ScienceBox
Converging to Kubernetes containers in production for on-premise and hybrid clouds for CERNBox, SWAN, and EOS

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Outline

- ScienceBox

- Use cases
  - HEP: TOTEM Experiment Analysis on Commercial Cloud
  - Education: Up To University
  - Collaborators and External Sites

- Conclusions
Why ScienceBox

- Growing interest in CERN cloud software from external collaborators
  - High Energy Physics sites
  - National Research and Education Networks
  - European projects collaborators

- Facilitate distribution outside CERN
  - Simplified installation leveraging on container technologies
  - Flexible and scalable deployment with container orchestration

- Disposable deployment for development at CERN
  - Software updates, new functionalities, …
ScienceBox

- Self-contained Docker-based software package

  - **EOS**: Storage backbone for LHC+physics data, and CERNBox

    EOS the CERN disk/cloud storage for science, Luca Mascetti

    Thu, 12:15 @Riverbank R8

  - **CERNBox**: Sync&Share for Personal and Project Files

  - **SWAN**: Data Analysis with Interactive Jupyter Notebooks
One-Click Demo Deployment

- Single-box installation
- Download and run in 5 minutes
  
  https://github.com/cernbox/uboxed

Production-ready Deployment

- Scale out service capacity
- Tolerant to node failures
  
  https://github.com/cernbox/kuboxed
ScienceBox Architecture

- CVMFS Client
- EOS Fuse Mount
- JupyterHub
- Interactive Notebooks
- MySQL Backend
- CERNBox
- CERNBox Gateway
- Synchronization and Sharing
- File Storage Servers
- Management Node
- Storage Backbone

- CVMFS Software
- SWAN
Use Cases

- TOTEM Analysis on Commercial Cloud
- Up to University
- Collaborators and External Sites
TOTEM Analysis on Commercial Cloud

- Goal: Use commercial clouds as extension of CERN computing centre

- Deployment on Helix Nebula Cloud
  - 2400+ CPUs
  - 10+ TB memory
  - Virtually unlimited block storage

- ScienceBox with Apache Spark for massive computations
TOTEM Analysis on Commercial Cloud

- Allow interactive analysis with ROOT RDataFrame + SWAN + Spark
  - RDataFrame: Interface for declarative analysis with implicit parallelism
  - Use Spark cluster with no changes to the code
  - Monitor Spark jobs from SWAN

Distributed data analysis with ROOT RDataFrame

Thu, 15:00 @Riverbank R3
TOTEM Analysis on Commercial Cloud

- **TOTEM Analysis Dataset:**
  - 4.7 TB, 1153 files, 2.8B events
  - Imported via xrootd, results synchronized with CERNBox

- **Reduced processing time**
  - Wall-clock down to ~2m
  - Optimal at ~750 cores

- **Validated Physics Results**

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Big Data Tools and Cloud Services for High Energy Physics Analysis in TOTEM Experiment - V. Avati et al.

Up to University EU Project

- Allow students in high-schools to adopt tools used in science
  - SWAN – Full data analysis ecosystem in a web browser
  - CERNBox – Cloud storage for easy sharing and access form any device

- ScienceBox in production for Up2U users for 1.5 years
  - Deployed at Poznan Supercomputing and Networking Center, Poland
  - Kubernetes on VMs, Ceph volumes for persistent storage

- Pilot service at CERN – [http://up2u.cern.ch](http://up2u.cern.ch)
  - CERNBox and SWAN on Kubernetes VMs
  - EOS on VMs and bare metal disks
External Collaborators

- External SWAN deployments inspired by ScienceBox
  - Australia's Academic and Research Network (AARNET)
  - SURFSARA, The Netherlands
  - Joint Institute for Nuclear Research (JINR), Russia
  - Academia Sinica Grid Computing Centre (ASGC), Taiwan
Conclusions
Conclusions

- ScienceBox is CERN cloud software in containers

- Delivers fully-fledged services on premises
  - Run a (tiny) datacenter on your laptop
  - Deploy on any cloud infrastructure (AWS, OpenStack, …)

- Suitable for diverse use cases
  - HEP Analysis
  - Education and Outreach
  - Provisioning and Integration with existing on-site Services
Future Plans

- Use ScienceBox containers for CERNBox and SWAN production
  - Easy roll-out of new functionalities and software updates
  - Advanced features: Cluster Autoscaling, Replication across Availability Zones, …
ScienceBox

sciencebox.web.cern.ch

Thank you!

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Backup Slides
ScienceBox Scalability

- Kubernetes: Deploy, orchestrate, and manage containers in a cluster
- It provides means to horizontally scale applications
  - Deployment, StatefulSet, Horizontal Pod Autoscaler, LoadBalancer on Services, …

- Storage – Extend EOS capacity
  - Add machines with additional storage
  - Replicate File Storage Server containers

- Computing – Sustain concurrent SWAN sessions
  - Need of multiple cluster nodes where to spawn Single-user Jupyter Servers
  - Replicate EOS and CVMFS containers for SWAN sessions
Elastic resources for SWAN

CVMFS Client
EOS Fuse Mount
SWAN

JupyterHub
Elastic resources for SWAN
Elastic resources for SWAN

CVMFS and EOS containers replicated on any “Swan Worker”
Elastic resources for SWAN

CVMFS and EOS containers replicated on any “Swan Worker”

Start my Session

Spawn Single-user Server on Swan Worker nodes

Single-user Jupyter Server
Elastic resources for SWAN

CVMFS and EOS containers replicated on any “Swan Worker”

New SWAN Worker nodes

Start my Session

Spawn Single-user Server on Swan Worker nodes

Single-user Jupyter Server
TOTEM Analysis on Commercial Cloud

- **RDataFrame**
  - Implicit parallelization
  - Better utilization of multicore resources

```cpp
ROOT::EnableImplicitMT();                      // Run a parallel analysis
ROOT::RDataFrame df(dataset);                  // on this (ROOT, CSV, ...) dataset
auto df2 = df.Filter("x > 0")                  // only accept events for which x > 0
    .Define("r2", "x*x + y*y");              // define r2 = x^2 + y^2
auto rHist = df2.Histo1D("r2");              // plot r2 for events that pass the cut
df2.Snapshot("newtree", "out.root");         // write the skimmed data and r2
to a new ROOT file
```
CS3MESH

- EU-funded project
  - 6M EUR, 12 partners, 2020-2022

- Goal: Global collaborative environment for research
  - Share documents, files, projects, data, …
  - Connected Application Hubs
  - Data/metadata-aware workflows \(\Rightarrow\) FAIR
    - Find, Access, Interoperate, Reuse

- Federation of existing CS3 sites
  - 30+ sites (e.g. CERNBox, DesyBox, Universities, …)
  - 300K+ users

Cloud Storage Services for Synchronization and Sharing

[cs3community.org]
ScienceBox for CS3MESH

- ScienceBox is the reference platform in CS3MESH for distribution and deployment of cloud software

- SWAN will become part of the federated service portfolio
  - Bigger community using CERN software
  - Contribute back and improve SWAN for CERN users

- Benefits for SWAN users at CERN
  - Share SWAN projects beyond the CERN borders
  - Work easily with your experiment collaborators outside CERN