ICSC
Centro Nazionale di Ricerca in HPC,
Big Data and Quantum Computing

UNIVERSITÀ
DI TORINO

Software & Integration lab at the University of Torino - Italy

SC'24BoF: Advanced Architecture "Playgrounds" — Past Lessons, Current and Future Accesses of Testbeds

Marco Aldinucci - U. of Torino - https://alpha.di.unito.it/

21 Nov 2024

Parallel Programmers tenant

SiFive RISC-V
2 nodes

Intel Skylake SGX
2 nodes

Cloud playground
Dell Intel + NVidia T4
4 nodes

FPGA
2 nodes

Tenant-1

Tenant-2

Tenant-3

openstack
CLOUD SOFTWARE

30 servers 2400 cores
120 GPUs 60 TB RAM

slurm
workload manager

4 clusters

Broadwell
70 nodes

ARM-Ampere
+A100 4 nodes

Cascadelake
+V100

Sapphire Rapids-
+H100 ?? nodes

E4 CEPH
replica3
fast

EMC2
Unity
work

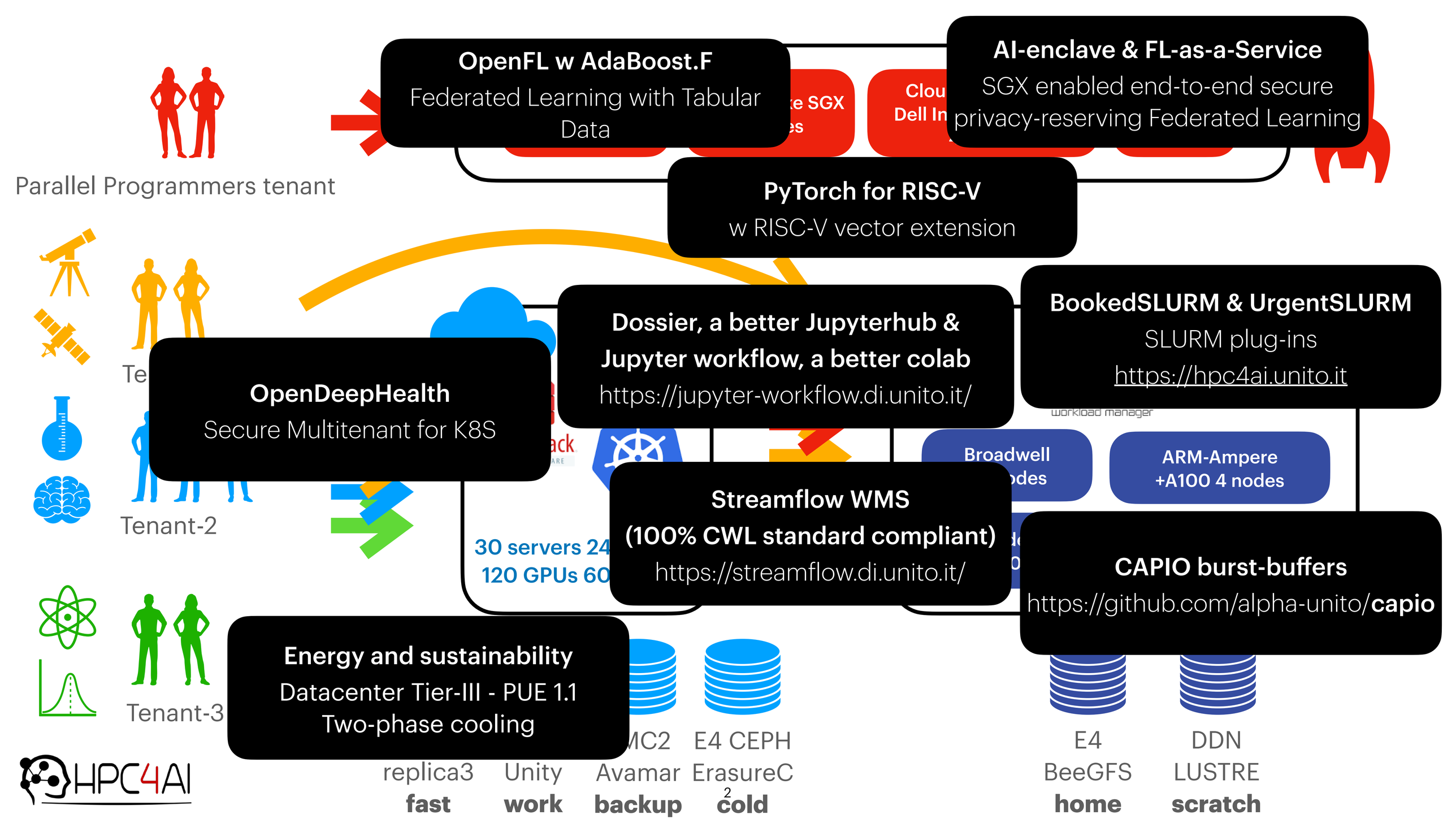
EMC2
Avamar
backup

E4 CEPH
ErasureC
cold

E4
BeeGFS
home

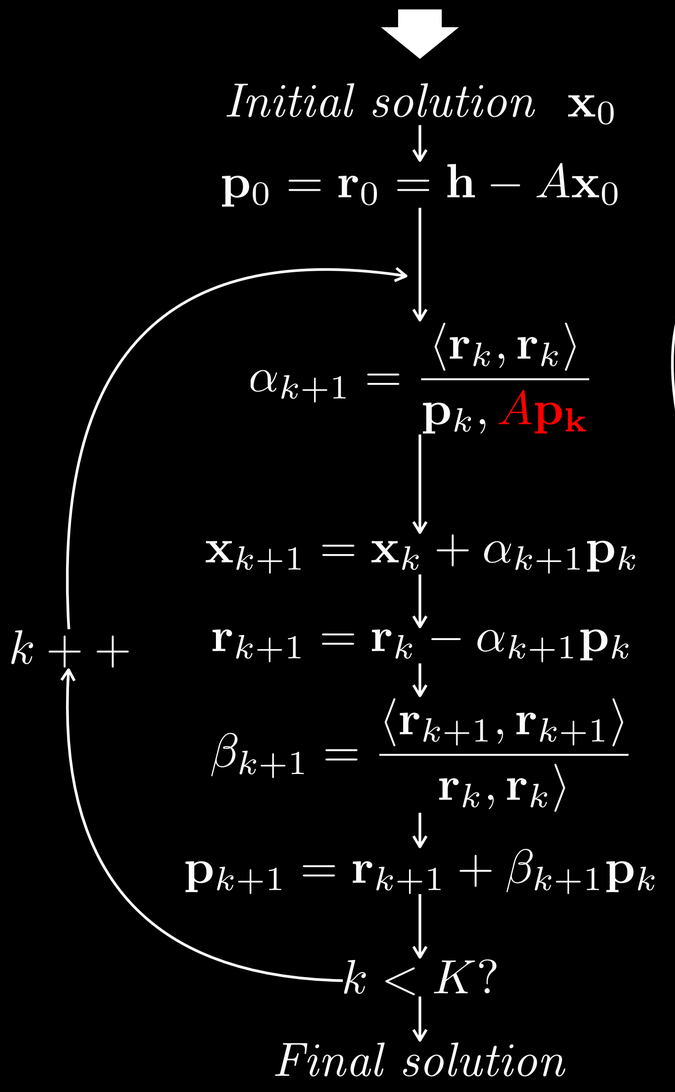
DDN
LUSTRE
scratch

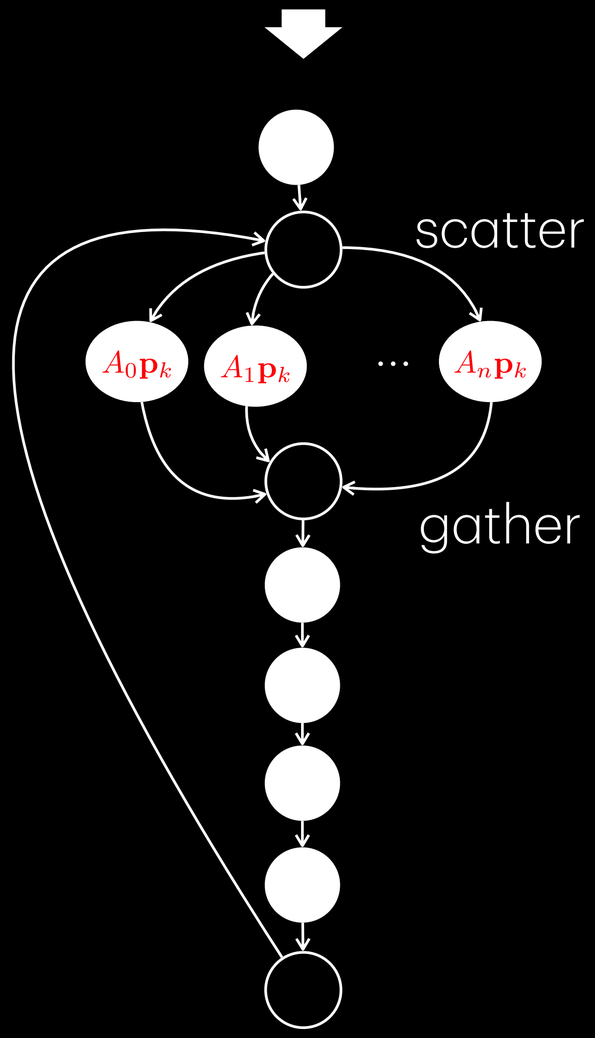
HPC4AI

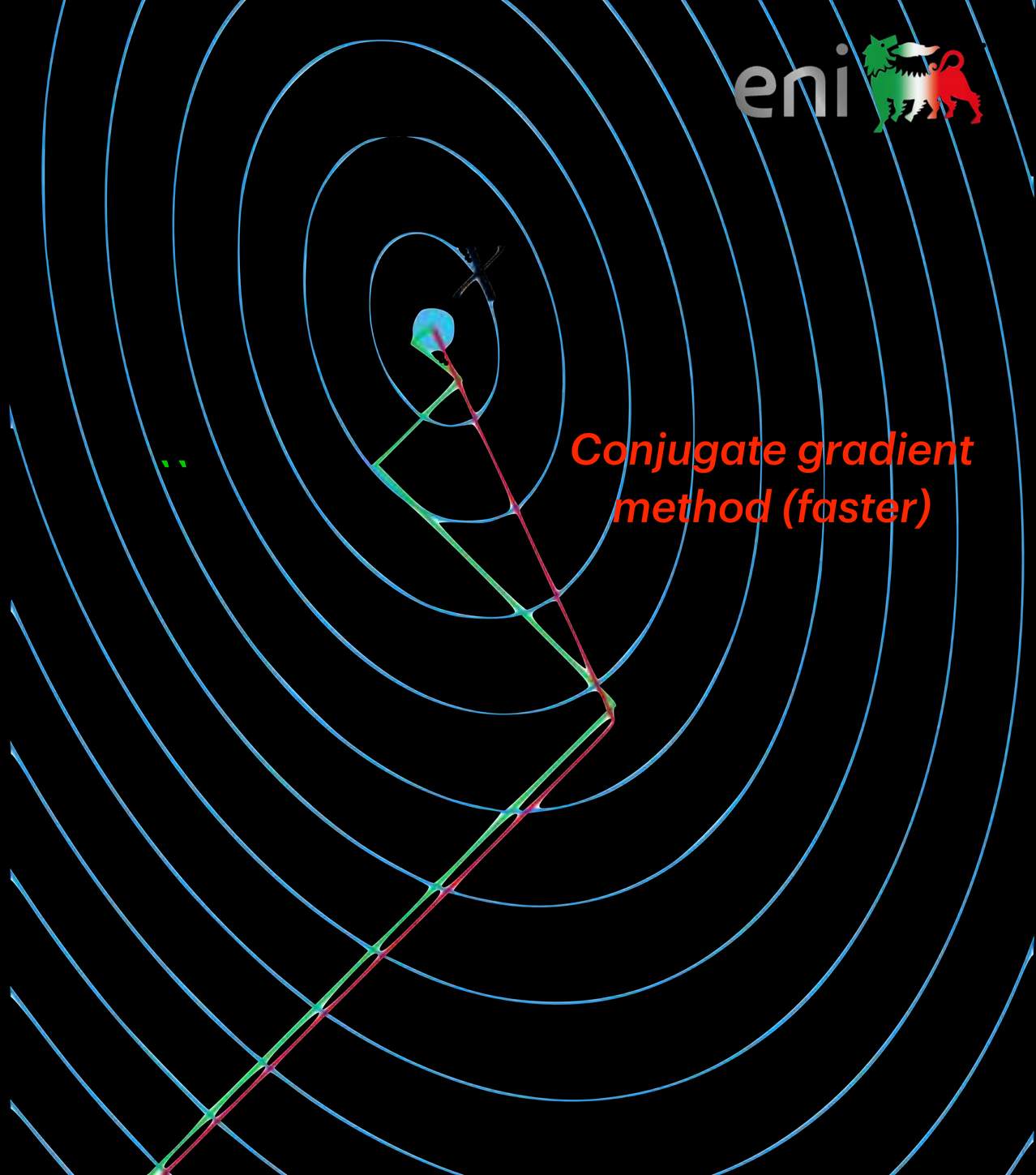

OpenFL w AdaBoost.F
Federated Learning with Tabular Data
AI-enclave & FL-as-a-Service
SGX enabled end-to-end secure privacy-reserving Federated Learning
Parallel Programmers tenant
PyTorch for RISC-V
w RISC-V vector extension
Dossier, a better Jupyterhub & Jupyter workflow, a better colab
https://jupyter-workflow.di.unito.it/
BookedSLURM & UrgentSLURM
SLURM plug-ins
https://hpc4ai.unito.it
workload manager
OpenDeepHealth
Secure Multitenant for K8S
Broadwell
ARM-Ampere
+A100 4 nodes
Streamflow WMS
(100% CWL standard compliant)
https://streamflow.di.unito.it/
30 servers 24
120 GPUs 60
CAPIO burst-buffers
https://github.com/alpha-unito/capio
Tenant-2
Tenant-3
Energy and sustainability
Datacenter Tier-III - PUE 1.1
Two-phase cooling
MC2
Avamar
backup
E4 CEPH
ErasureC
cold
replica3
fast
Unity
work
E4
BeeGFS
home
DDN
LUSTRE
scratch
HPC4AI

