The XDC project

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Data Management for extreme scale computing
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

The targeted platforms are the current and next generation e-Infrastructures deployed in Europe

- European Open Science Cloud (EOSC)
- The e-infrastructures used by the represented communities

Addresses the EINFRA-21-2017 (b)-2: “Computing e-infrastructure with extreme large datasets”

- Deal with heterogeneous datasets
- Bring to TRL8 and include in a unified service catalogue services and prototype at least at TRL6
The Approach

- 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
The partners owning/involved in each of the tools are the main developers for that solution in XDC.

We always aim to push back the code in the main development tree on the original projects. This widely increases the sustainability of the services.
A User Driven Project
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

<table>
<thead>
<tr>
<th>ID</th>
<th>Partner</th>
<th>Country</th>
<th>Represented Community</th>
<th>Tools and system</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>INFN</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</td>
<td>dCache</td>
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<tr>
<td></td>
<td>(XFEL)</td>
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<td>(XFEL)</td>
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<td>3</td>
<td>CERN</td>
<td>CH</td>
<td>HEP/WLCG</td>
<td>EOS, DYNAFED, FTS, RUCIO</td>
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<tr>
<td>4</td>
<td>AGH</td>
<td>PL</td>
<td></td>
<td>ONEDATA</td>
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<tr>
<td>5</td>
<td>ECRIN</td>
<td>[ERIC]</td>
<td>Medical data</td>
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<tr>
<td>6</td>
<td>UC</td>
<td>ES</td>
<td>Lifewatch</td>
<td></td>
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<td>CNRS</td>
<td>FR</td>
<td>Astro [CTA and LSST]</td>
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<td>8</td>
<td>EGI.eu</td>
<td>NL</td>
<td>EGI communities</td>
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</tbody>
</table>

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

Storage Federation

User metadata service

Storage Orchestration

AAI Service

Storage Resources

Platform Event collection

Reliable File Transfer Service

XDC message bus

INDIGO PaaS orchestrator

FTS3

RUCIO

ONedata
Connection to external Entities

- **DEEP-DataCloud**
  - Connection to compute workloads
  - SQA common baseline

- **DOMA (Data Organization, Management, Access)**
  - DOMA “Access”
  - DOMA “QoS” (XDC Workgroup Leader)
  - DOMA “3rd Party Copy”

- **ESCAPE – WP2 (XDC Task Leader)**
  - Deployment of a European Data Lake

- **RDA**
  - Defining QoS vocabulary
  - Data Management workshop at the next plenary in Helsinki

- **SNIA**
  - Rendering CDMI to reflect QoS
  - XDC introduced at 2018 SNIA conference
SQA baseline


What?

- Set of conventions and recommendations for software development, aiming “to serve as a reference within the European research ecosystem related projects”

Why?

- Enhance the visibility, accessibility and distribution of the produced software
- Promote code style standards => readability & reusability
- Reliable operation
XDC 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

10/07/2019
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.
XDC Storage Components

- 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

SARA'S SPACES
- SENTINEL 2
- SKY MAPS
- MY DATA

JOHN'S SPACES
- SENTINEL 2
- DEEP LEARNING
- PUBLICATIONS

10/07/2019 eXtreme-DataCloud Overview - Creating platform-driven e-Infrastructure innovation on EOSC - Athens
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

First XDC Release

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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”: https://indico4.twgrid.org/indico/event/8/session/23/contribution/45
First XDC Release

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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
Key technical highlights

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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’s presentation:

XFEL Use Case in XDC

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- Refer to the Patrick’s presentation:
CTA Use Case Workflow in XDC

Canary Island

Chile

Online Process

DL0/Bulk Archive

Calib

Reconst

DL3 / High level data

Scientist Interface

20PB/yr
Max 500 files/s
CTA Use Case Workflow in XDC

Canary Island

Chile

Online Process

DL0/Bulk Archive

Calib

Reconst

DL3 / High level data

Scientist Interface
CTA Use Case Workflow in XDC

1. **File Generator**
   - Ingest

2. **File System**
   - Query by LFN

3. **Metadata**
   - Query by Metadata

4. **Restquery**

5. **preprocessing**
   - CTA, HDF5 Extraction

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**eXtreme-DataCloud Overview** - Creating platform-driven e-Infraestructure innovation on EOSC - Athens
CTA Use Case Workflow in XDC

