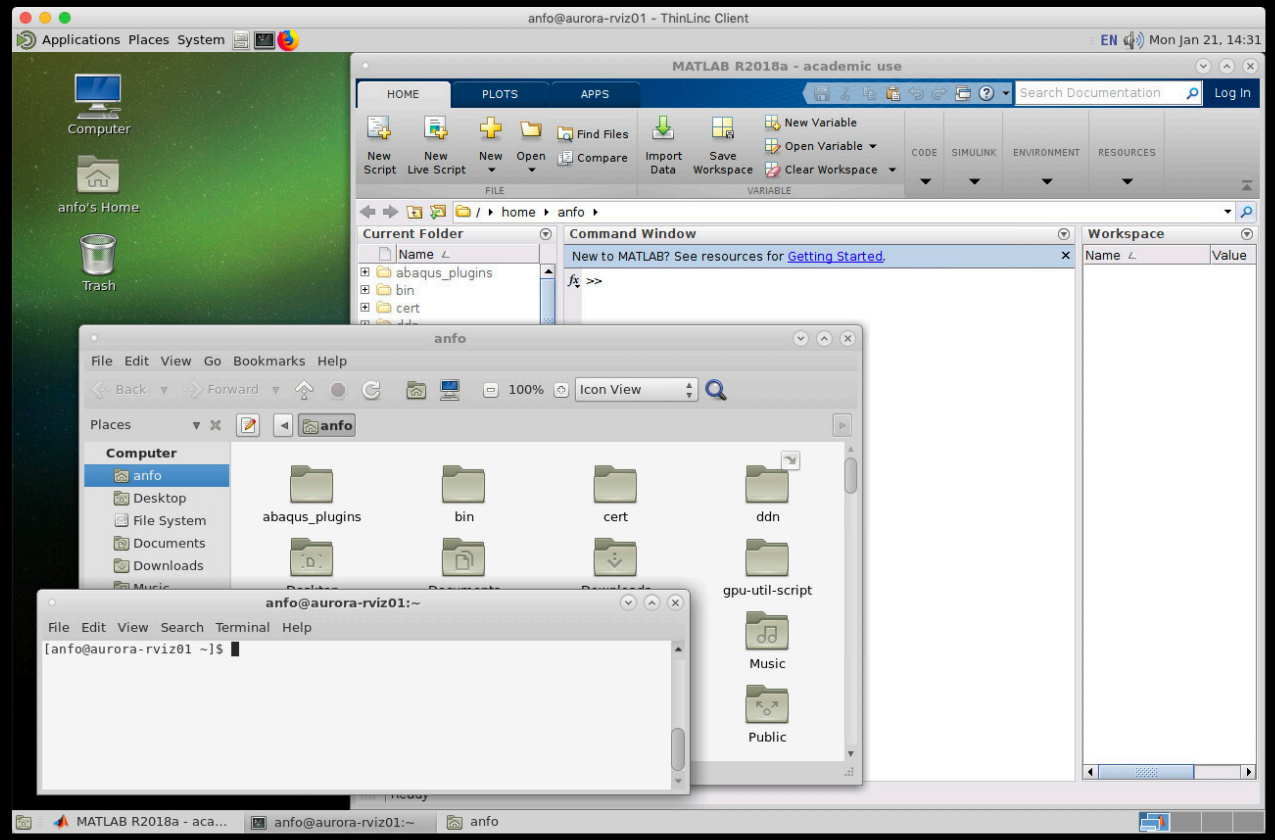
Remote terminal user

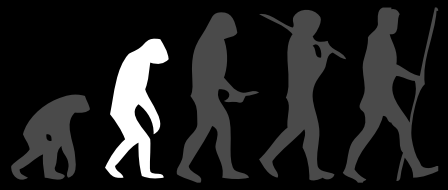




Evolution of interactive HPC and visualisation

2. Distributed 2D Desktop (TL 2D DT with custom menus)





Evolution of interactive HPC and visualisation

2. Distributed 2D Desktop (TL 2D DT with custom menus)

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2D Desktop Agent 1

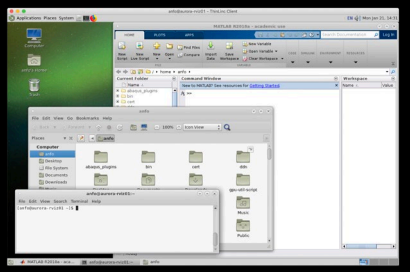
2D Desktop Agent 2

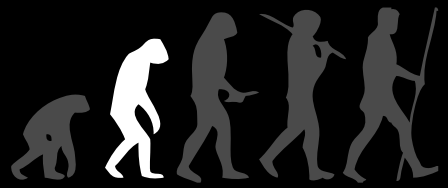
2D Desktop Agent n

Scalable load balancing
2D backend

Desktop session

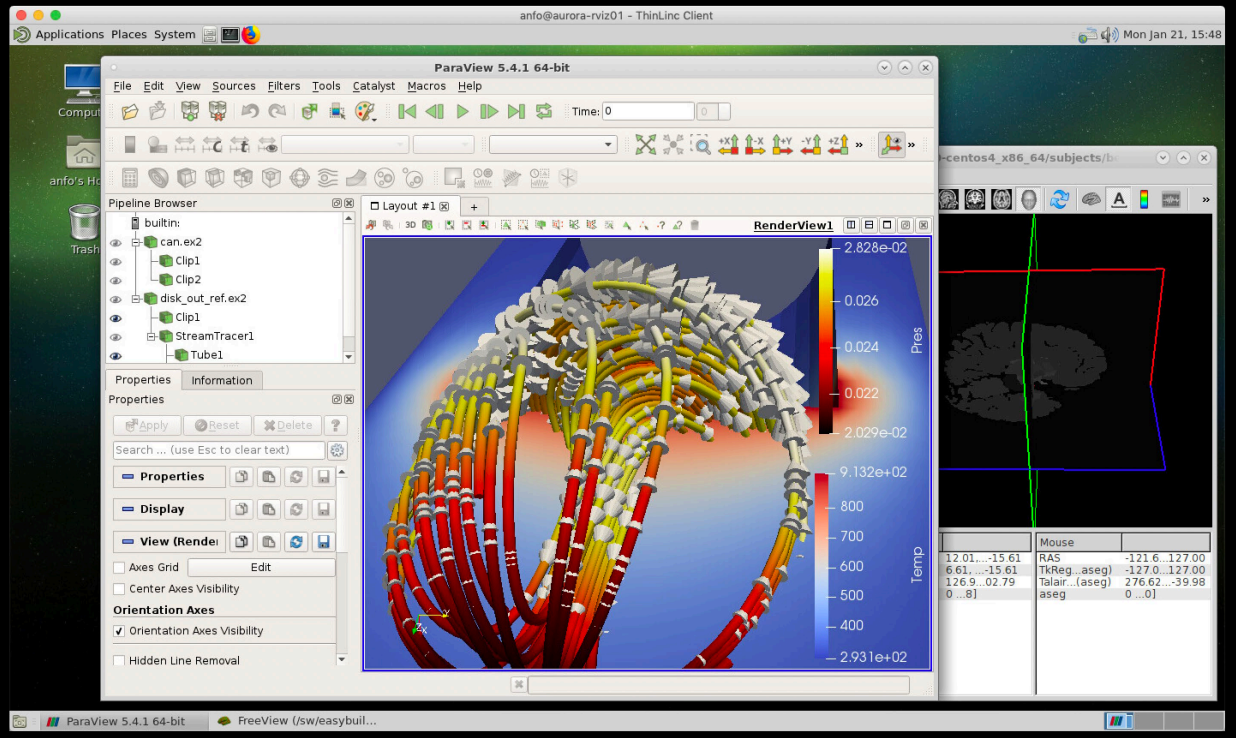
Remote LUNARC
Desktop user

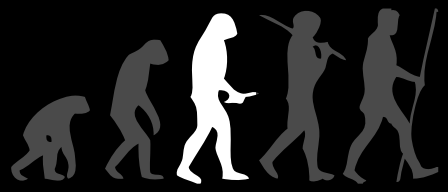




Evolution of interactive HPC and visualisation

3. Accelerated 3D Desktop (2D DT + gfx app servers)





Evolution of interactive HPC and visualisation

3. Accelerated 3D Desktop (2D DT + gfx app servers)

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2D Desktop Agent 1

2D Desktop Agent 2

2D Desktop Agent n

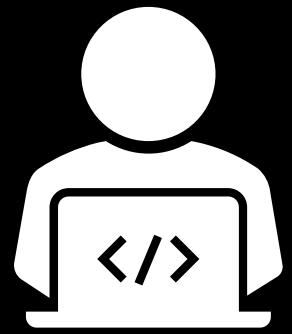
3D Application server 1

