



CernVM: Towards a Containerized Compatibility Layer

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CernVM (Container or VM)

- Curated Linux platform with all the dependencies to run LHC applications
- RHEL compatible
- “Batteries included”: ready for most IaaS clouds
- Strongly versioned: `/cvmfs/cernvm-prod.cern.ch/.cvmfs/snapshots/cernvm-system-4.1.0.0`
- Minimal image (~ 20 MB)
- Graphical (development/outreach environment) and batch flavors
- Customizable through contextualization
- Launcher for easy image instantiation with VirtualBox

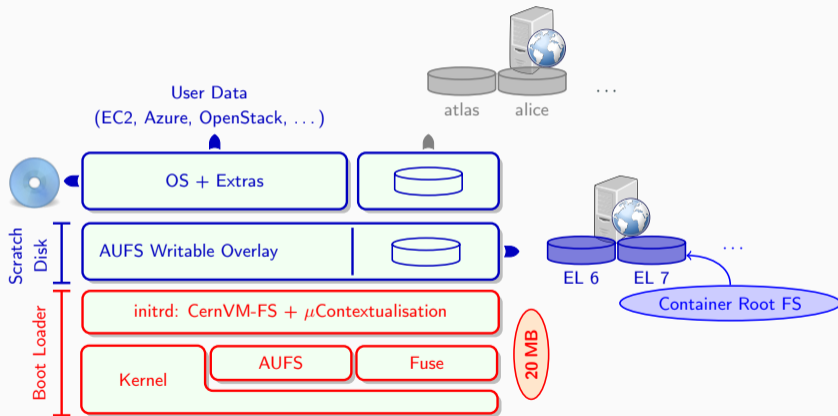
Singularity-ready root file system:

- `/cvmfs/cernvm-prod.cern.ch/cvm3` (EL6, frozen)
- `/cvmfs/cernvm-prod.cern.ch/cvm4` (EL7, production)

