Status of Tape-less Archive Storage project @ KISTI-GSDC

AHN SANG-UN @ WLCG GDB, 9 DECEMBER 2020

Outline

- Introduction

- System Architecture

- QRAIN Layout

- Current Status
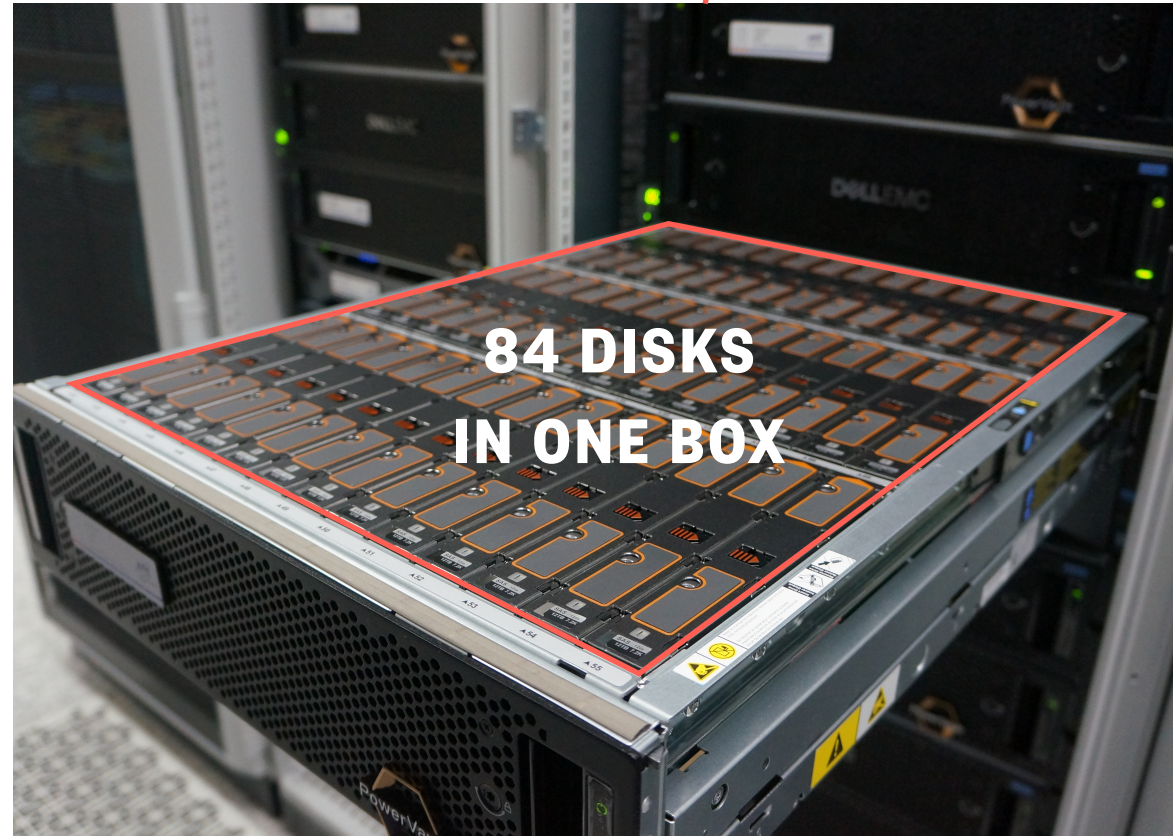
- Monitoring

- Plan

- Summary

Introduction

- Replacing tape library (+3PB) with disk-only storage for archiving @ KISTI for ALICE experiment

  - Simpler architecture, less operational efforts, cost-effective comparable to tape

- Found domestic suppliers of high-density(> 60 disks/box) JBOD models

- Relying on EOS erasure coding implementation (RAIN layout) for data protection

- About 1M CHF budget (2019) included

  - 18 High-density JBOD boxes (84 disks/box $\simeq$ 18PB raw capacity)

  - 9 Servers for EOS front-end nodes (12Gbps SAS HBAs, 40Gbps uplinks + switches)

