EMI Data, dCache.org and Standards

Patrick Fuhrmann (DESY)
EMI Data Area lead
The EMI – data team / credits

- Alejandro Alvarez
- Alex Sim
- Claudio Cacciari
- Christian Loeschen
- Dirk Duellmann
- Elisabetta Ronchieri
- Fabrizio Furano
- Giuseppe Fiameni
- Giacinto Donvito
- Giuseppe Lo Presti
- Jon Kerr Nilsen
- Jan Schaefer
- Jean-Philippe Baud
- Michele Carpene
- Michele Dibenedetto
- Michail Salichos
- Mischa Salle
- Oscar Koeroo
- Oliver Keeble
- Paul Millar
- Ralph Mueller-Pfefferkorn
- Ricardo Rocha
- Riccardo Zappi
- Tigran Mkrtchyan
- Zsolt Molnar
- Zsombor Nagy

Our wiki: https://twiki.cern.ch/twiki/bin/view/EMI/EmiJra1T3Data
Outline

The European Middleware Initiative within the FP7 Framework

- EMI in the European FP7 context.
- What is EMI doing?
- Why are we doing this?
- EMI Data in the EMI context.
- When are we doing what?
- What is EMI Data doing in particular?

dCache.org and EMI

- dCache in a nutshell
- dCache in use.

Standardization

- SRM, spec plus security protocol
- WebDav
- NFS 4.1
The last Decade in Europe (HTC)


Infrastructure

EDG | EGEE I | EGEE II | EGEE III | EGI

Software development and support

EMI | StratusLab | EDGI | IGE | Venus-C | Siena

Coordination

Nov 8, 2010 Patrick Fuhrmann

EMI and dCache.org

Presented @ LBNL
Project details

StratusLab is developing and deploying cloud technologies with the aim of simplifying and optimizing the use and operation of distributed computing infrastructures such as the European Grid Infrastructure (EGI). The StratusLab Toolkit will integrate cloud and virtualization technologies and services within grid sites and enrich existing computing infrastructures with “Infrastructure as a Service” (IaaS) provisioning paradigms.

VENUS-C is focused on a reliable, industry-quality, sustainable platform: letting scientists be scientists and supporting small & medium enterprises.

SIENA will support Europe’s Distributed Computing Infrastructure (DCI) initiatives and the European Commission in working towards the delivery of a future e-Infrastructures roadmap that will be aligned with the needs of European and national initiatives.

Desktop Grids: EDGI will develop DG-Cloud bridge middleware with the goal to get instantly available additional resources for DG systems if the application has some QoS requirements that could not be satisfied by the available resources of the DG system.

IGE wants to knit a tight European network between the European Globus developers and users, thus ensuring a fast response time to European user requests and the provision of up-to-date information to the European developers of the European user requirements.
**EGI.eu** coordinates the European Grid Infrastructure with National Grid Initiatives, European International Research Organizations and other parties, to provide a generic e-infrastructure for all European researchers.
According to our Project Director, Alberto Di Meglio:

The European Middleware Initiative (EMI) project represents a close collaboration of the major European middleware providers - ARC, gLite, UNICORE and dCache - to establish a sustainable model to support, harmonise and evolve distributed computing middleware for deployment in EGI, PRACE and other distributed e-Infrastructures (DCI’s).
How this all works together
FP7 Interactions

EGI, PRACE, WLCG, OSG

Requirements

SLAs & Support

Releases

Collaborations

ESFRI, VRCs

Stolen from Alberto Di Meglio

Standards Industry

DCI collaborations

StratusLab  VENUS-C  SIENA  EDGI  IGE

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Now about EMI
EMI Factsheet

Budget : about 23 Million Euros
Funding : about 50% by EU-FP7, rest by partners
Covers : JRA, SA and NA
Partners : 22
Middlewares: Arc, gLite, UNICORE and dCache
What is EMI doing

EMI Middleware Evolution

Before EMI

3 years

After EMI

Applications Integrators, System Administrators

Specialized services, professional support and customization

EMI Reference Services

Standards, New technologies (clouds) Users and Infrastructure Requirements

Stolen from Alberto Di Meglio

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EMI and dCache.org

Presented @ LBNL
Why again?

Why are WE doing this?

