ARC-CE on EuroHPC Vega

EGi 2023 - Training

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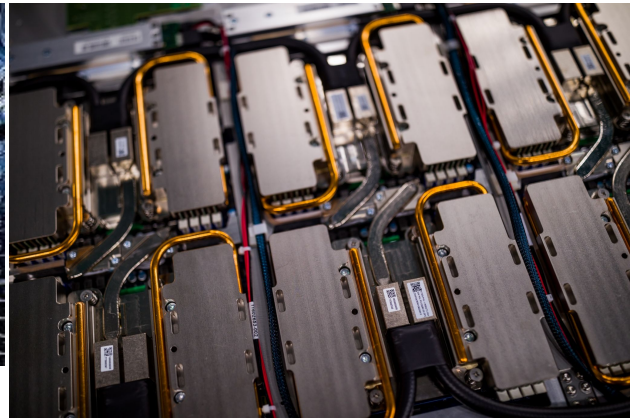
MINISTRY OF EDUCATION, SCIENCE AND SPORT

EuroHPC
Joint Undertaking

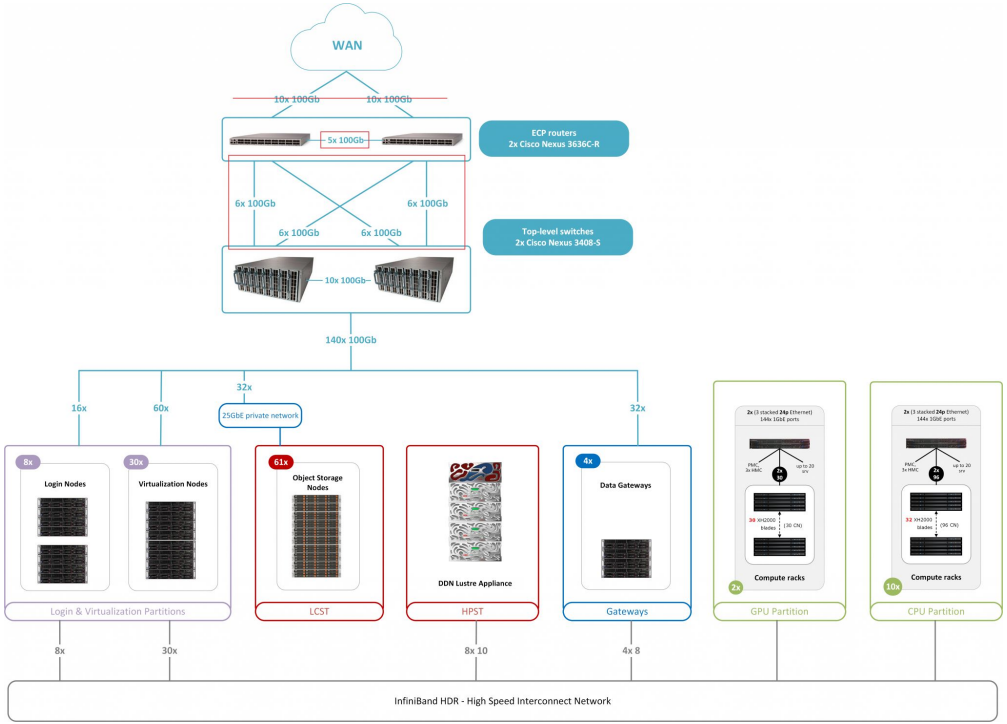


Number of Nodes	1020
Number of login nodes	4 CPU login nodes and 4 GPU login nodes
Compute partitions	CPU partition: 960 (768 standard CPU nodes and 192 high memory CPU nodes * GPU partition: 60 nodes
Storage capacity	1 PB high-performance NVMe storage, 23 PB raw large-capacity storage (18 PB usable)
Sustained Performance	6,9 petaflops
Peak Performance	10.1 petaflops

Vega Slovenian EuroHPC - design goals

- General purpose HPC - useful to **all user communities**
- Requirements (EuroHPC vision):
  - HPC compute intensive: CPU + GPU partitions
  - HPDA - high-performance data analytics
  - Artificial Intelligence + Machine Learning
- In addition:
  - Extreme data processing: >> HPDA
  - WAN node connectivity
  - Hyper-converged network - fast data exchange with other centres (~1Tb/s)
  - Remote access (job submission, data)
- Good scalability for:
  - Massively parallel jobs
  - Fast throughput for large number of small jobs
  - High sequential + random storage access