- Providing production service to ALICE before the start of RUN3 (by June 2021) ← **POSTPONED**
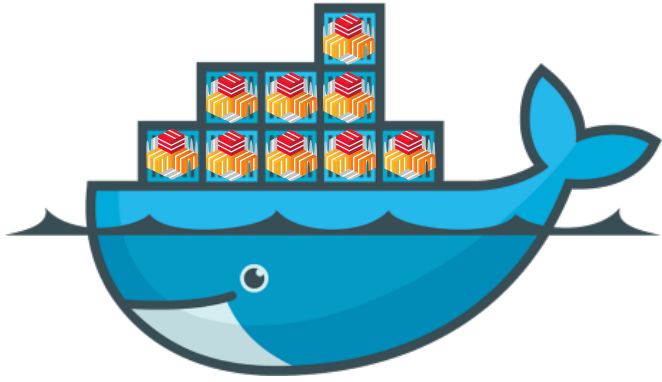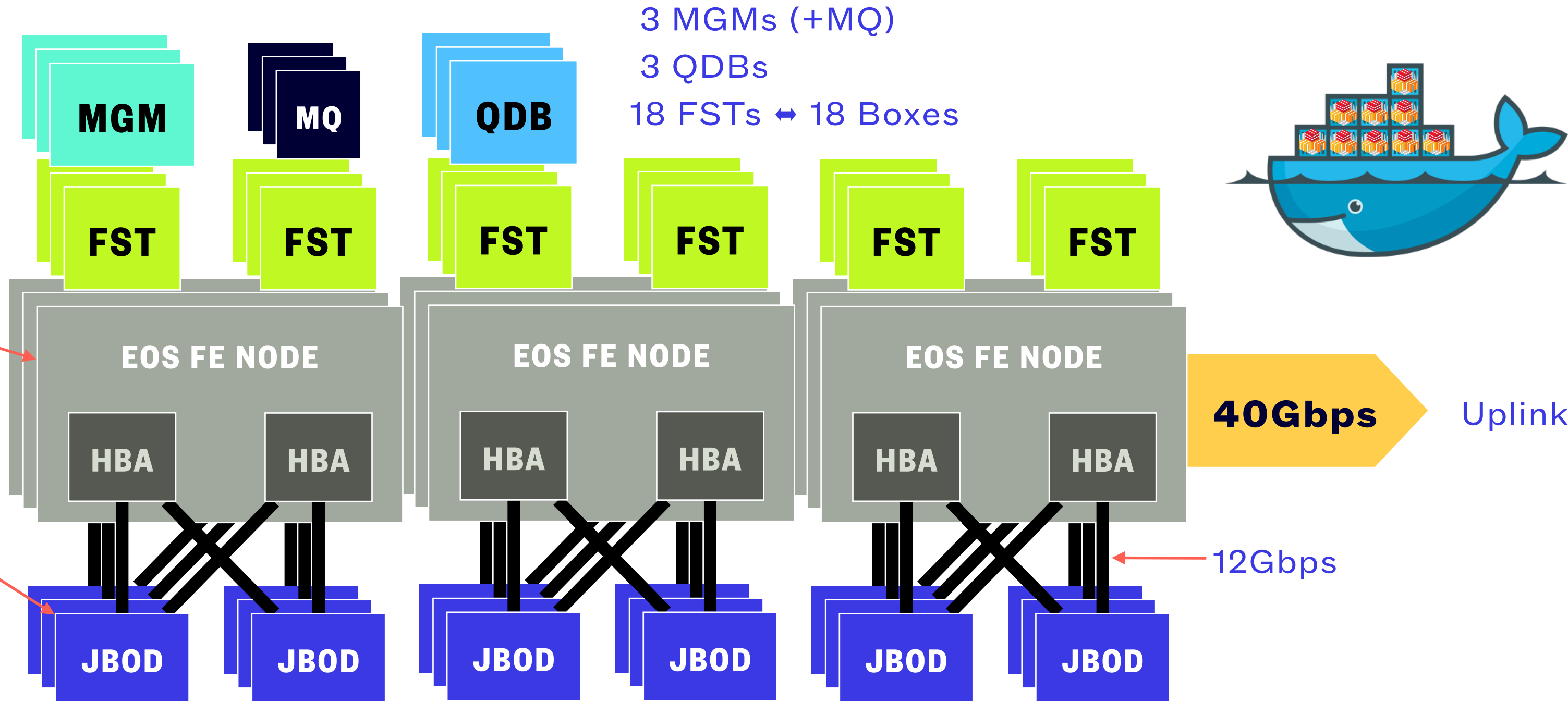
System Architecture

