Potential of Virtualization Technology for Long-term Data Preservation

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CERN PH-SFT
Potential of Virtualization Technology

Preserve the historic data analysis environment
(This capability is only a part of long-term data preservation)
Potential of Virtualization Technology

Preserve the historic **data analysis environment**

(This capability is only a part of long-term data preservation)

**Motivation:**

1. **Process legacy data**
   - Data formats are typically self-describing or convertible
   - Software implicitly encodes knowledge about the correct interpretation of the data
   - After substantial upgrades and modifications of the detector, the new software might lose this legacy knowledge

2. **Validation of new software versions**
   - Otherwise, if the new software can process legacy data, comparison with historic version provides input for validation
CernVM Goal: a uniform and portable environment for developing and running LHC data processing applications
$\sum_{n=1}^{N} e^{\frac{\pi n^2}{N}}$
Data Processing Environment for LHC Experiments

N \sum_{n=1}^{e \pi in^2} N

Data Packets (Events)
Data Processing Environment for LHC Experiments

> cmsRun DiPhoton_Analysis_cfg.py

Data Packets (Events)
Data Processing Environment for LHC Experiments

```
> cmsRun DiPhoton_Analysis_cfg.py
```

- Individual Analysis Code: 0.1 MLOC
- Experiment Software Framework: 4 MLOC
- High Energy Physics Libraries: 5 MLOC
- Compiler System Libraries OS Kernel: 20 MLOC

Data Packets (Events)
Data Processing Environment for LHC Experiments

> cmsRun DiPhoton_Analysis_cfg.py

<table>
<thead>
<tr>
<th>Component</th>
<th>MLOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compiler</td>
<td>20</td>
</tr>
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<td>System Libraries</td>
<td>5</td>
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Data Packets (Events)
Data Processing Environment for LHC Experiments

> cmsRun DiPhoton_Analysis_cfg.py

```
N \sum_n=1 e \pi n^2
```

Data Packets (Events)

Individual Analysis Code
- 0.1 MLOC

Experiment Software Framework
- 4 MLOC

High Energy Physics Libraries
- 5 MLOC

Compiler System Libraries OS Kernel
- 20 MLOC

Amplifying

- Frequent Updates
- Not a single binary – a development environment
- Hundreds of libraries with partially untracked dependencies
- Not easily chunkable
- Not easily packagable
CernVM Blueprint for Preserving the Data Processing Environment

Provide the analysis environment **including** the operating system on CernVM-FS.

- No packaging, the environment is provided on demand
- CernVM-FS is a **snapshotting** and **versioning** file system
- Only 2 CernVM-FS “version strings” describe the data analysis environment
Maintenance of the repository must not become a Linux distributor’s job

Idea: Automatically generate a fully versioned, closed package list from an unversioned “shopping list” of packages
(Standard package managers are not designed for preservation!)

Formulate dependencies as Integer Linear Program (ILP)
Versioning and Snapshots in CernVM-FS

/datastore

software

17.0.0

ChangeLog

Compression, SHA-1

806fbb67373e9...

Data Store

- Compressed chunks (files)
- Eliminates duplicates
- Never deletes

File Catalog

- Directory structure, symlinks
- Content hashes of regular files
- Digitally signed \( \Rightarrow \) integrity, authenticity
- Plain files, stored as chunks in the data store

The root hash (40 characters) defines a file system snapshot (similar to git)

Intrinsic and explicit versioning required
Versioning and Snapshots in CernVM-FS
Simple API

- Instantiate + Contextualize
- Terminate
- List instances, list images

Amiconfig plug-ins

- Credentials (ssh, X.509)
- Condor head & batch services
- Squid server
- XrootD storage proxy
- Monitoring & directory service agents
- Network configuration & tuning
### Dashboard

