Mini-Challenges: Building from DC24

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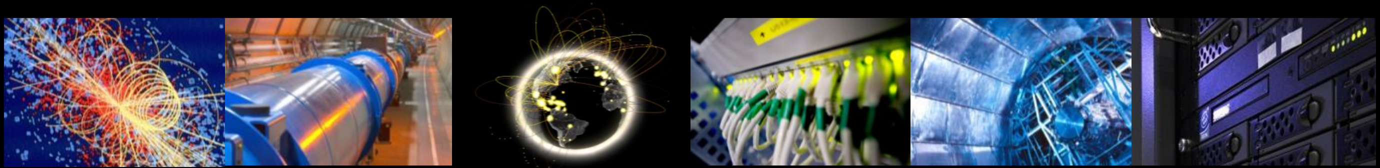


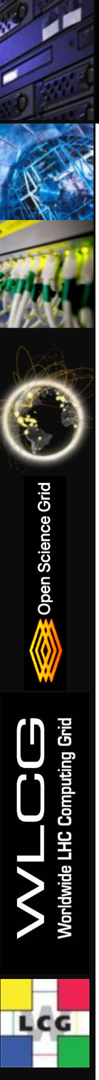
WLCG Data Challenges

The **WLCG Data Challenges** are a ~biennial series of four increasingly-complex exercises which started in 2021 and are aimed at demonstrating readiness at the HL-LHC scale.

Next data challenge (DC26?) targets **50%** of HL-LHC scale and includes T1/T2 and any improvements we can integrate into our infrastructure.

These data challenges provide many benefits, allowing **sites**, **networks** and **experiments** to evaluate their progress, motivate and validate their developments in hardware and software and show readiness of technologies at suitable scale.

For **USLHC**, we believe it is critical to fully participate in future challenges, both by preparing and testing before each and analyzing the results after each.



Plan and Overview

The plan for today is to discuss future mini-challenges (note document should be open for everyone to contribute to: https://docs.google.com/document/d/1Xjq8CvotPAYSsp28Ntn_hKZAQiyS4pwpX5t_p_a_6oM/edit?usp=sharing)

Topical Questions to think about for this presentation:

What is a mini-challenge?
What do we want to test?
Who wants to participate?
What role does IRIS-HEP play?
What technologies should we test?
When do we want to run our first tests?
How (what tools) will we run mini-challenges?

Mini-Challenge Introduction, History and Context

During DC21, 2 objectives, apart from achieving data rates, were established:

- Commissioning of HTTP-TPC transfer protocol
- Achieve common WLCG network monitoring

So DC became a platform for showcasing new “technologies”

Then on a presentation: “*The path to the next WLCG Data Challenge*” from *Mario Lassing* at the LCHOPN-LHCONE meeting in October 2022[*], the following is stated about the different technologies to be tested during DC24:

Start with a series of distributed, constrained, and isolated ***ramp-up challenges*** *..*
…Independently organized, and report via WLCG/DOMA

[*]https://indico.cern.ch/event/1146558/contributions/4908525/attachments/2534611/4361807/The%20path%20to%20the%20next%20WLCG%20Data%20Challenge.pdf

What is a “mini-challenge”

Given the cadence and scope of the WLCG Network Data Challenges, it is important to understand what we mean by “mini-challenge”. Here is a possible definition:

- A mini-challenge is a lightweight way to test capacity or capability with one or more sites

The goal is to make it easy to test and track both our capabilities and capacities, finding and fixing bottlenecks, identifying bad architectures and hardware and improving our visibility into how our sites perform as part of a globally distributed infrastructure.

Goals for DC26

For DC26 (or DC27 if it moves later) we are targeting:

- All sites should be moving the majority of their data via **IPv6**
- We should have a few **IPv6-only** sites for each experiment
- At least 80% of the traffic should be **identified via SciTags**
- At least 50% of the traffic should be using **jumbo frames**
- **Rucio/SENSE** to be used by few Production sites
- Sites should be able to easily utilize **90% of their declared WAN bandwidth** for an extended period (many hours to days)
- **Network traffic monitoring** should be able to track throughput by network type (LHCOPN, LHCONE, Research & Education, Commercial/Commodity)