3 MGMs (+MQ)
3 QDBs
18 FSTs ↔ 18 Boxes

MGM **MQ** **QDB**

FST **FST** **FST** **FST** **FST** **FST**

EOS FE NODE **EOS FE NODE** **EOS FE NODE**

9 servers
18 boxes

HBA **HBA** **HBA** **HBA** **HBA** **HBA**

40Gbps Uplink

JBOD **JBOD** **JBOD** **JBOD** **JBOD** **JBOD**

12Gbps

**84 DISKS
IN ONE BOX**

- Total raw capacity = 18,144TB (= 12TB * 84 disks * 18 boxes)
- EOS version = 4.8.25 (released on 2020.11.10)
- EOS components are running on containers (a fork of EOS-Docker project)
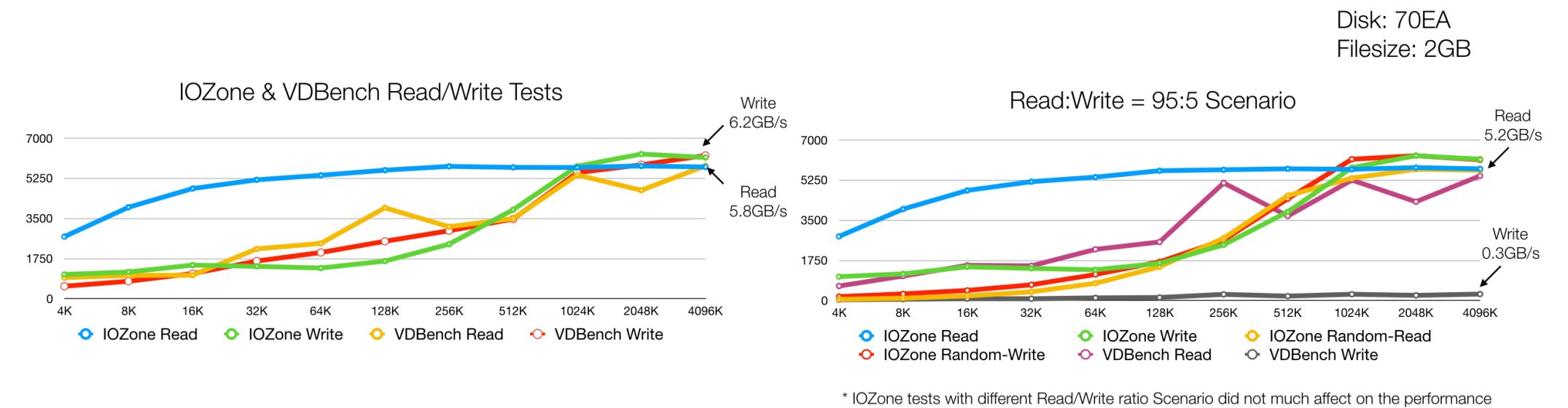 - Ansible playbook available at https://github.com/jeongheon81/gsdc-eos-docker

Recap
CHEP2019

- EOS Erasure Coding implementation => RAIN layout

  - 2 FSTs (data server) on a single FE node to maximize usable space (~70%) out of raw capacity

- Upper cap on total throughput limit by PCI-e 3.0 (~6GB/s)

- Power consumption ~ 1.75W/TB (JBOD+Server+S/W)

