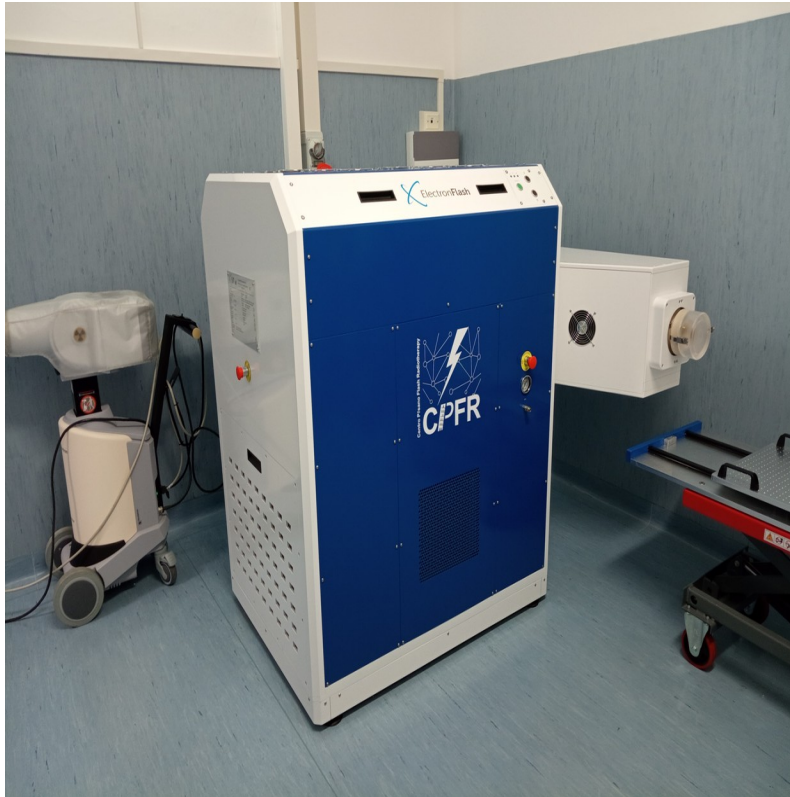


# Setting up an open-source XNAT IT platform for medical imaging research



# Progetto PNRR



- THE “Flash Effect”
- Spoke leader: CNR
- Affiliated partners:  
UNIFI, UNIPI, INFN



Finanziato  
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Ministero  
dell'Università  
e della Ricerca



Italiadomani  
PIANO NAZIONALE  
DI RIPRESA E RESILIENZA

# I soliti problemi...

- Gruppi multidisciplinari → requisiti specifici e comuni
- Dati clinici e immagini → Privacy, GDPR, ISO
- Processi e impatto sull'organizzazione
- Autenticazione e autorizzazione
- Gestione del ciclo di vita dei dati
- Condivisione e collaborazione
- Conservare la nuova conoscenza
- E così via...



# XNAT

- What Is XNAT ?
- XNAT is an open source imaging informatics platform developed by the **Neuroinformatics Research Group** at Washington University. XNAT was originally developed at Washington University in the Buckner Lab, which is now located at Harvard University. It facilitates common **management, productivity, and quality assurance tasks** for imaging and associated data. Thanks to its extensibility, XNAT can be used to support a wide range of imaging-based projects.

## What does XNAT provide?



**Full DICOM Integration and Anonymization:**  
Get image data in, and keep PHI out.



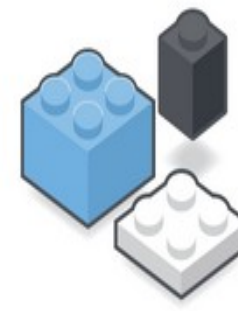
**Secure Access & Permission Control:**  
You decide who does what with your data.



