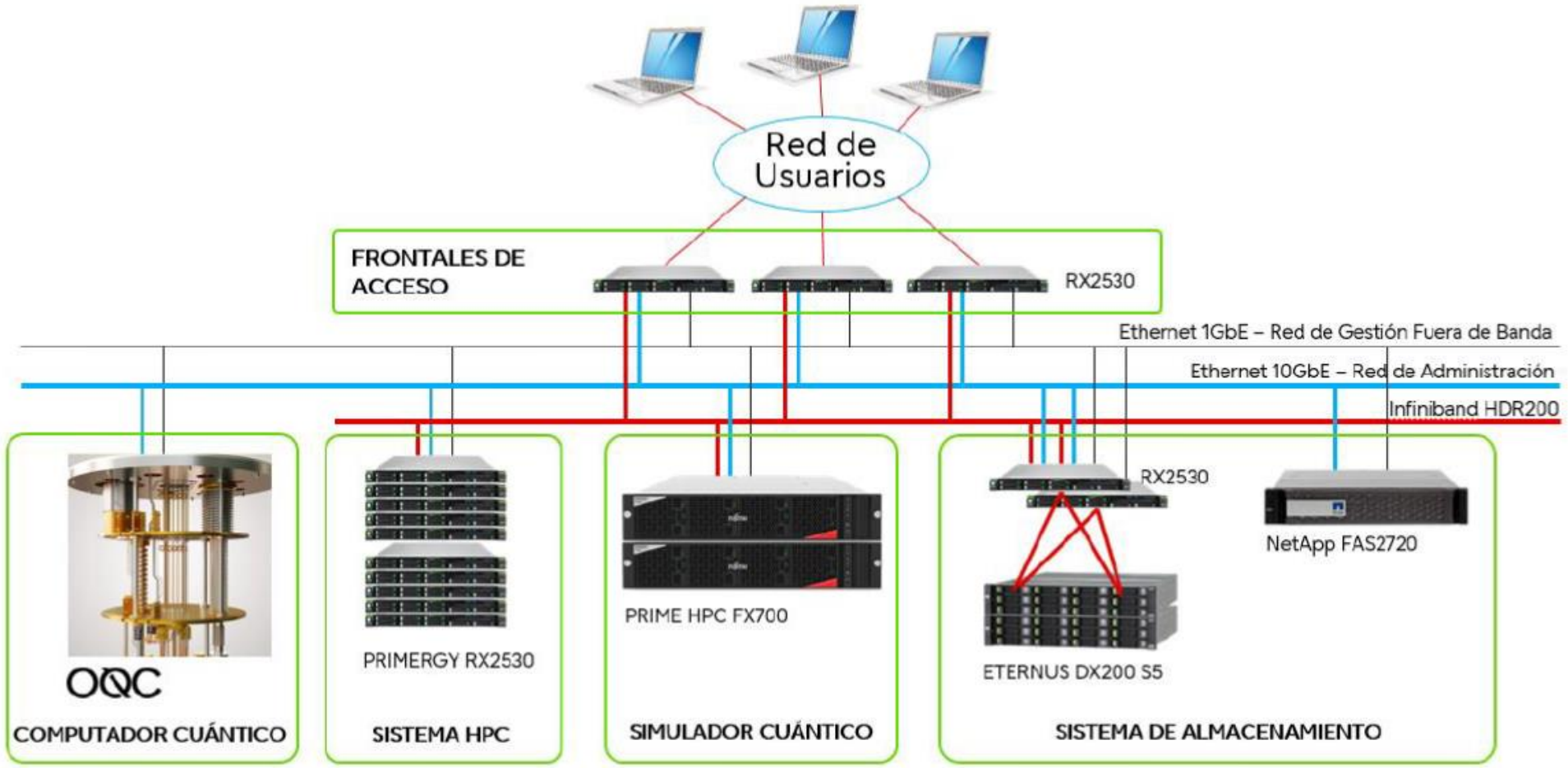