  - Enterprise Disk storage: 5 ~ 9W/TB
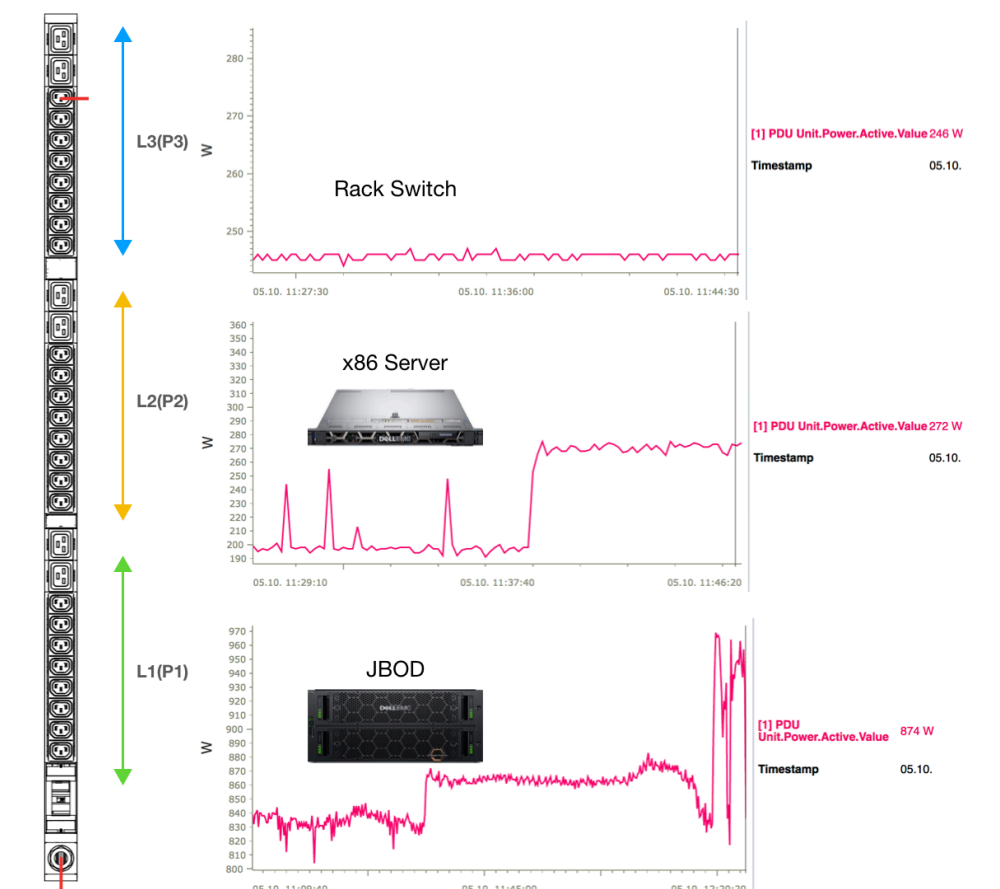
  - Tape library ~ 0.5W/TB

I/O Test: Read/Write

- XFS read/write performance (simultaneous read and/or write from 70 disks)

  - **VDBench** shows full read/write transfer performance @ transfer size >= 2048k (6GB/s)

  - **IOZone** shows full read/write transfer performance @ transfer size ~ 2048k (6GB/s)

Disk: 70EA
Filesize: 2GB

IOZone & VDBench Read/Write Tests

Read:Write = 95:5 Scenario

* IOZone tests with different Read/Write ratio Scenario did not much affect on the performance
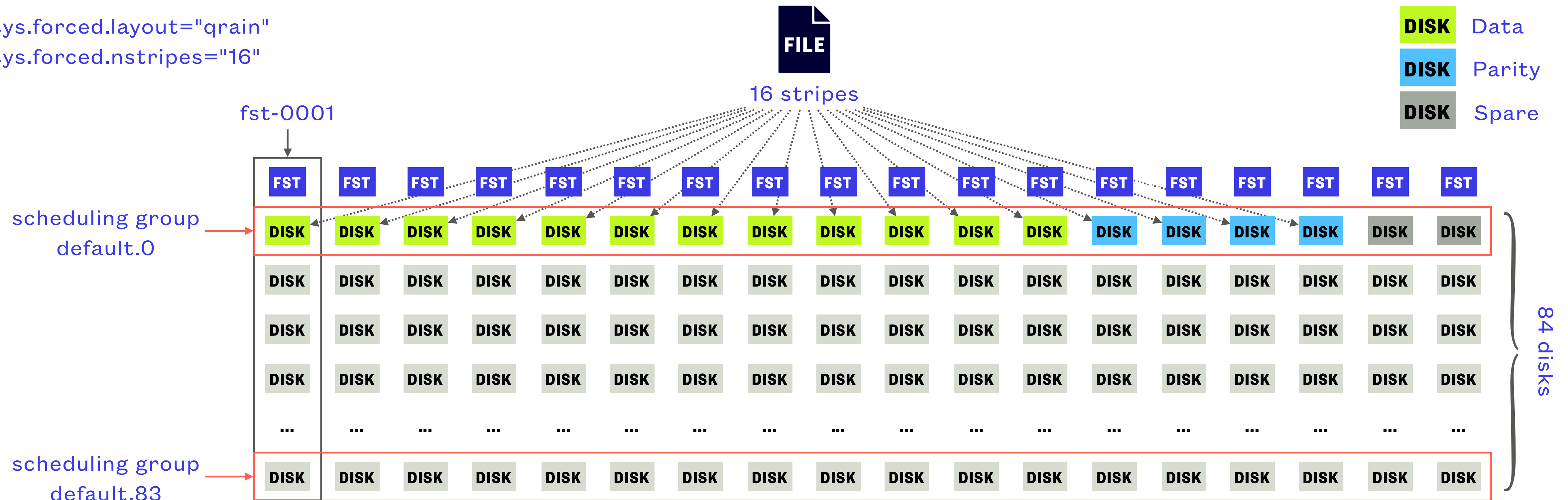
Power Consumption