Mini-challenges should help get us there…

Running an upgrade Campaign

- What’s the most effective way to get sites up to speed on these technologies?
- Weekly focus on a site to get it started on SciTags / IPv6 / Jumbo Frames?
  - For example, pick a site (Michigan for example?) and drill down on what’s needed to get them to support the site technologies?
  - Designate a campaign leader to manage the campaign
  - Have a location to share findings, tools and results.
- We need to organize efforts from the ground up, identifying advocates and interested participants and then running suitable mini-challenges to evaluate how things are working.
- **Host a site-admin training on the new technologies needed for DC26?**

Needed Visibility for Data Challenges

For DC24, a site network monitoring campaign was undertaken to provide better visibility into each site’s capabilities (see CERN Gitlab)

- This was a result of DC21 noting a deficiency in our monitoring
- For DC24 we just wanted total IN/OUT for each site
- We still have USLHC sites **missing** (see plot)
- For DC26, we may want to improve the level of detail (traffic by experiment)

We need to continue to improve (and verify) the monitoring we have, since this underlies all our attempts to identify friction points in our infrastructure.

For DC26, we would like to have at least 80% of our WAN traffic identified via the SciTags Initiative (there is also an IRIS-HEP metric for number of USLHC sites marking traffic; currently the number is ‘1’ [Nebraska])

We need to identify what monitoring is missing and fix any incorrect monitoring and clarify any misleading monitoring.

Carry out a Monitoring validation

- Not really a mini-challenge but necessary for them
- At the very least all sites should be part of the WLCG monitoring dashboard
- (recommended) Supporting **Scitags** would make the post-analysis easier
- We need to make sure the data in the dashboard is validated for each site
    - During DC24 we noticed discrepancies between the dashboard and reality
- Very important to have all sites reporting their site network usage to WLCG
    - Not all USCMS or all USATLAS sites are doing this yet…

Q. Who can do this?

Running periodic 1-to-1 load tests (NANO-challenge?)

- Run periodic throughput tests between the T1 and each T2:
  - Start by **clearly defining the target rates** for each site for DC26
  - Pick a week in the calendar that is suitable for both sites
  - Define a target throughput for the test
  - Use the *dc_inject* tool to execute the test

- Run periodic throughput tests for the T1
  - Run a similar test (as above) using a group of T2s to inject data to/from the T1

This requires each participant site to have a **validated** site network monitoring

Q. Who can do this?

A. for USCMS: Diego Davila (UCSD), for USATLAS: Hiro Ito (BNL)

Management and Logistics for Mini-Challenges

Commonly mini-challenges that test **new technologies** are run independently, (specially if they do not interfere with day-by-day Ops) by the people around the related project

On the other hand, those that run throughput tests are run in coordination with the site admins of the sites involved and the relevant R&E network responsibles.

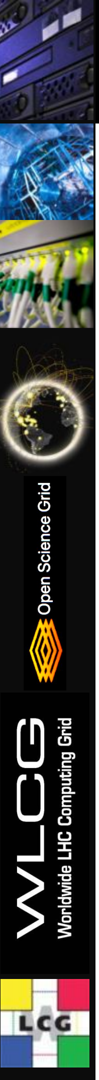
In any case every mini-challenge should be reported in advance to the WLCG DOMA conveners.

USATLAS and USCMS Activities: What is in Common?

If we are going to undertake various mini-challenges that are experiment-based, there may be benefit in running them at the same time.

Certain resources or network transit locations may be shared and identifying any contention can be an important outcome from running tests at the same time so we can address the issues as they are observed.

On the other hand, we don’t want to make mini-challenges heavy weight or over constrained as to when they be run.   One of the advantages of mini-challenges are supposed to be the ability to quickly and easily test capability or capacity for a site or set of sites.



Preparing Technologies and Capabilities

HL-LHC will require more resources than we can currently afford.

- To address this, the experiments are working hard to optimize workflows
- New technologies and capabilities will play a critical role in bridging the gap

The WLCG data challenges are designed to regularly test where we are relative to where we need to be for HL-LHC.

Possible technologies to test and, if beneficial, integrate

- **New / improved storage servers** (Gen5 PCIe, NVMe, new NICs, etc)
  - Define/document LHC server best practice for hardware and configuration
- **SciTags** (traffic identification anywhere in the network)
- **Traffic optimization** (via Jumbo Frames, pacing, new protocols)
- **Network Orchestration** (SENSE/Rucio, NOTED, GNA-g efforts, etc)
- Improvements (alternatives) to **WebDAV and Xrootd protocols**
- Improvements to **storage elements** (dCache, Xrootd, STORM, EOS, etc)
- Evolution of **Distributed Data Management** (Rucio, FTS, etc)

Site Testing, Motivation and Benefits

We hope to have sites as **enthusiastic participants** in planning and executing various mini-challenges.

