Data Management services in highly distributed environments: recent achievements of the eXtreme-DataCloud project

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The eXtreme DataCloud is a software development and integration project

Develops scalable technologies for federating storage resources and managing data in highly distributed computing environments

- Focus on efficient, policy driven and Quality of Service based DM

Improve already existing, production quality Data Management services

- By adding missing functionalities requested by research communities
- Based mainly on technologies provided by the partners and by the INDIGO-Datacloud project
- Must be coherently harmonized in the European e-Infrastructures
XDC Topics

- Intelligent & Automated Dataset Distribution
  - Orchestration to realize a policy-driven data management
  - Data distribution policies based on Quality of Service (i.e. disks vs tape vs SSD)
    - supporting geographical distributed resources (cross-sites)
  - Data lifecycle management

- Data pre-processing during ingestion

- Metadata management

- Data management based on storage events

- Smart caching
  - Transparent access to remote data without the need of a-priori copy
    - To support dynamic inclusion of diskless sites
    - To improve efficiency in multi-site storage systems and storage federations (i.e. Datalakes)

- Sensitive data handling
  - secure storage and encryption
# XDC Consortium

- **8 partners, 7 countries**
- **6 research communities represented + EGI**
- **XDC Total Budget: 3.07Meuros**

<table>
<thead>
<tr>
<th>ID</th>
<th>Partner</th>
<th>Country</th>
<th>Represented Community</th>
<th>Tools and system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INFN (Lead)</td>
<td>IT</td>
<td>HEP/WLCG</td>
<td>INDIGO-Orchestrator</td>
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<tr>
<td>2</td>
<td>DESY</td>
<td>DE</td>
<td>Research with Photons (XFEL)</td>
<td>dCache</td>
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<td>CH</td>
<td>HEP/WLCG</td>
<td>EOS, DYNAFED, FTS, RUCIO</td>
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<td>AGH</td>
<td>PL</td>
<td></td>
<td>ONEDATA</td>
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<td>5</td>
<td>ECRIN [ERIC]</td>
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<td>Medical data</td>
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<td>6</td>
<td>UC</td>
<td>ES</td>
<td>Lifewatch</td>
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<td>8</td>
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<td>NL</td>
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</tbody>
</table>
General Architecture Definition

- XDC acts at all the e-infrastructure levels
  - Storage systems at sites
  - Federations of storage systems
    - regional and global
  - High level orchestration
  - User experience

- The “toolbox” was mapped in those levels to define the general architecture
  - Taking into account the user requirements
XDC General Architecture

- Users
  - User metadata service
  - Storage system at sites
  - XDC message bus
  - Platform Event collection
  - Reliable File Transfer Service
  - Storage Orchestration
  - AAI Service
  - IAM

- Storage Federation
- Storage Resources
- Storage Orchestration
- INDIGO PaaS orchestrator
- RUCIO
- FTS3
- ONEDATA
- Dynamic

- OneData
- Storage Resources
- Storage System at Sites
- Reliability File Transfer Service
First XDC Release

Involved tools
- CachingOnDemand
- dCache
- Dynafed
- EOS
- FTS, GFAL
- Onedata
- PaaS Orchestrator plugin
- TOSCA types & templates plugin

Key technical highlights
- OpenIDConnect support for token based authentication
- New QoS types integration and support in dCache, FTS, GFAL
- Orchestrator integration with other components
- Performance improvements in Onedata
- Support for groups and roles in Onedata
- EOS-dCache integration
- Caching systems instantiation
- Storage events notification in dCache
- EOS caching with XCache for geographic deployment
- EOS external storage adoption

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- Deployment of Geo-distributed caches
- Network of unmanaged storage for hot data
- On-demand cache resources

Based on xRootD/xCache

See D. Ciangottini talk on “Integration of the Italian cache federation within CMS computing model”:
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Onedata Transparent POSIX File System
Processing transparently cached data - 37GBytes/sec

Data Migration at combined Throughput 56 Gbit/s

- Data Transfer Mesh
- 3 Oneproviders connected by 20+Gbit/s links
- Transfer data between all them
- Single VM Node per Provider
- Linear scalability
First XDC Release

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The XFEL UseCase is driving the developments on storage events notifications support. A reference implementation is done using dCache as backend.