- JBOD Test Equipment (70 Disks)
  - JBOD (DELL ME484): idle = 830W; load = 860W (Max 960) **(1.12W/TB)**
  - Server: idle = 200W; load = 270W
  - Switch: idle = 246W; load = 246W
  - **1.75W/TB** including JBOD, Server and Switch
- Disk Storages (Full Load)
  - DellEMC SC7020, 2.5PB - 12,120W **(4.8W/TB)**
  - EMC Isilon, 16 Nodes, 2.95 PB- 13,730W **(4.6W/TB)**
  - EMC VNX, 12 Nodes, 2.36 PB - 5,100W **(2.2W/TB)**
  - HITACHI VSP, 2 PB - 18,300W **(9.15W/TB)**
  - EMC Isilon, 15 Nodes, 1.43 PB - 12,880W **(9W/TB)**
  - EMC CX4-960, 1.5PB - 14,900W **(9.9W/TB)**
- Tape Library (Full Load)
  - **IBM TS3500 5-Frame (3.2PB) - 1,600W (0.5W/TB)**

QRAIN Layout

sys.forced.layout="qrain"
sys.forced.nstripes="16"

DISK Data
DISK Parity
DISK Spare

FILE

16 stripes

fst-0001

scheduling group
default.0

scheduling group
default.83

84 disks

- Thanks to spare FSTs,
  - Data are still accessible if 6 FSTs are offline
  - Data can be written if 2 FSTs are offline
  - One node (= 2 FSTs) can be turned off for maintenance at any time

- Data loss rate in a year is $\approx 8.6 \times 10^{-5}$%, where 5 disks are failed simultaneously, considering 1.17% of AFR in practice
  cf. vendor published AFR is 0.35% (AFR = Annualized Failure Rate)

QRAIN Configuration

- 'eos attr' command

  - One can have different layouts on different directories in an EOS instance

  - Available layouts = plain (default, 1 single copy); replica (2 copies); raid6, raiddp (2 parities); archive (3 parities); qrain (4 parities), ...

```
eos attr -r set default=raid6 /eos/gsdc/testarea/raid6
eos attr -r set default=archive /eos/gsdc/testarea/archive
eos attr -r set default=replica /eos/gsdc/testarea/replica
eos attr -r set default=qrain /eos/gsdc/testarea/rain12
```

  - # of stripes can be changed, e.g. 3 copies, 16 stripes...

    eos attr -r set default=qrain /eos/gsdc/testarea/rain16
    eos attr -r set sys.forced.nstripes=16 /eos/gsdc/testarea/rain16

```
sh-4.2# eos attr ls /eos/gsdc/testarea/rain16
sys.eos.btime="1605069261.927407367"
sys.forced.blockchecksum="crc32c"
sys.forced.blocksize="1M"
sys.forced.checksum="adler"
sys.forced.layout="qrain"
sys.forced.nstripes="16"
sys.forced.space="default"
sys.recycle="/eos/gsdc/proc/recycle/"
```

Fileinfo

EOS fileinfo command

Layout type
# of stripes
# of replica

File chuck location
Scheduling group
Filesystem status

```
sh-4.2# eos fileinfo /eos/gsdc/testarea/rain16/testfile.10G
  File: '/eos/gsdc/testarea/rain16/testfile.10G'  Flags: 0640
  Size: 10485760000
Modify: Thu Oct 22 00:01:35 2020 Timestamp: 1603324895.724750000
Change: Thu Oct 22 00:00:51 2020 Timestamp: 1603324851.619542497
 Birth: Thu Oct 22 00:00:51 2020 Timestamp: 1603324851.619542497
  CUid: 0 CGid: 0 Fxid: 0000159b Fid: 5531 Pid: 40 Pxid: 00000028
XStype: adler     XS: a1 1c 00 01     ETAGs: "1484716507136:a11c0001"
Layout: qrain Stripes: 16 Blocksize: 1M LayoutId: 40640f52 Redundancy: d5::t0
  #Rep: 16
```