This is a great opportunity to identify how each site performs and identify where there are issues.

It should be a significant help in defining how the site should evolve their hardware, software and architecture.

Transforming our Sites

The data challenges provide us with an opportunity to evaluate our existing hardware, software and architecture to identify bottlenecks, limitations and misconfigurations.

Given that HL-LHC is ~6 years away, now is the perfect time to re-evaluate our site's hardware configuration and architecture so that we can have a suitable baseline ready for HL-LHC requirements.

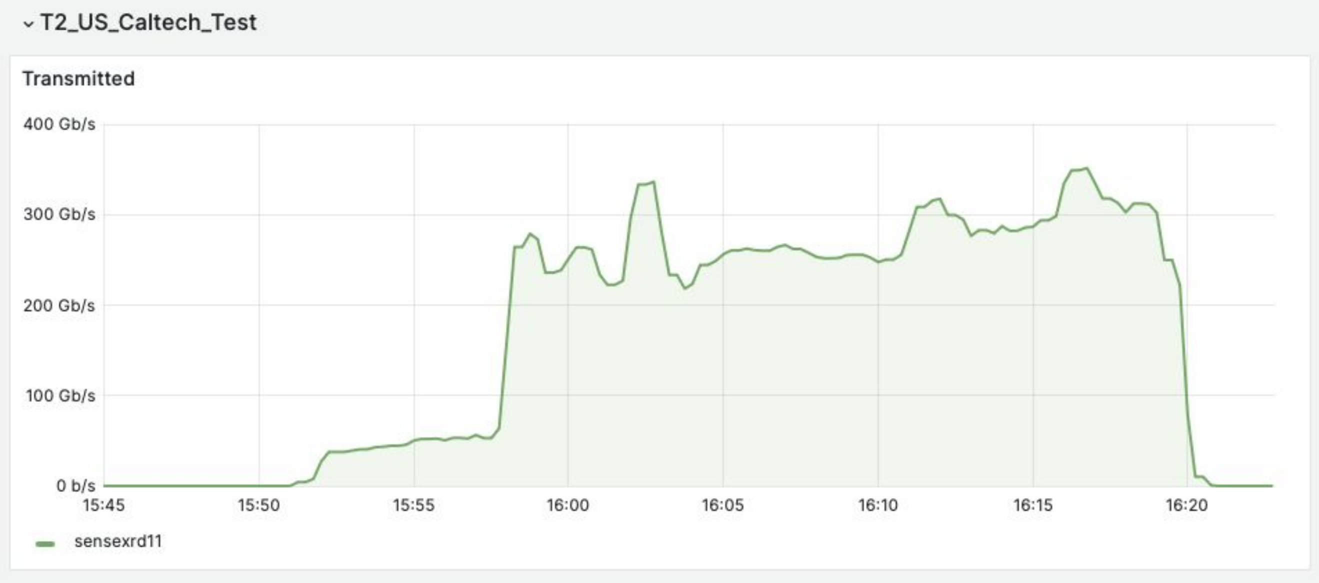
- Six years of hardware purchases can fully replace our current hardware
- Incrementally transforming sites should allow a smooth transition in capability

It is **critical** that sites understand how they fit into our globally distributed infrastructure so they can meet the HL-LHC requirements and use-cases.

- Mini-challenges are a great opportunity to understand our current capabilities, identify bottlenecks and prototype new technologies.

Transforming our Sites (cont'd)

An example of the above is the case of Caltech that went from performing at 80Gbps during DC24 to ~250Gbps this week by analyzing the results from DC24 and upgrading and tuning their system



Caltech (Prod) => UCSD (test) HTTP-TPC transfer throughput

Mini-Challenges and Ongoing Testing

The mini-challenges prior to DC24 turned out to be very beneficial for finding problems in our infrastructure and we should plan to have regular mini-challenges going forward

- The injection tool, used for DC24, is relatively easy to use. We could/should use it to run periodic tests with individual sites e.g. FNAL => MIT to help them understand possible limitations
- Hiro Ito / BNL has developed a load tester that can also be used
- Regional sets of sites (up to “North America”) should be tested simultaneously by USATLAS/USCMS to verify we don’t conflict at PoPs
- Mini-challenges should also include tests of technologies and new capabilities

Ongoing mini-challenges a few times a year provide important guidance and validation for site changes in hardware, software and tunings.

