Interactive Data Analysis for End Users on HN Science Cloud

Status Report on Totem Test

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Helix Nebula Science Cloud Pilot Phase
14th June 2018, CERN, Geneva

Contributors

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What is the Totem Test about

- **Goal:** Enable end users to run data analysis interactively
  - ✓ Analysis scenario: Totem experiment
  - ✓ End users: Totem collaborators and scientists

- **How:** Deployment of “Science Box” on Helix Nebula Cloud
  - ✓ EOS, CERNBox, SWAN + SPARK
  - ✓ Data transfer to import relevant datasets

- **Measure of success:**
  Quantification of analysis done with SWAN
  - ✓ Real physics analysis with ROOT (RDataFrame) + SPARK
  - ✓ Functional tests + synthetic benchmarks via specialized tools

First Tests (2017)

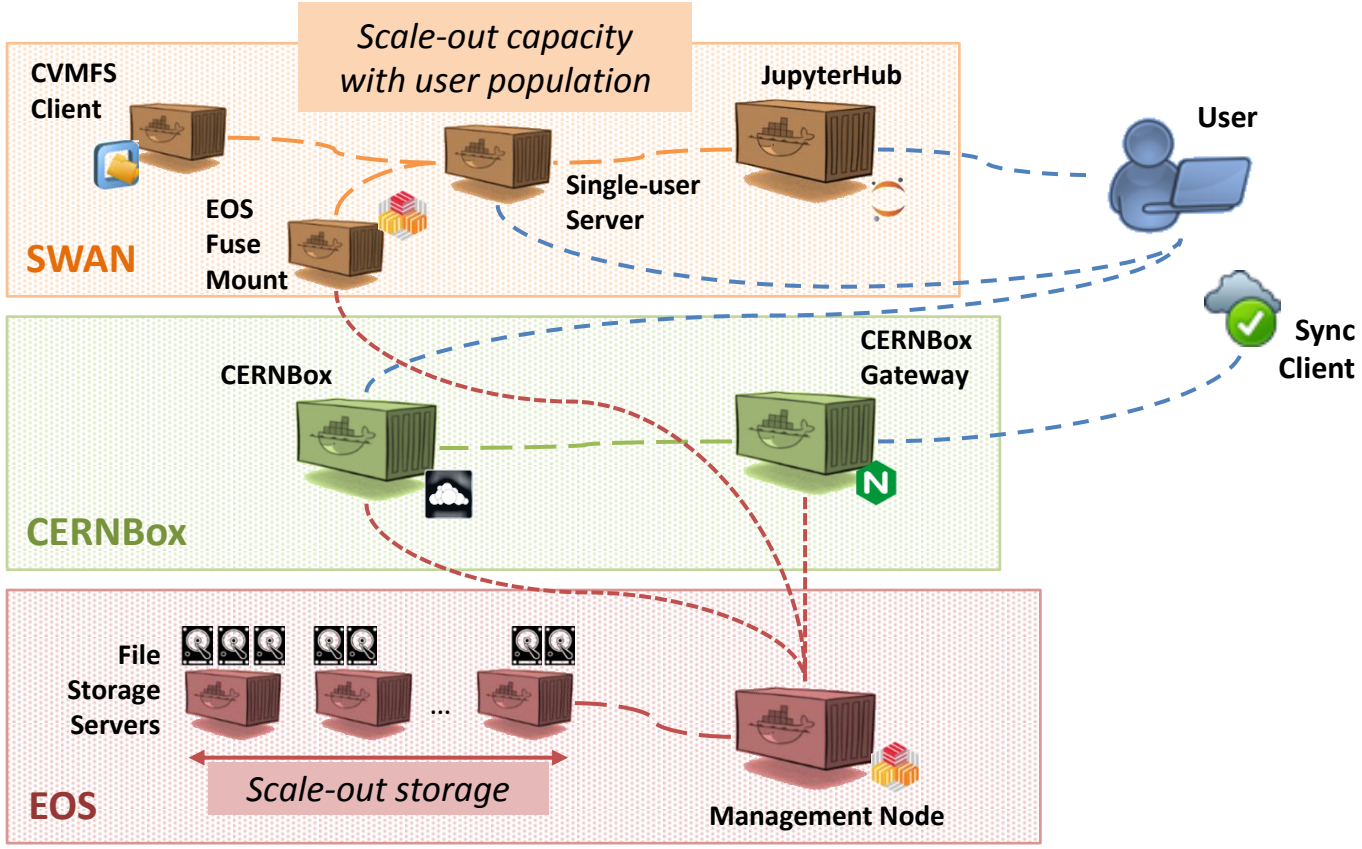
- "Science Box" on a single VM

- ✓ Streamlined installation – No configuration required
- ✓ Automated functional tests for validation