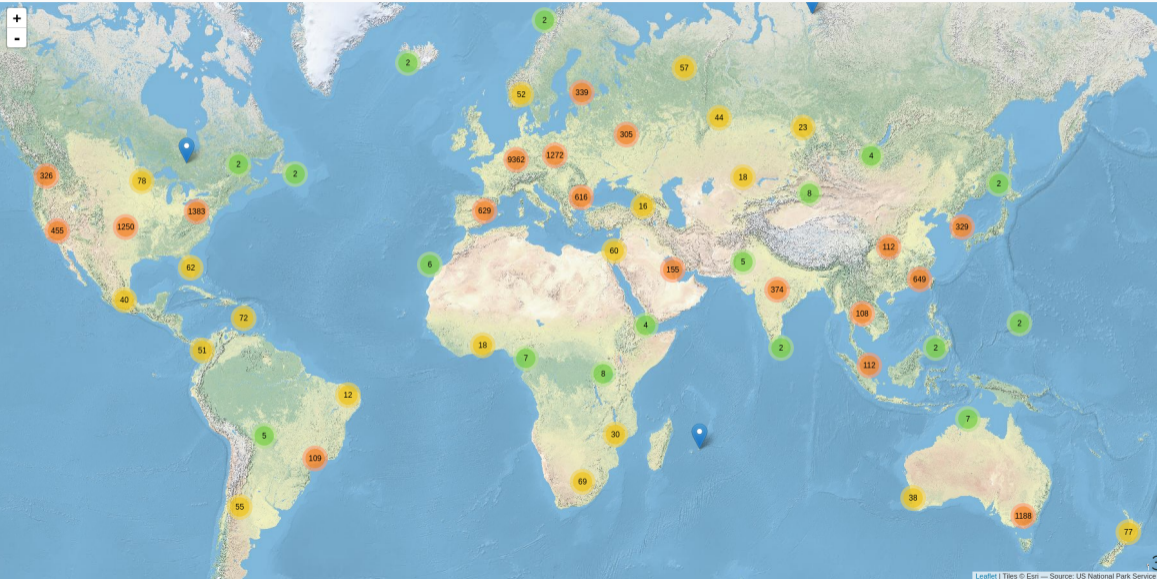
Reminder: Building Blocks of CernVM



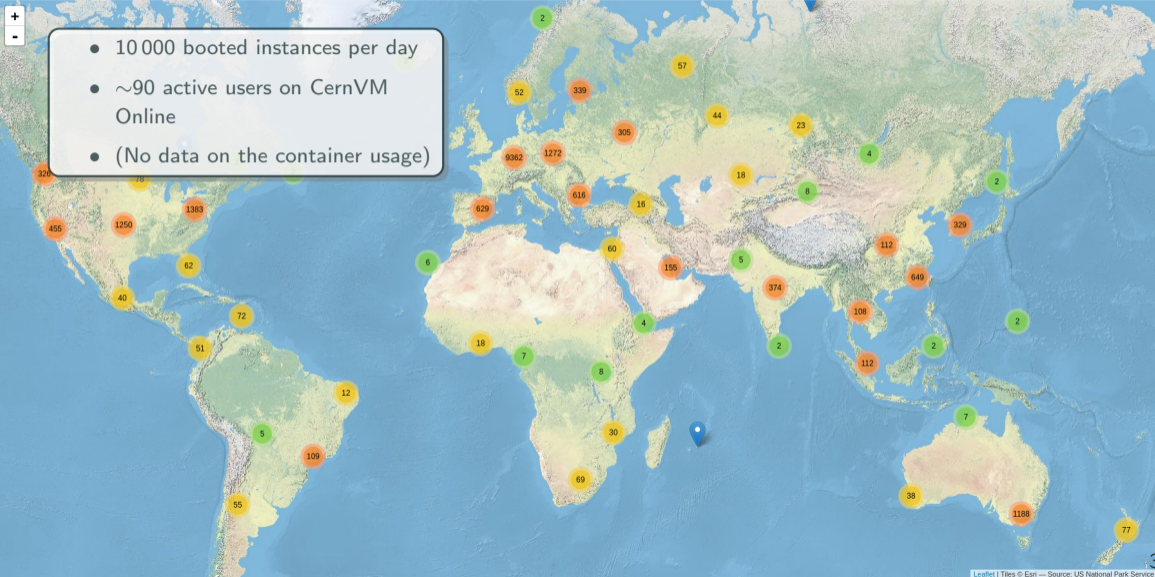
Twofold system: μ CernVM boot loader + OS delivered by CernVM-FS



CernVM Full Virtualization Usage Q4/2020



CernVM Full Virtualization Usage Q4/2020





- ATLAS Sim@P1 on-demand cloud on trigger farm
- Through CloudScheduler and VAC at various academic and commercial clouds

→ Chris' presentation



localhost:36689

ATLAS SIMULATIONS

ATLAS EXPERIMENT

ATLAS SIMULATIONS

YOUR SIMULATIONS

YOUR JOB

BADGES

These are examples of ATLAS simulations

← → ←

BOINC Manager

File View Options Tools Help

Tasks: ATLAS Simulation

From: **LHC@home**
CERN (European Organization for Nuclear Research)
Physics
The Large Hadron Collider (LHC) is a particle accelerator at CERN, the European Organization for Nuclear Research, the world's largest particle physics laboratory. It is the