| no.	fs-id	host	schedgroup	path	boot	configstatus	drain	active	geotag
0	995	jbod-mgmt-06.sdfarm.kr	default.70	/jbod/box_12_disk_070	booted	rw	nodrain	online	kisti::gsdc::g02
1	1499	jbod-mgmt-09.sdfarm.kr	default.70	/jbod/box_18_disk_070	booted	rw	nodrain	online	kisti::gsdc::g03
2	659	jbod-mgmt-04.sdfarm.kr	default.70	/jbod/box_08_disk_070	booted	rw	nodrain	online	kisti::gsdc::g02
3	407	jbod-mgmt-03.sdfarm.kr	default.70	/jbod/box_05_disk_070	booted	rw	nodrain	online	kisti::gsdc::g01
4	827	jbod-mgmt-05.sdfarm.kr	default.70	/jbod/box_10_disk_070	booted	rw	nodrain	online	kisti::gsdc::g02
5	491	jbod-mgmt-03.sdfarm.kr	default.70	/jbod/box_06_disk_070	booted	rw	nodrain	online	kisti::gsdc::g01
6	1079	jbod-mgmt-07.sdfarm.kr	default.70	/jbod/box_13_disk_070	booted	rw	nodrain	online	kisti::gsdc::g03
7	71	jbod-mgmt-01.sdfarm.kr	default.70	/jbod/box_01_disk_070	booted	rw	nodrain	online	kisti::gsdc::g01
8	743	jbod-mgmt-05.sdfarm.kr	default.70	/jbod/box_09_disk_070	booted	rw	nodrain	online	kisti::gsdc::g02
9	1247	jbod-mgmt-08.sdfarm.kr	default.70	/jbod/box_15_disk_070	booted	rw	nodrain	online	kisti::gsdc::g03
10	155	jbod-mgmt-01.sdfarm.kr	default.70	/jbod/box_02_disk_070	booted	rw	nodrain	online	kisti::gsdc::g01
11	1415	jbod-mgmt-09.sdfarm.kr	default.70	/jbod/box_17_disk_070	booted	rw	nodrain	online	kisti::gsdc::g03
12	911	jbod-mgmt-06.sdfarm.kr	default.70	/jbod/box_11_disk_070	booted	rw	nodrain	online	kisti::gsdc::g02
13	1331	jbod-mgmt-08.sdfarm.kr	default.70	/jbod/box_16_disk_070	booted	rw	nodrain	online	kisti::gsdc::g03
14	239	jbod-mgmt-02.sdfarm.kr	default.70	/jbod/box_03_disk_070	booted	rw	nodrain	online	kisti::gsdc::g01
15	575	jbod-mgmt-04.sdfarm.kr	default.70	/jbod/box_07_disk_070	booted	rw	nodrain	online	kisti::gsdc::g02

```
*******
```

Current Status

- EOS update: 4.8.12 → 4.8.25 (2020.11.10 release)

- MGM load-balancing and fail-over tests confirming that

    - Xrdcp write/read requests through MGM secondaries work well

    - Automatic fail-over happens within a few seconds (~10s) when primary MGM is unresponsive

- Public DNS alias pointing to 3 MGMs

- IPv4/IPv6 dual stack configured

Monitoring

- Prometheus node_exporter + Grafana dashboard

  - Hardware level monitoring using *smartmon* tools

    - Corrected/uncorrected error counts

    - Temperature, defects count, etc.