Because with EMI we got the money and the organizational infrastructure to achieve goals, which we were planning to do anyway but didn’t find time nor money yet, e.g.:

- Moving towards standards
  - https / webDav
  - NFS 4.1
  - SRM

- Fixing flaws
  - Catalogue synchronization

- Improving usability
  - Storage Accounting
  - Monitoring Interface
  - Individual efforts of product teams of components
When will it happen?

Release Plan

Stolen from Alberto Di Meglio
See Alberto Aimar’s presentation for details (yesterday)

Support & Maintenance
Support & Maintenance
Support & Maintenance

01/05/2010  31/10/2010  30/04/2011  30/04/2012  28/02/2013

Start  EMI 0  EMI 1  EMI 2  EMI 3

Major releases

Support & Maintenance

01/05/2010  31/10/2010  30/04/2011  30/04/2012  28/02/2013
EMI Data in context

EMI and dCache.org

Presented @ LBNL

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ARGUS, VOMS, UNICORE-Gate, gridSite, etc

A-REX, UAS-Compute, WMS, CREAM, MPI, etc

dCache, StoRM, DPM, FTS, LFC, GFAL, arc-libs, UNICORE-SMS, etc

Information system, accounting, bookkeeping

DATA

COMPUTING

SECURITY

INFRA STRUCTUR
EMI Data in context

EMI and dCache.org
Presented @ LBNL

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Information system, accounting, bookkeeping
EMI workplan (activities)

- WLCG ARC
- Catalogue Synchronization
- DATA client Library consolidation
- ARGUS Integration
- EMI SECURITY
- SRM Security
- Standards NFS 4.1
- Standards http(s) WebDav
- Standardization OGF IETF

- UNICORE Integration
- GLUE 2.0
- Storage Accounting
- SRM Spec Simplification

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Standardization efforts within EMI
The EMI Storage Elements

Storage Layer

Custodial Layer

Access
- Monitoring
- Accounting
- API

SRM

NFS 4.1
- Posix
- WebDav
- http(s)
- gsi
- FTP

Namespace API

Storage Control

dCache

StoRM

DPM

Storage Control

WebDav

GPFS

Other

EMI and dCache.org

Presented @ LBNL

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Standardization: the easy bit
WebDav

- Very useful for new (non-LHC) communities.
- Already available in dCache.
- Will be added to StoRM and DPM after EMI-1.
- Allows “File system like” access with
  - Mac OS
  - Linux
  - Windows
Standardization: fixing the missing bits
### Standardization: SRM, specification

**SRM** is a remote *storage management* protocol.

The SRM does:
- Transfer protocol negotiation
- Name space operations
- Space management
- Storage Management: access latency, retention policy (tape, disk,...)
- Allows bulk operations.

- Specification not easy to understand by customers.
- Spec might need a cleanup based on our experience.
- Better documentation from user perspective.
- The SRM is an extremely useful and btw the only tool to remotely manage data in a standardized way across SE’s.
Standardization: SRM, security

- Right now: GLOBUS: library and protocol (non standard)
- Goal: replacing GSI by SSL/TLS-X509

Step I:
- No delegation (srmcp)
- GLOBUS library in SSL compatibility mode.
- Prove of concept done: dCache SRM server and client.

Step II
- No delegation.
- Server and client can use standard java/openssl libraries.

Step III
- Agreement on delegation service: done GDS
- Agreements in progress 😊
  - Who tells to create delegated proxy: client or server
  - How does the server tell the client w/o changing the WSDL
  - Where do we store the delegation ID (w/o WSDL change)
  - How close should the delegation service be to the SRM service
Wider agreement necessary

However, things are slightly more complicated because …
The big picture

SRM
CASTOR SRM
BeStMAN
CASTOR Stager
EOS
Any FS
dCache
Any FS
StoRM
GPFS
Any FS
DPM
HSM Interface
HSM
CASTOR
ENSTORE
Any Other
TSM
Any FS

EMI INFSO-RI-261611
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Wider agreement

All agreements, concerning the SRM security and the SRM specification cleanup, have to be coordinated with Alex (BeStMAN) and people from CASTOR.
Standardization: the tough part
Standardization: NFS 4.1 (pNFS)

- NFS 4.1 (pNFS): industry standard (defined by IETF)
- Genuine POSIX access through mounted file system.
- pNFS supports highly distributed data sources.
- Clients provided and maintained by OS.
- Will be used by industry heavyweights: IBM, EMC, Panasas...
- Production dCache 1.9.10

Linux, Solaris OS

Native File System driver
The NFS 4.1 Initiative

Funding

EMI and dCache.org

Presented @ LBNL
In order to understand why dCache is so keen on NFS 4.1 we need to understand a bit more about dCache.