**Integrated Search & Reporting:** Report on your image and clinical data together.



**Pipeline Processing:**  
Use the power of high-performance computing on your data.



**Modular Extensibility:**  
Expand the capabilities of your XNAT to meet your needs.



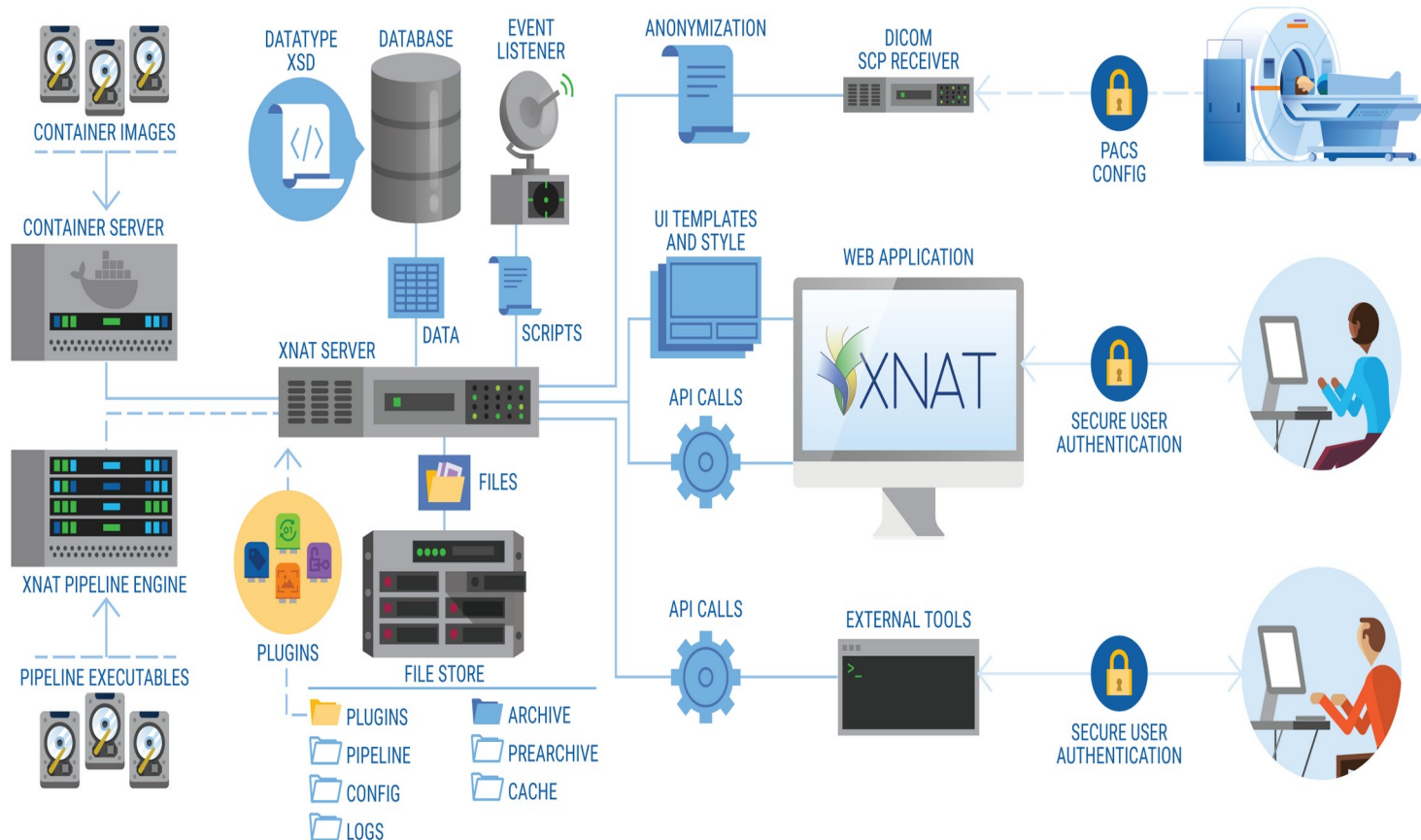
**Developer Community:**  
Benefit from an active and engaged set of XNAT power users.



# Understanding the Components of XNAT



FILED UNDER: GETTING STARTED



## CONTAINER SERVICE

Run processing in containers where each container image controls its own environment. Enabled via plugin.

## XNAT PIPELINE ENGINE

Run processing on XNAT data and return outputs to XNAT.

## PLUGIN FRAMEWORK

Add data types, API, UI & features.

## XNAT SERVER

Java-based web application on an Apache Tomcat server.

## XNAT DATABASE

PostgreSQL used to store indexed project data according to defined XSD Schemas.

## FILE STORE

All file resources are stored. Only the Archive should be backed up.

## EVENT SERVICE & AUTOMATION

Script automated responses to user or system events.

## ANONYMIZATION

DicomEdit scripts can be applied site-wide or on a per-project basis to remove PHI from DICOM headers.

## FRONT END

UI is built in Velocity templates and delivered as HTML / CSS for use in a web browser.

