Preparing for HL-LHC

Increasing the LHCb software publication rate to CVMFS by an order of magnitude

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vCHEP 2021, 19th May

Introduction

- **Software** is crucial for HEP
  - Operation of experimental facilities
  - Events filtering during data acquisition
  - Reconstruction jobs for analysis
- … as well as its efficient **distribution at scale**
  - Software to be provided to thousands of clients
  - Heterogeneous resources at different sites

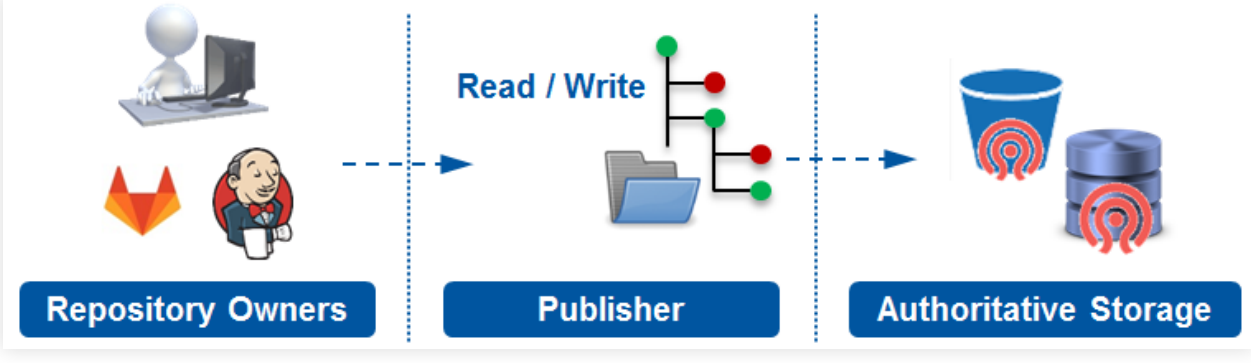
CVMFS for software delivery at scale

Increase publication rate on CVMFS

- Use case: **LHCb nightly builds**
  - Challenging use-case with strict requirements
  - Nightly builds and partial stack builds
  - 3.8 M files, 200 GB to be installed daily
- Goal: **Faster publication of LHCb software**
  1. Parallelize publication process
  2. More performant storage backend
  3. Efficient management of installations

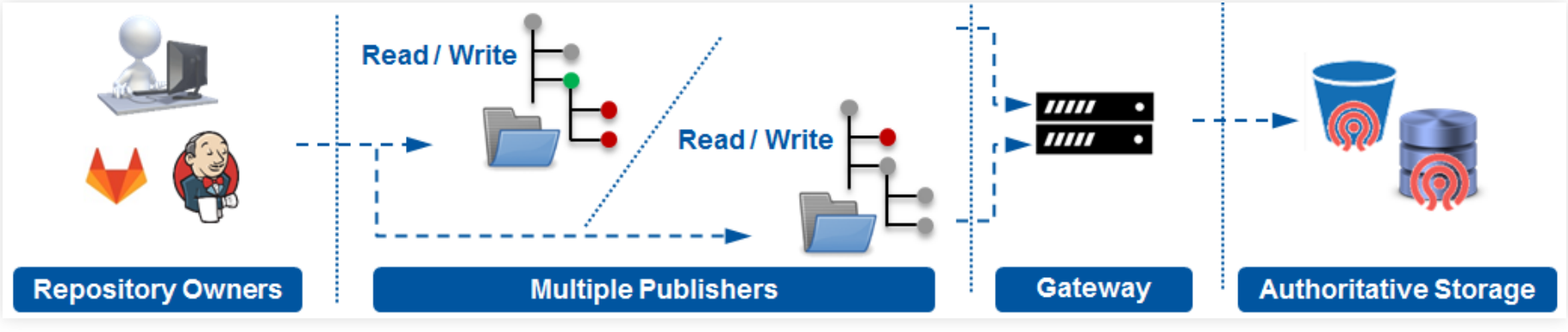
Traditional CVMFS setup

- One publisher applies changes to the repository
  - Acquires global write lock
  - Accesses authoritative storage directly
  - Only one publication at a time possible