Getting Effort to Analyze Results

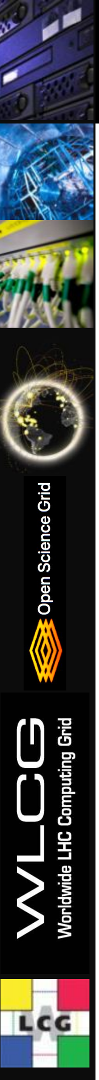
One important issue is ensuring that we have enough effort targeting analyzing results we obtain.

For DC24, we didn't really have enough effort to fully benefit from all the work that went into running DC24 and gathering the data.

- One example: ESnet has a significant amount of high-touch data from DC24 that has yet to be fully analyzed.
- High-touch provides packet level detail for specific flows, with each packet time-stamped at the hardware level with nano-second resolution
- This data can tell us a lot about our flows and their behavior and limitations.

We need to make sure we have effort not just to organize and run mini-challenges but to follow through and thoroughly explore the results.

Questions To Discuss (and Try to Answer)



How do we best organize mini-challenges in common between USATLAS/USCMS?

- Use the HSF calendar to identify upcoming tests?
- Use Google docs to develop and define tests?
- How best to coordinate with ATLAS/CMS?
- What cadence is best: 1, 2 or 3 times a year?

Who will organize and operate the tests?

Who will analyse results and identify bottlenecks?

What technology-focus mini-challenges are needed?

- Driven by advocates or site interest?
- Co-scheduled with capacity mini-challenges?

How do sites share and implement beneficial changes identified by mini-challenges?

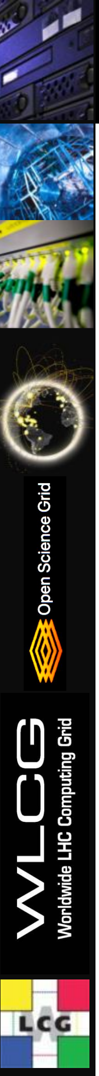
Summary

We (IRIS-HEP/OSG-LHC/US-LHC) need to **clarify** and **document** existing plans, **mini-challenges** and goals for the next year and for DC26/DC27

We have an **opportunity** to leverage DC24 results to improve our infrastructure, to drive technology deployment, to show value and to demonstrate capabilities at scale.

Let’s Discuss

https://docs.google.com/document/d/1Xjq8CvotPAYSsp28Ntn_hKZAQiyS4pwpX5t_p_a_6oM/edit#heading=h.mewhmbcpz1f1



Acknowledgements

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Background Material

Here are some resources we know about:

Presentations

- WLCG Data Challenge 2024 (DC24) Status and Plans Related to ATLAS DDM (Jun 2023)
- DC24 Planning and Near Term Activities (Jul 2023)
- USATLAS Data Challenge 2024 Take-aways (Feb 2024)
- Medium to Long Term Network Plans for ATLAS and CMS (Mar 2024)
- DC24 Network Activities & Results (May 2024)

Some Google Docs

- WLCG/DOMA Data Challenge 2024: Final Report
- USATLAS Milestones/MiniChallenges for Next WLCG Data Challenge in 2024
- Planning Mini-Challenges for US ATLAS Facilities and Distributed Computing
- NOTES: USATLAS Facility Status and Evolution Discussion

DC24 Links

Official DC24 report
https://zenodo.org/records/11402618

DC24 Network Activities and Results:
https://docs.google.com/presentation/d/1s0VvbXEpj1PN9umFT8wgsHsHmG9EYucymbalKNrvuKQ/edit#slide=id.p1