Elapsed: 00:04:23
Remaining (estimated): 01:22:54

5.023%

Status: Running

Task Commands

Projects: Add Project

LHC@home

Work done for this project: 0

Project Web Pages Project Commands

Notices Suspend Help

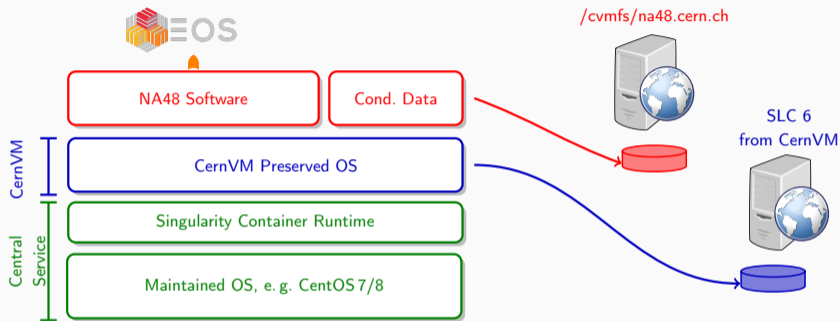
Current Use Cases III: OpenData



The screenshot displays a virtual machine environment titled "CMS-OpenData-1.5.0 [Running] - Oracle VM VirtualBox". The main window shows the "cmsShow: DoubleMu.root [1/1], event [1/5]" interface. It includes a "Summary View" on the left with a tree of detector components like ECAL, HCAL, JETS, TRACKS, MUONS, ELECTIONS, VERTEXES, BEAMSPOT, DT-segments, CSC-segments, PHOTONS, MET, and CONVERSIONS. The central area shows a detector simulation with tracks and calorimeter hits. A "Terminal - CMS Shell" window is open in the foreground, showing the following output:

```
Probing /cvmfs/cms.cern.ch... OK
Probing /cvmfs/cms-opendata-conddb.cern.ch... OK
Starting up CMS shell...
WARNING: Non existent mountpoint (directory) in container:
'/var/singularity/mnt/final/etc/cms'
WARNING: Container does not have an exec helper script,
calling '/bin/bash' directly
CMS Shell > cmsrel CMSSW_5_3_32
CMS Shell > cd CMSSW_5_3_32/
CMS Shell > cmsenv
CMS Shell > cmsShow
Starting cmsShow, version CMSSW_5_3_32.
```

In the background, a "Table" window displays a list of jets with columns for ID, pT, and other properties. The terminal window also shows system resource usage: "cpu mem net 0.00 KIB 0.00 KIB".



```
[jblomer@lxplus7] singularity exec -B /cvmfs -B /eos \  
> /cvmfs/cernvm-prod.cern.ch/slc6 /cvmfs/na48.cern.ch/my_application
```

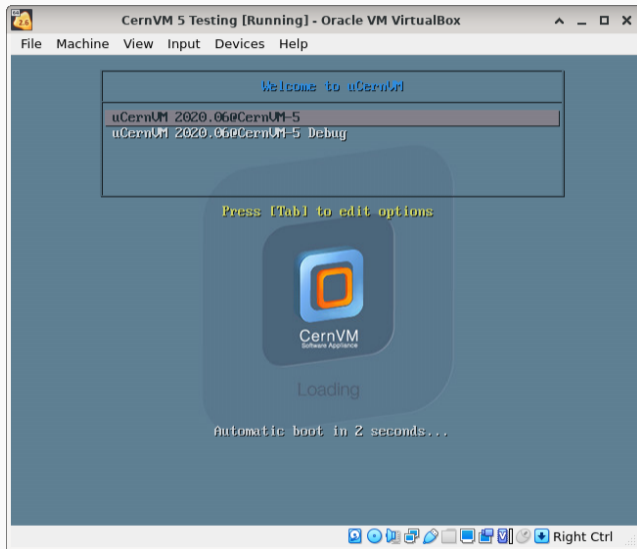


Updates since the 2019 Workshop

- Freeze of CernVM 3 (EL 6 based)
- Minor updates to CernVM 4 and the bootloader to follow upstream updates
- Documentation now available on [ReadTheDocs](#)