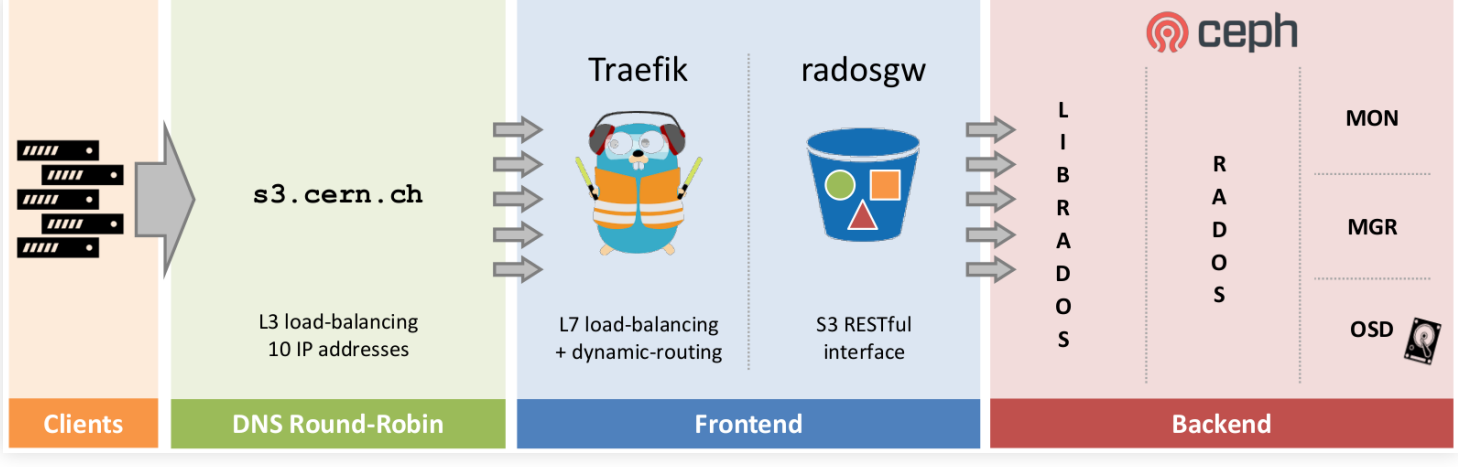
CVMFS setup with Gateway

- Allows for **concurrent publications**
  - Issues time-limited leases for specific sub-paths
  - Provides API to coordinate across publishers
- Coordinates multiple publishers
  - Each publisher locks a repository sub-tree
  - Parallelism depends on a good repository structure

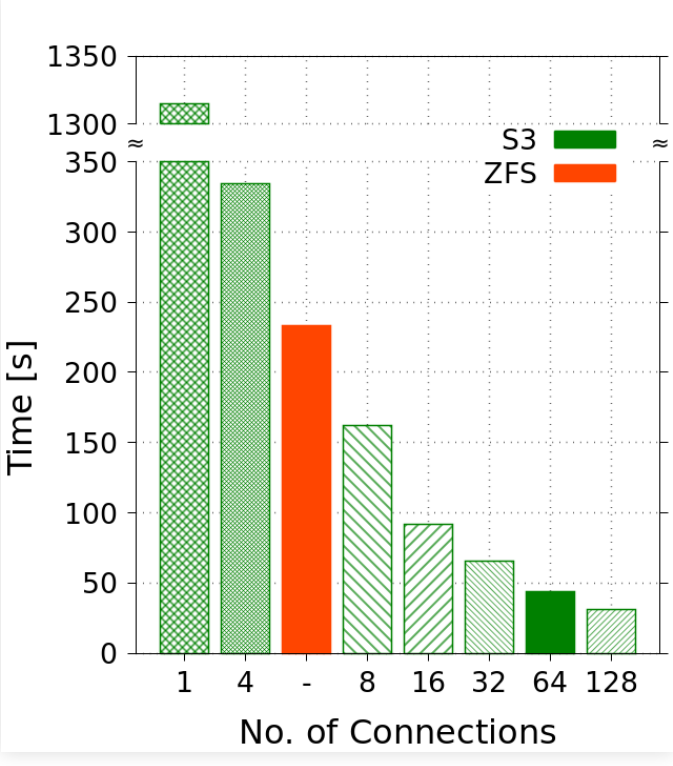


CVMFS migration to S3 storage

- All repositories hosted at CERN migrated to S3
- `s3.cern.ch`:
  - Single-region Ceph cluster, 5.8 PB raw
  - Load-balanced across 16 Traefik frontends
  - 4x dedicated RGWs for CVMFS