- IBM
- RHEA
- T-Systems

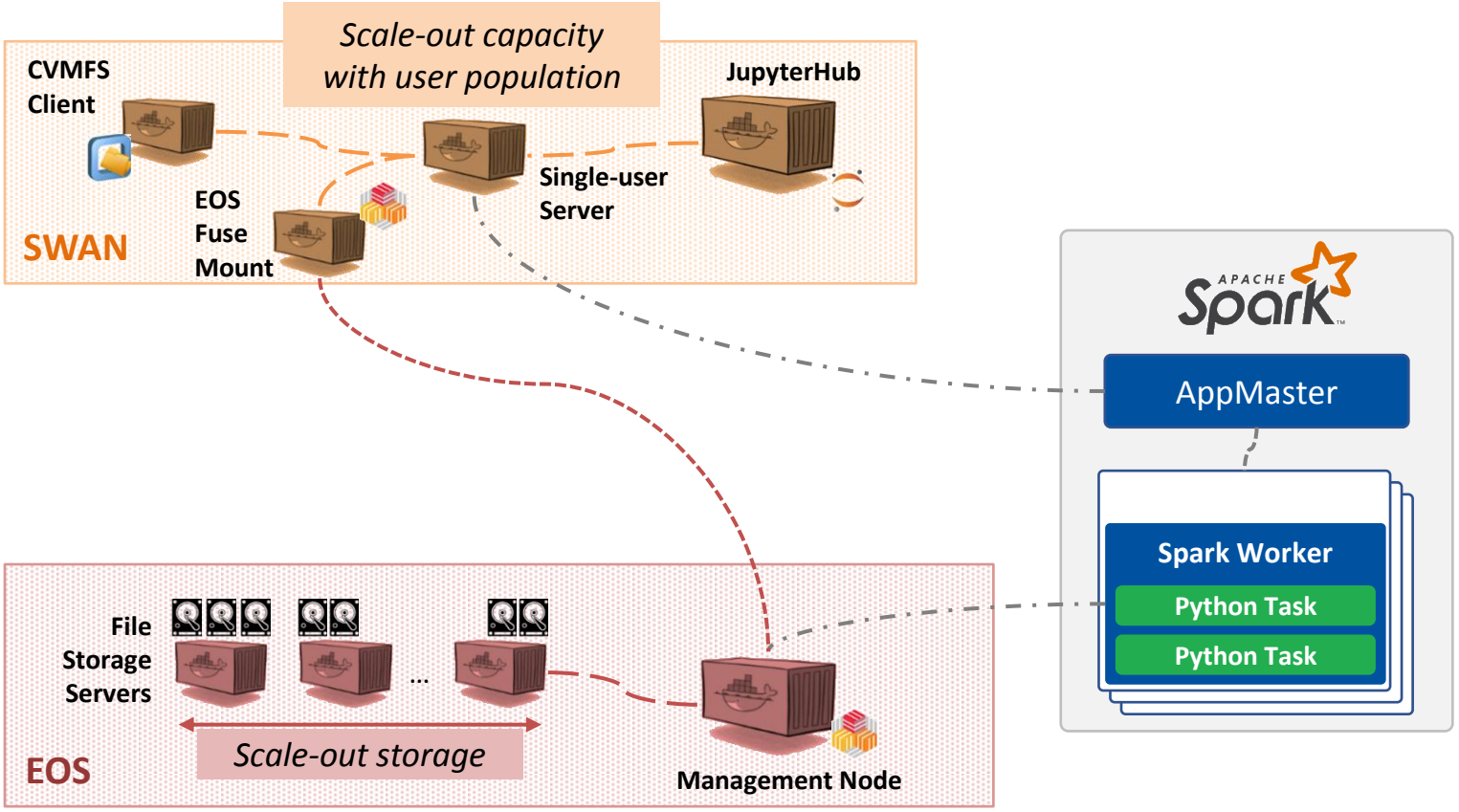
Current Tests: Science Box

- Scalable deployment with Kubernetes



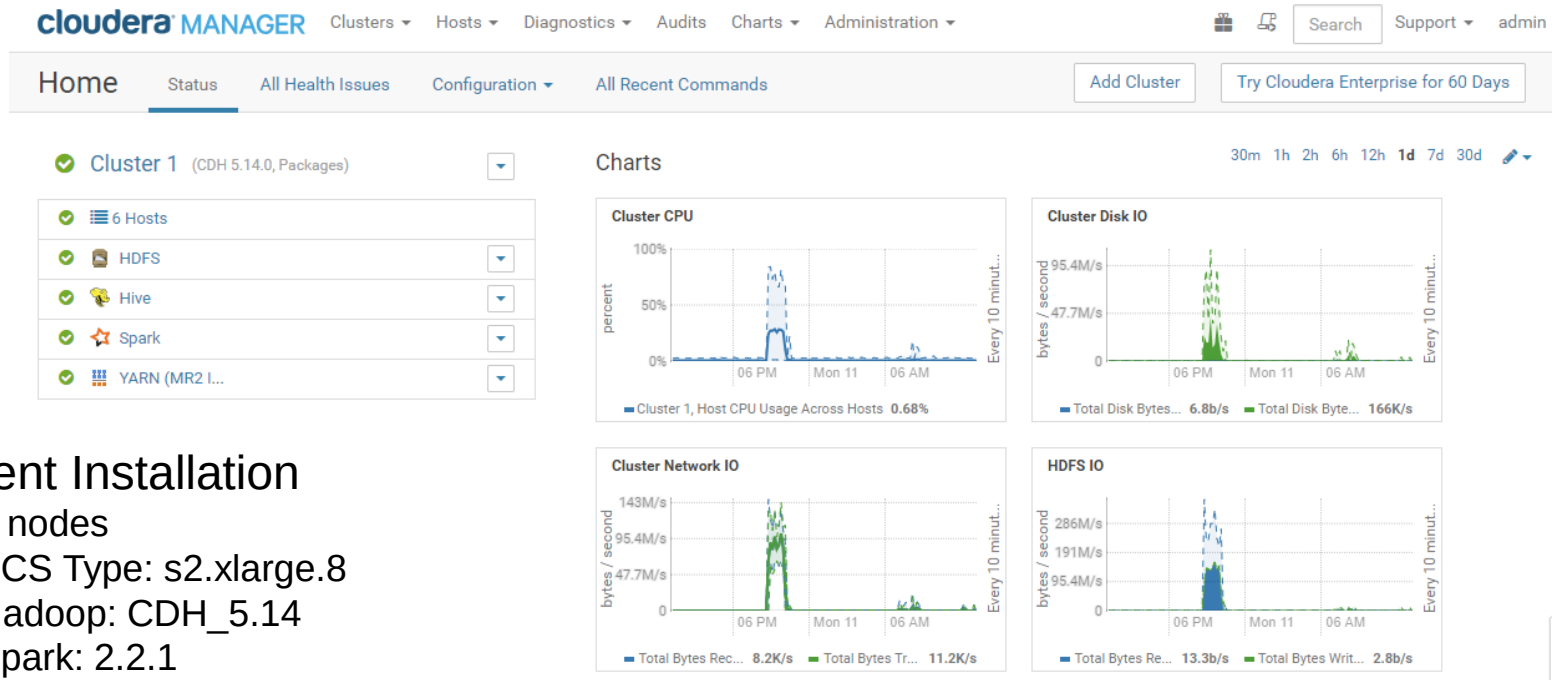
Current Tests: Science Box

- Scalable deployment with Kubernetes
- SPARK as a computing engine



Current Tests: Spark Cluster

- ✓ Hadoop and Spark installed via yum on plain VMs
- ✓ Configuration via Cloudera Manager
- ✓ Validation with industry standard TPC-DS benchmark + user workloads