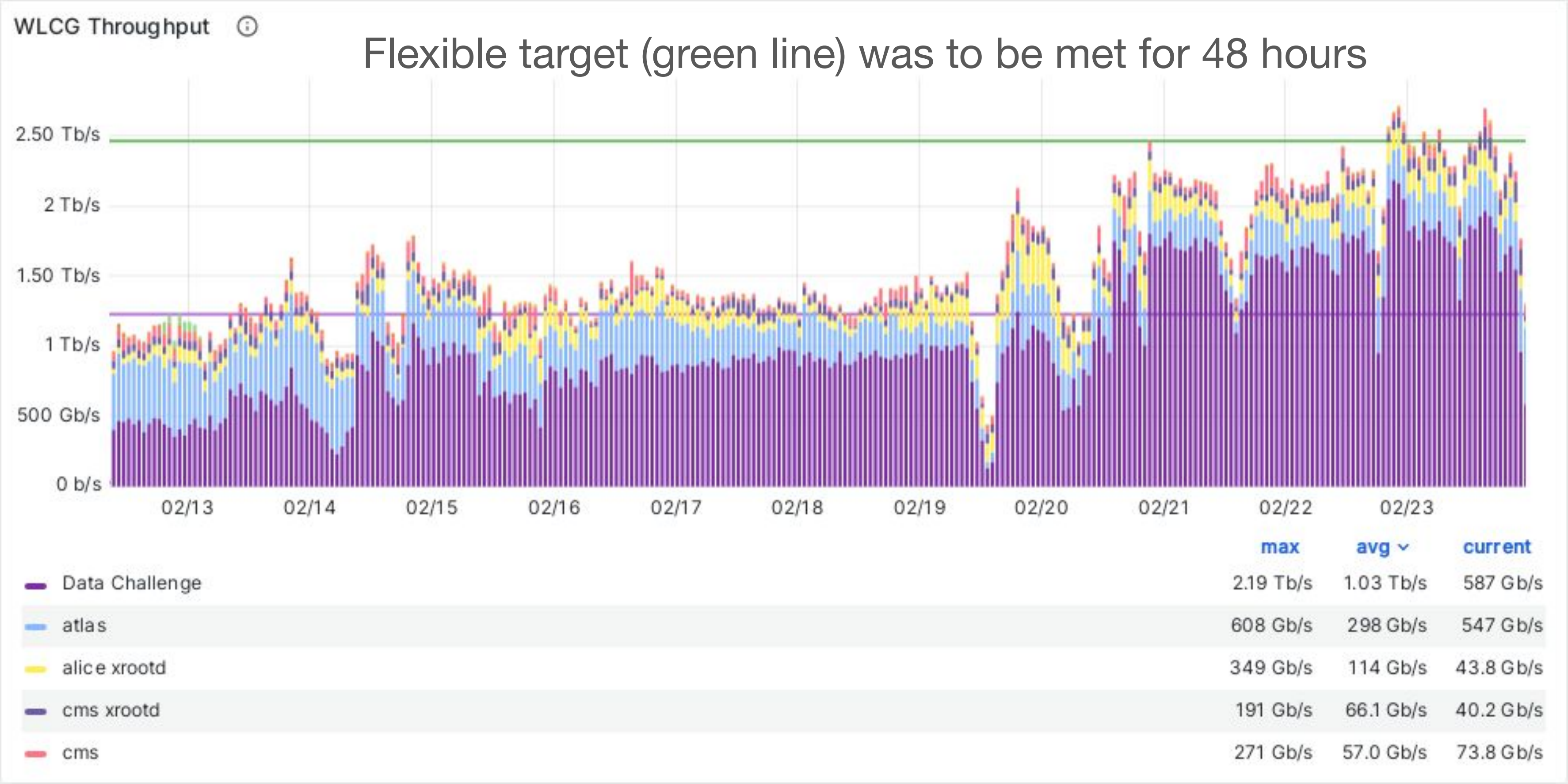
Katy Ellis LHCONE/LHCOPN DC24 presentation:
https://docs.google.com/presentation/d/1Tm3pCMkfHj5KHTW3PXbgS7mdHf72Ir27qr1JgMbrnRg/edit#slide=id.g1ea89411ecb_0_4

Next Steps Towards DC26:
https://docs.google.com/presentation/d/1mMx6QaihWJWpbVEQgxNjZXRT5_s4SkBTXu0SpELtuvl/edit#slide=id.gd170caf633_1_0

DC24 ATLAS Retrospective:
https://docs.google.com/presentation/d/1Lh_D57BvWn13AFClhhuczm-j-tKV-yMez_oD4yYUtBo/edit#slide=id.gd170caf633_1_0