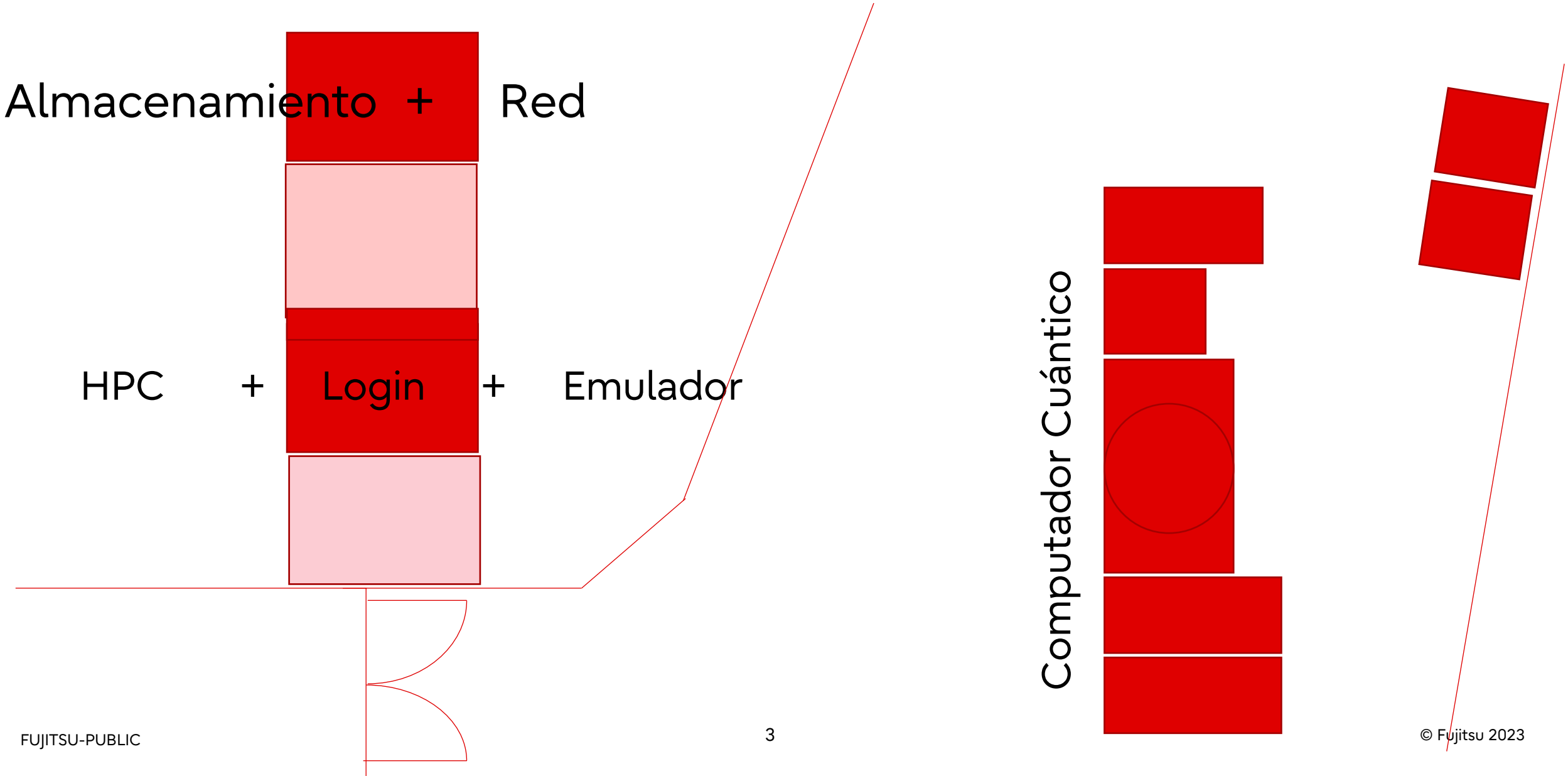
FUJITSU