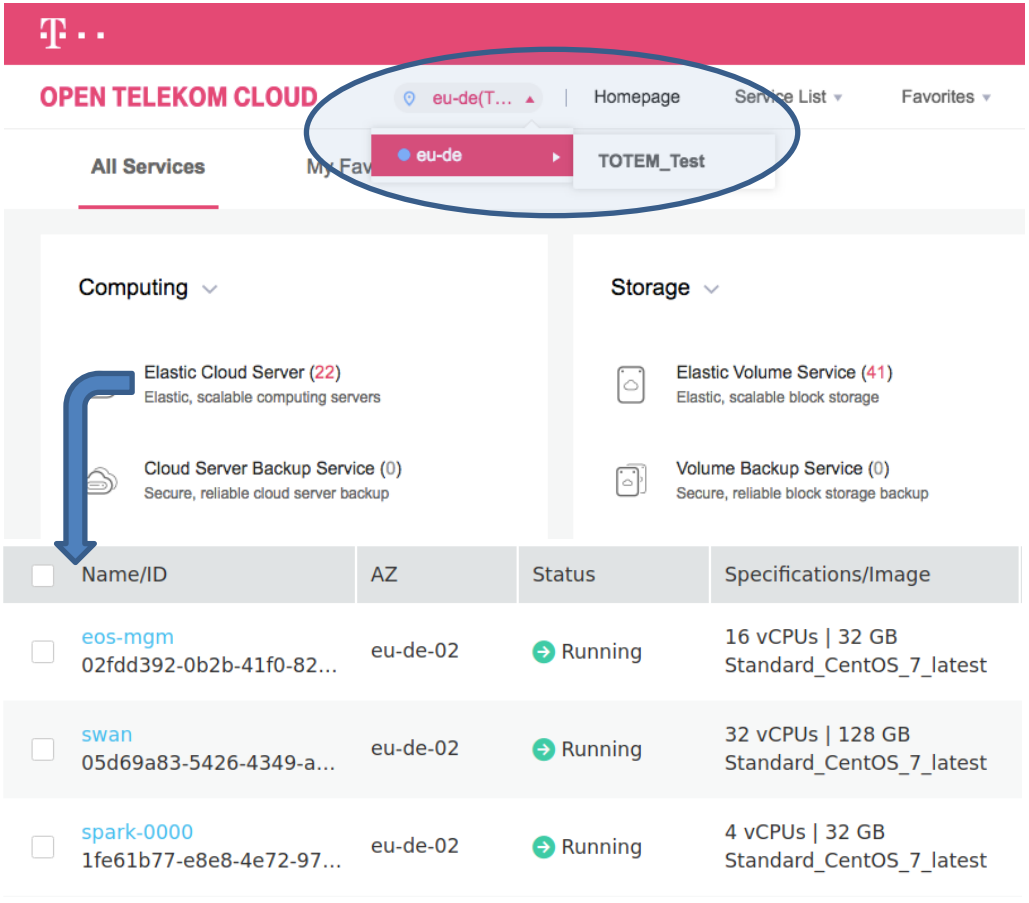


Current Installation

- ✓ 6 nodes
- ✓ ECS Type: s2.xlarge.8
- ✓ Hadoop: CDH_5.14
- ✓ Spark: 2.2.1
- ✓ JAVA: 1.8.0_161-b12

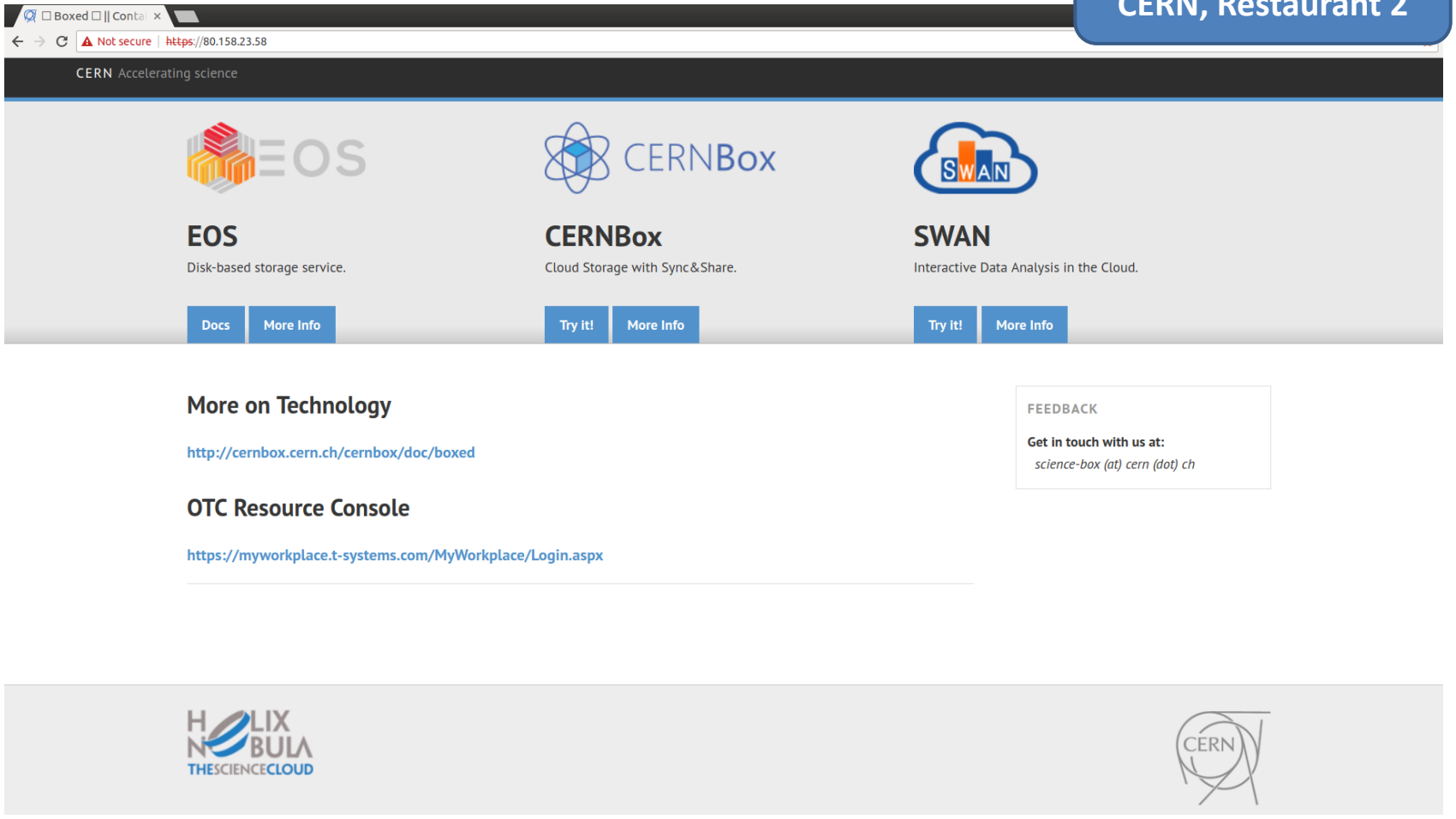
Deployment Status in HN Cloud

- Deployment **OK** on OTC
- All resources managed as sub-tenant "*TOTEM_Test*"
- Small scale for now
  - ✓ 22 VMs, 41 Block Devices
  - ✓ 128 CPUs, 488GB Memory
  - ✓ 22 System Volumes (950GB)
  - ✓ 19 Data Volumes (~12TB)
- Functional tests successful
  - ✓ Storage, Sync, Analysis
  - ✓ SWAN to Spark connection
  - ✓ Import small dataset