## API

Core data functions and commands can be accessed by external tools or scripts with proper authentication.

## DICOM SCP RECEIVER

Allows your XNAT to be set up as a destination for PACS to send image sessions to. Requires PACS to be set up separately.

## USER AUTHENTICATION

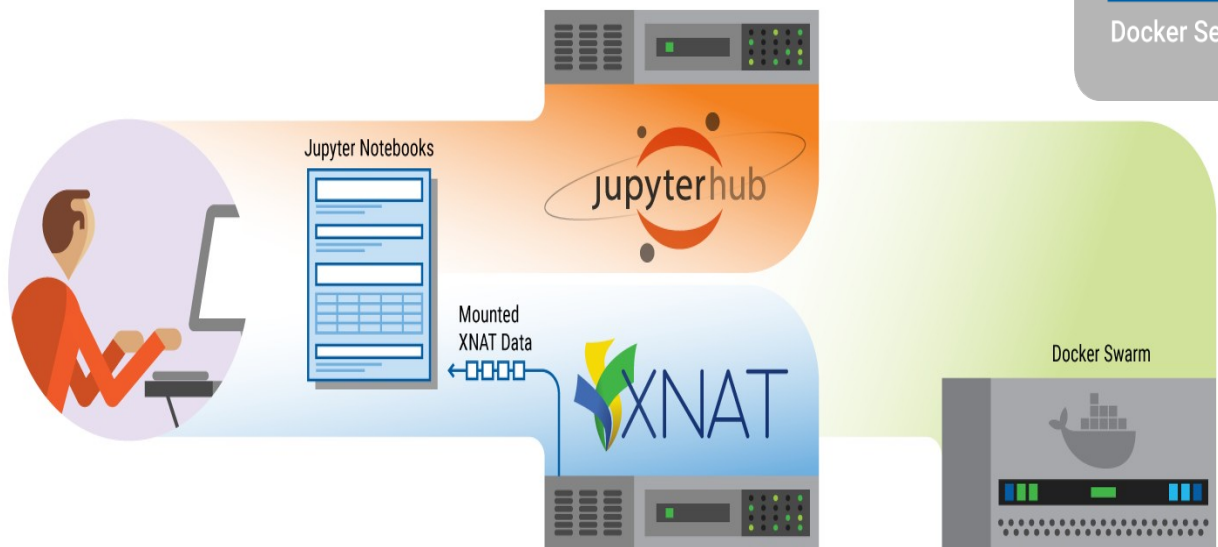
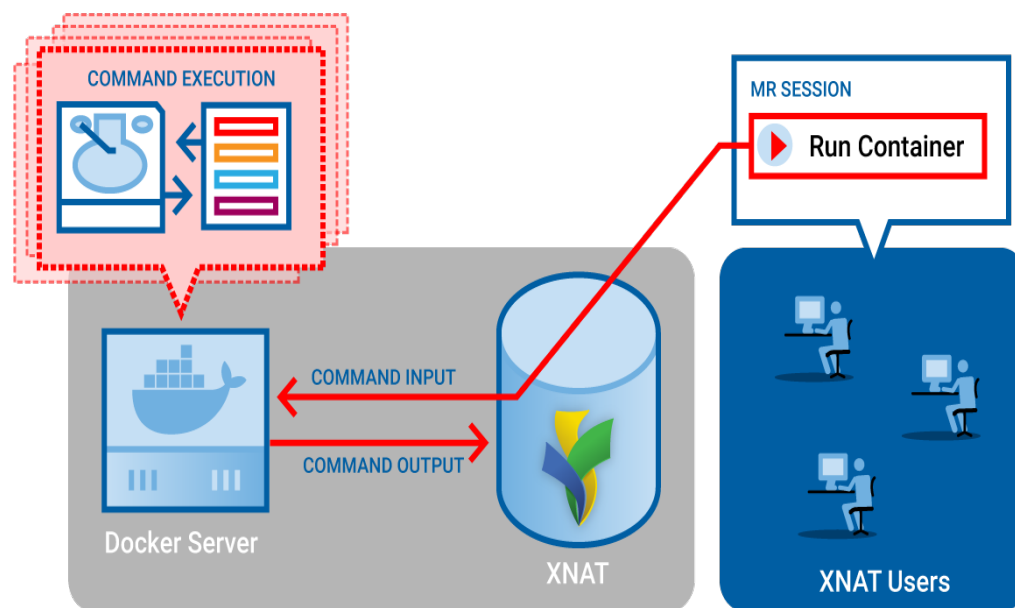
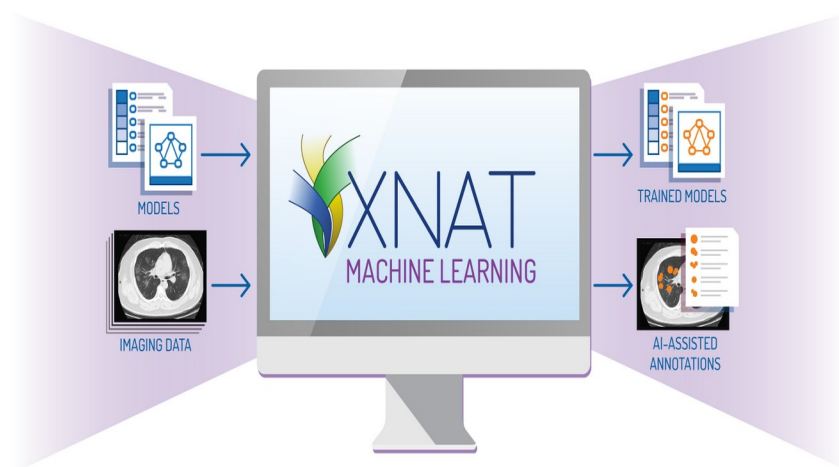
Spring Security used by default. LDAP / OpenID can be enabled by plugins.