Network Topology & Partitions



- Infiniband: HDR100
  - Compute, Lustre, Service
- Ethernet: 100G/s
  - Ceph, Service
- IB Gateway:
  - 4x Mellanox Skyway, 3.2Tb/s
- WAN: planned Tb/s
  - 500Gb/s to ARNES for now
  - 200Gb/s to Geant/LHCONE/PRACE

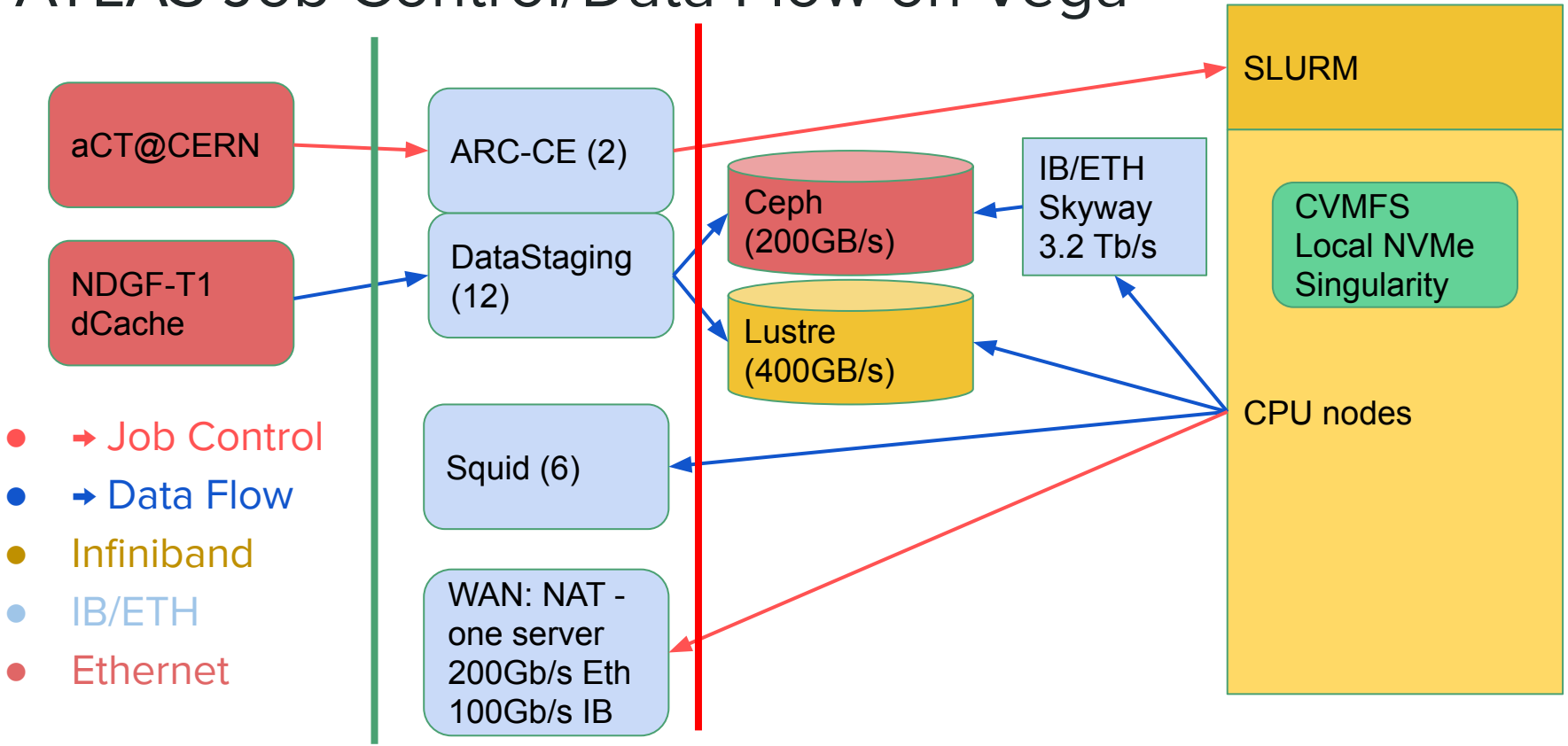
Why ARC-CE on Vega?