File Generator → ingest → preprocessing → CTA HDF5 Extraction

Query by Metadata → Restquery

Query by LFN

SPACE-CTA

LAPP-PROVIDER

POSIX 40TB

CC-PROVIDER-02

S3 4TB

POSIX 6TB

eXtreme-DataCloud Overview - Creating platform-driven e-Infrastructure innovation on EOSC - Athens
CTA Use Case Workflow in XDC

File Generator

Ingest

Preprocessing

CTA HDF5 Extraction

Query by Metadata

Restquery

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CTA Use Case Workflow in XDC

1. File Generator
2. Ingest
3. Query by Metadata
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5. Restquery
6. Preprocessing
7. CTA HDF5 Extraction
8. LAPP PROVIDER
9. CC-PROVIDER-02
10. POSIX 40TB
11. S3 4TB
12. POSIX 6TB
LifeWatch Use Case in XDC

- **Objectives:** Integrate different and heterogeneous data sources: satellite data, real-time monitoring system based on sensors, observations, and meteorological data to feed the hydrological and water quality models, thus automating modeling and prediction of water quality.

- **XDC Services Requirements:**
  - XDC IAM
  - Onedata:
    - Onedata Attachment
    - Onedata Discovery
  - PaaS Orchestrator
LifeWatch Use Case in XDC
LifeWatch Use Case in XDC
<table>
<thead>
<tr>
<th>Problem</th>
<th>Goal</th>
<th>XDC services</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifewatch</td>
<td>Data Life Cycle Management of data related to Water Quality involving heterogeneous data sources</td>
<td>Integrate data sources and different types of modelling tools</td>
<td>Onedata PaaS Orchestrator</td>
</tr>
<tr>
<td>CTA</td>
<td>Complex and Big Data management in a distributed environment. Data quality Assurance.</td>
<td>Integration of tools for FAIR Data Management and user access control</td>
<td>Onedata QoS PaaS Orchestrator</td>
</tr>
<tr>
<td>ECRIN</td>
<td>Distributed information about clinical studies and data objects across different registries and repositories.</td>
<td>Single environment to find data objects across repositories and registries, based on metadata</td>
<td>Onedata</td>
</tr>
<tr>
<td>WLCG</td>
<td>Growing needs on storage space</td>
<td>Reduce costs, resource aggregation, smart data allocation</td>
<td>QoS Xcache EOS</td>
</tr>
<tr>
<td>XFEL</td>
<td>Complex Data management in a distributed and heterogeneous environment.</td>
<td>Data lifecycle management. Processing and analytics</td>
<td>QoS PaaS Orchestrator dCache Message BUS</td>
</tr>
</tbody>
</table>
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 Updates</th>
<th>End of Standard Updates</th>
<th>End of Security Updates &amp; EOL</th>
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<tbody>
<tr>
<td>XDC 1</td>
<td>Jan 2018</td>
<td>May 2019</td>
<td>Sep 2019</td>
<td></td>
<td>Nov 2019</td>
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</table>

XDC products can be downloaded from XDC repositories or from each components upstream repositories after they have been pushed back.
Software quality process and testbeds

- XDC defined a rigorous process for ensuring software quality
  - Definition of roles
  - SQA Policies and Procedures
  - Development testbed
  - Integration testbed
  - Pilot testbed
  - Maintenance of Tools and Repositories

- Pilot Testbed is for internal use but can be opened to external communities for specific activities
Conclusion

- XDC is adding new functionalities to already existing, production quality, data management services
- XDC-1/Pulsar was released in January 2019
  - A step towards the complete implementation of the defined architecture
  - Research communities can already start implementing their use cases using Pulsar
- A second release is foreseen by next October
- Scalability verification is in progress and is one of the core activities in 2019
- XDC consortium members are acting as service providers to facilitate the uptake of the XDC services by the EOSC communities
  - We are involving external service providers to increase the uptake of new user communities
Website: [www.extreme-datacloud.eu](http://www.extreme-datacloud.eu)

@XtremeDataCloud on Twitter

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