## USER ACCESS

Data access in XNAT is segregated by project. Each project determines who has access to its data. User access can be enabled or disabled by site administrators as needed.

# Plugin

- XNAT Desktop Client (Mac OS, Windows e Linux)
- LDAP Authentication Plugin
- OpenID Authentication Plugin
- Container Service Plugin
- JupyterHub Integration Plugin
- XNAT OHIF Viewer
- XNATpy
- XNAT ML



# Configurazione server XNAT @ INFN-Pisa

- **Macchina virtuale con GPFS a bordo**
- **Running XNAT in a Dockerized Container with Configurable Dependencies**
  - 1) **\$ git clone <https://github.com/NrgXnat/xnat-docker-compose>**
  - 2) **\$ cd xnat-docker-compose**
  - 3) **\$ git checkout features/dependency-mgmt**
- **Inizializzazione web application**
- **Configurazione certificato ssl**
- **Configurazione plugin LDAP**
- **Configurazione Container Service plugin**
- **Configurazione OpenId connect plugin**
- **...**

# Configurazione (2)

```
xnat:~ # docker ps -a
```

CONTAINER ID	IMAGE	COMMAND	STATUS	CREATED	PORTS	NAMES
f93d337e3b46	xnat/hello-world:1.0	"/hello"	Exited (0)	18 hours ago		18 hours
elbart						xenodochial_eng
77b06e8d56cf	hpc/wn-hpc2:cs7	"ls"	Exited (0)	18 hours ago		18 hours
t						eloquent_samme
ea8b7327757b	xnat-web	"wait-for-postgres.s..."	Up	About a minute	0.0.0.0:8000->8000/tcp, 0.0.0.0:8104->8104/tcp, 0.0.0.0:8144->8144/tcp, 8080/tcp	xnat-web
e5ed2a1fd3b3	xnat-db	"docker-entrypoint.s..."	Up	19 hours	5432/tcp	xnat-db
bd67689cb90f	traefik:latest	"/entrypoint.sh --lo..."	Up	19 hours	0.0.0.0:80->80/tcp, 0.0.0.0:443->443/tcp, 0.0.0.0:8080->8080/tcp	xnat-traefik

```
xnat:~ #
```

```
xnat:~ # ls xnat-docker-compose/xnat-data/plugins/
batch-launch-0.6.0.jar  ldap-auth-plugin-1.1.0.jar
containers-2.1.0-fat.jar  ohif-viewer-3.2.0-fat.jar

xnat:~ # ls xnat-docker-compose/xnat-data/
archive  build  config  logs  plugins  tomcat  webapps

xnat:~ # ls xnat-docker-compose/xnat-data/config/auth/
ldap-provider.properties

Xnat:~#xnat:~ # cat xnat-docker-compose/traefik/config/certificates.yml
tls:
certificates:
  - certFile: /etc/certs/server.crt
    keyFile: /etc/certs/server.key

xnat:~ #

xnat:~ # mmgetstate

Node number  Node name  GPFS state
6            xnat      active
```





