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INFN

Enabling INFN-T1 to support heterogeneous computing architectures

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CNAF Tier-1 (Grid / Batch computing)

- Providing ~ 715KHS06 / 59Kcores, 1010 Compute nodes to ~ 23 WLCG communities (HEP / astroparticle / astrophysics) and ~ 30 local research groups.
- 6 x HTCondor-CE 5.1.6 on top of HTCondor 9.0.17
- Moving to tecnopolo (➜ #392, track 7, 9 May 2023, 12:00)
  - Opportunistic usage of Computing resources from Leonardo HPC is foreseen by an early agreement
  - **x86_64** CPU, 128 cores, 512GB RAM, 4xAmpere GPU, Slurm batch system
- Initial investigations on: Marconi 100
  - **PPC** CPU, 192 cores, 256GB RAM, 4xV100 GPU, Slurm batch system

Our Goal: seamless integration of opportunistic and pledged resources.

Marconi 100: Power AC922 "Whiterspoon"

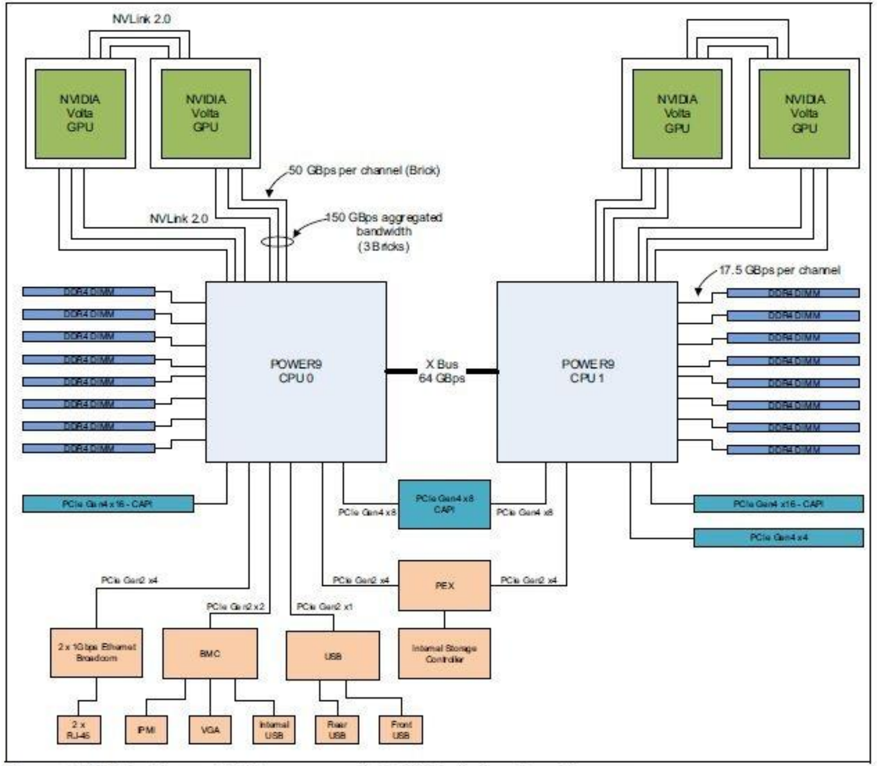


Figure 2-5 The Power AC922 server model GTH logical system diagram

- 980 CN + 3 login nodes
- 2x16 core **IBM 8335-GTG**@2.6GHz
  - Up to 128 threads
- 4xNVIDIA **V100 GPUs**
- RAM: 256 GB/node
- Local disk: 1.6TB NVMe
- Shared Disk Space: 8PB (GPFS)
- **Slurm scheduler** (whole node/**24h**)

Pledged vs Opportunistic

CNAF (Pledged)	M100 (Opportunistic)	General Case (Opp.)
Grid+local, HTC-CE / HTC	Local, Slurm	Batch, Cloud, K8S, …
1 or 8 cores, ≥ 3.5GB/core	Whole node, 2GB/core	…
x86_64	PowerPC, NVIDIA V100	X86_64, ARM, PPC, GPU
72h or more runtime	24h max runtime	…
Full network for cluster operation,sw distribution (cvmfs) and data transfer	Agreed Outbound Connectivity toward known networks (CNAF, CERN) + cvmfs	Outbound connectivity is assumed. CVMFS is a strong requirement

Jobs must be able to run with the available QoS ➔ 2 problems:

- Experiment side: Have suitable payloads to run on opportunistic resources
- Provider side: steer most suitable jobs there

Note: Opportunistic != Free

M100: From Slurm CN to CNAF WN

- Two simple ideas:
  - have a HTCondor STARTD running as Slurm Job
  - Detect pending jobs for ppcml64 @CNAF and trigger resource creation

How to implement it

1. From a M100 Login Node submit a Slurm job
2. At start, it launches a Singularity container which
   - activates an HTCondor STARTD, which
   - authenticates to the Central Manager and join the CNAF pool
     - CCB (Connection Control Broker 9618 port)
     - IDTOKENS for authentication
   - Becomes available to execute jobs submitted to HTCondor-CE at CNAF.
     - StartJobs expression to only accept proper jobs

CNAF: Steering jobs to M100

Main Idea: Make Jobs for M100 identifiable at submit time. Needed information must be available at the JobRouter of the HTC-CE

Different approaches possible, each has pros and cons

1. Set a custom attribute in the Submit File:
   - Example: `+WantRoute = “cms_m100”`
   - Define a JobRouter entry to add `Arch == “ppc64le”` to the Requirements of the routed job
2. Set an agreed claim in the access token (SCITOKEN, IAM Token, EGI Check-in Token)
   - Several token claims can be inspected as Classad Attributes by the JobRouter
   - Latest HTCondor versions (10.4.1) makes possible further customization