Conjugate gradient

From **Devito** code to **StreamFlow**







Streamflow

Portable cloud-HPC workflows - CWL open standard

Iacopo Colonnelli, Barbara Cantalupo, Ivan Merelli, Marco AldinucciStreamFlow: cross-breeding cloud with HPCIn: IEEE Transactions on Emerging Topics in Computing, vol. 9, no. 4, 2021

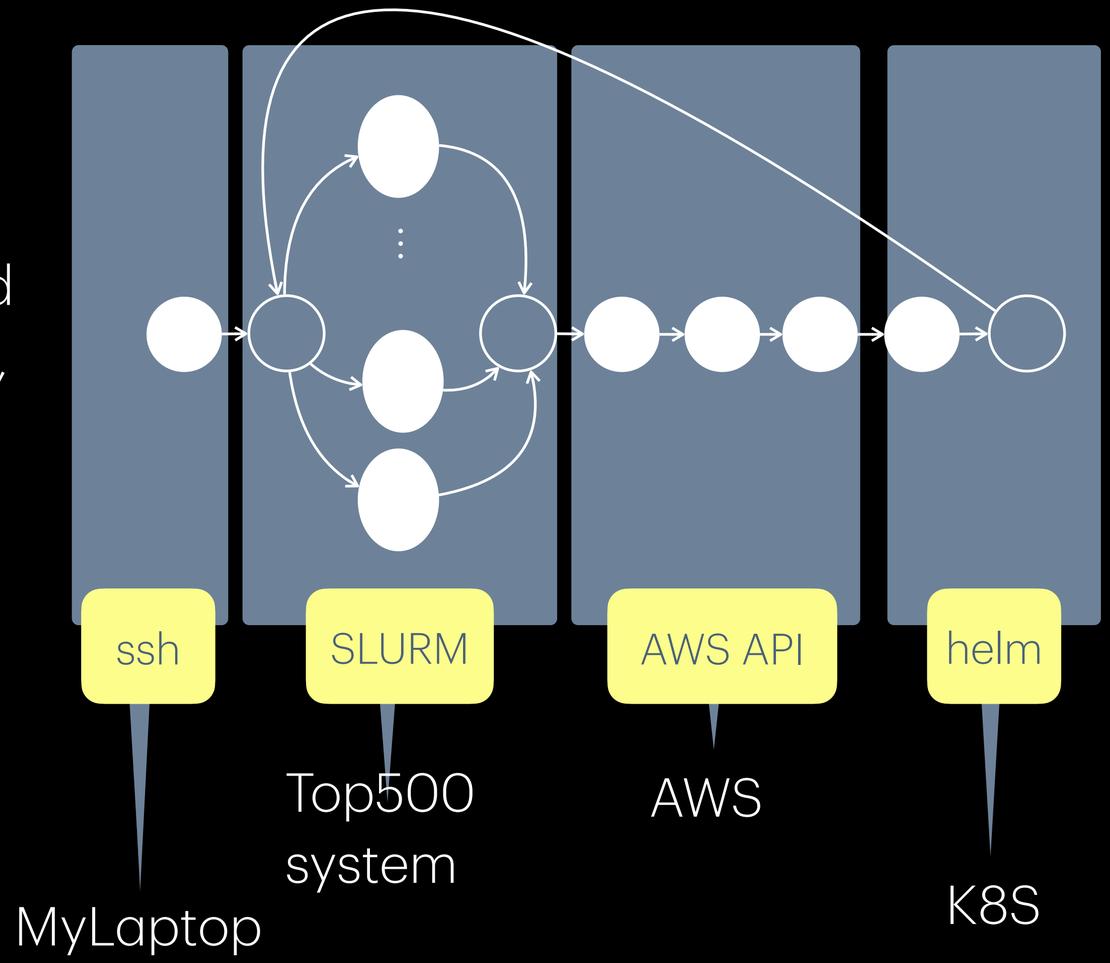
Workflow

Description of data dependence among different applications. They could be native (e.g. MPI), services (e.g. Spark), containers (e.g. docker/singularity) ...