## Toy Platform for Phantom CT images

Details Access Manage Pipelines

**ID:** ToyPhantom  
**Description:** Toy platform to try XNAT features to store CT images of phantoms.  
**PI:** Scapicchio, Camilla

Edit Details

Delete

Manage Custom Variables

### Actions

- Add ▶
- Add to Favorites
- Download XML
- Download Images
- Processing Dashboard ▶
- Manage Files
- Upload Images
- View Prearchive
- Project Settings
- Scan Type Cleanup

## Subjects ✕

Add Tab ▾

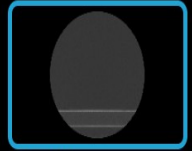
<< < prev next > >>

<< first < prev 1 next > last >> 200 ▾ 1 of 1 Pgs (4 Rows)

Reload

Options ▾

Subject	M/F	Hand	YOB	View	Phantom_name	Scanner	CTDivol	kVp	ReconstructionAlgorithm	IterativePercentage	PixelSpa
<a href="#">CAT_fc18_2_aidrSTD</a>	U				Catphan	TOSHIBA	2		AIDR3D	40	0.428
<a href="#">CAT_lung_2_asir10</a>	U				Catphan	GE	2		ASIR	10	0.406
<a href="#">RAD_lung_4_FBP</a>	U				Radiomik	TOSHIBA	4	120	FBP	0	0.781
<a href="#">RAD_lung_7_asir10</a>	U				Radiomik	GE	7		ASIR	10	0.703