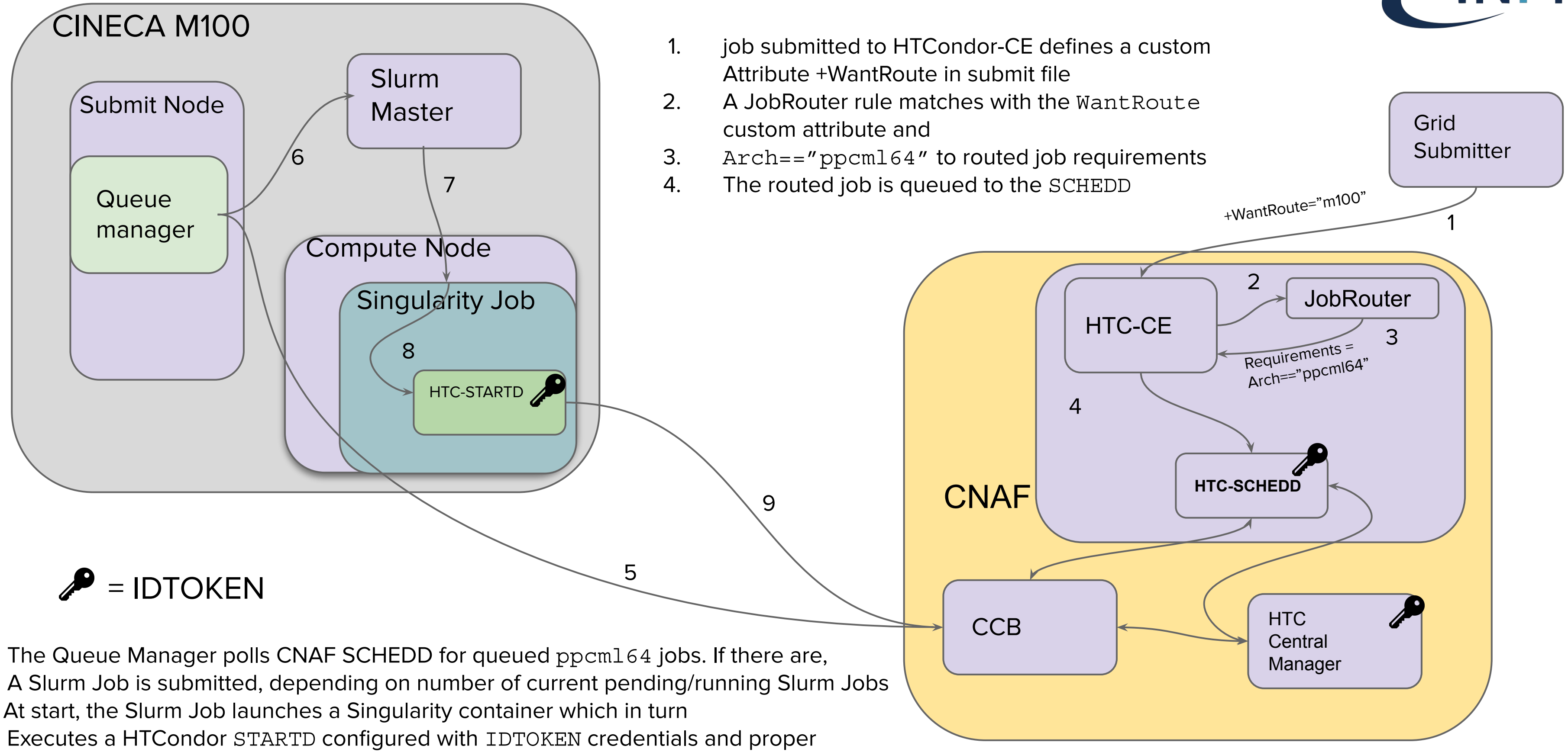
M100: Autoscaling availability

Goals:

- Trigger instantiation of M100 resources (i.e. submit Slurm wholenode jobs) only when suitable payloads are queued at CNAF.
- Avoid having unused PPC nodes running without payload.

- A script running on a M100 login node:
    - checks CNAF queues to for jobs awaiting PowerPC resources
    - checks Slurm for running and pending wholenode jobs (Slurm_R, Slurm_P).
    - If pend_CNAF > 0, it submits some wholenode jobs to Slurm.
    - If pend_CNAF == 0, Idle Slurm jobs (the hosted STARTD has no jobs) are terminated. This ensures that M100 resources are accounted only upon real need. **Note:** this cannot work with late binding (i.e. pure pilot) model

The Model



1. job submitted to HTCondor-CE defines a custom Attribute +WantRoute in submit file
2. A JobRouter rule matches with the `WantRoute` custom attribute and
3. `Arch=="ppcml64"` to routed job requirements
4. The routed job is queued to the `SCHEDD`

5. The Queue Manager polls CNAF SCHEDD for queued `ppcml64` jobs. If there are,
6. A Slurm Job is submitted, depending on number of current pending/running Slurm Jobs
7. At start, the Slurm Job launches a Singularity container which in turn
8. Executes a HTCondor `STARTD` configured with `IDTOKEN` credentials and proper `StartJobs` policies
9. The STARTD authenticates with the CNAF HTCondor pool through the Connection Control Broker

Generalizations

The above model is quite generic and can be easily generalized for different computing architectures / infrastructures. This has been actually done:

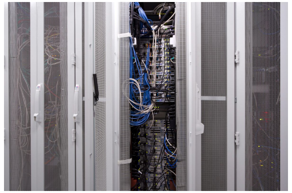
Herd: K8S WN-pod instantiated via Cloud for preliminary tests, preparing for usage on ASI resources

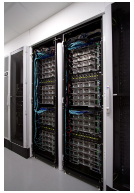
UniBO - Open Physics Hub: Slurm Batch, x86_64 Compute Nodes (debian) with containerized STARTD

Textarossa: ARM architecture, see next slides

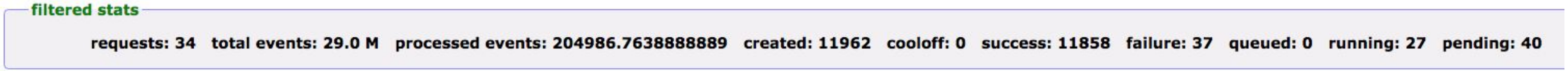
ARM@CNAF!

- E4 is a company with historical ties with CNAF and CERN computing
- Using hardware form the TEXTAROSSA EU project (EuroHPC), we had access to 2 Ampere Altra MAX nodes:
  - Dual 128 cores Neoverse N-1; the variant with 3.0 GHz (M128-30)
    - 256 cores per node
  - 2 memory settings: 256 GB and 1 TB
  - Fast local disk, poor WAN networking