Deployment Status in HN Cloud

Demo at Lunchtime
CERN, Restaurant 2



Experience with OTC as a User

- **Incidents:**
  - ✓ May 7th Outage:
    3 containers lost due to VMs reboot
    Manual intervention required

> Dear user of the Open Telekom Cloud,
>
> We do apologize for the partial downtime of our Open Telekom Platform on 7th may and we would like to provide you the final error analysis of Open Telekom Cloud's partial outage.
>
> **Date / time**: 2018-05-07, 21:25 – 22:24 CEST (19:25 – 20:24 UTC)

  - ✓ May 14th: VM reported IO errors on system disk – VM was rebuilt
  - ✓ Early June: OTC web console unavailable for short periods

- **Requests:**
  - ✓ Streamline VM name <==> hostname <==> IP address resolution
    E.g., Internal DNS to resolve VM name to its private IP address
    Worked-around with entries in /etc/hosts + dnsmasq

Next Steps

- Application layer optimization for TOTEM use-case
  - ✓ Performance tuning, caching of frequently-used software packages, …
  - ✓ Focus on relevant metrics for users, e.g., total execution time

- Scale-out storage and computing resources
  - ✓ Leverage on scalable architecture design (EOS, Swan, Spark)
  - ✓ Storage:
    - Import larger dataset (10-50TB) → Additional file servers and block devices
    - Investigate caching layer for Spark for improved performance
  - ✓ Computing:
    - Experiment and identify best VM flavor for Spark computing nodes
    - Additional spark workers to crunch bigger datasets

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Backup Slides

Project Description

- This is a deployment test of the ScienceBox IT services (EOS, SWAN, CERNBox, and Spark) in a particular analysis scenario for TOTEM experiment (conducted jointly with SFT group and interested TOTEM collaborators).

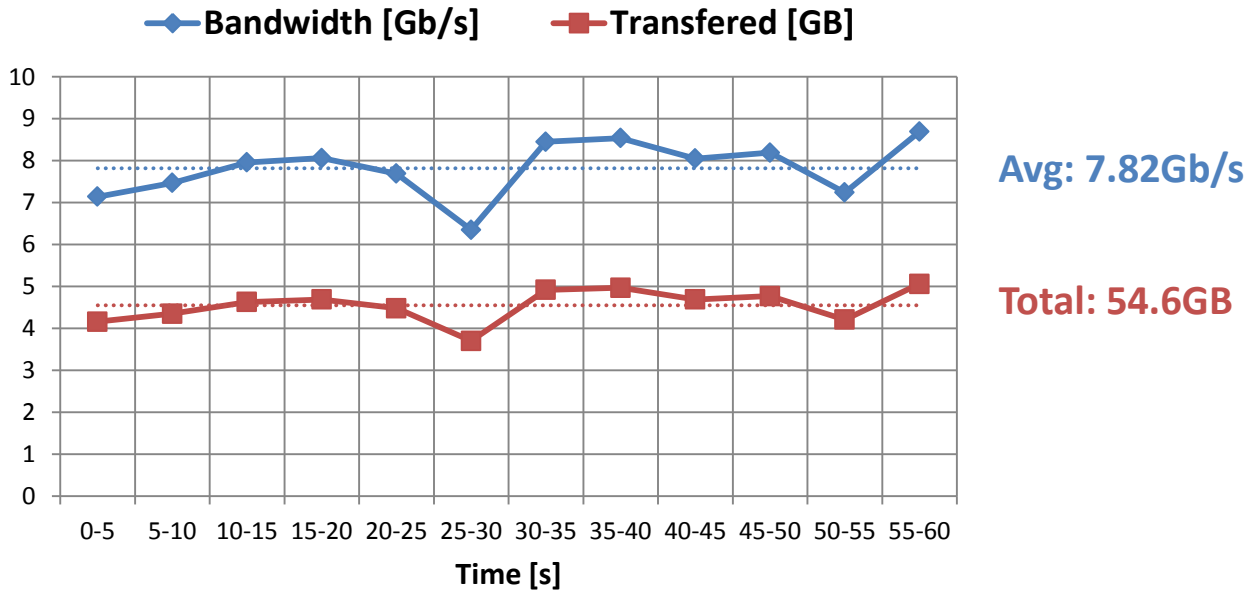
- Phase 1 (April-September) is a feasibility study: (a) verification of the deployment of the services; (b) performance tuning and testing of a TOTEM data analysis example. If feasibility tests are successful then Phase 2 (September-November) is to use available resources opportunistically to understand the scaling limitations of the system and, if possible, to actually perform analysis for use-cases defined by the TOTEM collaborators.