Lung 1.0 s: 9 79

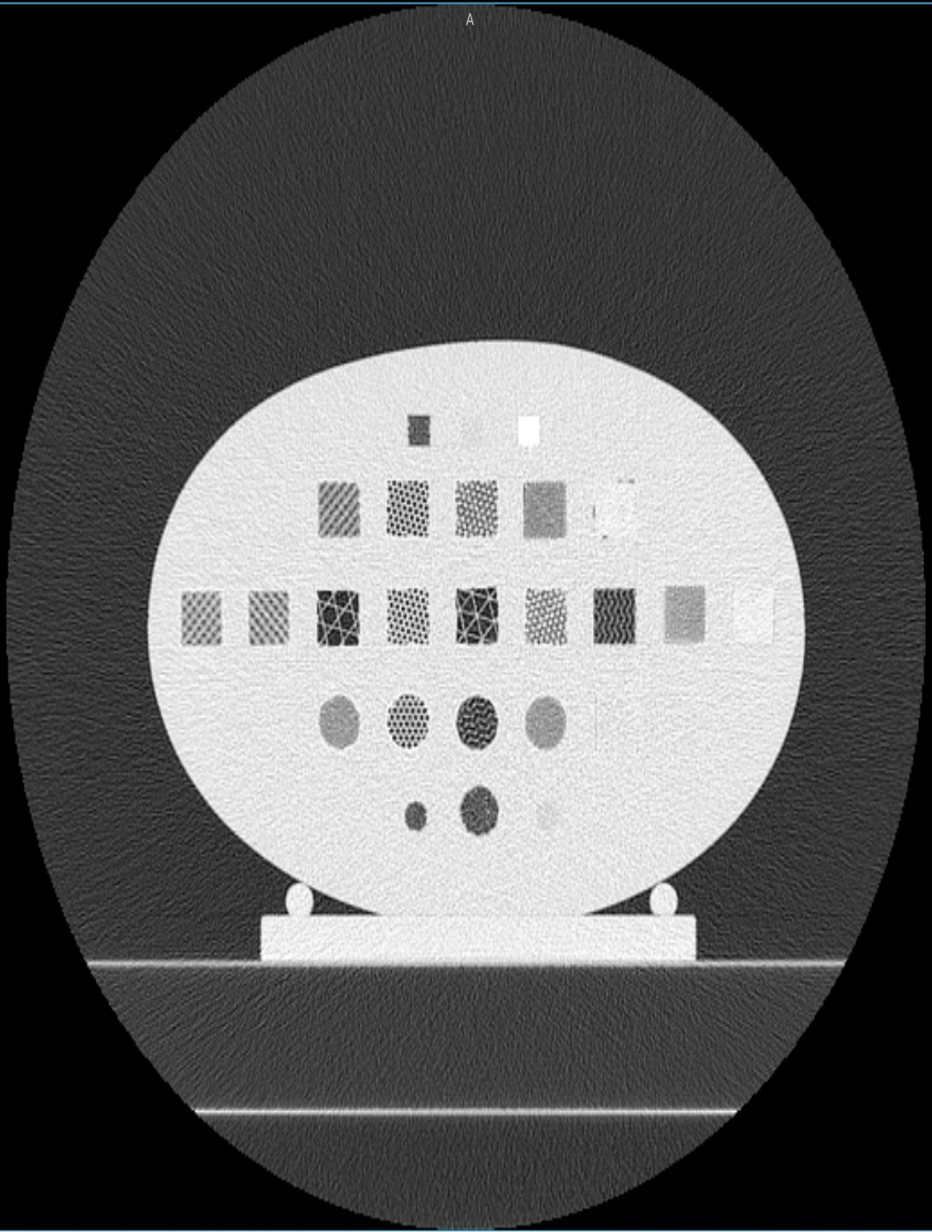


Lung 1.0 s: 9 79



Lung 1.0 s: 9 79

XXXXXX-003  
999999-003



R

CT  
Ser: 9  
Img: 79 37/79  
512 x 512  
Thick: 1.00 mm  
Lung 1.0

Zoom: 217%  
W: 1600 L: -550  
Windowing: Default  
Lossless / Uncompressed

# LDAP e la gestione dei ruoli in XNAT

- `ldap-provider.properties:`

`name=LDAP`

`provider.id=ldap`

`auth.method=ldap`

`visible=true`

`auto.enabled=false` → L'utente non deve essere automaticamente abilitato nel sistema !

`auto.verified=true` → La verifica può essere automatica, altrimenti il sistema invia una mail con link di verifica su cui l'utente clicca

...

...

The screenshot displays the 'Edit User Info' window in XNAT. The window title is 'Edit User Info' and it shows the user 'camilla'. The 'User Details' section includes fields for Username, First Name, Last Name, Email, Verified, and Enabled, all with 'Yes' status. An 'Actions' menu contains 'Edit' and 'View XML'. The 'Assign project membership and roles' section shows a table with columns for Project Label, Project ID, and Group, containing one entry: 'Toy Platform Phantom' with Project ID 'ToyPhantom' and Group 'Owners'. Below this is an 'Add Role' button. The 'Define security settings' section includes 'System Roles' with 'Site Manager' checked, and 'Allow All Data Access' with 'Read, Edit & Delete' selected. Both sections contain warning messages. A 'Save' button is at the bottom right, and a 'Close' button is at the very bottom right.

Logged in as: admin | Auto-logout in: ...

### Edit User Info

Details | Stored Searches

#### User Details

Username: camilla  
First Name: Camilla  
Last Name: Scapicchio  
Email: camilla.scapicchio@pi.infn.it  
Verified:  Yes  
Enabled:  Yes

Actions  
Edit  
View XML

#### Assign project membership and roles

Project Label	Project ID	Group	
Toy Platform Phantom	ToyPhantom	Owners	<a href="#">✎</a> <a href="#">✖</a>

Add Role

#### Define security settings

System Roles:

Site Manager : This allows users to access the Administrative pages of the web interface.

Non-expiring : This prevents this accounts password from expiring.

WARNING: Granting administrative privileges allows this user great power over the entire site.

WARNING: Granting a user account a non-expiring password is a security risk and should be limited to accounts that perform automated system tasks. In addition if any users are designated as non-expiring access to the user list should be restricted to administrators.

Allow All Data Access:

WARNING: Allowing 'All Data Access' will allow this user to see ALL data stored in this system, superseding project membership. This permission is automatically granted to all site administrators, but should not be granted to most other users.

No  Read Only  Read, Edit & Delete

Save

Close

## Federazione IDEM: OpenID Connect plugin

- Attualmente XNAT è agganciato al ramo (PI) di INFN-AAI;
- Configurazione plugin OpenID per XNAT è in corso, ringrazio Enrico M.V. Fasanelli per il supporto;
- È fondamentale garantire accesso a identità afferenti ad altri EPR e Università;
- Openid-provider.properties



*“L’orchestra non ha bisogno del direttore durante le melodie ma nei momenti di ritmo.”*

Riccardo Muti

Fin qui tutto bene ma a questo punto sarebbe possibile integrare XNAT nella nostra infrastruttura di calcolo scientifico ?