(Shameless product placement 😊 )
- WLCG
  - 8 Tier I's
  - 40 Tier II's

```
Percentage Data Stored

- 58%
- 20%
- 15%
- 7%
```

- Academic storage network in Sweden
- LOFAR, European radio antenna
- Lot’s of groups at DESY and FERMI

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EMI and dCache.org
Presented @ LBNL
Native file system extremely useful for WLCG analysis

dCache supports a lot of communities for which direct file system access is essential.

*Open ‘/foo/filename’* is the only way they know to open a file.
Two slides on how dCache works

(more product placement)
How dCache is build (layer)

- **Common Security Layer**
  - Authentication: Kerberos, X509, Password
  - Authorization: ACL's for File system and storage control (SRM)
  - Unified ID management

- **Common Name Service Layer**
  - Extended Names Service Queries (SQL)

- **Extended Names Service Queries (SQL)**

- **Data Movement Layer**
  - Tape <-> Disk ; Disk <-> Disk ; Replication ; Draining; e.t.c.

- **“multi-media” storage layer**
  - DISK
  - DISK
  - SSD

- **Standard File Access Protocols**
  - http(s)
  - NFS 4.1
  - gsiFtp

- **CDMI (SNIA)**
  - Cloud Data Management Interface

- **Storage Management**
  - SRM

- **NON Standard**
  - dCap & xRoot

- **Planned**

- ✔ File replication on hot-spot detection
- ✔ Draining of pools
- ✔ Resilient dataset management
- ✔ Replication on arrival
How dCache is build (data flow)

dCache Headnode

META
DATA

DATA

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EMI and dCache.org
Presented @ LBNL
How is this related to NFS 4.1?
How does NFS 4.1 (pNFS) work?

Stolen from:
http://www.pnfs.com/

Plus
✓ Mandatory security
✓ Compound RPC's

EMI and dCache.org
Presented @ LBNL
So NFS 4.1 (pNFS) fits perfectly into the dCache design. It will benefit from all dCache features, like ACL’s and automated file location management and it takes full advantage of the highly distributed way dCache works.
So what’s the NFS 4.1 initiative?
What is the NFS 4.1 initiative?

- Industry initiative between all the major storage and OS vendors.
- Coordinated by CITI at the University of Michigan.
- It is an WLCG demonstrator.
- Funded effort within the European Middleware Initiative.
- Major effort in dCache
  - For non LCG communities
  - Hopefully for HEP as well.
Who is behind NFS 4.1 (pNFS)?

Stolen from: http://www.pnfs.com/

Industry Support - Implementations

Clients
- Linux
- Sun (Solaris)

Servers
- Desy
- EMC
- IBM
- Linux
- NetApp
- Panasas
- Sun (Solaris)

Presented at SC’08

Several other implementations have been tested at Bake-a-thons and Connectathons

EMI and dCache.org
Presented @ LBNL

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Benefits of Parallel I/O

- Delivers Very High Application Performance
- Allows for Massive Scalability without diminished performance

Benefits of NFS (or most any standard)

- Ensures Interoperability among vendor solutions
- Allows Choice of best-of-breed products
- Eliminates Risks of deploying proprietary technology

Stolen from: http://www.pnfs.com/
Why is HEP interested?

- Don’t have to care about client software anymore.
- No specific ROOT drivers (dCap, rfio, xroot). Just ‘open /foo/blah’
- Less software components to maintain.
- Can be used by unmodified applications (e.g. Mathematica®)
- Regular mount-point as any other FS e.g. /afs, /pnfs.
- File/Block caching algorithms provided by professional computer scientists within the OS kernel.

More more arguments see:

“11 reasons you should care” by Gerd Behrmann

At dCache.org/manuals
Within the European Middleware Initiative, DPM, dCache and very likely StoRM will provide an NFS 4.1 (pNFS) interface.

Imposed by the EC: EMI will only fund standards.

dCache production ready: 1.9.10
DPM: pNFS being finished later.
NFS 4.1 (pNFS) evaluation in dCache

dCache NFS 4.1 evaluation done by:

Yves Kemp
Tigran Mkrtchyan
Dmitri Ozerov
About
50 % av. Tier II CPU
20 % av. Tier II Storage
Dedicated to
NFS 4.1 evaluation

32 node
265 cores

Our NFS 4.1 (pNFS) small Tier II ?