3D Application server 2

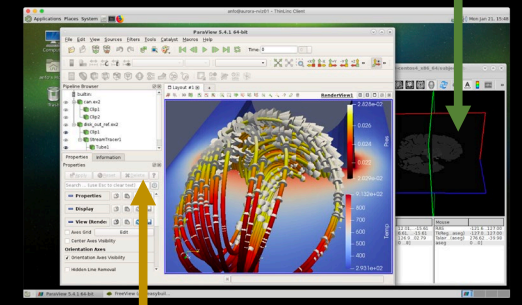
3D Application server n

Desktop session

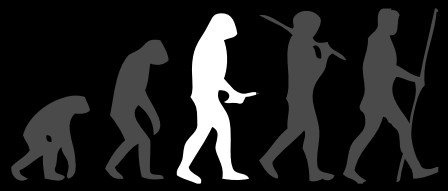
Remote LUNARC Desktop user



Executed on 2D DT Agent



Executed on 3D Appl Server. Accelerated pixels assembled into 2D DT

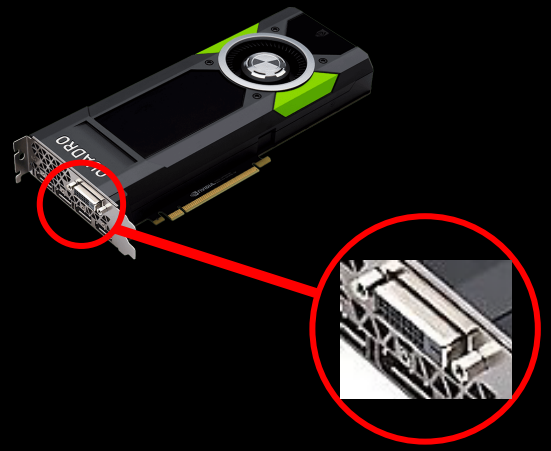


Evolution of interactive HPC and visualisation

3. Accelerated 3D Desktop (2D DT + gfx app servers)

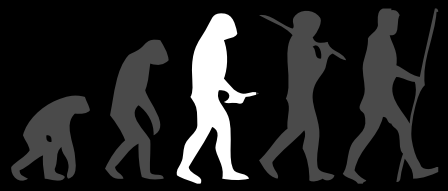
How to get accelerated pixels from application servers to the remote user accross the network?

NV QUADRO (WORKSTATION CARD)
- On board fans (not intended for data center use)
- Physical video output



This is not an option (we can't pull an DVI extension cable across the campus)

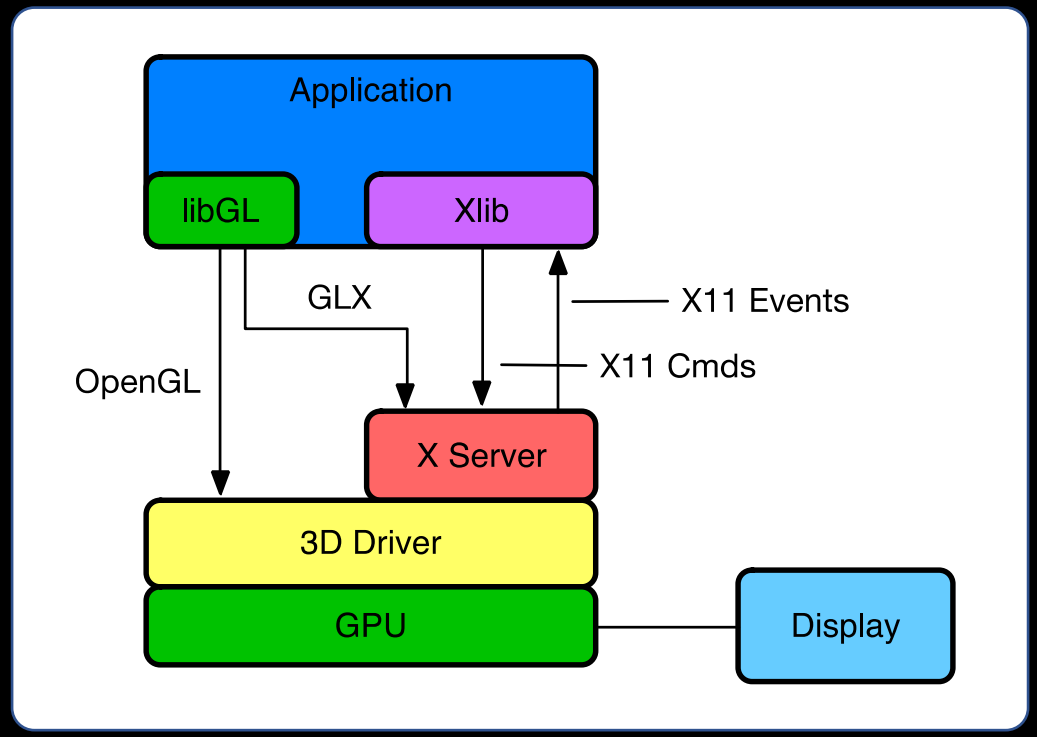
NV V100 (SERVER CARD)
- Passive cooled
- No physical video output

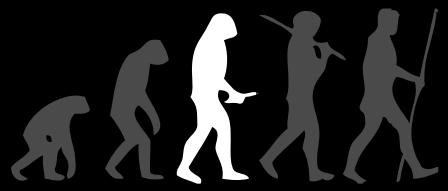


Evolution of interactive HPC and visualisation

3. Accelerated 3D Desktop (2D DT + gfx app servers)

3D OpenGL on a workstation (with local display)