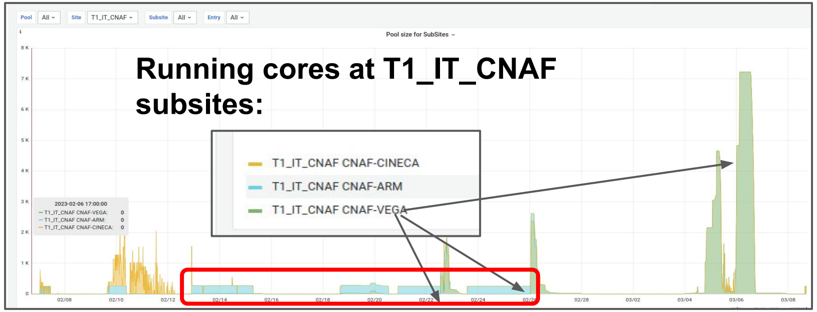


- Using the experience gained on CINECA systems, we were able to integrate the nodes in CNAF computing (via HTCondor CEs) and run typical workflows on them; we also enabled the manual GlideIn method
  - HepScore: 3884 HepScore23
  - CMS: we were able to insert the machines in the production system, and start a the standard validation machinery
    - Unfortunately, only @ pileup 0, due to the networking
    - Amazing results, still: less than 1% errors
    - In course of validation (but physics validation not conclusive w/o pileup)

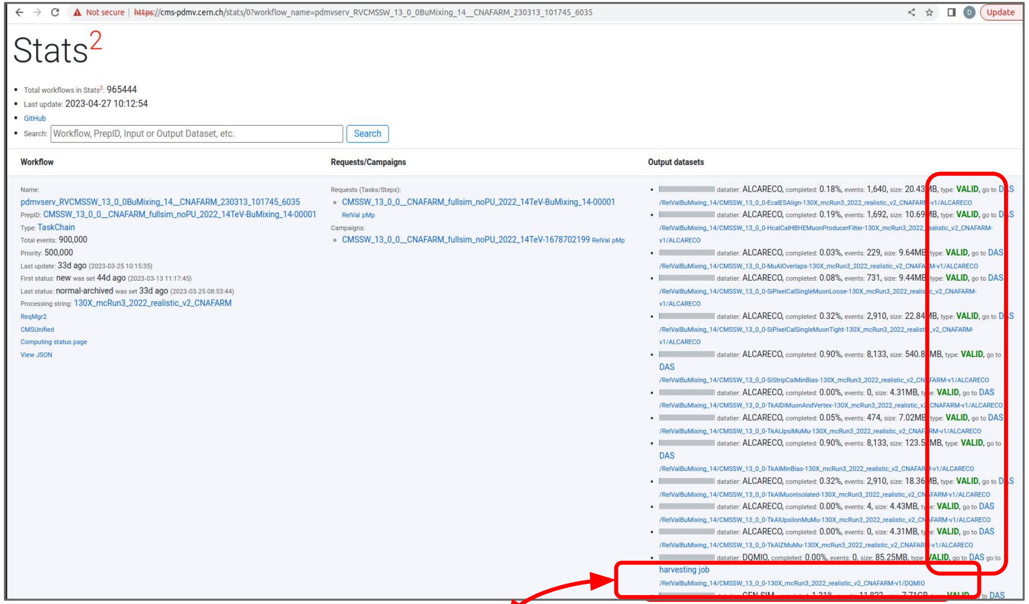


```
filtered stats
requests: 34   total events: 29.0 M   processed events: 204986.7638888889   created: 11962   cooloff: 0   success: 11858   failure: 37   queued: 0   running: 27   pending: 40
```

Validation process



Running cores at T1_IT_CNAF subsites:


Not secure
https://cms-pdmv.cern.ch/stats/0?workflow_name=pdmvserv_RVCMSSW_13_0_0BuMixing_14__CNAFARM_230313_101745_6035
Update

Stats^2

- Total workflows in Stats^2: 965444
- Last update: 2023-04-27 10:12:54
- GitHub
- Search: Workflow, PrepID, Input or Output Dataset, etc. Search

Workflow

Name: pdmvserv_RVCMSSW_13_0_0BuMixing_14__CNAFARM_230313_101745_6035
PrepID: CMSSW_13_0_0__CNAFARM_fullsim_noPU_2022_14TeV-BuMixing_14-00001
Type: TaskChain
Total events: 900,000
Priority: 500,000
Last update: 33d ago (2023-03-25 10:15:35)
First status: new was set 44d ago (2023-03-13 11:17:45)
Last status: normal-archived was set 33d ago (2023-03-25 08:53:44)
Processing string: 130X_mcRun3_2022_realistic_v2_CNAFARM
ReqMgr2
CMSUnified
Computing status page
View JSON