CREAM-CE

Workernode
2 * 4 * Cores

1 GBit

Force 10

ARISTA 1

ARISTA

dCache
Head

10 GBit

10 GBit

10 GBit

10 GBit

5 Pools
80 TBytes

10 GBit

10 GBit

10 GBit

10 GBit

2 * 4 * Cores

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EMI and dCache.org
Presented @ LBNL
**NFS 4.1 / dCap evaluation logic**

**Client**
- ROOT Application
- TTreeCache
- Protocol Driver (Txxx)
- `file://`
- `dCap://`

**dCache Pool (Server)**
- Protocol Engines (dCap, pNFS)
- FS Cache
- KERNEL
- Primary Storage (Disk)

- Protocol Driver
  - NFS 4.1

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Class of test

- Stability evaluation
- Simple I/O testing
- ROOT tests
- ATLAS HammerCloud

All tests done with:

dCache 1.9.10
SL 5.3 2.6.36-rc3.pnfs
Stability
Stability

- **CFEL Production Transfers from SLAC to DESY**
  - 13 TBytes over 10 days
  - 100 GBytes average file size
  - No crash, no unexpected behaviour

- **U-n-taring Linux Kernel into NFS 4.1**
  - No crash

- **High-latency test**
  - Recursive ‘ls –l’ over 60,000 files via DSL from home.
  - Finished w/o problem.

- **4 days at 330 MB/sec sustained Hammercloud. (stopped after 4 days)**

- **128 Processes writing into the same file**
  - Client nodes get stuck
  - Server was still ok
Simple I/O
Simple I/O Setup

Either

dccp <filename> /dev/null’

Or

cat <filename> /dev/null

Only interested in protocol performance. Preventing any client side caching effect.

✓ Reading each file only once.
✓ Reading files sequentially only.
Removing server disk congestion effect by keeping all data in file system cache of the pool.

Limited WN
1GB network

Limited by
disk bandwidth

Limited : 20 GB network

Total throughput doesn’t depend on the protocol.
ROOT
New ROOT version 5.27.06, compiled with dCap support

Files provided by René Brun: atlasFlushed.root (re-organized files with optimized buffers) and AOD.067184.big.pool_4.root (some other original file) (optimized: 1GByte, original 1.3 GByte)

Test script provided by René: simple script reading events: taodr.C

Different test runs:
- Reading via NFS or dCap
- Reading with 60MByte TreeCache, or with 0Byte TreeCache
- Reading all branches or only 2 branches
- 32, 64, 128, 192 or 256 jobs running in parallel

Last minute-result! Have not spoken with ROOT people!
ROOT: Non optimized files, 2 trees only

- Non optimized files
- Reading only 2 trees.
- TTreeCache does vector read with dCap.
- VR = fadvise disabled in ROOT for NFS.

Initial load into pool file system cache.
ROOT: optimized versus non optimized files

2 trees only

Non optimized files

Optimized files

Initial load into pool file system cache.

NFS, with TTreeCache

NFS, no TTreeCache

dCap, with TTreeCache

dCap, no TTreeCache

ROOT : optimized versus non optimized files

Non optimized files

Optimized files

Initial load into pool file system cache.

NFS, with TTreeCache

NFS, no TTreeCache

dCap, with TTreeCache

dCap, no TTreeCache

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Presented @ LBNL
ROOT: optimized versus non optimized files

All trees

Non optimized files

Optimized files

NFS, with TTreeCache

NFS, no TTreeCache

dCap, with TTreeCache

ROOT: optimized versus non optimized files

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Two important concepts dominate analysis performance:

Client side caching

Vector Read
The above evaluation doesn’t at all use client side caching

But

- From evaluation (last hepix) we know that caching is 50% of the game.

- This can be achieved by
  - TTreeCache for ROOT application
  - dCap ++ (see Patrick’s talk at Lisboa Hepix) any application using dCap.
  - Or client file system cache for NFS 4.1 (pNFS)

- For ROOT application, the TTreeCache has a slight advantage, as it knows the structure of the ROOT files and can act accordingly
The vector read magic

The above evaluation demonstrates the advantages of Vector-Read by ROOT.