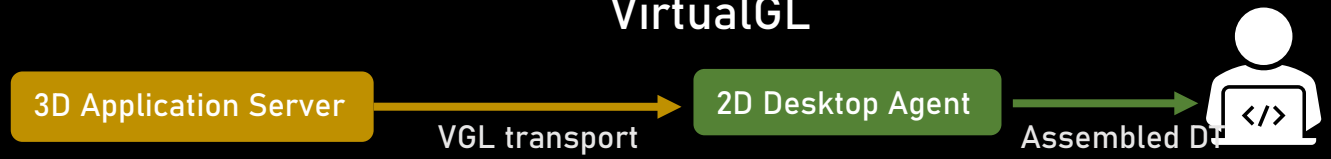


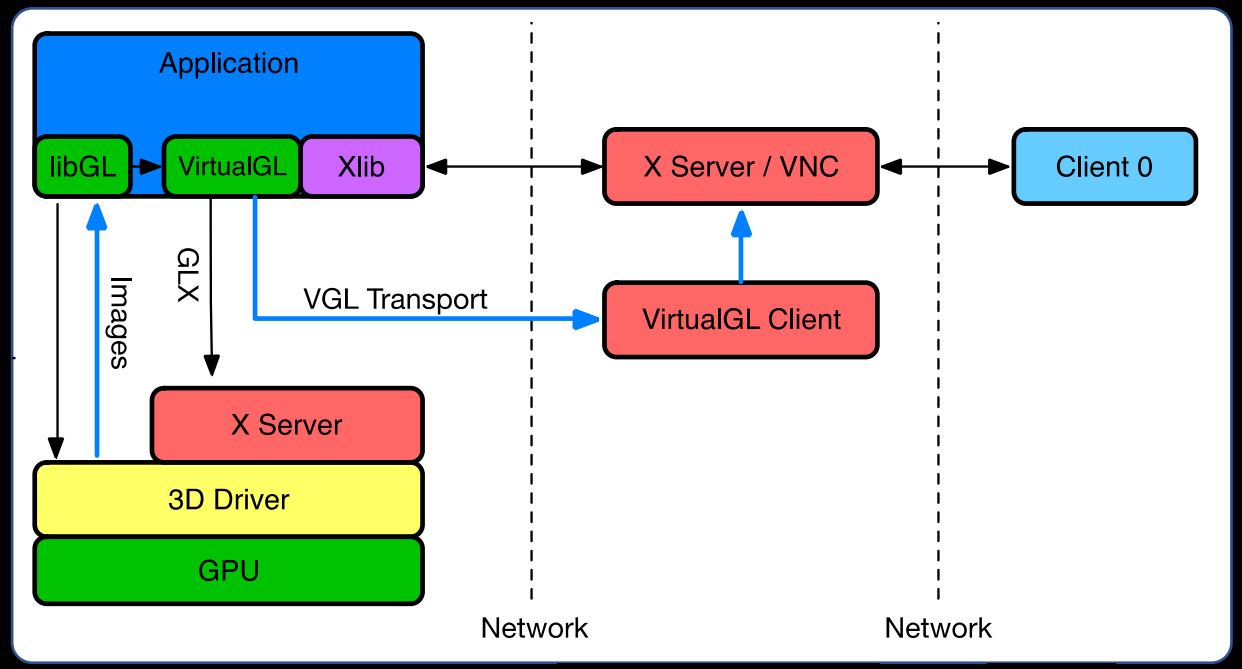


Evolution of interactive HPC and visualisation

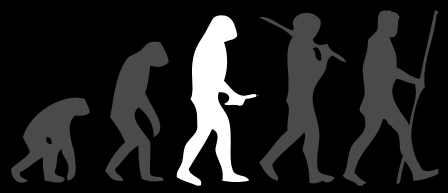
3. Accelerated 3D Desktop (2D DT + gfx app servers)

VirtualGL



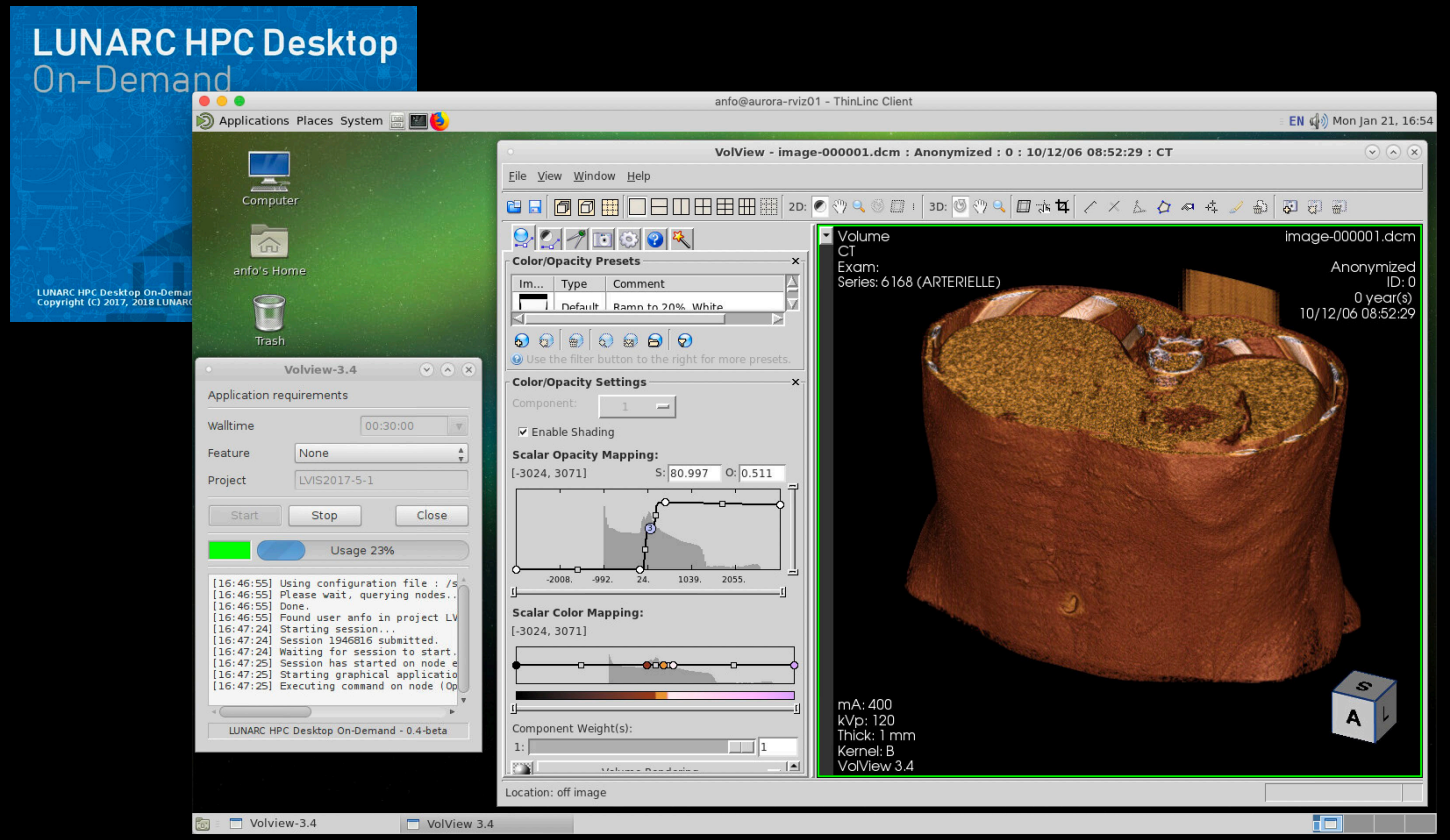


- OpenGL commands are redirected to the application server GPU and rendered locally into a pbuffer instead of being sent to remote (or local) Xserver
- Only rendered frames sent across network to host
- Linux apps only