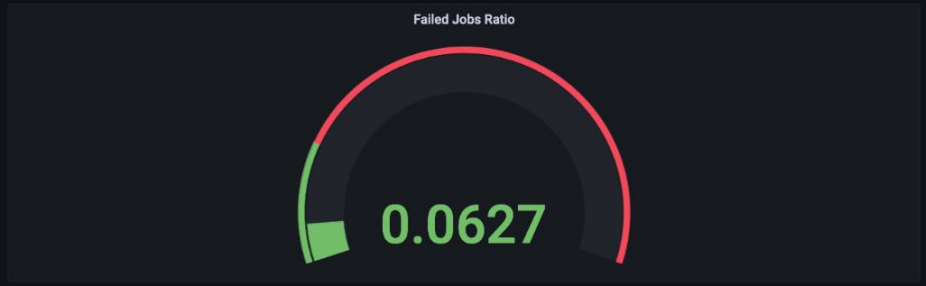
- ATLAS, Belle-2, Pierre Auger, Vera Rubin:
  - Slovenia pledges compute resources to these experiments
  - Central distribution of production jobs - remote job submission
  - Transparent transfer of input/output files to experiment storage
- Other data-demanding communities on Vega
  - Cryomicroscopy
  - Genomics, DNA sequencing
  - AI image processing (generative networks development)
- Many individual users also use ARC-CE
  - Managing jobs on local PC
  - submission to other SI clusters
- Some communities have private service VMs (eg FAIR data, custom executors)

Setup

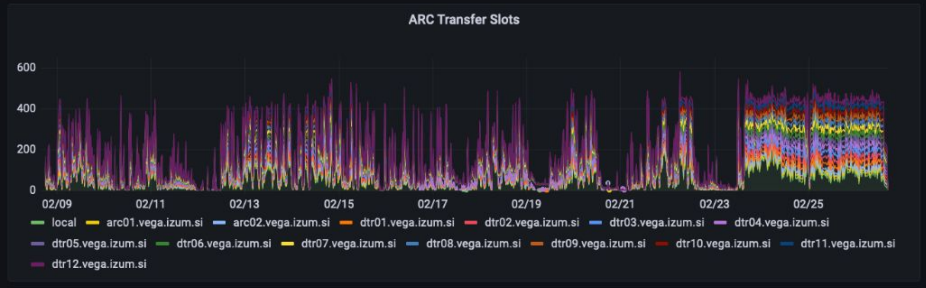
- 2 ARC-CEs - physical machines (for now), all other are VMs
  - All servers are connected to DMZ + internal network
- 12 ARC Data Delivery service (small) VMs
  - To scale to 200Gb/s WAN, and in future to 1Tb/s
  - 150Gb/s ARNES/Geant traffic baseline for weeks measured in data-intensive periods
- 6 Squids for CVMFS and remote Frontier/Oracle access
  - cvmfs available on all Vega nodes - required by EuroHPC Centers of Excellence as well
  - All Vega SW distributed through cvmfs
- Shared filesystem:
  - Lustre for ARC data cache (higher bandwidth due to topology and NVMEs)
  - CephFS for everything else
- Nodes have only 100Gb/s to WAN - Skyway lack of ipv6 - on demand transfers not recommended