#### Your context definitions

<table>
<thead>
<tr>
<th>Name</th>
<th>ID</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrivateCloud-CatalogServer</td>
<td>22b13425af7244c4b7de60dbbecca64728</td>
<td>Remove, Use as template</td>
</tr>
<tr>
<td>PrivateCloud-Worker</td>
<td>632e7ad3c64774ec9316f99e086640</td>
<td>Remove, Use as template</td>
</tr>
<tr>
<td>PrivateCloud-MakeflowPool</td>
<td>f7e9ba92a55146119ac3cd6141fd957</td>
<td>Remove, Use as template</td>
</tr>
<tr>
<td>Private-Desktop</td>
<td>793832c71d79760ab3977cc28d2a2ed</td>
<td>Remove, Use as template</td>
</tr>
<tr>
<td>PrivateCloud4ALL</td>
<td>37bbd937803b407e6fb469d55fac74c</td>
<td>Remove, Use as template</td>
</tr>
</tbody>
</table>

#### Your virtual machines

<table>
<thead>
<tr>
<th>Machine</th>
<th>CernVM</th>
<th>Context</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>128.141.235.19 (b5906583-a250-1b95-901a-2555703c9f)</td>
<td>2.1.0</td>
<td>PrivateCloud-CatalogServer</td>
<td>Unmanage</td>
</tr>
</tbody>
</table>

© Copyright CERN 2012 - PH Department - SFT - CernVM Software appliance
CernVM Online: Context Bookkeeping & Pairing

Context template

Please fill the following parameters and click create in order to create a new virtual machine context definition

General

Context name: PrivateCloud-Monitor

Description:
A monitoring entity for my private cloud.

- Make this context visible on the public lists
- Enable CernVM Agent Infrastructure
- Protect this context with a secret key

Repository

Users

Contextualization
CernVM Online: Context Bookkeeping & Pairing

Pair instance - Step 1

Please select the contextualization template you want to use for your VM:

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<td>PrivateCloud-CatalogServer</td>
<td><img src="https://cernvm-online.cern.ch/machine/pair/" alt="Pair with this context" /></td>
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</tr>
<tr>
<td>LHC@Home</td>
<td><img src="https://cernvm-online.cern.ch/machine/pair/" alt="Pair with this context" /></td>
</tr>
</tbody>
</table>

Create new context
Pair instance - Step 2

Wait your virtual machine to boot and put the following key in your virtual machine contextualization screen. You will have the option to contextualize it right after.

85 91 16

This website will reload when the VM is successfully paired.
Components of the CernVM Blue Print

CernVM - based data analysis environment preservation

- Linux distribution based on Scientific Linux.
- Supports all popular hypervisors.
- Minimal footprint, the VM interface is needed.
- Flexible contextualization.

- CernVM-FS environment is defined version strings. OS packages are defined by a versioned, closed package group (Meta-RPM)
- You need only the CernVM version string to rebuild CernVM image on demand.

- Read-only, globally distributed file system optimized for software distribution.
- Based on plain files and HTTP
- Snapshotting and versioning file system
  - Already used in production by LHC experiments.

- Ensembles of CernVMs can recreate a virtual cluster for data processing.
- CernVM can be contextualized using a small subset of EC2 API that allows it to be deployed on public or private clouds

More info: A practical approach to virtualization in HEP: http://dx.doi.org/10.1140/epjp/i2011-11013-1

CernVM Homepage: http://cernvm.cern.ch

May 2012
NA61 Production Jobs in Belgrade
Integration of a CernVM cloud with a data provenance system

Belgrade’s cluster registered and monitored on NA61/SHINE production page (under construction)
http://dmaletic.web.cern.ch/dmaletic/cgi-bin/na61prod
• Plain virtualization is not sufficient to preserve the data processing environment

• CernVM and CernVM-FS technologies provide handles to re-create a **data processing environment identified by a few version strings**

• As such, it is easy to integrate the definition of the data processing environment in data provenance systems

• The exposed interface is very slim: CernVM clusters run on private and public clouds without grid infrastructures

• Such virtual machines are easy to use and they can be given to “interested citizens” (see also *LHC@Home 2.0 volunteer cloud*)

Please contact us for any further questions!