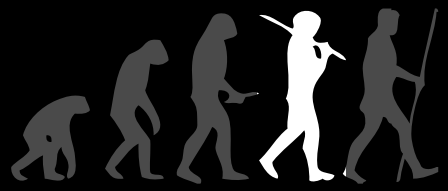


Evolution of interactive HPC and visualisation

4. Accelerated 3D Desktop (LUNARC HPC Desktop On-Demand gen1)



- User interface for specifying resource allocation through SLURM
- User "owns" 100% graphics server resources during walltime i.e. no resource sharing (RAM, CPU, GPU)
- Bare metal servers with hardware accelerated graphics



Evolution of interactive HPC and visualisation

4. Accelerated 3D Desktop (LUNARC HPC Desktop On-Demand gen1)

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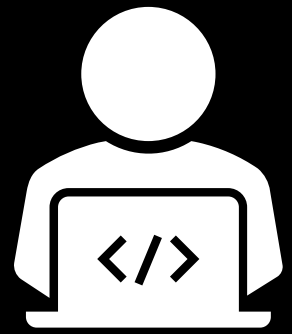
2D Desktop Agent 1

2D Desktop Agent 2

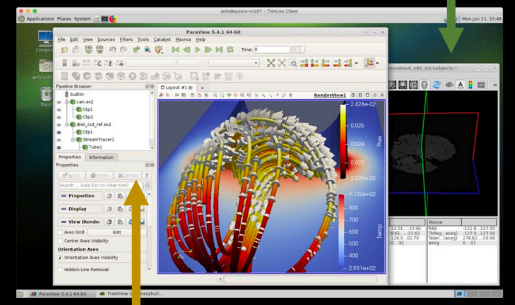
2D Desktop Agent n

Desktop session

Remote LUNARC Desktop user



Executed on 2D DT Agent



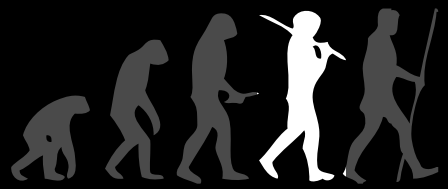
Executed on L-VIS bare metal node

L-VIS Node 1

L-VIS Node 2

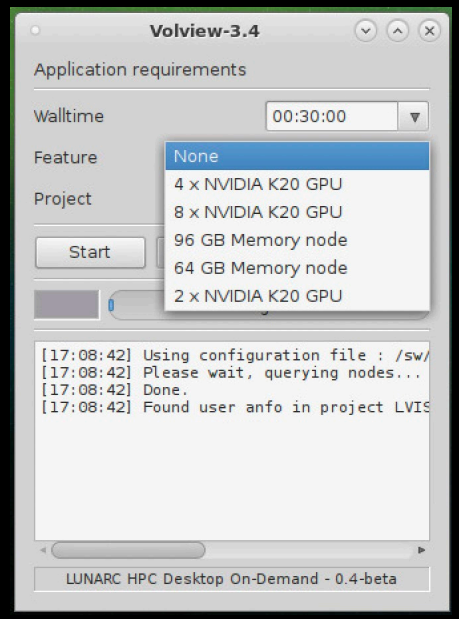
L-VIS Node n

L-VIS BARE METAL VISUALISATION CLUSTER
24 INDIVIDUAL NODES, 68 GPUs

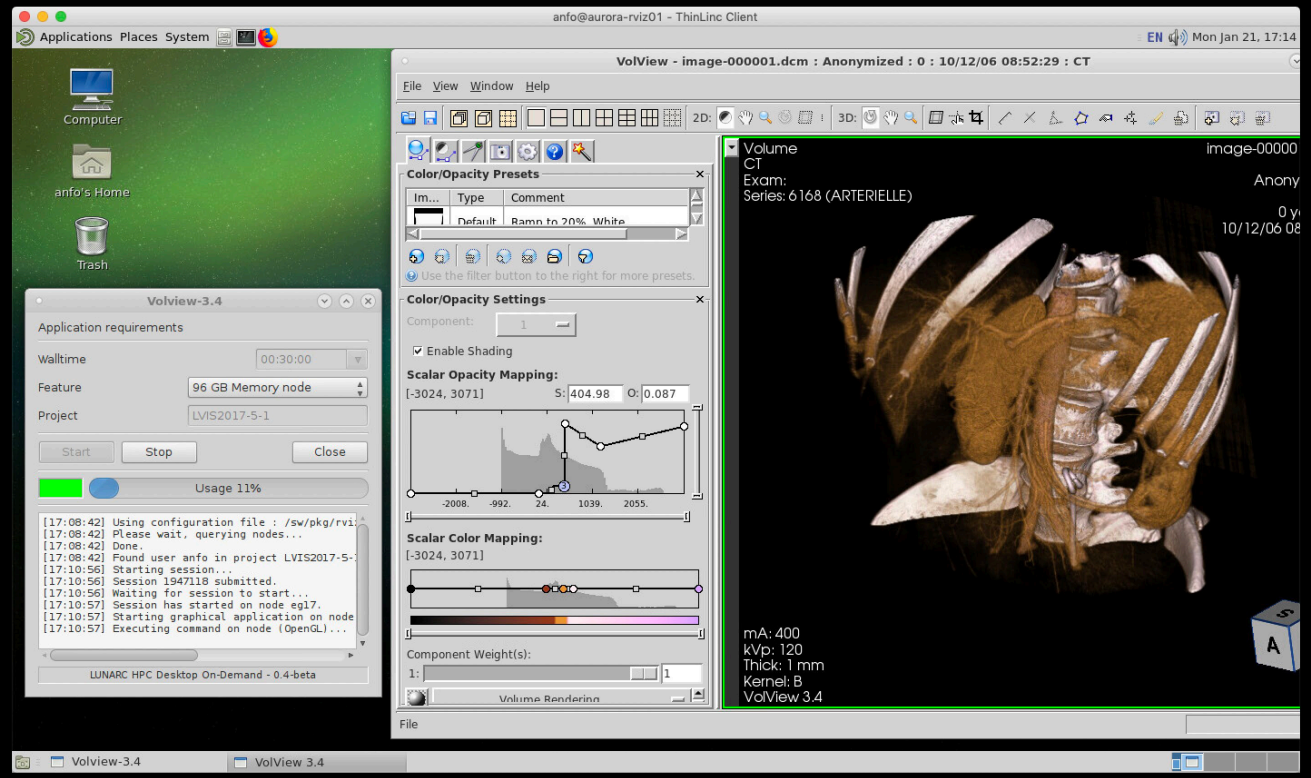


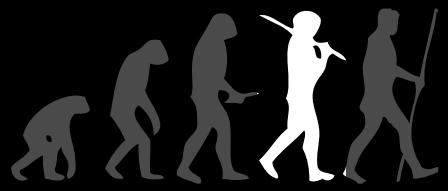
Evolution of interactive HPC and visualisation