# |Qmio> First steps

# Estructura



# CPD View



# Computador Cuántico

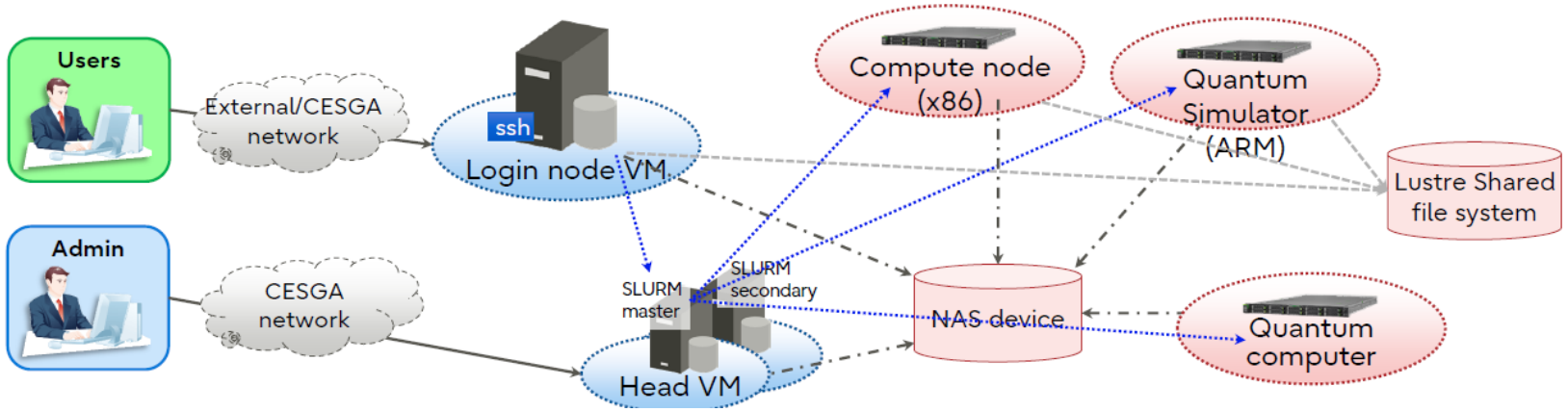
FUJITSU

# Funciones

- Nodos de Administración
  - Controlador de colas

## Nodos de login

Acceso
Qmio.cesga.es



# Estructura

- Almacenamiento
  - Cabina netapp – NFS
  - Lustre

- Almacenamiento
  - $HOME
  - $STORE
  - $LUSTRE
  - $Q_SWAP

myquota
batchlim

# Gestor de colas - slurm

- Slurm
  - Particiones por arquitectura.
    - -p a64
    - Máximo número de cores por nodo 48
    - Máximo número de nodos 16
  - Acceso a almacenamiento del CESGA
    - El directorio de lanzamiento debe ser accesible por slurm en todos los nodos del trabajo.
  - Lanzar trabajo a las colas –> sbatch
  - Trabajos interactivos –> compute/salloc ...

# Colas por arquitectura

- Nodos de Cómputo
  - HPC – x86_64 –> -p ilk
  - **Emulador Cuántico – A64FX -> -p a64**
  - Computador Cuántico – Superconductor -> -p qpu

```
acaride@login03 ~
$ sinfo
PARTITION       AVAIL  TIMELIMIT  NODES  STATE NODELIST
qpu                up   infinite      1   idle c7-23
ilk_interactive    up   infinite      2   idle c7-[1-2]
ilk*               up   infinite     20   idle c7-[3-22]
a64                up   infinite     16   idle c7-[101-116]
acaride@login03 ~
```

sinfo
scontrol
…

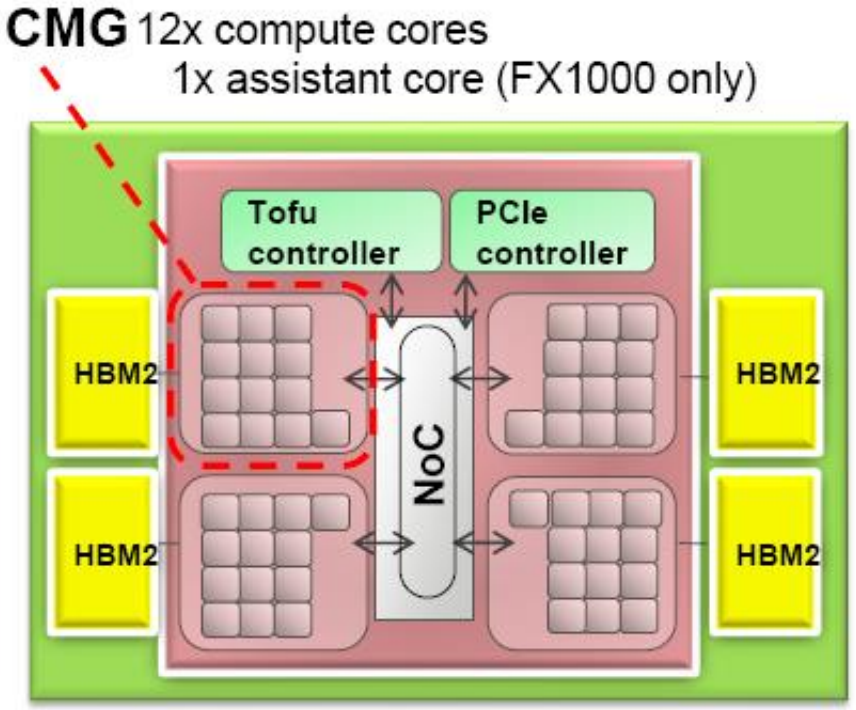
```
acaride@login03 ~
$ scontrol show Node=c7-101
NodeName=c7-101 Arch=aarch64 CoresPerSocket=12
   CPUAlloc=0 CPUEfctv=48 CPUTot=48 CPULoad=0.08
   AvailableFeatures=a64
   ActiveFeatures=a64
   Gres=(null)
   NodeAddr=c7-101 NodeHostName=c7-101 Version=23.11.4
   OS=Linux 4.18.0-425.3.1.el8.aarch64 #1 SMP Thu Nov 10 00:36:38 UTC 2022
   RealMemory=30000 AllocMem=0 FreeMem=22343 Sockets=4 Boards=1
   State=IDLE ThreadsPerCore=1 TmpDisk=0 Weight=30 Owner=N/A MCS_label=N/A
   Partitions=a64
   BootTime=2024-04-18T09:56:35 SlurmdStartTime=2024-05-08T15:35:04
   LastBusyTime=2024-05-12T10:53:05 ResumeAfterTime=None
   CfgTRES=cpu=48,mem=30000M,billing=48
   AllocTRES=
   CapWatts=n/a
   CurrentWatts=0 AveWatts=0
   ExtSensorsJoules=n/a ExtSensorsWatts=0 ExtSensorsTemp=n/a
```