  - Learning metrics to identifying and predicting disk failures

- Custom script parsing JBOD enclosures status from *sg_ses* command output
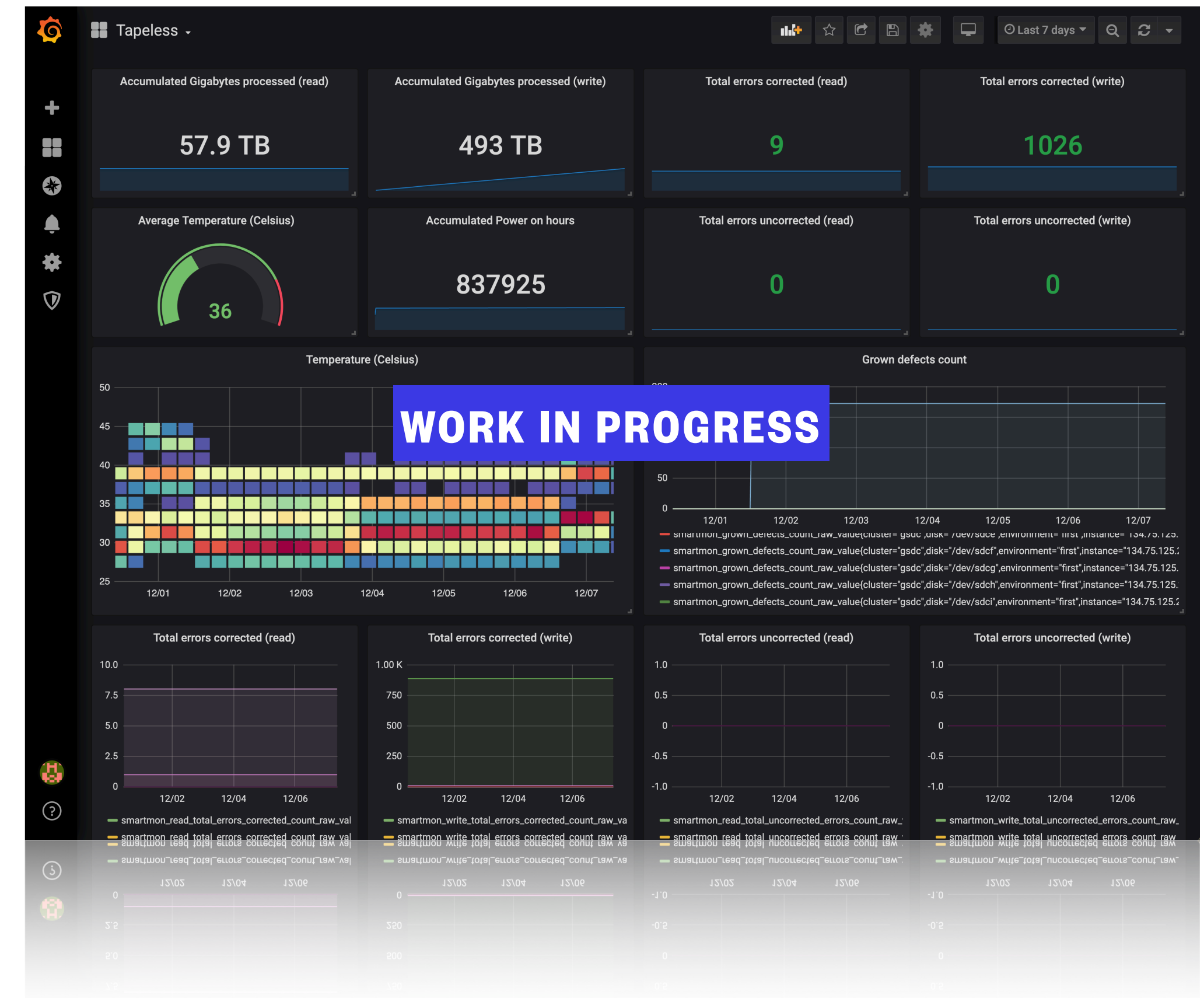
Debugging