- The amount of data currently foreseen is ~10-50TB. HN resource is treated as an extension of CERN resource. Any data stored in HN cloud will be automatically erased at the end of 2018.

- This project does not provide guarantee of service but will make opportunistic use of resources if feasible.

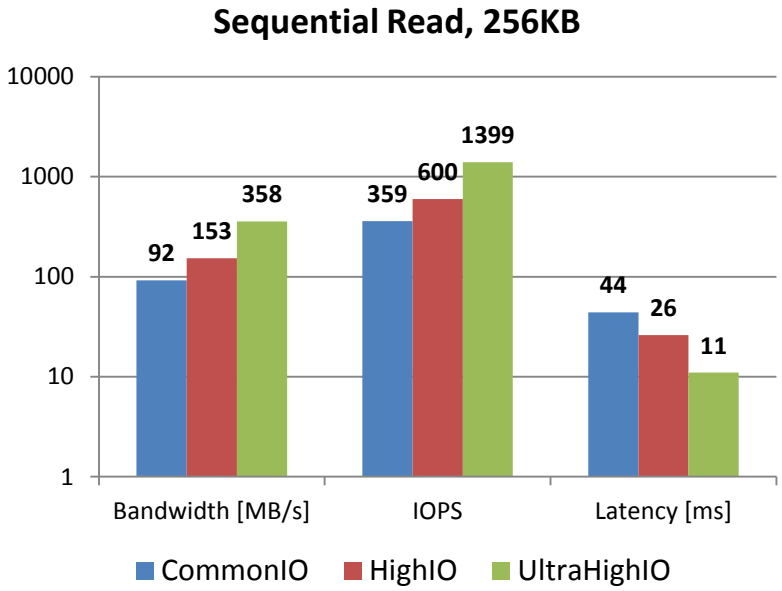
Synthetic Benchmarks

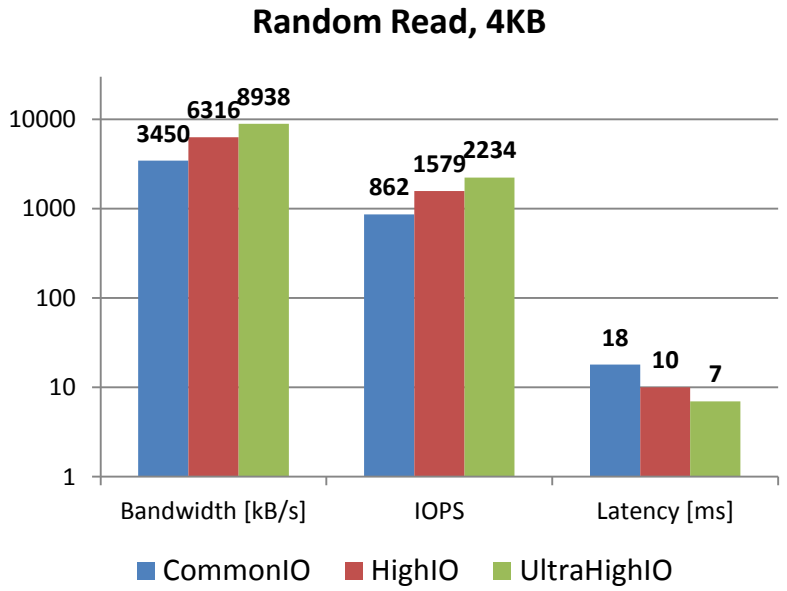
- Network – iperf, ping
  - ✓ TCP connection, 128K buffer, 60s test (5s binning)
  - ✓ Average bandwidth: ~7.8 Gb/s (both directions)
  - ✓ Very low latency (~0.3ms) and jitter (sdev ~0.07ms)



Synthetic Benchmarks (cont'd)

- Block Devices – fio
  - ✓ Three types of VDBs: Common-IO, High-IO, and UltraHigh-IO
  - ✓ No disk encryption, No disk sharing
  - ✓ Size form 10GB to 1TB (not related to performance)