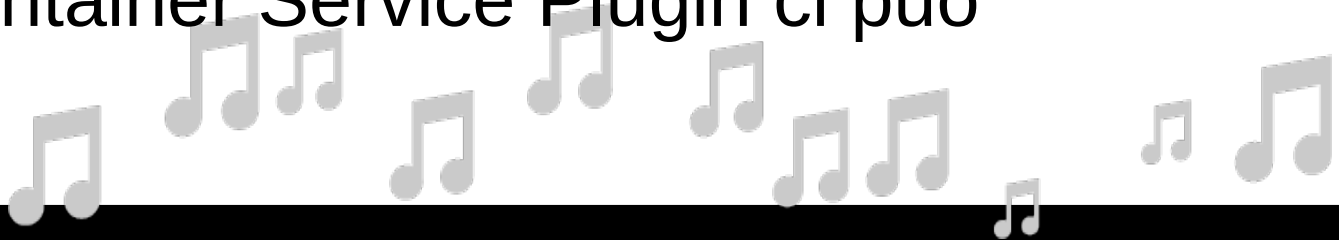
# Pipeline Engine

- Java-based framework that links sequential activities, human and computer.
- In most laboratories, some processes (or pipelines) are carried out automatically without any human intervention while others require a person to do manual steps, such as drawing a region of interest.
- Pipeline Engine facilitates both fully automated and semi-automated workflows.
- The process flow is defined in an XML document called the pipeline descriptor and the executables are defined in a separate XML document called resource descriptors.
- Pipeline engine ships with support for Sun Grid Engine (SGE).



# Idea

- E se il nodo xnat si trasformasse in una login user interface ?
- Possibilità di sottomettere job batch (container a scelta) verso una coda dello scheduler
- La pipeline in XNAT → upload automatico dei risultati dentro il progetto A (è un requisito irrinunciabile ?)
- Pro: uso ottimale delle risorse di calcolo e facilità d'uso
- Contro: immagine docker deve essere XNAT ready ? (complessità)
- Vediamo se il Container Service Plugin ci può aiutare...



# Container Service

Settings for [Test-2](#)

Container Service

Configure Commands

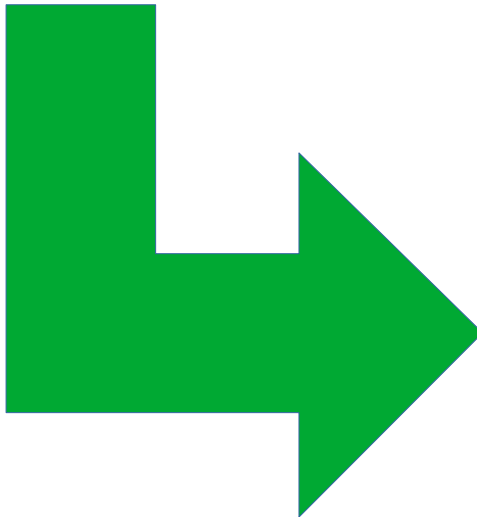
Command Automation

Command History

## Project Command Configurations

**i** This panel lists all enabled commands from all installed images, and allows project owners to define a custom configuration for each command. This configuration will be used by default by all users in this project, but users can override certain parameters.

XNAT Command Label	Container	Enabled	Actions
Enable / Disable All Commands		<input checked="" type="checkbox"/>	
<a href="#">Run hello-world command with a project input.</a>	xnat/hello-world:1.0	<input checked="" type="checkbox"/>	<button>Set Defaults</button>
<a href="#">Run ls command</a>	hpc/wn-hpc2:cs7	<input checked="" type="checkbox"/>	<button>Set Defaults</button>



Logged in as: [formuso](#) | Auto-logout in: 0:14:46 - [renew](#) | [Logout](#)

[Browse](#) [New](#) [Upload](#) [Tools](#) [Help](#) [Advanced](#) Search

Test-2

[Details](#) [Access](#) [Manage](#) [Pipelines](#)

ID: Test-2

Edit Details Delete Manage Custom Variables

Actions

- Add
- Add to Favorites
- Download XML
- Download Images
- Manage Files
- Upload Images
- View Prearchive
- Project Settings
- Scan Type Cleanup
- Run Containers
  - Hellow World: Project
  - ls