# FX700

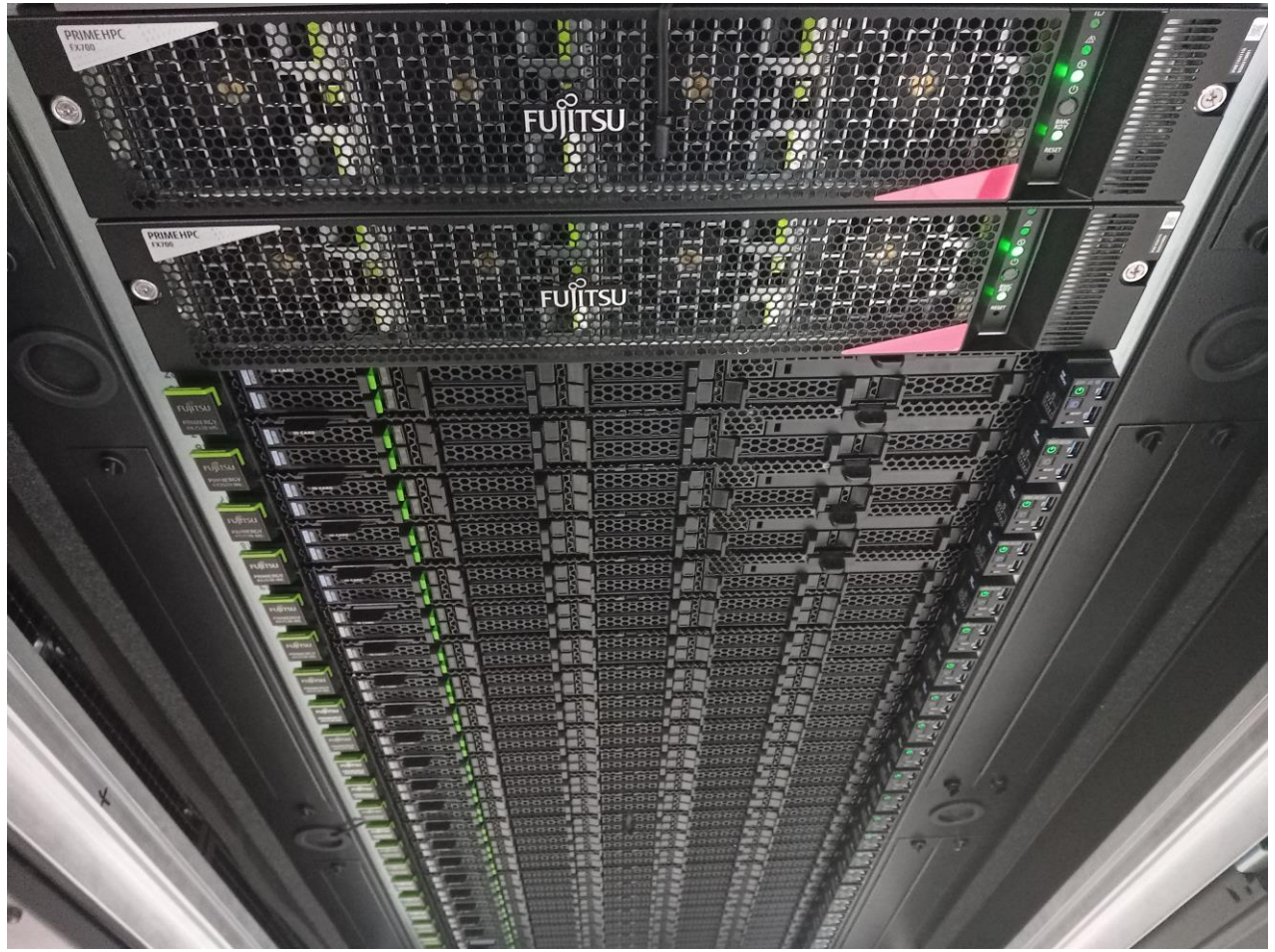
- Hardware Específico:
  - 2 Chasis (4us) correspondientes a 16 nodos en total.
  - Cada nodo cuenta con un procesador A64FX con 48 cores, NoC y 32 GB de memoria. Están interconectados por IB.
  - Procesadores ARM 64 bits con instrucciones vectoriales extendidas (SVE).
- Software:
  - Rocky Linux 8.7
  - OpenHPC
    - gnu12
    - HPC-X
    - UCX
    - Python3.8.13
    - Papi, extrae, likwid...
    - Módulos