Deployment

Cloud, multi-cloud, HPC, almost any method.
K8S, SLURM, AWS, LFS, ...

Plug-in based



Testbeds to evaluate energy-efficient computing technologies?

via Streamflow

- **Decouple workflows from their deployment to maximise portability and reconfigurability**
  - *I. Colonnelli et al. StreamFlow: cross-breeding cloud with HPC. IEEE Trans. on Emerging Topics in Computing, 9,(4), 2021.*
- **Optimize and “streamize” the data plane (I/O) at the Intermediate representation level**
  - Streaming, scatter-fusion, data caching, etc.
  - *I. Colonnelli et al. Introducing SWIRL: An Intermediate Representation Language for Scientific Workflows. FM 2024.*
  - *A. Martinelli et al. CAPIO: a Middleware for Transparent I/O Streaming in Data-Intensive Workflows. HiPC 2023*
- **Monitor workflow execution - energy-aware scheduling**
  - E.g. matching cpu-intensive and I/O-intensive resources
  - Define a workflow benchmark suite
  - *17 other papers here: https://alpha.di.unito.it/parallel-computing-papers/?tgid=19#tppubs*

Federated Learning

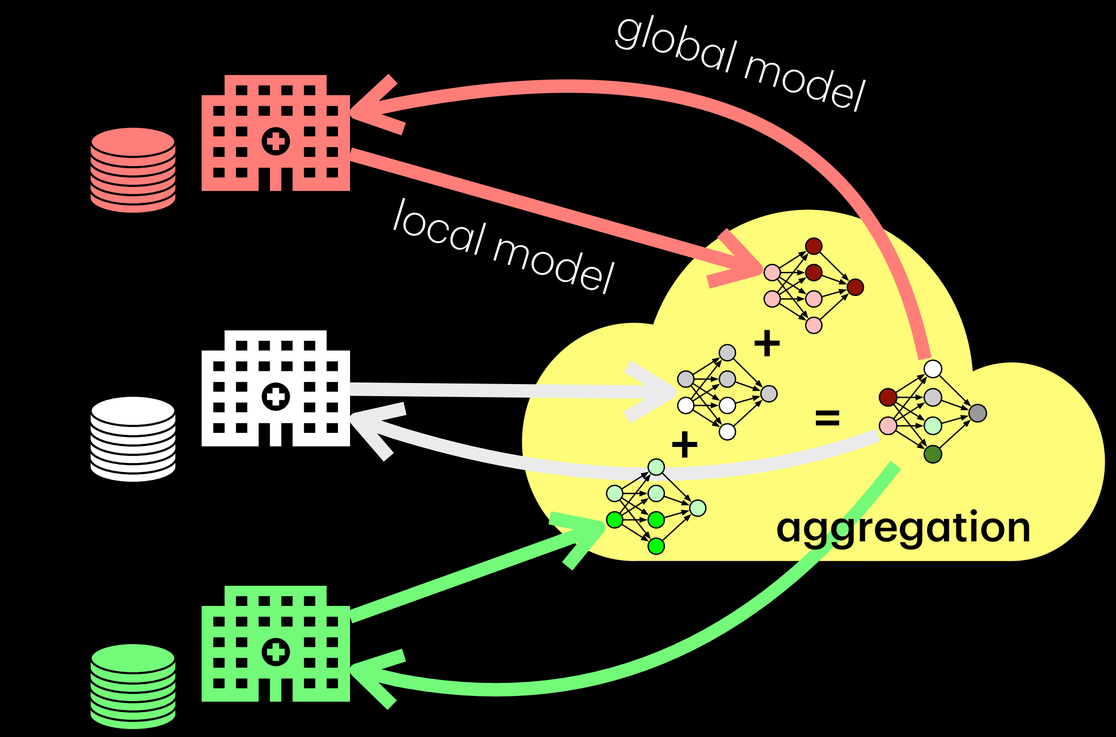
INTESA SANPAOLO

iFAB
INTERNATIONAL FOUNDATION
BIG DATA AND ARTIFICIAL INTELLIGENCE
FOR HUMAN DEVELOPMENT

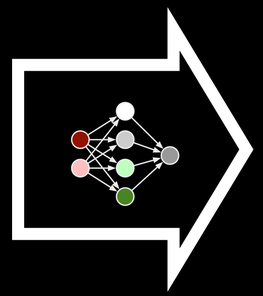
1 Privacy-preserving federated learning

2 Distribution of the trained global model

3 Inference on private data



private (not shared)