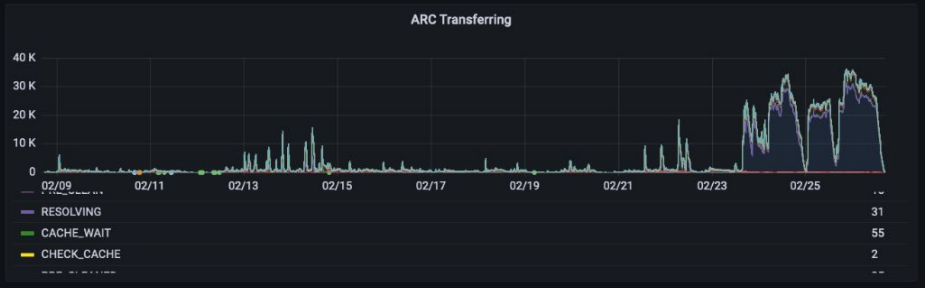
ATLAS Job Control/Data Flow on Vega

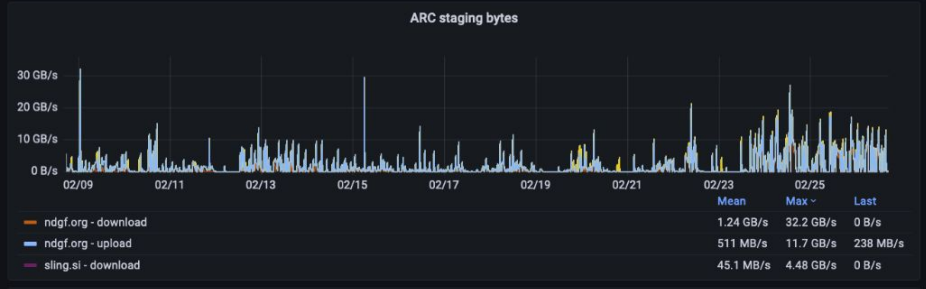


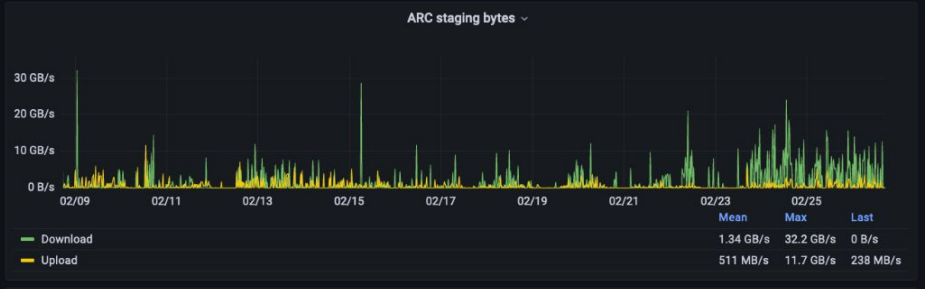

Failed Jobs Ratio
0.0627

FAILED/FINISHED
1000000
500000
0
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25
Min Max Mean Last *
Finished 775464 1178384 981099 775464
Failed 31375 48817 39137 48629

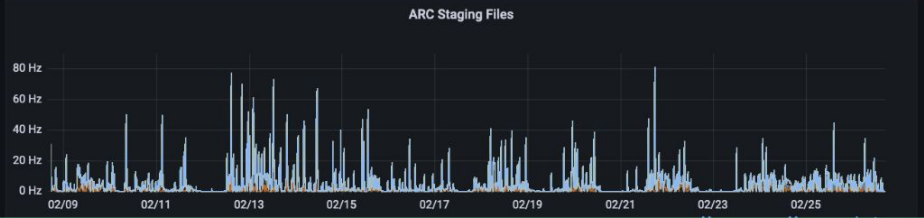

ARC Transfer Slots
600
400
200
0
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25
local
arc01.vega.izum.si
arc02.vega.izum.si
dtr01.vega.izum.si
dtr02.vega.izum.si
dtr03.vega.izum.si
dtr04.vega.izum.si
dtr05.vega.izum.si
dtr06.vega.izum.si
dtr07.vega.izum.si
dtr08.vega.izum.si
dtr09.vega.izum.si
dtr10.vega.izum.si
dtr11.vega.izum.si
dtr12.vega.izum.si


ARC Transferring
40 K
30 K
20 K
10 K
0
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25
RESOLVING 31
CACHE_WAIT 55
CHECK_CACHE 2