FUJITSU

| Specifications | A64FX |
|---|---|
| ISA (Base, extension) | Armv8.2-A, SVE |
| Process technology | 7 nm |
| Peak DP performance | 2.7 or 3.0 TFLOPS |
| SIMD width | 512-bit |
| # of cores | 48 (+ 4) |
| Memory capacity | 32 GiB (HBM2 x4) |
| Memory peak bandwidth | 1024 GB/s |
| PCIe | Gen3 16 lanes |
| High speed interconnect | TofuD integrated |



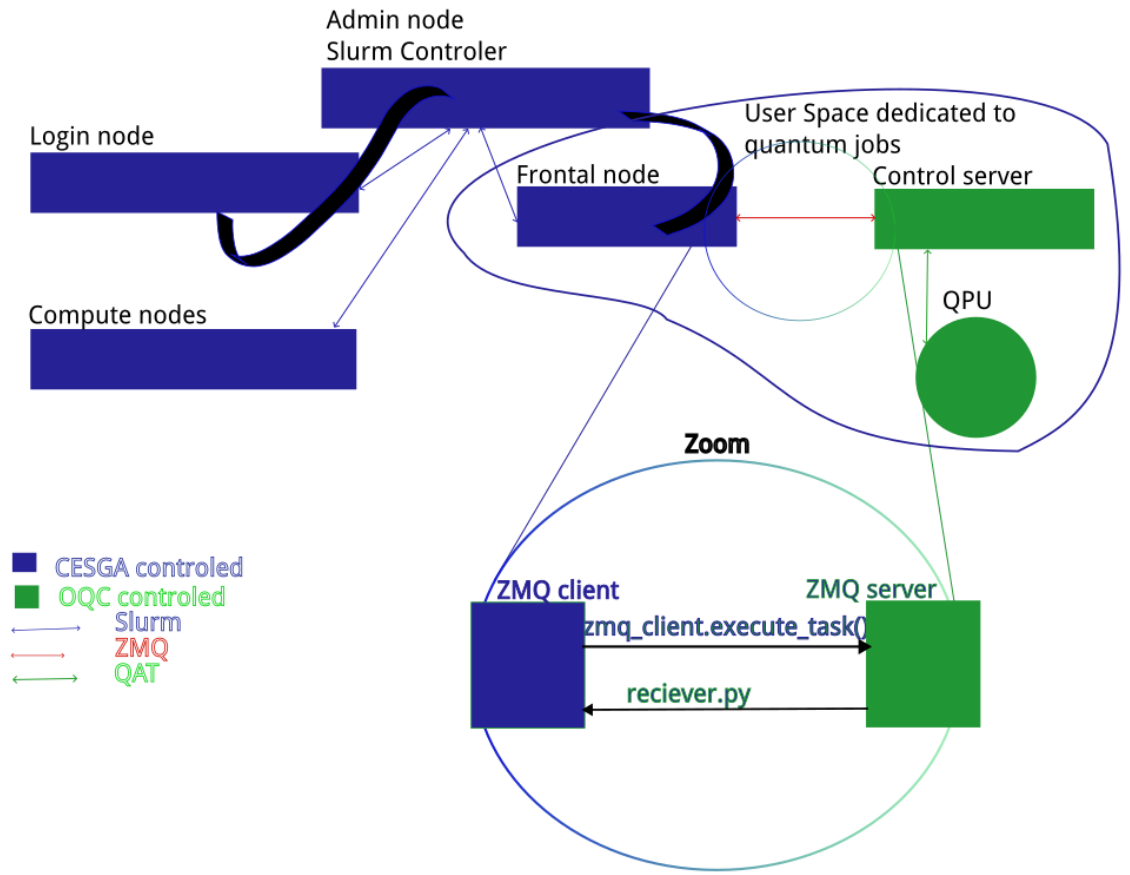
- Hardware
  - 23 nodos en total.
  - 20 nodos en ilk, 2 en para interactivo
  - 1 como nodo frontal para el computador cuántico
  - Cada nodo cuenta con un procesador Intel Xeon gold 6338 de 64 bits con 64 cores y 1TB de memoria. Están interconectados por IB.
- Software:
  - Módulos



# Nodo frontal del Computador Cuántico

- Hardware
  - 1 nodo como los de la partición ilk.
  - Cuenta con un procesador Intel Xeon gold 6338 de 64 bits con 64 cores y 1TB de memoria.
  - Tiene conexión con el computador cuántico a través de paso de mensajes.