4. Accelerated 3D Desktop (LUNARC HPC Desktop On-Demand gen1)



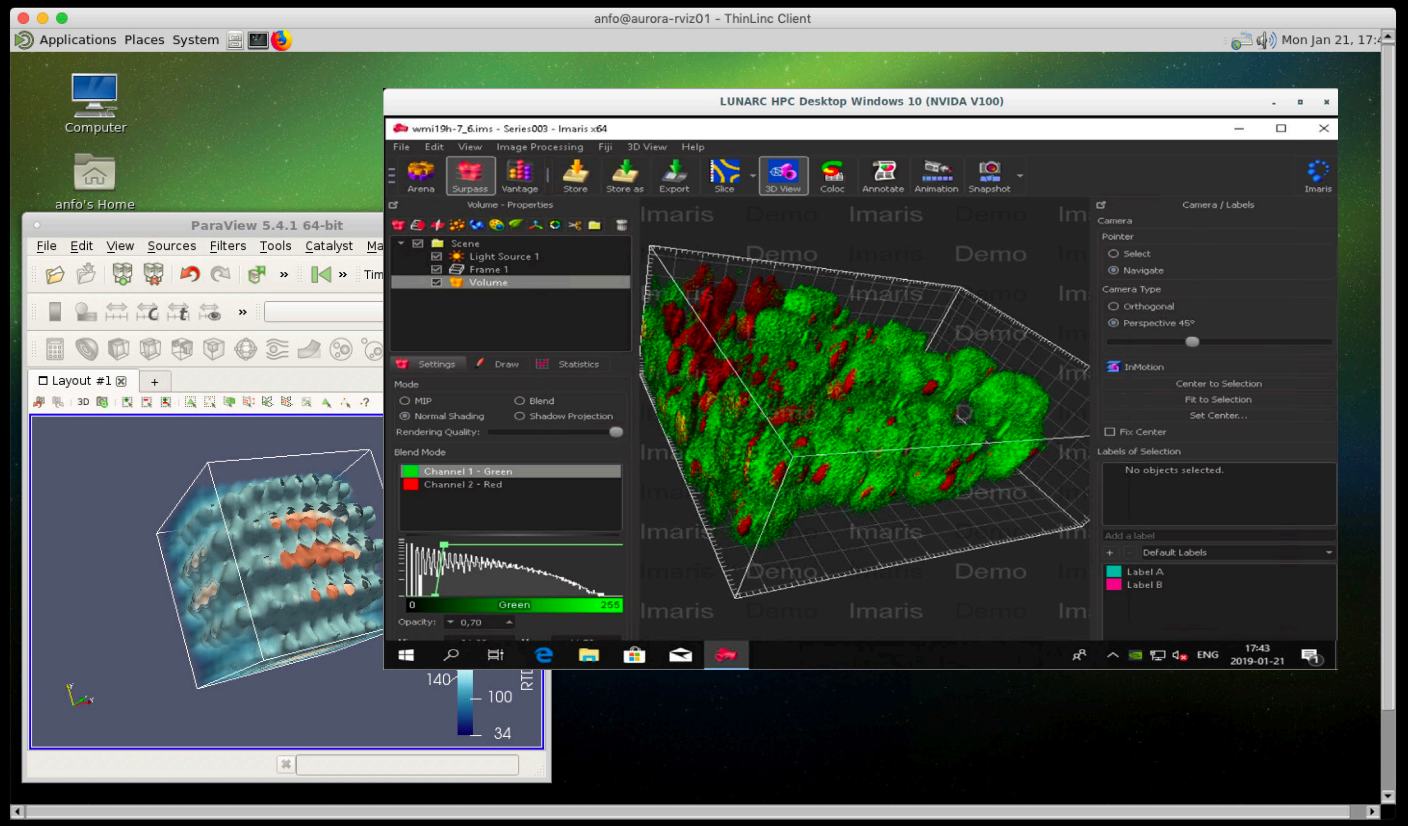
L-VIS node with selectable hardware features allocated for a certain time slot.



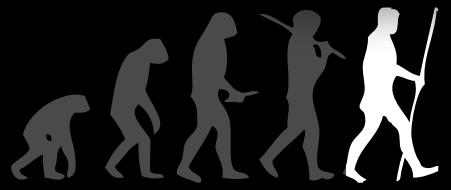


Evolution of interactive HPC and visualisation

5. Accelerated 3D Desktop (LUNARC HPC Desktop On-Demand gen2)



- Operative System Independent (MS Windows 10, Ubuntu, etc)
- Virtual machine resource management using Slurm scheduler
- 2D, 3D app server & VM hardware accelerated graphics assembled into one desktop