- EOS services log dump using *loki, promtail*

  - Easy access to container level logs (*MGMs, FSTs, ...*) by name

  - Live stream (like *'tail -f /var/log/eos/...xrd.log'*) from multiple nodes

  - Complementary to EOS CLI tools

- Remote support by EOS developers
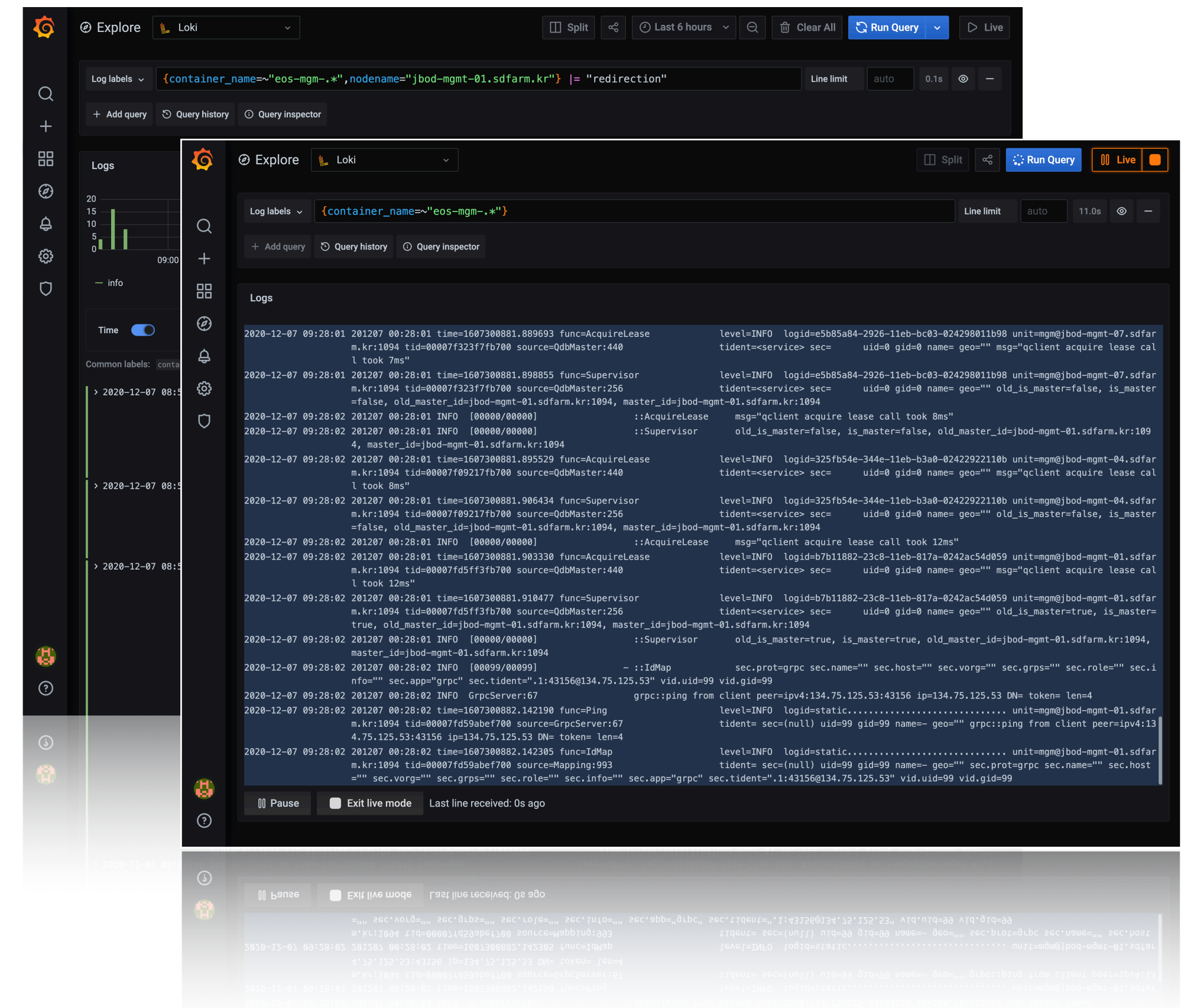
Issues Fixed

- When read a file with "eos cp" (or eoscp) from RAIN layout with more than 12 stripes

  - Redirection information over 2kB truncated

    - https://gitlab.cern.ch/dss/eos/-/commit/4cb0f733650e041a3153da60610a8d5a0e4672f4

    - https://gitlab.cern.ch/dss/eos/-/commit/03bcc4b55556bc0d7b3160670a41a98bfa50a941

- Failed to read a file with "eos cp" through MGM secondaries

  - Quota information propagation corrupting namespace

    - https://gitlab.cern.ch/dss/eos/-/commit/32b93012459f73409b45fceaa3c575cc6c47f421

Plan

- Update to EOS 4.8.31

  - Fix for namespace corruption due to wrong propagation of quota information

- Enabling token based authentication for ALICE

  - Host certificates for MGMs are issued and installed

- Integrating as a new ALICE tape storage element *without tape*

  - Performing periodic functional tests, and monitoring stability and reliability

- Establishing maintenance and operation scheme

  - Disk replacement, JBOD and server maintenance, rolling update of EOS components

Summary

- Working on providing a disk-only archive storage for ALICE experiment with the help of EOS erasure coding implementation for data protection

- Successfully deployed QRAIN layout with 16 stripes including 4 parities and made it working by fixing a couple of issues

- Working on establishing a dedicated monitoring framework for the archive storage

- On track of schedule to provide production service by June 2021, even though the start of RUN3 has been postponed

Thank you