- Software:
  - Módulos



# Software Stack

# Sistema de módulos

- Árbol de módulos (Lmod)
- Diferentes para las diferentes arquitecturas

```
acaride@login03 /mnt/netapp2/Home_FT2/home/cesga/acaride/DOJO_20240513/py/qulacs
$ module av

------------------------------------ /opt/cesga/qmio/hpc/software/Core/hpcx/2.17.1/modulefiles -------------------------------------
   hpcx-debug-ompi    hpcx-debug    hpcx-mt-ompi    hpcx-mt    hpcx-ompi    hpcx-prof-ompi    hpcx-prof    hpcx-stack    hpcx

---------------------------------------------------- Core ----------------------------------------------------
   apptainer/1.2.3                    (Tool)      libseccomp/2.5.5                   (Tool)
   bison/3.1                          (Tool)      libxml2/2.9.7                      (Tool)
   boost.python/1.85.0-python-3.9.9               libxslt/1.1.32                     (Tool)
   boost/1.85.0                       (Math)      m4/1.4.18                          (Tool)
   cmake/3.18.2                       (Tool)      meson-python/0.16.0-python-3.9.9
   cmake/3.25.0                       (Tool)      meson/0.53.1                       (Tool)
   cmake/3.27.6                       (D)         meson/1.4.0-python-3.9.9           (Tool,D)
   cython/3.0.9-python-3.9.9          (Comp)      miniconda3/22.11.1-1               (Comp)
   flex/2.6.4                         (Tool)      ncurses/6.1                        (Tool)
   gcc/12.3.0                         (Comp)      ninja/1.9.0                        (Tool)
   gcccore/12.3.0                     (Comp)      numpy/1.26.4-python-3.9.9-mkl      (Math)
   glib/2.58.2                        (VisF)      numpy/1.26.4-python-3.9.9-openblas (Math)
   glpk/4.65                          (Math)      numpy/1.26.4-python-3.9.9          (Math,D)
   gmp/6.1.2                          (Math)      openblas/0.3.24
   go/1.20.4                          (Comp)      openssl/1.1.0i                     (Tool)
   gocryptfs/2.4.0-linux-static_amd64 (Tool)      openssl/1.1.1b                     (Tool)
   gperf/3.1                          (Tool)      openssl/1.1.1q                     (Tool,D)
   help2man/1.47.6                    (Tool)      pixman/0.38.4                      (VisF)
   icu/75.1-python-3.9.9                          python/3.9.9                       (Comp)
   imkl/2023.2.0                      (Math)      qmio-run/0.1.1-python-3.9.9        (QComp)
   jupyter-server/1.13.5-python-3.9.9             rust/1.75.0
   libffi/3.2.1                       (Tool)      singularity/4.0.0                  (Tool)
   libffi/3.4.2                       (Tool)      sqlite/3.45.3
   libffi/3.4.4                       (Tool,D)    squashfs/4.3                       (Tool)
   libreadline/8.0                    (Tool)      squashfuse/0.5.0                   (Tool)

------------------------------------------------ /opt/cesga/modules/orgs-qmio -------------------------------------------------
   qmio/hpc (S,L)
```