federated model equivalent to a model trained on pooled data

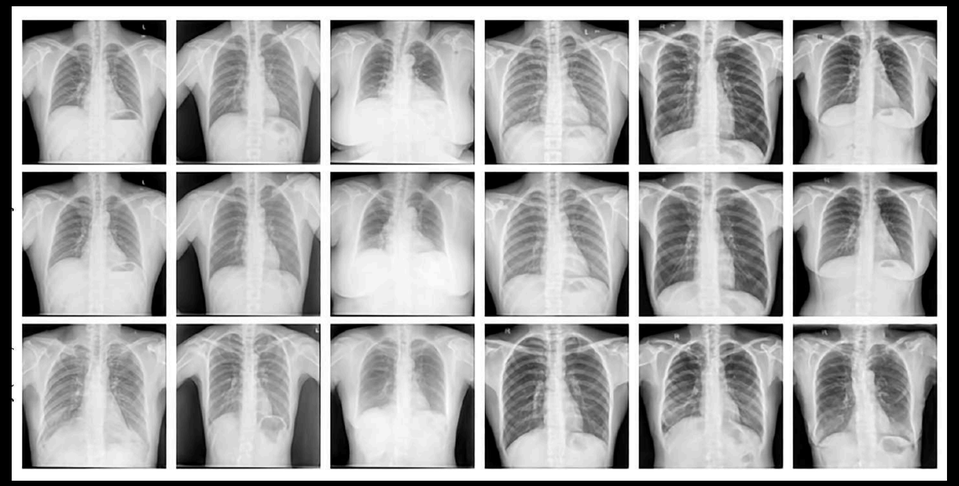
ID	Feat-1	Feat-2	Feat-3	Feat-4	Feat-5
001	...	...	...	...	...
002	...	...	...	...	...
003	...	...	...	...	...
004	...	...	...	...	...
005	...	...	...	...	...
006	...	...	...	...	...

private data → *support to diagnosis*

private data → *support to diagnosis*

Federated experience replay

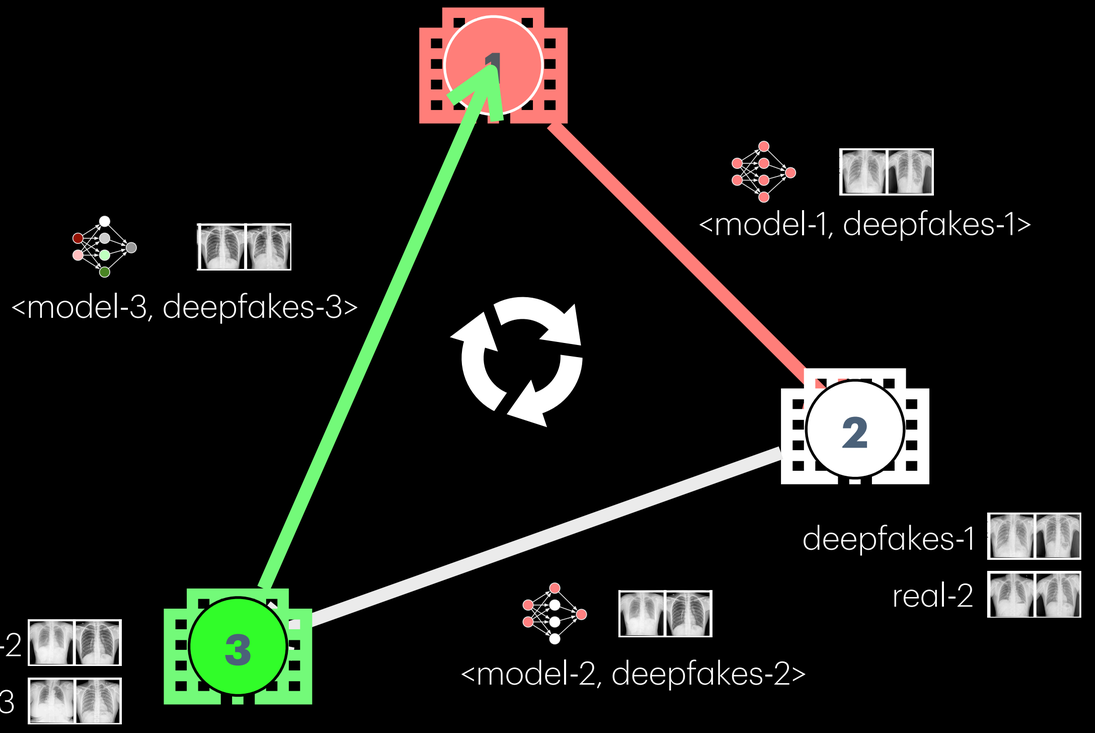
enhanced with privacy-preserving deep fakes against model inversion



real data

deep fakes (GAN)