- Vector read can only be used through proprietary protocols (dCap,..)
- The file system semantics doesn’t allow direct vector read. (bad)
- However, the is the famous ‘fadvise’ file system call:
  - Advised the file system (kernel) to prefetch certain portions of a file, if CPU time allows.
  - If those portions are read later, they are already available in the FS cache.
- Has been added to the ‘file://’ driver of ROOT and, according to Fons, improved access with ‘file://’ by up to 20%.
- Has been removed from the code again because it spoiled the TTreeCache I/O statistics. (very bad).
Hammer Cloud
8248 jobs in total
Cancelled after 4 days
Longest single test we did
  - No trouble during test
  - Reasonable outcomes (events/s,...)
No comparison made to dCap (yet)

4 days running at 
~330 MByte/s
dCache to clients 
via NFS

Longest test

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Client (kernel) availability
Kernel availability

Kernel used for evaluation: 2.6.36_rc3

- NFS 4.1 (pNFS) kernels expected in SL6.(>2)

2.6.36 back-port to SL5 available from DESY
  - Plus ‘mount tools’ RPM.
  - Kernel will very likely not cover all hardware setups.

- With a Joined Effort (e.g. CERN, FNAL, DESY), we would be able to provide an SL5 with NFS 4.1 (pNFS) kernel within months. (If we really want)
commit a4dd8dce14014665862ce7911b38cb2c69e366dd
Merge: b18cae4 411b5e0
Author: Linus Torvalds <torvalds@linuxfoundation.org>
Date:   Tue Oct 26 09:52:09 2010 -0700

Merge branch 'nfs-for-2.6.37' of
git://git.linux-nfs.org/projects/trondmy/nfs-2.6.git

* 'nfs-for-2.6.37' of git://git.linux-nfs.org/projects/trondmy/nfs-2.6:
  net/sunrpc: Use static const char arrays
  nfs4: fix channel attribute sanity-checks
  NFSv4.1: Use more sensible names for 'initialize_mountpoint'
  NFSv4.1: pnfs: filelayout: add driver's LAYOUTGET and
GETDEVICEINFO infrastructure
  NFSv4.1: pnfs: add LAYOUTGET and GETDEVICEINFO infrastructure
  NFS: client needs to maintain list of inodes with active layouts
  NFS: create and destroy inode's layout cache
  NFSv4.1: pnfs: filelayout: introduce minimal file layout driver
  NFSv4.1: pnfs: full mount/umount infrastructure
  NFS: set layout driver
  NFS: ask for layouttypes during v4 fsinfo call
  NFS: change stateid to be a union
  NFSv4.1: pnfsd, pnfs: protocol level pnfs constants
SUNRPC: define xdr_decode_opaque_fixed
NFSD: remove duplicate NFS4_STATEID_SIZE

First part of pNFS now in 2.6.37
Next Steps

• For more details check CHEP’10 presentation by Yves and Dmitri.
• More investigation with various different ROOT setups.
• Working with the CMS official test-case.
• Investigating X509 Certificate/Proxy security.
• Wide area transfer evaluation. (DPM, dCache, DESY, CERN)
• Setting up a regular NFS 4.1 (pNFS) system e.g. : NetApp and Pillar.
• Evaluation by the HEPIX working group.
• Trying to find groups as guinea-pigs for NFS4.1 production.
NFS 4.1 Conclusion

- Stability is much better than expected: Production ready.
- Kernel situation: short term solution for SL5 would be available, if we want.
- pNFS is partially already in 2.6.37
- Performance already comparable with existing solutions.
- Nevertheless: more evaluation on ROOT framework interaction needed. (vector read, fadvise)
- Efforts will continue within the EMI/dCache.org framework.
- You want to volunteer?
  - Get dCache 1.9.10 from dCache.org
  - Get nfs enabled kernel: http://www.dcache.org/chimera/x86_64/
Conclusions

- **EMI Data** is a good opportunity to get our storage management middleware into a maintainable shape.
- It provides the money and the infrastructure.
- Standardization is the way to get broader acceptance by other communities.
- Everybody can join or may provide suggestions through WLCG or EGI.eu.
Further reading

https://twiki.cern.ch/twiki/bin/view/EMI/EmiJra1T3Data

EMI is partially funded by the European Commission under Grant Agreement INFSO-RI-261611