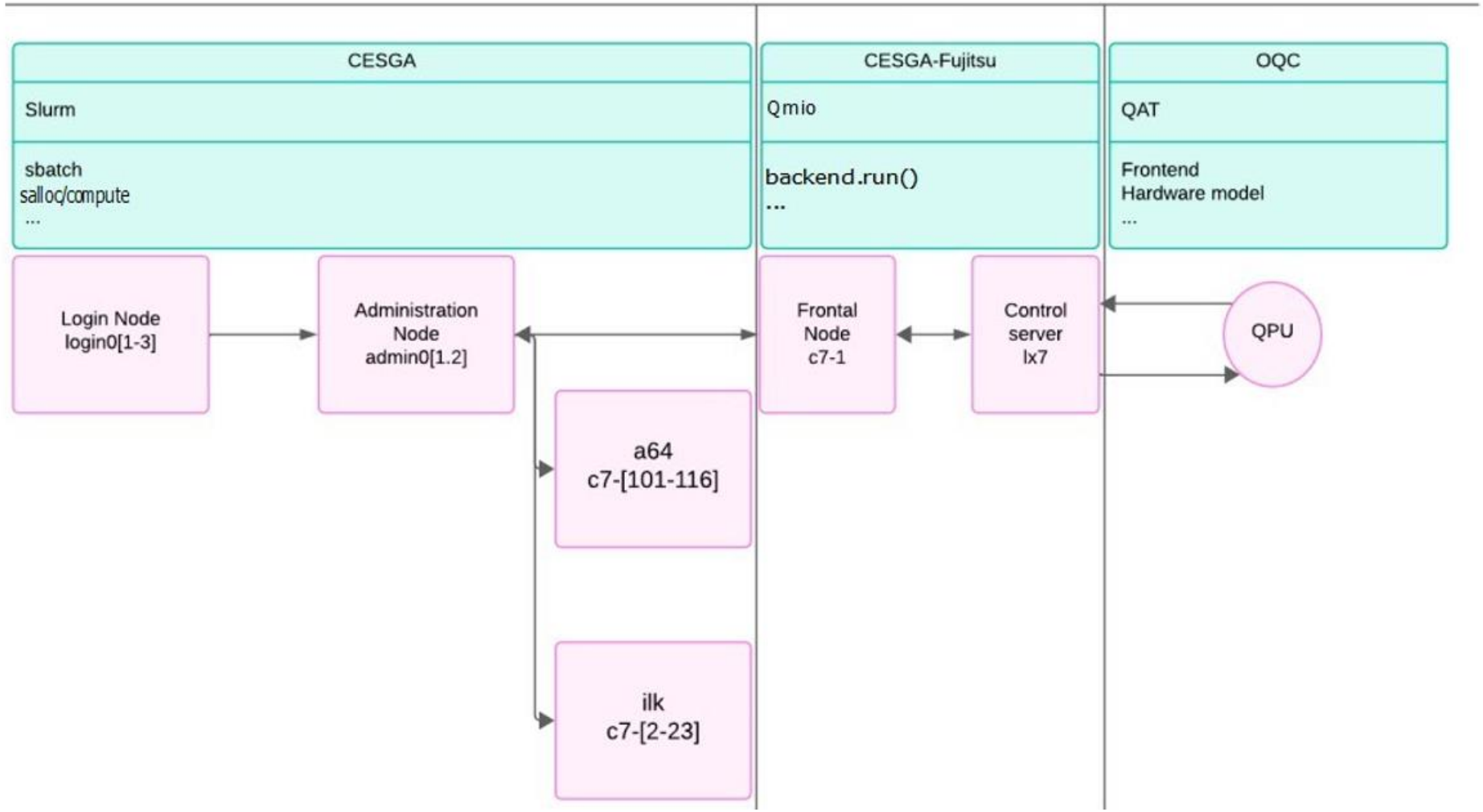
# x86 + gcc

```
$ module av

---------------------------------------- GCC/12.3.0 ----------------------------------------
   boost.python/1.85.0-python-3.9.9 (D)        pytket/1.23.0-python-3.9.9          (QComp)      qulacs/0.6.3-python-3.9.9 (QComp,D)
   boost/1.85.0                     (Math,D)   qiskit-qulacs/0.1.0-python-3.9.9-mpi (QComp)      qutip/5.0.0-python-3.9.9
   cvxpy/1.4.3-python-3.9.9                    qiskit-qulacs/0.1.0-python-3.9.9     (QComp,D)    scipy/1.11.0-python-3.9.9 (Math)
   networkx/2.8.8-python-3.9.9      (Tool)     qiskit/1.0.2-python-3.9.9-mpi        (QComp)      scipy/1.13.0-python-3.9.9 (Math,D)
   openblas/0.3.24                  (D)        qiskit/1.0.2-python-3.9.9            (QComp,D)
   pythran/0.15.0-python-3.9.9                 qulacs/0.6.3-python-3.9.9-mpi        (QComp)

------------------------------------------------ Core ------------------------------------------------
   apptainer/1.2.3                      (Tool)      matplotlib/3.5.3-python-3.9.9        (VisF)
   binutils/2.40                        (L,Tool)    meson-python/0.16.0-python-3.9.9     (D)
   bison/3.1                            (Tool)      meson-python/0.16.0-python-3.9.9
   bison/3.1                            (Tool,D)    meson/0.53.1                         (Tool)
   boost.python/1.85.0-python-3.9.9                 meson/0.53.1                         (Tool)
   boost/1.85.0                         (Math)      meson/0.63.3-python-3.9.9            (Tool)
   catch2/2.13.9                                    meson/1.4.0-python-3.9.9             (Tool,D)
   cmake/3.18.2                         (Tool)      meson/1.4.0-python-3.9.9             (Tool)
   cmake/3.18.2                         (Tool)      miniconda3/22.11.1-1                 (Comp)
   cmake/3.25.0                         (Tool)      mpc/1.3.1
   cmake/3.25.0                         (Tool)      mpfr/4.2.1
   cmake/3.27.6                                     nasm/2.16.03
   cmake/3.27.6                         (D)         ncurses/6.1                          (Tool)
   conan/1.64.0-python-3.9.9                        ncurses/6.1                          (Tool,D)
   conan/2.2.3-python-3.9.9             (D)         ninja/1.9.0                          (Tool)
   cython/0.29.24-python-3.9.9          (Comp)      ninja/1.9.0                          (Tool,D)
   cython/3.0.9-python-3.9.9            (Comp,D)    nlohmann_json/3.11.3
   cython/3.0.9-python-3.9.9            (Comp)      nodejs/18.12.1-python-3.9.9-with-icu (Comp)
   eigen/3.4.0                          (Math)      numpy/1.26.4-python-3.9.9-mkl        (Math)
   flex/2.6.4                           (Tool,D)    numpy/1.26.4-python-3.9.9-openblas   (Math)
   flex/2.6.4                           (Tool)      numpy/1.26.4-python-3.9.9            (Math)
   flint/3.1.2                          (Math)      numpy/1.26.4-python-3.9.9            (Math,D)