Evolution of interactive HPC and visualisation

5. Accelerated 3D Desktop (LUNARC HPC Desktop On-Demand gen2)

aurora.lunarc.lu.se

2D Desktop Agent 1

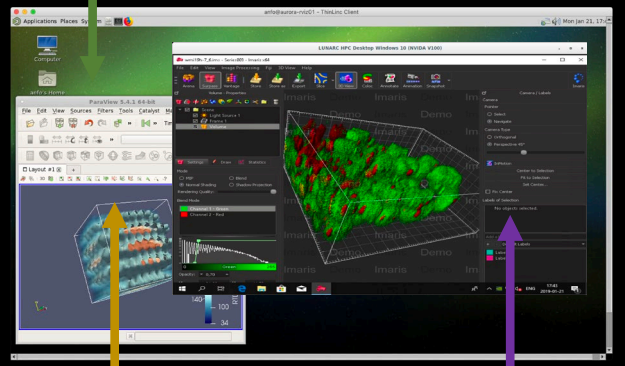
2D Desktop Agent 2

2D Desktop Agent 3

Desktop session

Remote LUNARC Desktop user

Executed on 2D DT Agent



L-VIS Node 1

Hypervisor node 1

L-VIS Node 2

Hypervisor node 2

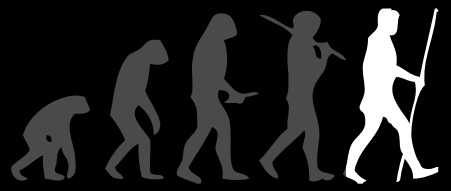
L-VIS Node n

Hypervisor node n

L-VIS Gen2 VISUALISATION CLUSTER
Xenserver Hypervisor, NVIDIA V100 GPUs

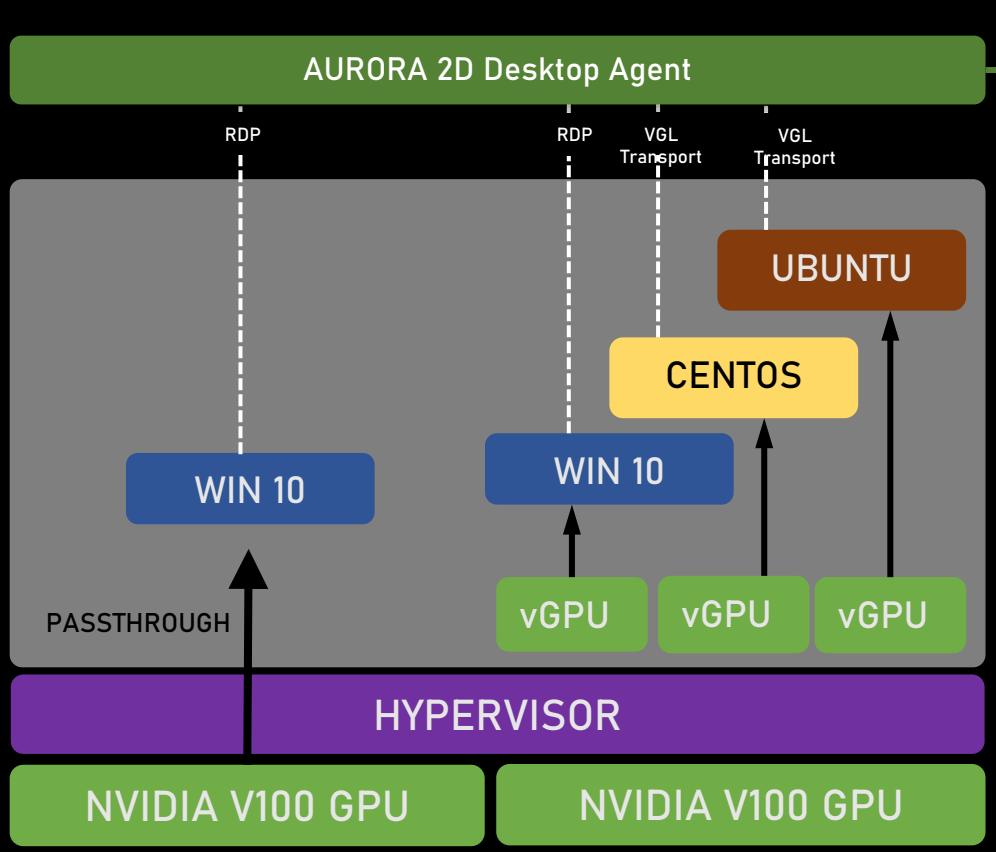
Executed on L-VIS bare metal node

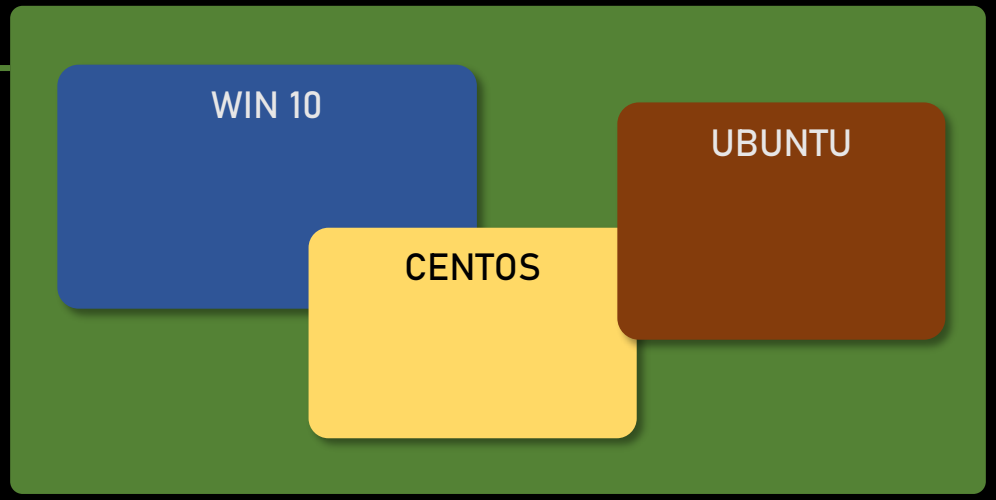
Executed on L-VIS virtual node



Evolution of interactive HPC and visualisation

Hypervisor node architecture





- Operative System Independent
- Currently using Citrix Hypervisor (XenServer)

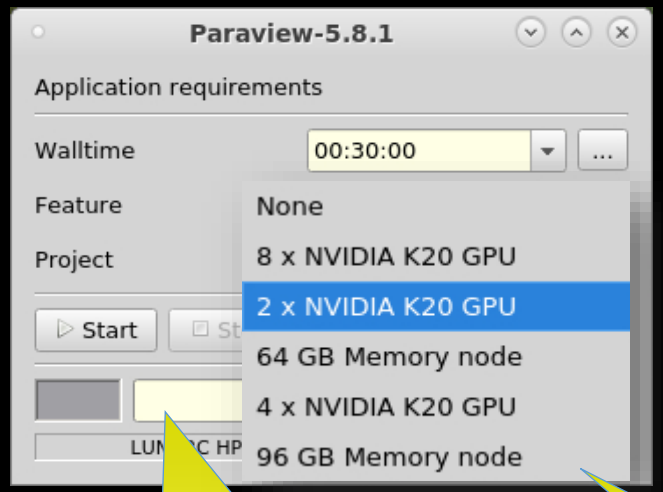
LUNARC HPC Desktop On-Demand

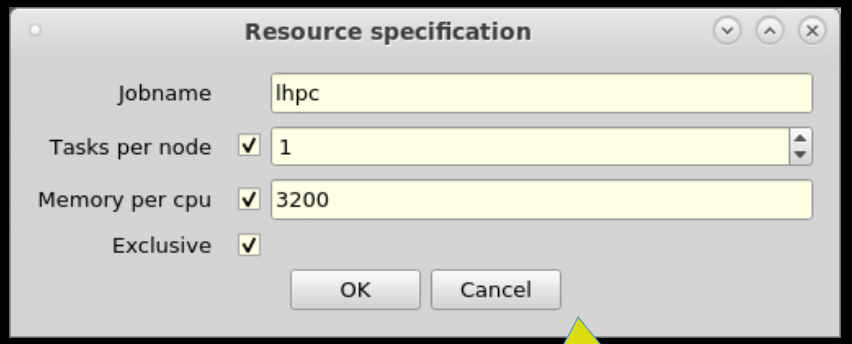
Architecture

LUNARC HPC Desktop On-Demand

- Graphical client for launching, monitoring and user resource selection
- All interactive applications launched through SLURM
- Supports launching of
  - Interactive graphical applications
  - Interactive graphical applications with hardware acceleration
  - Jupyter Notebooks with automatic connection with automatic start of browser against notebook
  - Windows based VMs through SLURM

GfxLauncher – Application launcher





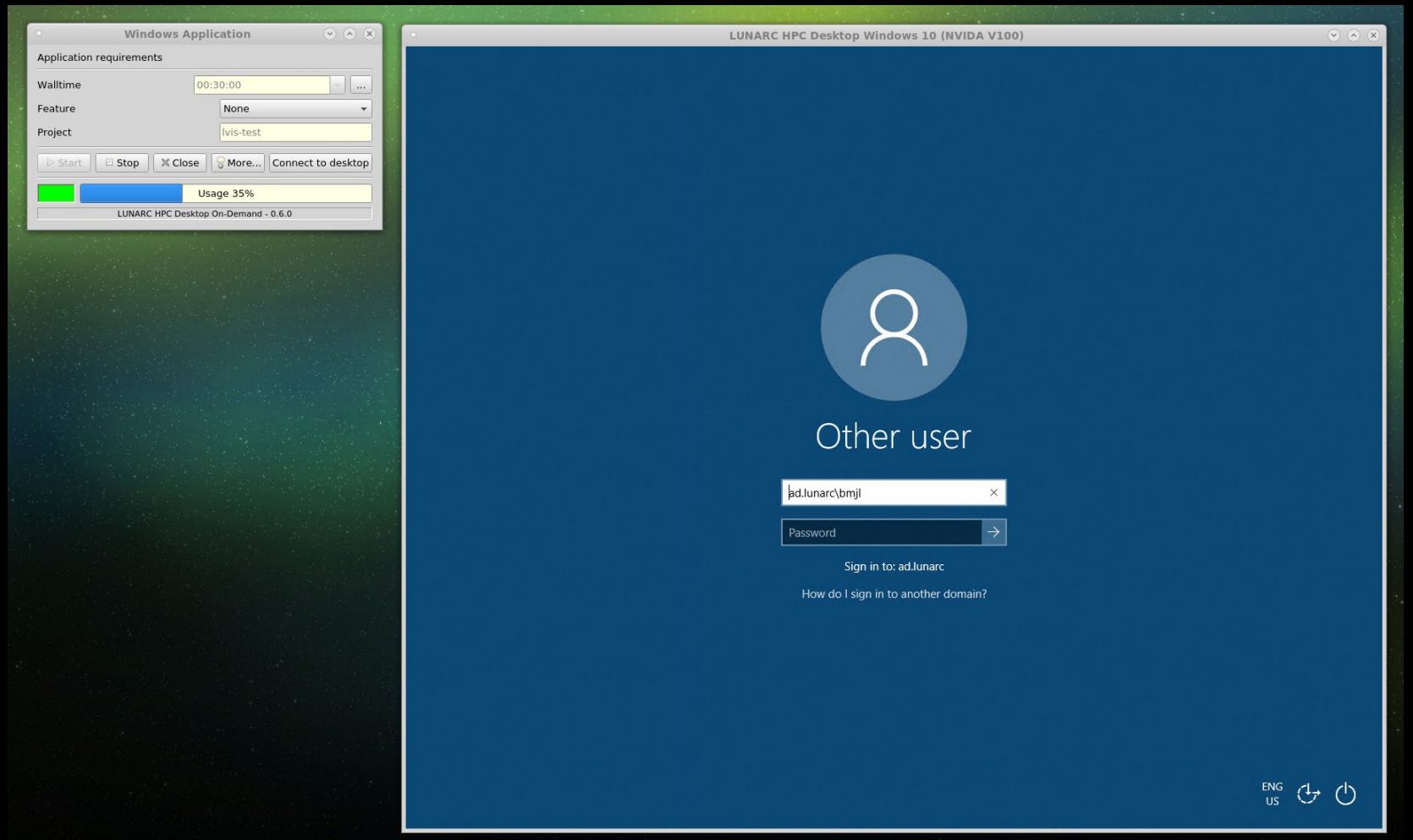
Usage bar displaying how much of the session time that has been used.