privacy-preserving deep fakes

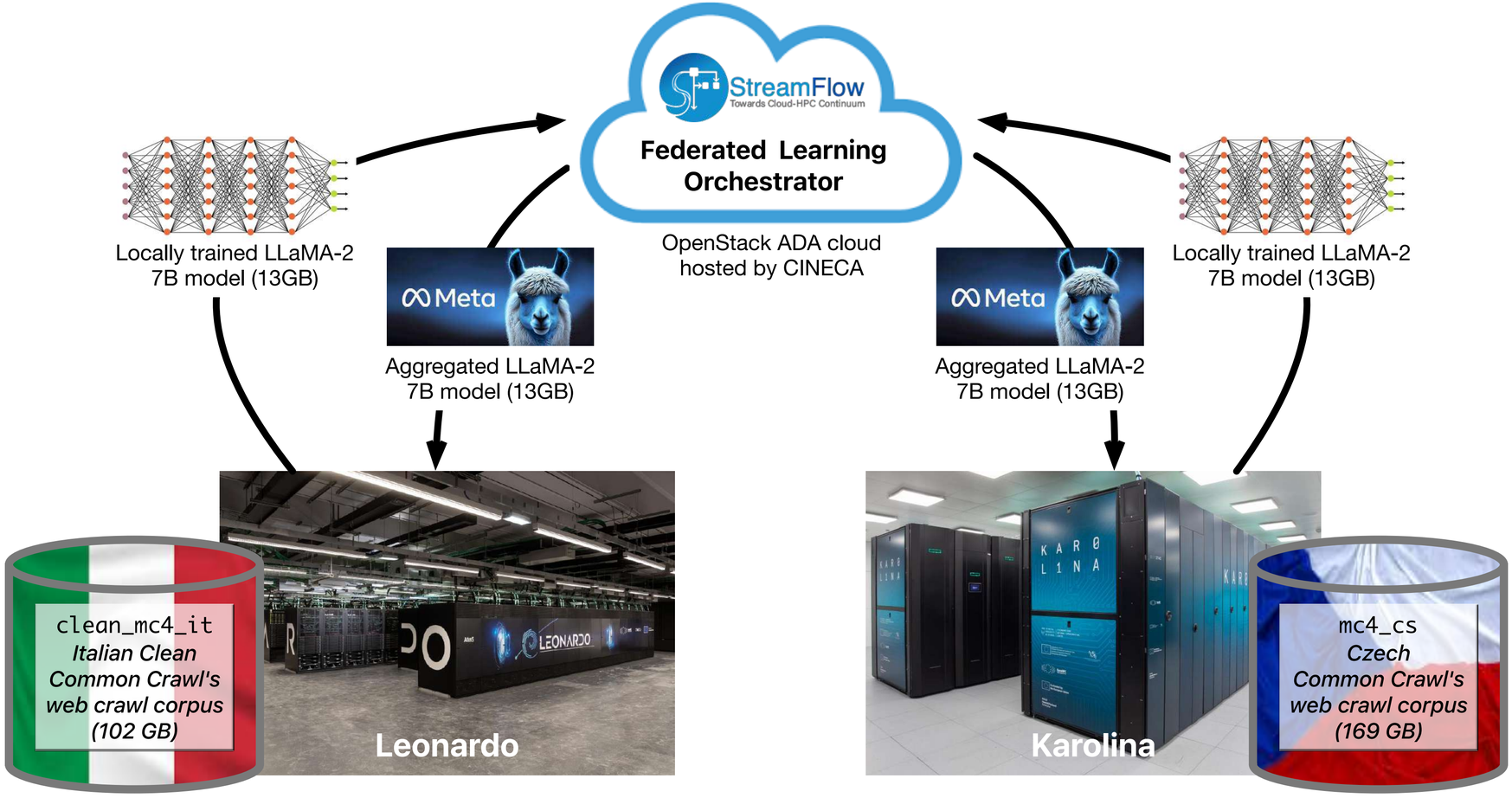


Pennisi et al. FedER: Federated Learning through Experience Replay and Privacy-Preserving Data Synthesis, Computer Vision and Image Understanding, vol. 238, pp. 103882, 2023.