Plans for the next months

- Maintenance of CernVM 4, bootloader, launcher
- Documentation update to match hypervisor and cloud platform updates
- Updating CernVM Online to the new Single Sign-On system





```
CernVM 5 Testing [Running] - Oracle VM VirtualBox
File Machine View Input Devices Help
[INF] Starting CernVM File System... connected to cernvm-e10.cern.ch
[INF] Posting kernel modules... check
[INF] Booting CERN Virtual Machine 5.0.10.0

Welcome to CentOS Linux 8 (Core)!

[ OK ] Listening on Journal Socket (/dev/log).
[ OK ] Listening on Process Core Dump Socket.
[ OK ] Reached target Local File Systems.
[ OK ] Created slice User and Session Slice.
[ OK ] Started Dispatch Password Requests to Console Directory Watch.
[ OK ] Listening on initctl Compatibility Named Pipe.
[ OK ] Reached target Remote File Systems.
[ OK ] Listening on Journal Socket.
      Starting Rebuild Journal Catalog...
      Starting Rebuild Dynamic Linker Cache...
      Starting Apply Kernel Variables...
      Starting Mark the need to relabel after reboot...
[ OK ] Reached target Slices.
[ OK ] Reached target Swap.
      Mounting Huge Pages File System...
      Starting Journal Service...
      Mounting FUSE Control File System...
      Mounting Kernel Configuration File System...
      Mounting Kernel Debug File System...
      Mounting POSIX Message Queue File System...
[ OK ] Set up automount Arbitrary Executable File Formats File System Automount Point.
[ OK ] Started Forward Password Requests to Wall Directory Watch.
[ OK ] Reached target Paths.
      Starting Create System Users...
[ OK ] Mounted Huge Pages File System.
[ OK ] Mounted FUSE Control File System.
[ OK ] Mounted Kernel Configuration File System.
[ OK ] Mounted Kernel Debug File System.
[ OK ] Mounted POSIX Message Queue File System.
```



```

Welcome to CERN Virtual Machine, version 5.0.10.0
  based on CentOS Linux release 8.1.1911 (Core)
  Kernel 5.4.44-3.cernvm.x86_64 on an x86_64

IP Address of this VM: 10.0.2.15
In order to apply cernvm-online context, use #<PIN> as user name.

localhost login:

```



- Back to the “Just enough Operating System” (JeOS) approach would allow us to deploy CernVM as a **virtual machine** for fully virtualized clouds and as a **regular container** for commercial k8s clusters
- Target: < 500 MB CernVM base container, bootable in < 30s

CernVM 5 Layering

Experiment application from /cvmfs

Full app universe provided by /cvmfs

Minimal Compatibility Container

`glibc + ε`

Bootloader (only for full virtualization)

Minimal container contents (ϵ)

- CernVM-FS client
- cloud-init
- HepOSLibs (?)

App universe from /cvmfs/sft.cern.ch

- Desktop environment (*Enlightenment?*)
- Python, compilers, ROOT, XrootD client
- ...

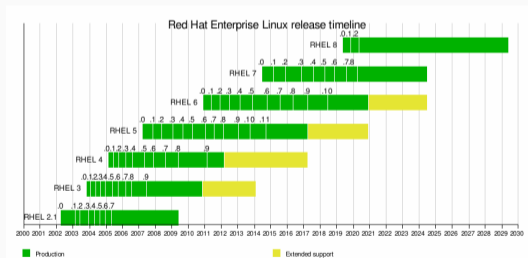
Backup Slides

Software and Platform Lifecycle

- Our standard Linux platform, Red Hat Enterprise Linux (aka Scientific Linux, CentOS), has a life time of ~ 10 years per release
- No security updates once out of maintenance, hence availability on central services stops (lxbatch, lxbatch, ...)

Two options for experiment application software to manage the operating system change

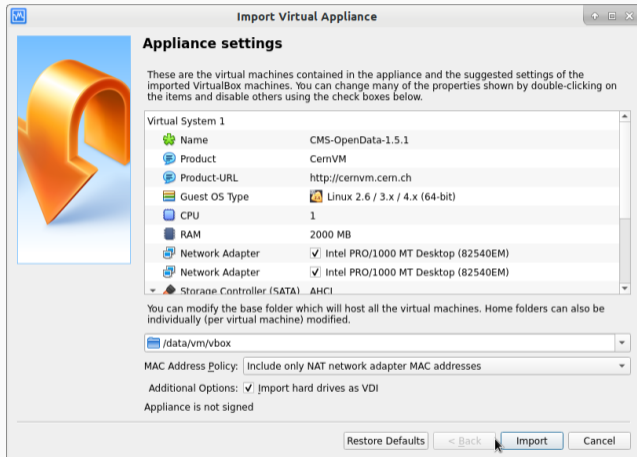
1. **Porting & validation**
can be challenging wrt. legacy dependencies such as CERNLIB
2. **Freezing & sandboxing**
Captures legacy software plus OS and compilers using virtualization technology