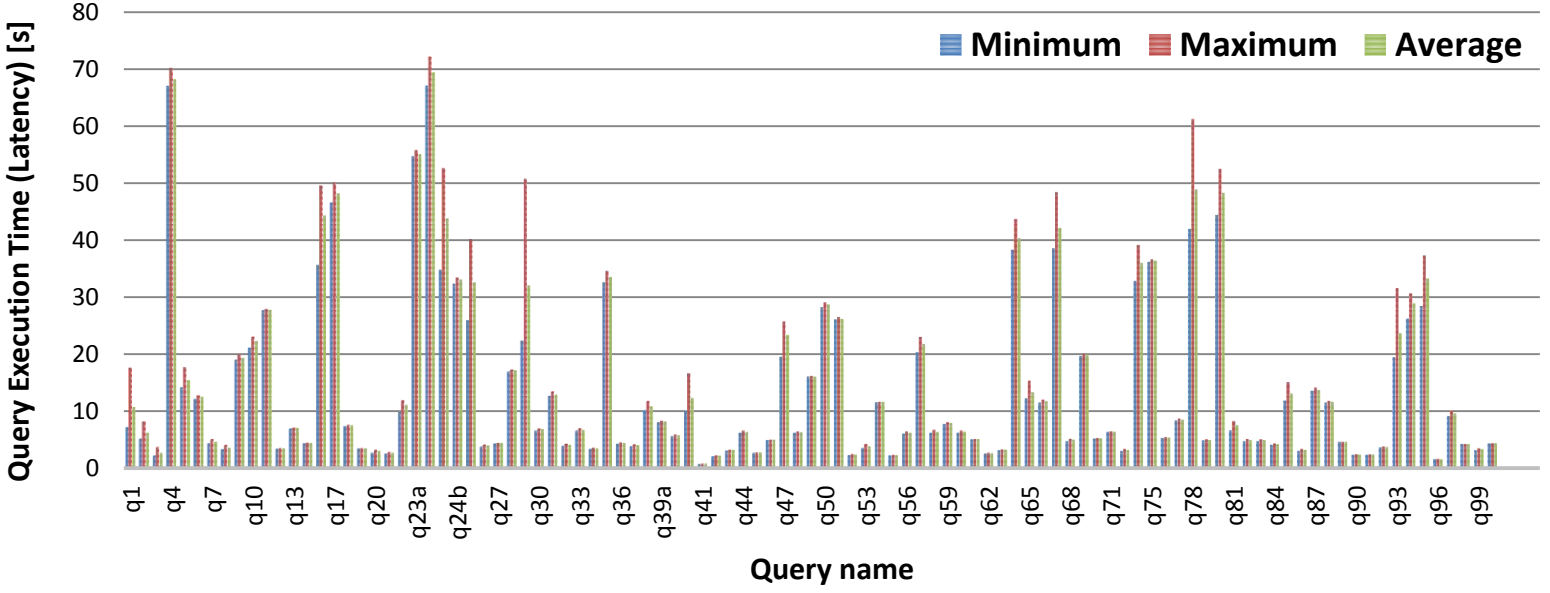
Synthetic Benchmarks (cont'd)

- CPU and Memory – sysbench
  - ✓ CPU - Total events: 10'000
    - Avg. time per event: 1.11ms
    - 95th percentile: 1.12ms
  - ✓ Memory – Transfer (write) 10GB
    - IOPS: 1'614'325
    - Throughput: 1576.49 MB/s

- Two (main) flavor of VMs:
  - ✓ 4CPUs, 8GB memory – General purpose VM
  - ✓ 4CPUs, 32GB memory – Spark workers
  - ✓ Performance is consistent across VM sizes

Synthetic Benchmarks (cont'd)

- Spark Cluster – TPC-DS Benchmark
  - ✓ Small case test: Dataset size 20GB
  - ✓ 5 executors (2 cores, 7GB memory), Query Set v1.4, Spark 2.2.1



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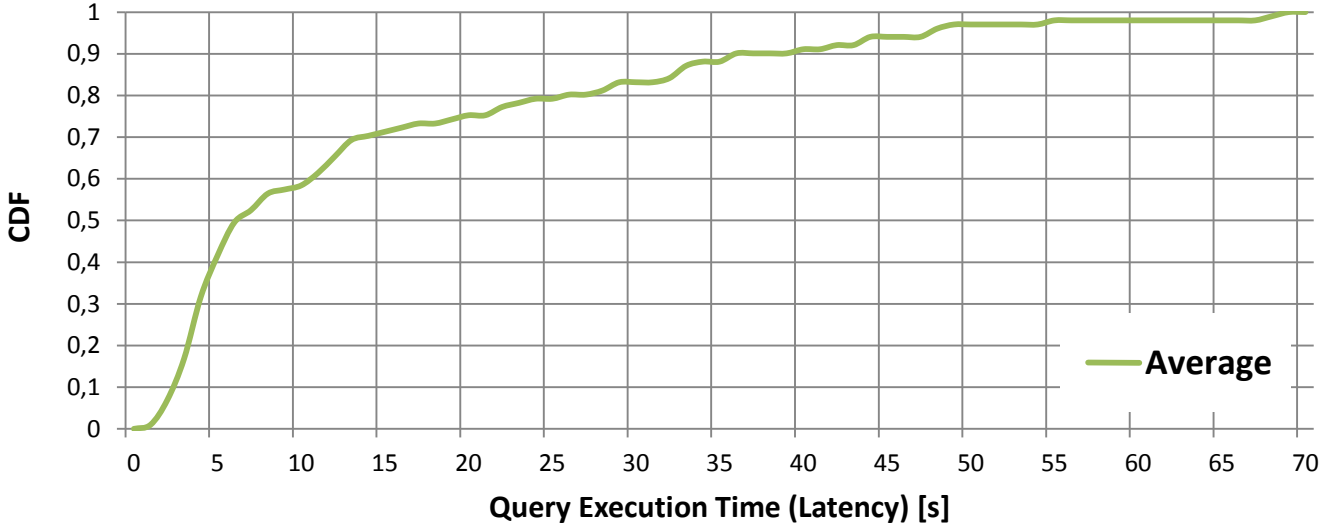