Aggregate remote and local models as in FL & merge remote deep fakes with local private data to produce a new model and new privacy-preserving deep fakes - **never communicate real data**

LLaMA-2 across supercomputers

https://hpc4ai.unito.it/hpc-federation/



Sustained performance: **246.54 PFLOPS**
Peak performance: **313.90 PFLOPS**
Accelerated module: **13824 GPUs**
(3456 nodes w 4xNVidia A100 60GB RAM)

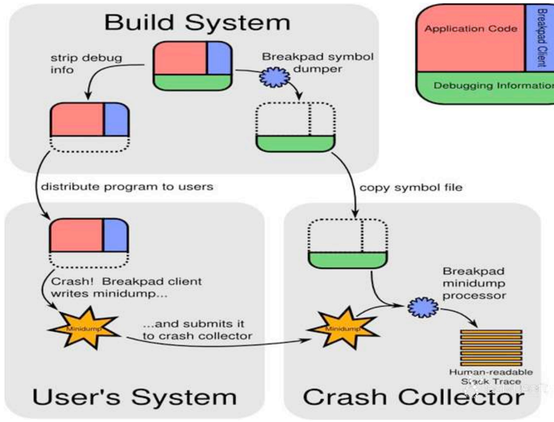
Sustained performance: **9.59 PFLOPS**
Peak performance: **12.91 PFLOPS**
Accelerated module: **560 GPUs**
(70 nodes w 8xNVidia A100 40GB RAM)

HPC4AI

Pytorch on RISC-V

First porting worldwide - submitted and accepted by Google in 2022

Google Breakpad



https://chromium.googlesource.com/breakpad/breakpad/+/28cf16bc342c0e39f867ccc1a30357a803b9a15a

PyTorch

SLEEF

SIMD Library for Evaluating Elementary Functions

https://github.com/shibatch/sleef/pull/448

PyTorch cpuinfo

pytorch/**cpuinfo**

CPU INFOrmation library (x86/x86-64/ARM/ARM64, Linux/Windows/Android/macOS/iOS)

37 Contributors · 35 Issues · 801 Stars · 271 Forks

C 77.7% · **C++** 20.7% · **CMake** 0.7% · **Shell** 0.4% · **Python** 0.4% · **Starlark** 0.1%

https://github.com/pytorch/cpuinfo/pull/148


Activities
python
Jun 14 18:59
Processes
Resources
File Systems
CPU
Memory and Swap
Memory
5.7 GB (4.2%) of 135.1 GB
Cache 3.7 GB
Swap
0 bytes (0.0%) of 8.6 GB
Network
Receiving
Total Received
2.0 KiB/s
716.2 MiB
Sending
Total Sent
0 bytes/s
4.7 MiB
RISC-V
gmittone@fedora-riscv:~ — sh run.sh
0: 480x640 1 person, 1 cell phone, 514.7ms
0: 480x640 1 person, 1 refrigerator, 408.6ms
0: 480x640 1 person, 1 chair, 1 cell phone, 1 refrigerator, 446.3ms
0: 480x640 1 person, 1 chair, 1 cell phone, 1 refrigerator, 598.2ms
0: 480x640 1 person, 1 chair, 1 remote, 1 refrigerator, 575.1ms
0: 480x640 1 person, 1 chair, 1 laptop, 2 refrigerators, 487.2ms
0: 480x640 2 persons, 2 refrigerators, 484.8ms
0: 480x640 2 persons, 1 chair, 2 refrigerators, 440.3ms
0: 480x640 2 persons, 1 chair, 1 refrigerator, 493.0ms
0: 480x640 1 person, 1 cat, 1 chair, 1 refrigerator, 499.1ms
0: 480x640 1 person, 1 remote, 1 refrigerator, 464.5ms
0: 480x640 1 person, 1 refrigerator, 531.2ms
0: 480x640 2 persons, 1 refrigerator, 457.8ms
0: 480x640 2 persons, 1 refrigerator, 451.8ms
0: 480x640 1 person, 1 cell phone, 1 refrigerator, 495.0ms
0: 480x640 1 person, 1 cell phone, 2 refrigerators, 459.8ms
0: 480x640 1 person, 1 cell phone, 2 refrigerators, 553.3ms
0: 480x640 4 persons, 2 cell phones, 1 refrigerator, 419.1ms
0: 480x640 3 persons, 1 backpack, 1 refrigerator, 461.7ms
0: 480x640 4 persons, 1 backpack, 1 cell phone, 454.3ms
0: 480x640 4 persons, 1 backpack, 1 cell phone, 450.5ms
0: 480x640 3 persons, 1 backpack, 1 cell phone, 1 refrigerator, 464.1ms
0: 480x640 4 persons, 1 backpack, 1 cell phone, 410.3ms
0
person 0.62
person 0.70
person 0.28
cell phone 0.26
person 0.9
back
COOLER MASTER
G500 GOLD
milkV
SOPHGO
SBPC/k88 Lite
DELL

SWI is a playground

each play needs rules

- It is an apprentice workshop; the product is skilled people
  - AI will accelerate the need for them
- Our focus is on a few flagship codes (tools). They should reach a high TRL
- We collaborate with the industry, but only if we can use our technology
  - no **consultancy**, no one-off projects
- We all want a pleasant, inclusive working environment