Lists available resources in SLURM in clear text

Detailed resource specification dialog.

- Launches graphical sessions through SLURM
- Configures and sets up sessions using hardware accelerated graphics
- Users gets dedicated server / part of server
- SLURM controls resource usage and session time

GfxLauncher – Window sessions



Case study

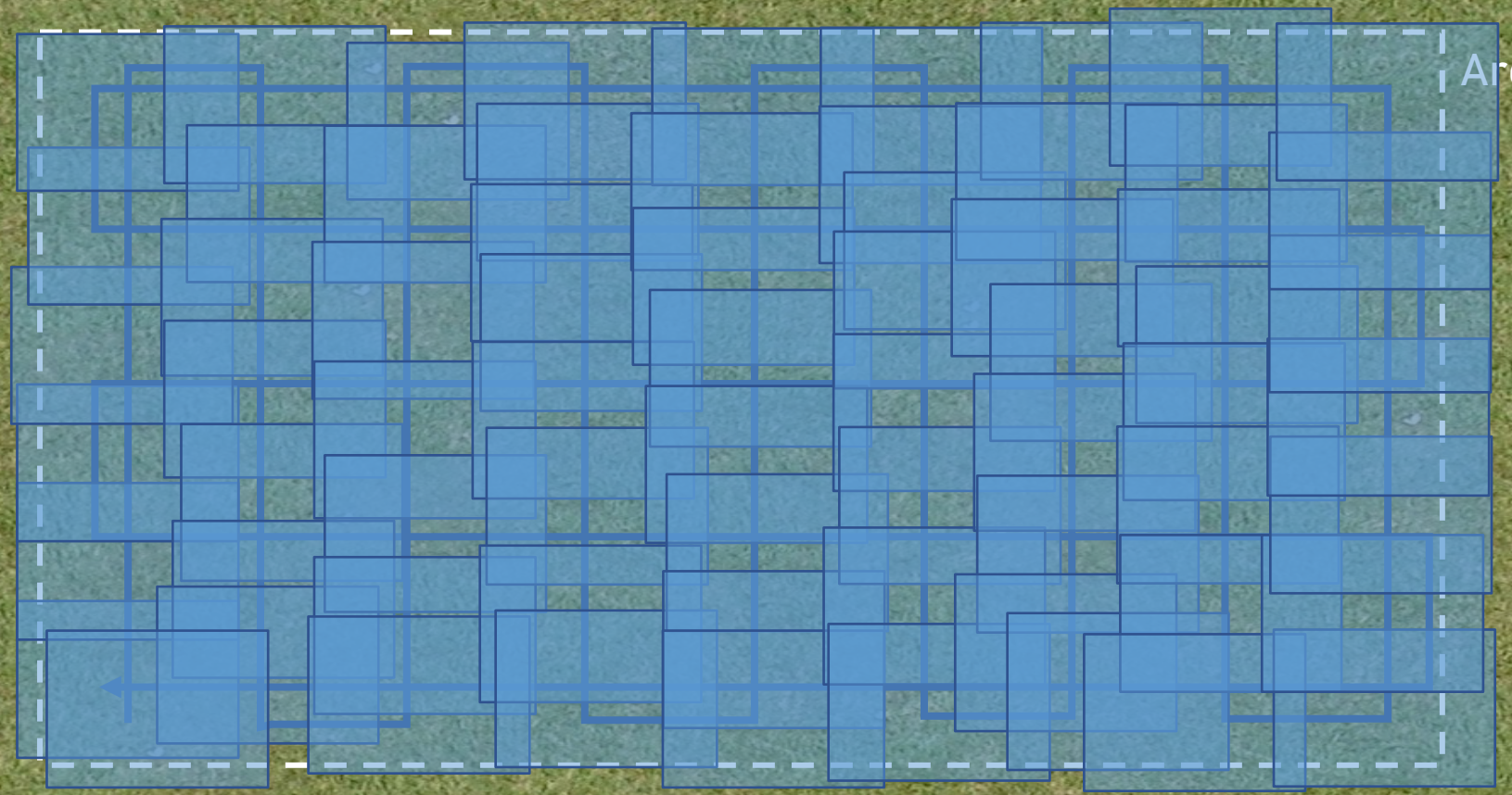
3D Scanning and reconstruction in Archeology