Data Analysis with RDataFrame

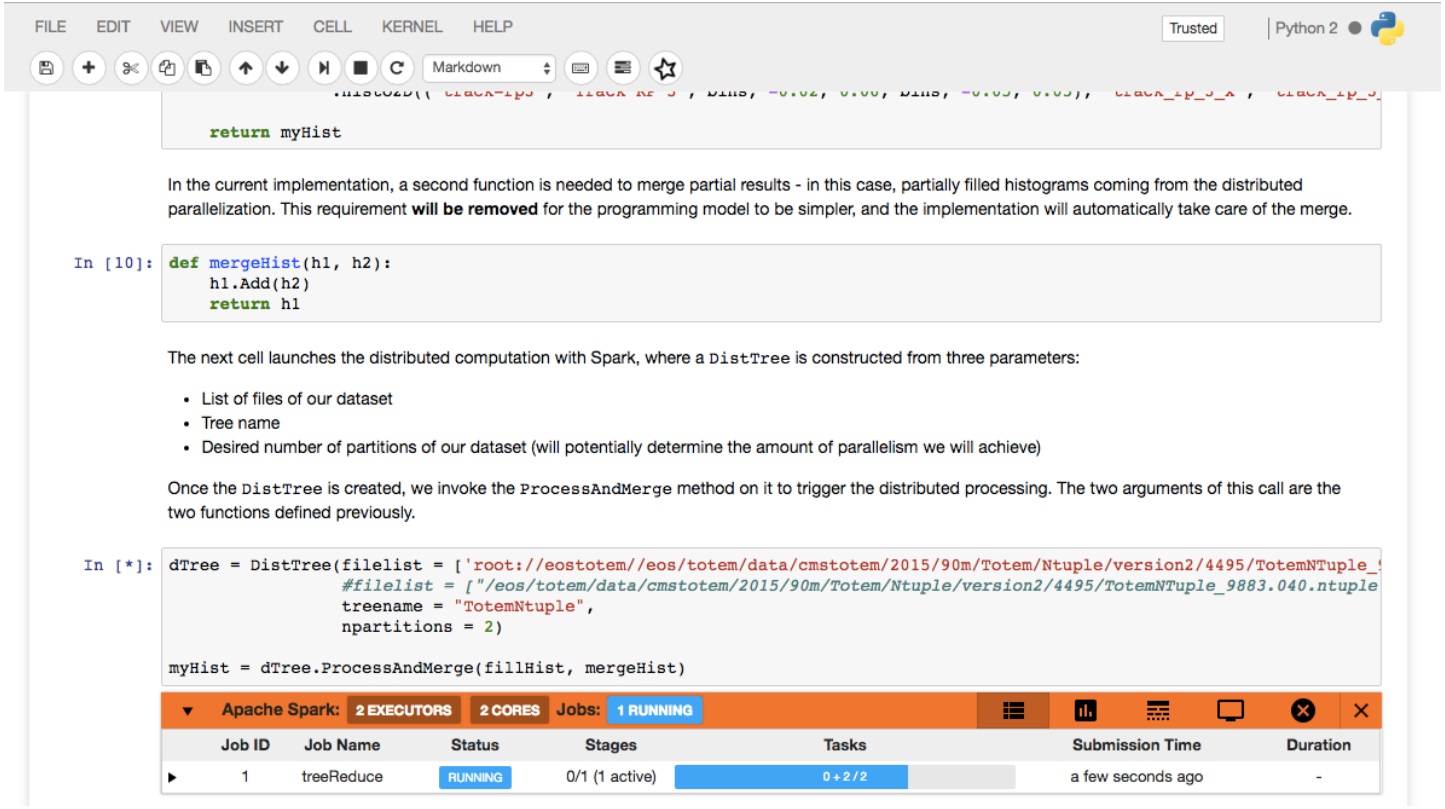
```
df = RDataFrame('t', 'f.root')
hist = df.Filter('theta > 0') \
        .Histo1D('pt')
hist.Draw()
```

◄---- Build data-frame object
◄---- Apply transformation
◄---- Apply actions

- Columnar dataset: ROOT, other formats
- Declarative analysis: **what**, not how
  - ✓ Transformations: cuts, definition of new columns
  - ✓ Actions: return a result (e.g., histogram)
- Implicit parallelisation
  - ✓ Multi-threaded, distributed

RDataFrame: Distributed Execution

- RDataFrame supports distributed execution on top of Spark
  - ✓ No changes in the app will be required to go distributed!



RDataFrame: Spark Monitoring

- Automatic monitoring when an RDataFrame Spark job is spawned
- Job progress, task distribution, resource utilization
  - ✓ Dataset split in ranges under the hood, one task per range