# JSON Command Definition

```
1 {
2   "name": "",
3   "label": "",
4   "description": "",
5   "version": "",
6   "schema-version": "1.0",
7   "type": "docker",
8   "image": "",
9   "working-directory": "",
10  "command-line": "",
11  "override-entrypoint" [],
12  "mounts": [ ]
13  "environment-variables": { },
14  "ports": { },
15  ...
16  "inputs": [list of inputs that will be used
17            to resolve the command and launch the container ],
18
19  "outputs": [where container saves objects to be
20             upload to xnat],
21
22  "secrets": [providing credentials to containers
23            that need to connect to external services],
24
25  "xnat": [define how to pull files and properties
26         from XNAT objects into your containers,
27         and upload the containers' outputs back]
28 }
```

The screenshot displays the 'Plugin Settings' interface for XNAT. On the left, a sidebar contains menu items: 'Container Service' (with sub-items 'Container Server Setup' and 'Images & Commands'), 'Command Configurations', 'Command Automation', 'Command History', 'OHIF Viewer', and 'OHIF Viewer Settings'. The main area is titled 'Installed Container Images and Commands' and shows two images: 'hpc/wn-hpc2:cs7' and 'xnat/hello-world:1.0'. Each image has a table of associated commands. The 'ls' command for the first image is highlighted, and its definition is shown in a dialog box titled 'Edit Definition For ls'. The dialog box contains a JSON definition for the 'ls' command, including fields for name, description, image, type, command-line, mounts, environment-variables, ports, inputs, outputs, and xnat configuration. The 'xnat' configuration includes a 'project' context and an 'external-inputs' array with a 'project' input. At the bottom of the dialog, there are 'Cancel' and 'Save' buttons. A status bar at the very bottom indicates 'Changes are not submitted automatically. The containing form will need to be submitted to save.'

**Plugin Settings**

**Container Service**

- Container Server Setup
- Images & Commands**
- Command Configurations
- Command Automation
- Command History

**OHIF Viewer**

- OHIF Viewer Settings

**Installed Container Images and Commands**

**hpc/wn-hpc2:cs7** [Add New Command] [Delete Image]

Command	XNAT Actions	Site-wide Config	Version	Actions
<a href="#">ls</a>	• xnat:projectData: Run ls command	N/A		[Edit] [Delete]

**xnat/hello-world:1.0** [Add New Command] [Delete Image]

Command	XNAT Actions	Site-wide Config	Version	Actions
<a href="#">hello-world</a>	• xnat:projectData: Run hello-world command with a project input.	N/A		[Edit] [Delete]

5 Images Hidden [Add New Image]

**Edit Definition For ls**

Command Info URL: n/a

```
1 {
2   "name": "ls",
3   "description": "A linux basic command",
4   "image": "hpc/wn-hpc2:cs7",
5   "type": "docker",
6   "command-line": "ls",
7   "mounts": [],
8   "environment-variables": {},
9   "ports": {},
10  "inputs": [],
11  "outputs": [],
12  "xnat": [
13    {
14      "name": "project",
15      "label": "ls",
16      "description": "Run ls command",
17      "contexts": [
18        "xnat:projectData"
19      ],
20      "external-inputs": [
21        {
22          "name": "project",
23          "description": "this input accepts a project",
24          "type": "Project",
25          "matcher": null,
26          "default-value": null,
27          "required": true,
28          "replacement-key": null,
29          "sensitive": null,
30          "provides-value-for-command-input": null,
31          "provides-files-for-command-mount": null,
32          "via-setup-command": null,
33          "user-settable": null,
34          "load-children": true
        }
      ]
    }
  ]
}
```

Changes are not submitted automatically.  
The containing form will need to be submitted to save.

[Cancel] [Save]

**View stdout**

```
afs
anaconda-post.log
bin
dev
etc
home
lib
lib64
media
mnt
opt
proc
root
run
sbin
srv
sys
tmp
usr
var
```

# Riflessioni finali

- XNAT as is
  - Gestione ruoli per progetto
  - Disponibilità plugin e API
  - Maturità del software (20 anni di sviluppo)
  - Favorisce la condivisione dati e la cooperazione tra gruppi di ricerca fra enti diversi
  - Completo ma complesso
  
- XNAT nice to have
  - Sviluppo plugin interfaccia batch job indipendente dallo scheduler
  - Condivisione workflow/immagini docker/comandi tra i gruppi di fisica medica interni all'ente e/o fra enti diversi
  - Container Service on Kubernetes (an example of setting up a non-production cluster using minikube)

```
{  
  "Messaggio": "Grazie a tutti per l'attenzione",  
  "Domande ?": [  
    "..."  
  ]  
}
```