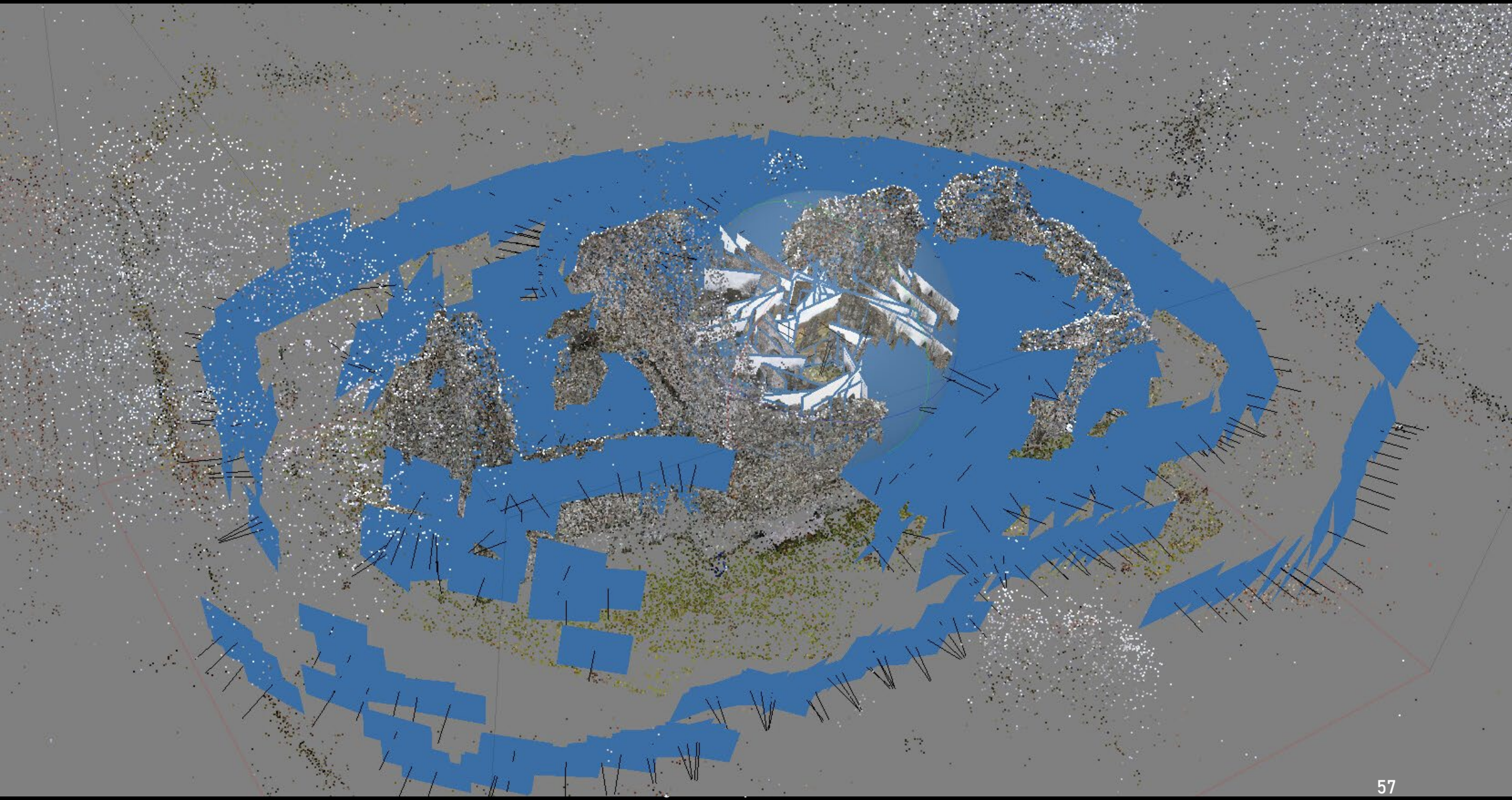
New users with large needs

Background

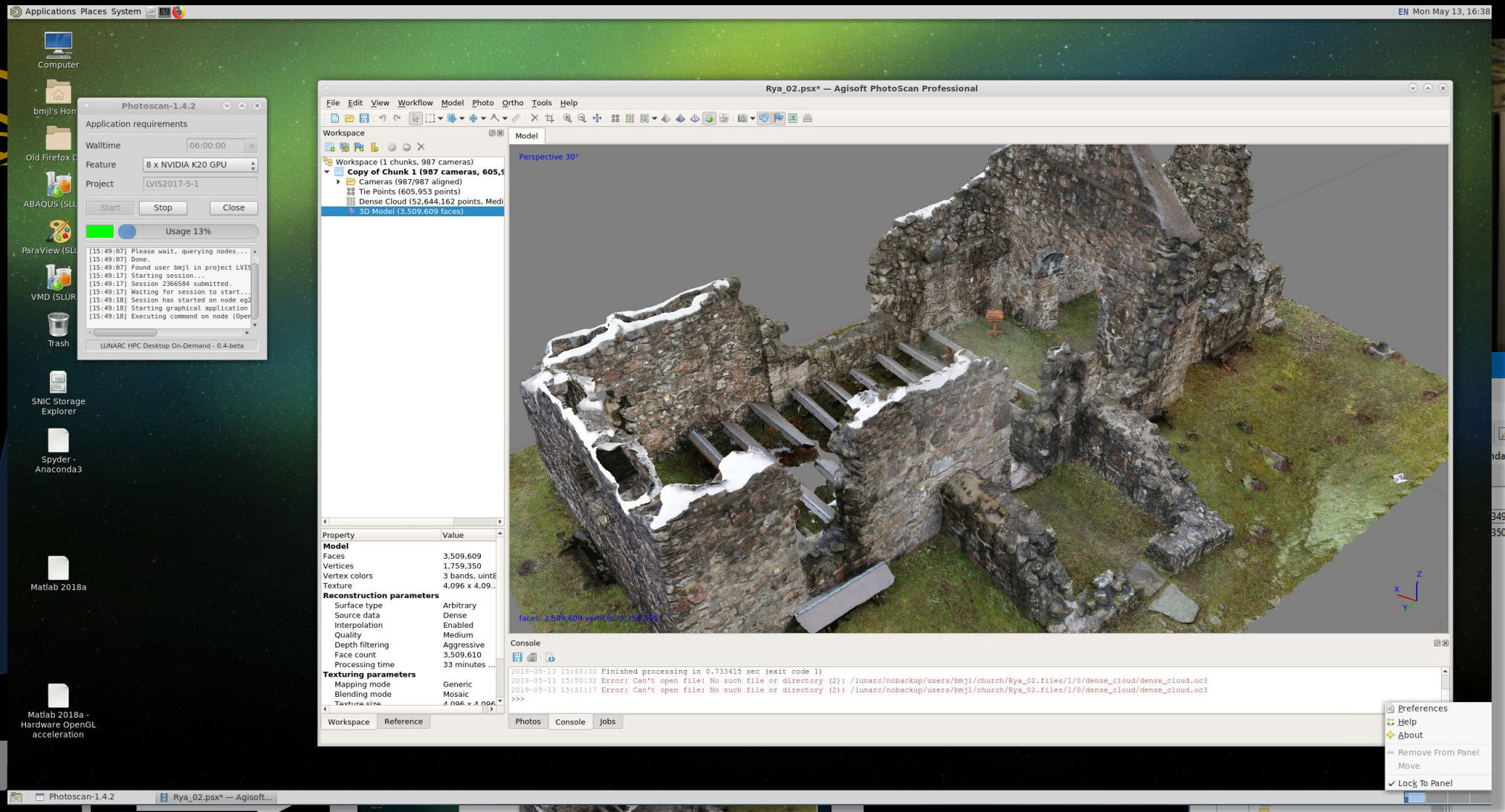
- Archeology in Lund was an early adopter of 3D photogrammetry and 3D reconstruction
- In the beginning only a limited set of photographs where used.
- Increased resolution of cameras produced larger images
- Drone photography could produce arial images in an automated way.
  - Create large 3D models av large areas
  - Generate a lot of images
- Slowly the demands for compute and storage grew
- Mainly uses interactive software and an interactive workflow for 3D reconstruction.

Bild på monitor – Skriptat arbetsflöde


Area of interest



A typical field study



LO Visualisation Meeting 8th of April

Data and compute requirements from a single site

- ~1000 images - 9 GB of data
- Processing time on laptop 7 days (if it fits in memory)
- Verifying data in the field not possible

LUNARC as a field tool

- Processing using LUNARC HPC On-demand
  - Minutes for a course mesh for coverage
  - 4 hours for complete model using GPU:s (older ones)
- Verification of data coverage is now available in the field
- Data processing and analysis can be started in the field
- Upload of data can be a problem depending on location
  - 5G will enable faster uploads
  - For slower connection uploads can be done between sessions
  - Even with slower speeds: "Hours instead of days" for computation
- Bring your favorite data center into the field

DEMO

Thank you!

- For more information
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  - anders.follin@lunarc.lu.se
  - www.lunarc.lu.se