Backup Slides

DC24 Throughput



Flexible target (green line) was to be met for 48 hours

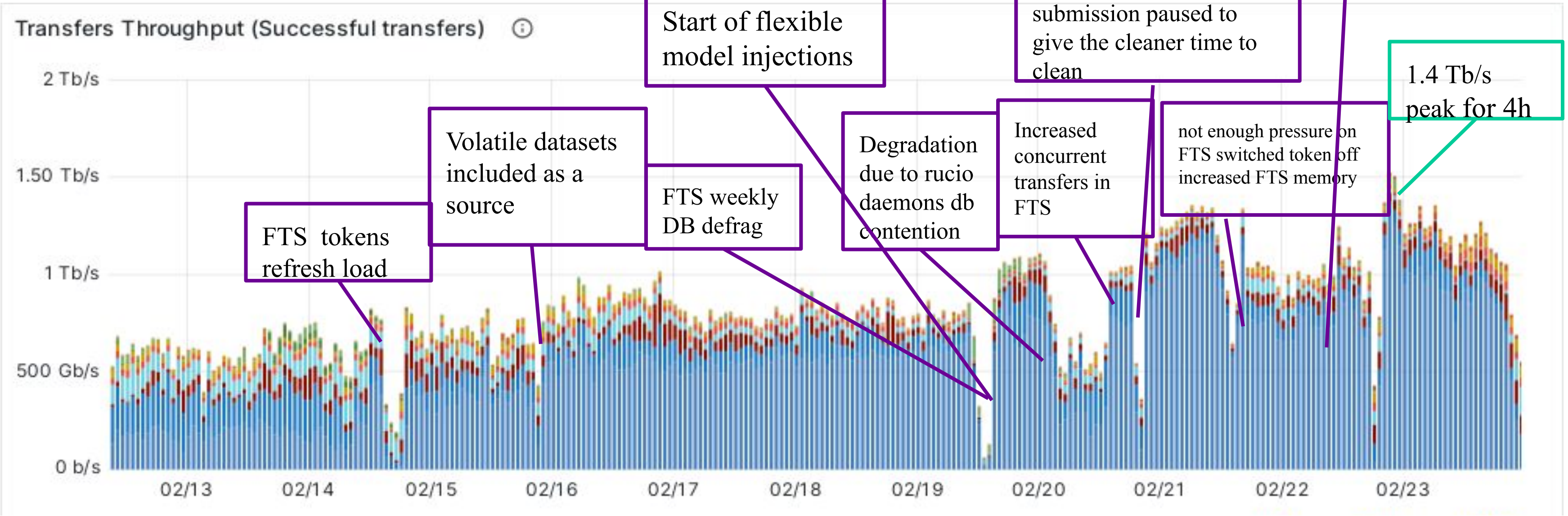
	max	avg ⌄	current
🟪 Data Challenge	2.19 Tb/s	1.03 Tb/s	587 Gb/s
🟦 atlas	608 Gb/s	298 Gb/s	547 Gb/s
🟨 alice xrootd	349 Gb/s	114 Gb/s	43.8 Gb/s
🟪 cms xrootd	191 Gb/s	66.1 Gb/s	40.2 Gb/s
🟥 cms	271 Gb/s	57.0 Gb/s	73.8 Gb/s

DC24 Throughput Annotations

DC24 met the baseline target, but not the flexible one

Wide-area Networking was NOT the bottleneck

FTS was one of the primary limitations



FTS tokens refresh load

Volatile datasets included as a source

FTS weekly DB defrag

Start of flexible model injections

Degradation due to rucio daemons db contention

Increased concurrent transfers in FTS

submission paused to give the cleaner time to clean

not enough pressure on FTS switched token off increased FTS memory

stopped submissions installed second high memory FTS instance for T2s. Cleanup 3M cancelled transfers

1.4 Tb/s peak for 4h

UCSMS DC24 summary

The planned target for FNAL was 32GB/s
The maximum injected/achieved rates for FNAL were 26/31GB/s for reads and 37/39 GB/s for writes making this a success for the T1.
Moreover, sustained rates of 24 GB/s for writes and 36 GB/s for reads were observed for 21 and 12 hrs. respectively

From the T2s perspective the initial targets set by CMS centrally, ranging from 1.2 to 4.8 GB/s, were dimmed lower than expected by USCMS and all sites performed above them.

On the last day, these rates were significantly increased as per USCMS request. The new rates ranged from 4 to 14 GB/s. This time only Nebraska performed above the new rates with other sites hitting marks around 50% of the updated targets.

USCMS planned upgrades

- Upgrade FNAL to 1.6 Tbps total link capacity
- Jumbo Frames performance evaluation
- FNAL working on distributed load generation technique to test Terabit science networks (as opposed to use the injection link)
- Develop a Perfsonar's Alert & Alarm (Grafana Dashboard)
- Deploying Flow label & Packet marking techniques
- Working with ESnet on AI/ML based traffic classification
- Move SENSE/Rucio into pre-production: add more sites, include ATLAS