Requests/Campaigns

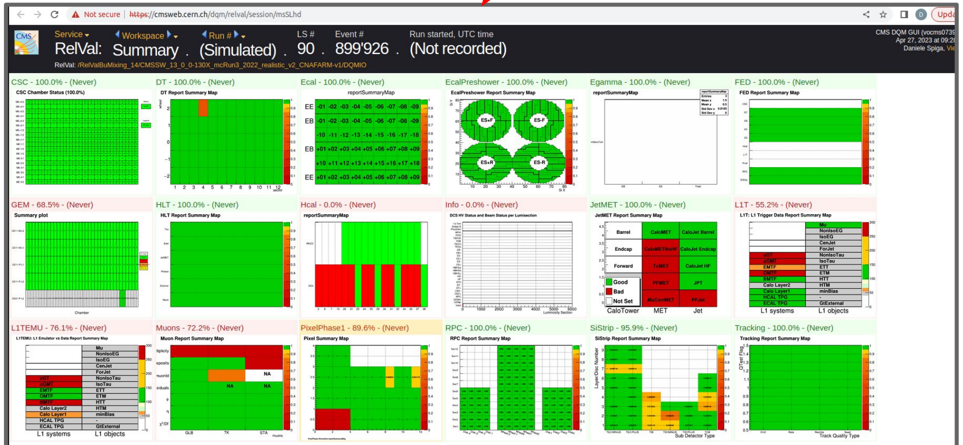
Requests (Tasks/Steps):
- CMSSW_13_0_0__CNAFARM_fullsim_noPU_2022_14TeV-BuMixing_14-00001 RelVal pMp

Campaigns:
- CMSSW_13_0_0__CNAFARM_fullsim_noPU_2022_14TeV-1678702199 RelVal pMp

Output datasets

- datatier: ALCARECO, completed: 0.18%, events: 1,640, size: 20.43MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-EcalESAlign-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.19%, events: 1,692, size: 10.69MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-HcalCalHBHEMuonProducerFilter-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.03%, events: 229, size: 9.64MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-MuAlOverlaps-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.08%, events: 731, size: 9.44MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-SiPixelCalSingleMuonLoose-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.32%, events: 2,910, size: 22.84MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-SiPixelCalSingleMuonTight-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.90%, events: 8,133, size: 540.8MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-SiStripCalMinBias-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.00%, events: 0, size: 4.31MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-TkAlDiMuonAndVertex-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.05%, events: 474, size: 7.02MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-TkAlJpsiMuMu-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.90%, events: 8,133, size: 123.5MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-TkAlMinBias-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.32%, events: 2,910, size: 18.36MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-TkAlMuonIsolated-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.00%, events: 4, size: 4.43MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-TkAlUpsilonMuMu-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: ALCARECO, completed: 0.00%, events: 0, size: 4.31MB, type: VALID, go to DAS
  /RelValBuMixing_14/CMSSW_13_0_0-TkAlZMuMu-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/ALCARECO
- datatier: DQMIO, completed: 0.00%, events: 0, size: 85.25MB, type: VALID, go to DAS go to harvesting job
  /RelValBuMixing_14/CMSSW_13_0_0-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/DQMIO
- datatier: GEN-SIM, completed: 1.21%, events: 11,022, size: 7.71GB, type: VALID, go to DAS

Technical integration successfully verified: CMS sees ARM resources as CNAF local computing capacity



RelVal: Summary . (Simulated) . 90 . 899'926 . (Not recorded)

RelVal: /RelValBuMixing_14/CMSSW_13_0_0-130X_mcRun3_2022_realistic_v2_CNAFARM-v1/DQMIO

CMS DQM GUI (vocms0739)
Apr 27, 2023 at 09:28
Daniele Spiga, Vie

Two campaigns of data generation have been successfully completed

- Run3 scenario
- Phase2 conditions

Samples are injected in the CMS computing infrastructure and ready for the next step

Observations

Dealing with Heterogeneous resources exposes several points **worth considering**

- **IDTOKENS** management: some improvement needed (distribution, revocation)
- **CCB** is a potential bottleneck? (keep sandbox transfer at a minimum!)
- Pilot “late binding” can be “too late”:
    - a precious resource can be dedicated to a pilot who has no suitable payload to run there
    - The QoS at the (opportunistic) resource is unacceptable by the payloads
- **Declaring needs in the Access Token** could help, better than adding custom attributes in the submit file: The “VO manager” can map execution privileges to groups, such as: “GPU_<model>”, “aarch64”, “ppc64lm”, thus controlling who can use special resources.
    - Easy to agree between small experiments and Site Administrators
    - Latest HTCondor (10.4.x) enables custom Token validation PLUGIN (custom token ➔ user mapping)

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