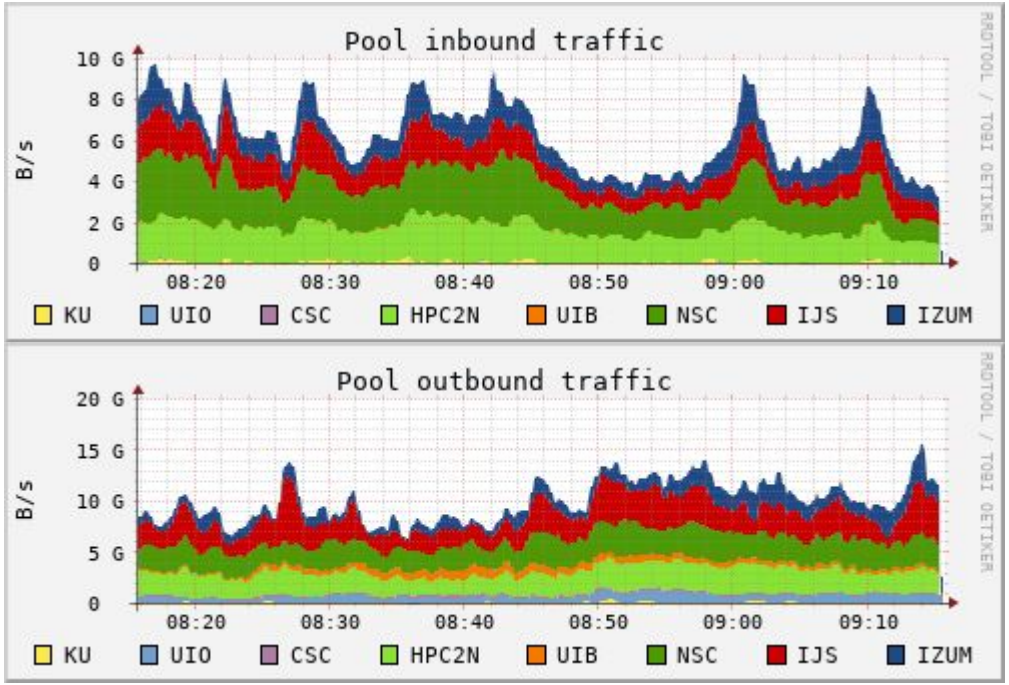

ARC staging bytes
30 GB/s
20 GB/s
10 GB/s
0 B/s
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25
Mean Max Last
ndgf.org - download 1.24 GB/s 32.2 GB/s 0 B/s
ndgf.org - upload 511 MB/s 11.7 GB/s 238 MB/s
sling.si - download 45.1 MB/s 4.48 GB/s 0 B/s


ARC staging bytes
30 GB/s
20 GB/s
10 GB/s
0 B/s
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25
Mean Max Last
Download 1.34 GB/s 32.2 GB/s 0 B/s
Upload 511 MB/s 11.7 GB/s 238 MB/s

ARC Active Jobs
30 K
20 K
10 K
0
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25

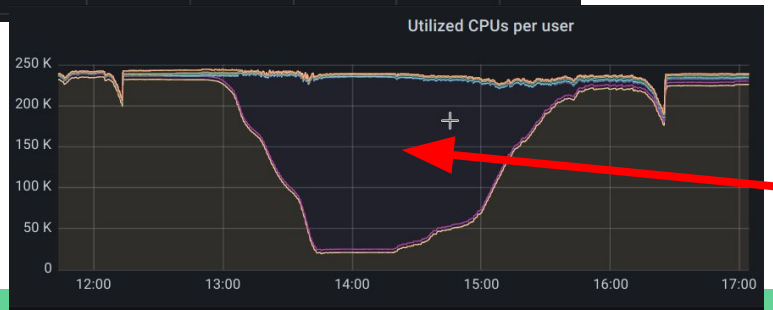

ARC Staging Files
80 Hz
60 Hz
40 Hz
20 Hz
0 Hz
02/09
02/11
02/13
02/15
02/17
02/19
02/21
02/23
02/25

NeIC 30PB NDGF-T1 dCache distributed storage



- dCache data lake
  - Single point of access
  - NO, SE, DK, FI, SI, CH storage pools
- Up to 40 GB/s downloads
  - 1/2 To Vega
- Vega provides 6PB of storage:
  - dCache pools on CephFS (faster than RBD) Usable/Raw = 84%

Extreme data processing - ATLAS



Traffic on nodes:

- Both CephFS (HDD) and Lustre (NVMe) used for inputs
- Network: ethernet traffic to Ceph
  - > 200Gb/s
- Infiniband: to Lustre
  - Close to 600Gb/s

Local high-priority jobs
- AI/ML overtaking resources

Conclusions

- ARC-CE service extremely stable and fast
  - After optimization and bug fixing for large scale processing
  - Up to 200Hz file transfers
  - Up to 100Hz jobs processing
  - No other distributed system comes close to these numbers
- Works for large, parallel jobs as well by runtime environment tuning and LRMS (slurm) options
- All jobs containerized by default
- Many users (10% SI) use it with data tasks
- (ATLAS) ARCControlTower is being extended to cover central submission to all SI HPCs