Refer to the Patrick Fuhrmann presentation for more details:

https://indico4.twgrid.org/indico/event/8/session/15/contribution/9
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CTA Use Case Workflow in XDC

- **File Generator**
- **ingest**
- **query by Metadata**
- **Restquery**
- **QUERY by LFN**
- **SPACE-CTA**
- **LAPP-PROVIDER**
  - POSIX 40TB
- **CC-PROVIDER-02**
  - S3 4TB
  - POSIX 6TB

- **preprocessing**
- **CTA HDF5 Extraction**
- **manage account**
- **DATA SPACE MANAGEMENT**

- **INTEGRATION**
  - LAPP-PROVIDER 01
  - CC-PROVIDER 02

- **40TB**
- **4TB**
- **6TB**

- **eXtreme-DataCloud Project - RDA 2019 - Helsinki**
XDC Main Releases

✗ A second major release is foreseen before the end of the project

- XDC Message bus implementation
- full orchestration
- finalize integration of RUCIO
- secure storage in Onedata
- finalize the ECRIN Use Case
- complete caching reference workflows with HTTP based systems

<table>
<thead>
<tr>
<th></th>
<th>Release Date</th>
<th>End of Updates</th>
<th>Full End of Standard Updates</th>
<th>of Security Updates &amp; EOL</th>
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<tr>
<td>XDC 1</td>
<td>Jan 2019</td>
<td>May 2019</td>
<td>Sep 2019</td>
<td>Nov 2019</td>
</tr>
</tbody>
</table>

XDC products can be downloaded from XDC repositories or from each components upstream repositories after they have been pushed back
XDC Contacts

Website: www.extreme-datacloud.eu

@XtremeDataCloud on Twitter

Mailing list: info<at>extreme-datacloud.eu

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BACKUP
XDC Components

The Components

- **Orchestration and Federation Components**
  - XDC Orchestrator
  - INDIGO PaaS Orchestrator
  - Flowable © (BPM)
  - Rucio Data Management System

- **Data Transfer and Data Federation technologies**
  - FTS, File Transfer Service,
  - Dynafed, Data Federator, Onedata

- **Storage Systems**
  - dCache
  - EOS
  - StoRM
XDC Orchestration Components

- **INDIGO PaaS Orchestrator**
  - Based on INDIGO-DataCloud developments.
  - Allows to coordinate complex deployments on hybrid clouds featuring advanced scheduling and federation capabilities.
  - Orchestrates compute resources and provides data-aware scheduling of jobs through data placement plugins (XDC extensions).
  - Integrates with Rucio for data location and transfer orchestration (XDC developments).
  - Operates with a professional BPM system. (Flowable)

- **Flowable © (BPM)**
  - Provides a workflow and Business Process Management (BPM) platform for developers, system admins and business users.

- **Rucio**
  - Originally LHC ALTAS data management tools.
  - Recently adopted by a growing number of other communities.
  - Already provides interfaces to most XDC components.
XDC Transport Components

- **FTS, File Transfer Service**
  - WLCG data transfer workhorse.
  - Transfers around 1 Exabytes of WLCG data per year between hundreds of storage sites around the world.
  - Performs request queueing and network shaping.
  - Can be used as “micro service” or with GUI (WebFTS).
  - Support X509 and token based authentication for endpoints.

- **Dynafed, Data Federator**
  - Federates storage endpoints to a single root namespace.
  - Supported Protocols: http/WebDAV, S3.
  - Performs metadata prefetching.
  - Provides location meta data to high level services.
XDC Storage Components

The Components

- **dCache**
  - Open Source Storage system provided by DESY, Fermilab and NDGF.
  - Handling 150 PBytes at more than 60 big data centers, including 7 WLCG Tier 1 centers.
  - Supports industry standard data access and security protocols on top of a geo-aware multi tier storage stack.

- **EOS**
  - Scalable storage running at CERN and elsewhere.
  - Geo-aware management of hundred of PBs.
  - HTTP interface.

- **StoRM**
  - Provided by INFN/CNAF
  - Engine providing multiple data transport and control protocols on top of GPFS and Lustre.
INDIGO CDMI Reference Implementation

- INDIGO re-implementation of the SNIA CDMI reference implementation, now hosted by SNIA.
- Provided the CDMI protocol engine and forwards the requests to a plug-in system.
- Provides plug-ins for a REST protocol dialect as well as for CEPH and GPFS.

XCache

- Read-only, block-level data cache
- Deployed close to CPU to hide latency and reduce WAN traffic
- HTTP interface
ONEDATA DISTRIBUTED DATA IN HYBRID CLOUDS

https://onedata.org