OVA Images

- Image bundled with user data
- Single-click import in VirtualBox
- Can be created on CernVM:

```
cvm2ova \  
-n CMS-OpenData-1.5.1 \  
-i cernvm4-2018.10-1.hdd \  
-u user-data.txt
```



cernvm-launch command-line utility

- Steers VirtualBox to instantiate CernVMs
- Copyable binary
- Interface similar to Docker and Vagrant
- Requires only the user-data text file ("context")

Implementation

- Uses libcernvm, the core of CernVM Online's WebAPI
- Creates the ISO image from context
- Downloads and caches CernVM image from the web
- Calls VirtualBox command line interface

↳ <https://cernvm.readthedocs.io/en/stable/cpt-launch.html>

↳ <https://github.com/cernvm/public-contexts>

Example Invocation of cernvm-launch

```
Terminal - jakob@meerkat:~/Documents/CERN/workshops/cernvm18/talk/launch
File Edit View Terminal Tabs Help
[jakob@meerkat launch]$ wget -q https://ecsft.cern.ch/dist/cernvm/launch/bin/Linux/cernvm-launch
[jakob@meerkat launch]$ chmod +x cernvm-launch
[jakob@meerkat launch]$ git clone https://github.com/cernvm/public-contexts
Cloning into 'public-contexts'...
remote: Counting objects: 38, done.
remote: Total 38 (delta 0), reused 0 (delta 0), pack-reused 38
Unpacking objects: 100% (38/38), done.
[jakob@meerkat launch]$ ls public-contexts/
aleph.context  alice-masterclass.context  cms-opendata.context  sft.context
alice.context  atlas.context              lhcb.context          squid.context
[jakob@meerkat launch]$ ./cernvm-launch create public-contexts/sft.context
Unable to load the global config file: /home/jakob/.cernvm-launch.conf
Creating a new global config: /home/jakob/.cernvm-launch.conf
Enter a directory where do you want keep all CernVM-Launch files: VM images, disk files, etc. These files can grow substantially.
Enter directory [/home/jakob]:
Using user data file: public-contexts/sft.context
Enter VM name [sft]:
Parameters used for the machine creation:
  name: sft
  cpus: 1
  memory: 2048
  disk: 20000
  cernvmVersion: 2.8-6
  sharedFolder: /home/jakob
[jakob@meerkat launch]$
```

Example Invocation of cernvm-launch

The image displays two overlapping windows. The background window is a terminal titled "Terminal - jakob@meerkat:~/Documents/CERN/workshops/cernvm18/talk/launch". It shows the following command sequence and output:

```
[jakob@meerkat launch]$ wget -q https://ecsft.cern.ch/dist/cernvm/launch/bin/Linux/cernvm-launch
[jakob@meerkat launch]$ chmod +x cernvm-launch
[jakob@meerkat launch]$ git clone https://gitlab.cern.ch/public-contexts/cernvm-launch
Cloning into 'public-contexts'...
remote: Counting objects: 38, done.
remote: Total 38 (delta 0), reused 0 (delta 0), packed 0 (delta 0), unpacked 38 (delta 0)
Unpacking objects: 100% (38/38), done.
[jakob@meerkat launch]$ ls public-contexts/
aleph.context  alice-masterclass.context  cm.context  lh.context
alice.context  atlas.context
[jakob@meerkat launch]$ ./cernvm-launch create
Unable to load the global config file: /home/jakob/.cernvm
Creating a new global config: /home/jakob/.cernvm
Enter a directory where do you want keep all the files can grow substantially.
Enter directory [/home/jakob]:
Using user data file: public-contexts/sft.config
Enter VM name [sft]:
Parameters used for the machine creation:
  name: sft
  cpus: 1
  memory: 2048
  disk: 20000
  cernvmVersion: 2.8-6
  sharedFolder: /home/jakob
[jakob@meerkat launch]$
```

The foreground window is an Oracle VM VirtualBox titled "sft [Running] - Oracle VM VirtualBox". It shows a desktop environment with a dark blue background and a large CernVM logo (a blue square with an orange square inside) and the text "CernVM Software Appliance". The top of the window displays system information: "Applications", "cpu", "mem", "net 0.00 KiB", "0.00 KiB", and the time "17:39". The bottom of the window shows a taskbar with various application icons and system tray icons, including a "Right Ctrl" button.