   gcc/12.3.0                           (L,Comp)    openblas/0.3.24
   gcccore/12.3.0                       (L,Comp)    openssl/1.1.0i                       (Tool)
   glib/2.58.2                          (VisF)      openssl/1.1.1b                       (Tool)
   glpk/4.65                            (Math)      openssl/1.1.1q                       (Tool,D)
   gmp/6.1.2                            (Math)      pcre2/10.35
   gmp/6.3.0                            (D)         pixman/0.38.4                        (VisF)
   go/1.20.4                            (Comp)      pybind11/2.8.1-python-3.9.9          (Tool)
   gocryptfs/2.4.0-linux-static_amd64   (Tool)      pybind11/2.12.0-python-3.9.9         (Tool,D)
   gperf/3.1                            (Tool)      pylatexenc/2.10-python-3.9.9         (Tool)
   graphviz/10.0.1                                  pyqt-builder/1.16.1-python-3.9.9
   help2man/1.47.6                      (Tool,D)    pytest/6.2.5-python-3.9.9
   help2man/1.47.6                      (Tool)      python/3.9.9-base                    (Comp)
   icu/75.1-python-3.9.9                            python/3.9.9                         (Comp)
   imkl/2023.2.0                        (Math)      python/3.9.9                         (Comp)
   jupyter-bundle/20240425-python-3.9.9             python/3.11.9                        (D)
   jupyter-server/1.13.5-python-3.9.9               qmio-run/0.1.1-python-3.9.9          (QComp)
```

```
acaride@c7-101 ~/Exploracion-qulacs/ejemplos
$ module av

------------------------------------------------------------ /opt/ohpc/pub/moduledeps/gnu12-openmpi4 ------------------------
   boost/1.80.0    extrae/3.8.3    py3-mpi4py/3.1.3

------------------------------------------------------------ /opt/ohpc/pub/moduledeps/gnu12 -----------------------------
   openblas/0.3.21    openmpi4/4.1.4 (L)    py3-numpy/1.19.5

------------------------------------------------------------ /opt/ohpc/pub/modulefiles ----------------------------------
   EasyBuild/4.6.2        gnu12/12.2.0 (L)    libfabric/1.13.0 (L)    papi/6.0.0        prun/2.2        (L)    valgrind/3.19.0
   autotools       (L)    hpcx-mt-ompi        ohpc             (L)    pmix/4.2.1        qulacs-hpcx/1.0
   cmake/3.24.2           hwloc/2.7.0  (L)    os                      pmix/4.2.9 (D)    ucx/1.11.2      (L)
```

# Integración con el computador cuántico

# Diagrama



# Ejemplo

```
from qmio import QmioRuntimeService

circuit="""OPENQASM 3.0;include "qelib1.inc";qreg q[32];creg c

service = QmioRuntimeService()

# Recommended usage
with service.backend(name="qpu") as backend:
        result = backend.run(circuit=circuit, shots=10)

print(result)
```

# Más ejemplos

En vivo.

# ¿Preguntas?

# Thank you

# Contacto

Álvaro Caride-Tabarés Sánchez,

Senior On-Site Technician

Fujitsu - IQC(CESGA)

Santiago de Compostela - SPAIN

M: 692338413

T: +34 981 921 251 | +34 981 569 810

email: alvaro.caride-tabaressanchez@fujitsu.com

---