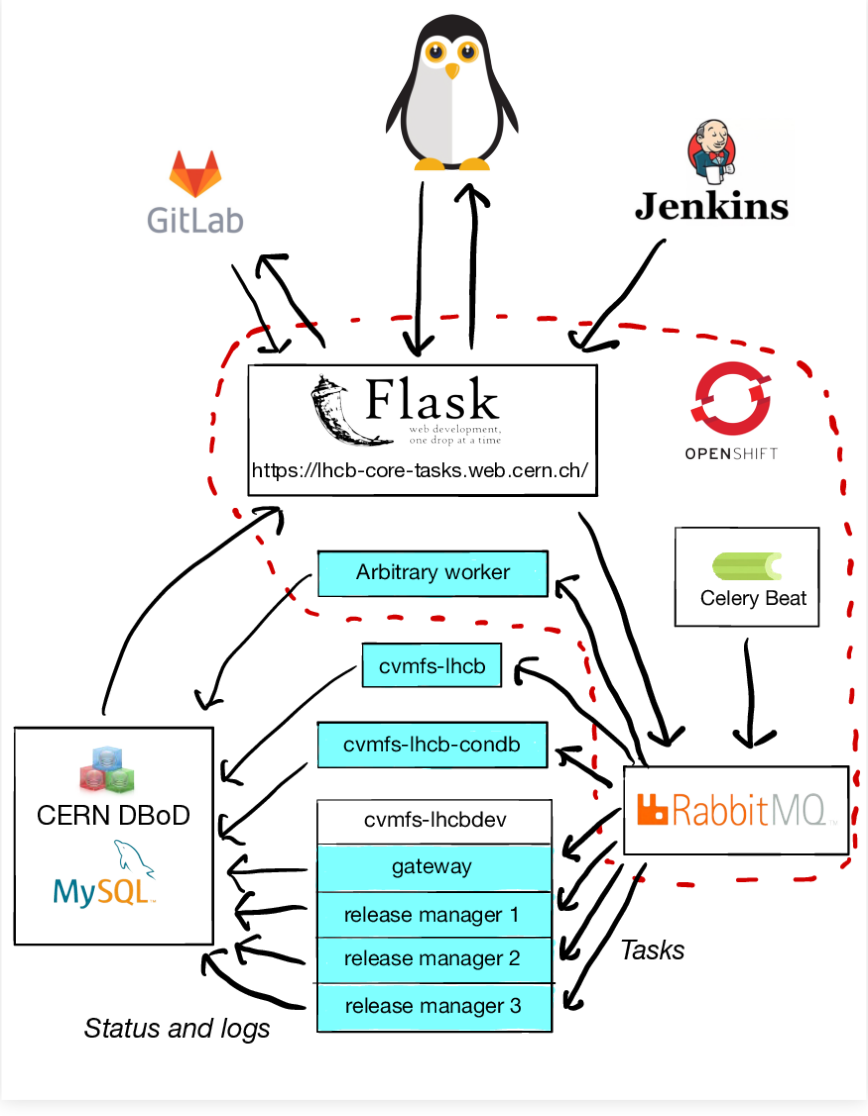


Performance improvements for CVMFS

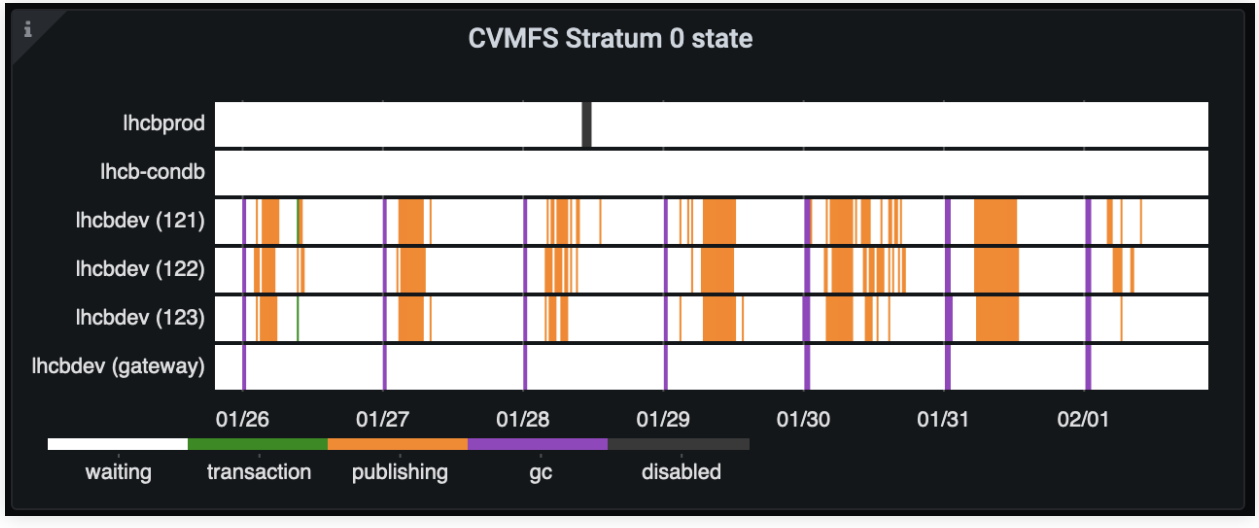


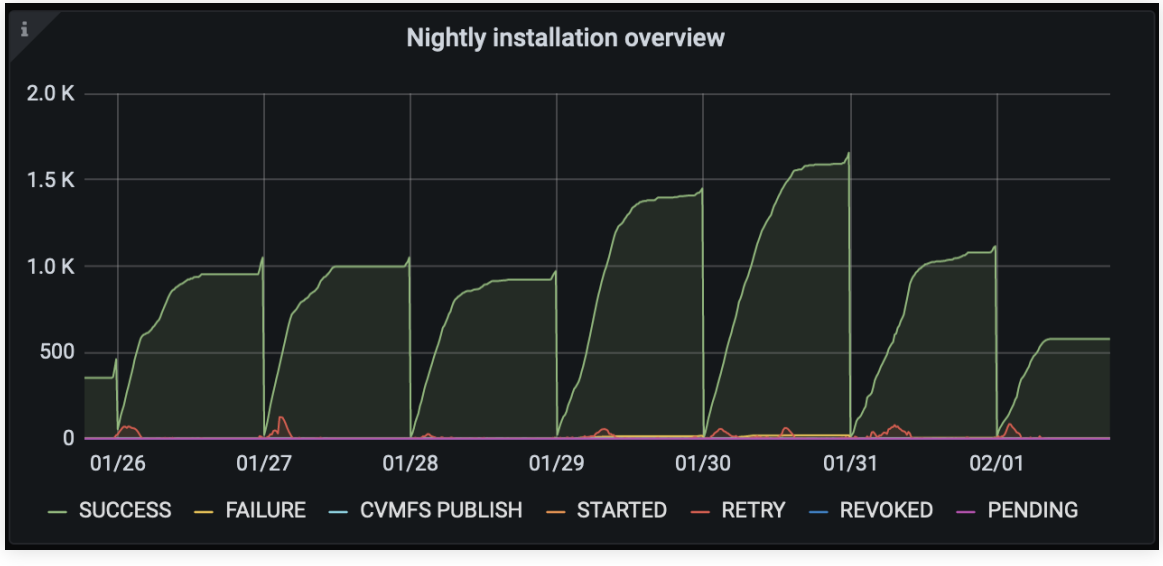
- Publication time benchmarking:
  - Workload: 250k files, 4 kB each
  - Files spread across 250 folders each with a cvmfs catalog
  - Full publication through CVMFS
- Default parallel connections: 64
- S3 outperforms volume storage: Publication on S3 is 5x faster

LHCb installations orchestration



Monitoring of CVMFS publications





Conclusions

- CVMFS and Storage teams brought major improvements
  - New gateway component for parallel publications
  - S3 object storage improved performance (5x faster)
- LHCb implemented advanced orchestration framework
  - Take advantage of the infrastructure underneath
  - Task queue, retry logic, error handling, …
- In production since November 2020
  - Meets today’s requirements for stability and speed
  - Room for scalability by adding publishers

Backup

CVMFS repositories for LHCb

- **`lhcb.cern.ch`**
  - Production software
  - Low churn rate, no garbage collection
- **`lhcb-condb.cern.ch`**
  - Conditions data
  - Slowly growing, no garbage collection
- **`lhcbdev.cern.ch`**
  - Nightly builds and partial stack builds
  - 3.8 M files, 200 GB to be installed daily
  - Requires frequent garbage collection

LHCb installations orchestration

- Installations are managed by Celery agent
  - Running on each publisher (3 at the moment)
  - Fetches jobs from RabbitMQ + MySQL (CERN DBoD)
- Each installation task
  1. Infers the destination directory on CVMFS
  2. Checks if lock exists on the directory
  3. If free, installs || Otherwise, waits and retries

Locking for garbage collection

- Deleted files on CVMFS are not purged from storage
  - To remove them completely, GC is needed
  - High churn rate repositories require frequent GC
- Garbage collection uses a **mark and sweep** approach
  - Requires exclusive access to the repository
  - Gateway is instrumented to take global lock
    - Daily, in the evening on `lhcbdev.cern.ch`
- Both mark and sweep are now parallelized
  - Take advantage of multicores and parallel connections
  - ~ 1 hour on `lhcbdev.cern.ch` to delete 100+ k files

Distribution to clients

- Typically, clients read from Stratum 1
  - Introduces (small) replication delay
  - Garbage collection inhibits replication
- With S3, clients could read from storage
  - No replication delay
  - Garbage collection is non-blocking
  - Still using intermediate caches