European Plate Observing System

Infrastructures Preparatory Phase

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Report on EPOS e-infrastructure prototype

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TABLE OF CONTENTS:

Introduction

This report describes the state and plans of the EPOS WP6 WG7 (e-infrastructure) team as of M42 of the project. Briefly, the team has produced:

a) RIDE: an inventory of assets in the community covering everything from people and their skills through data and software to computing facilities, laboratory equipment and instruments / detectors;

b) an architectural design for the EPOS e-infrastructure which is being implemented in three increasingly well-defined stages.

c) a collection of use cases which inform the architectural design including required facilities and service;

d) a demonstator web application to demonstrate (i) the architecture is appropriate (ii) the architecture satisfies the requirements; (iii) the architecture is flexible and extensible with respect to future requirements – but for a limited set of requirements and limited sources of information (including other extant systems).

EPOS Architecture

The research infrastructures (RIs) that EPOS aims to integrate include at least, but not only:

- Regionally-distributed geophysical observing systems (seismological and geodetic networks);
- Local observatories (including geomagnetic, and volcano observatories);
- Analytical and experimental laboratories;
- Integrated satellite data and geological information.

To understand the diversity of the RIs participating in the EPOS integration plan one can visit the Research Infrastructures Database for EPOS (RIDE http://epos-eu.org/ride/), which presently maps about 250 RIs with more than one Petabyte of data stored, more than 70 laboratories and thousands of instruments in seismic, GNSS networks, volcano and geomagnetic observatories. Such existing institutional or national RIs for Solid Earth Science in Europe generate data and information and are responsible for the operation of instrumentation in each country. The RIs form the basic layer of the EPOS integration plan. The EPOS architecture is structured as follows (Fig.1):

- **Integrated Core Services (ICS):** they provide access to multidisciplinary data, data products, synthetic data from simulations, processing and visualization tools. It is not just data access: EPOS means to **integrate**, **analyse**, **compare**, **interpret** and **present** data and information about **Solid Earth.** This is the place where integration occurs.

- **Thematic Core Services (TCS)** are infrastructures that provide data services to specific communities (they can also be international organizations, such as ORFEUS for seismology).
- **National Research Infrastructures and facilities** provide services at national level and offer data to the European thematic data infrastructures.

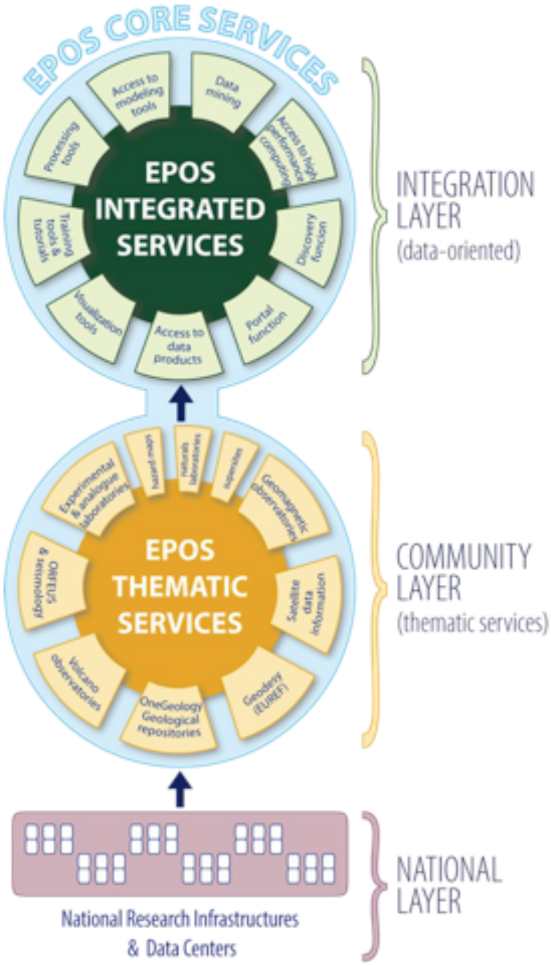

Figure 1: EPOS architecture

THE E-INFRASTRUCTURE

Some of the keywords often mentioned when referring to EPOS are: *multidisciplinary, integrated, holistic, comprehensive, efficient, e-Science*, all clearly identifying EPOS as a tool to make integrated use of data, data products, software and services (including laboratories) provided by different research infrastructures operating in the solid Earth Science domain. Hence, EPOS is *not only* a portal to domain-specific (thematic) datasets for download: EPOS is this, and much more.

The ambition of EPOS is to overcome the general complexity a researcher must face when using a wide diversity of data and data products to make her/his research, by providing a simple, "one-stop shop" tool.

The EPOS system will hence deal with all the complex aspects in place of the user, which include:

- *Complexity of offerings*: data, data products, software, services (e.g. facilities including computing) that can be provided by institutions, national centres, or Thematic Services to the EPOS system;
- *Complexity of users*: users role will be dynamic (the user can also be a data provider, a data consumer, a service provider/manager etc.) and associated to different authorities and responsibilities; a user can have personalized preferences (e.g. mobile, laptop);
- *Complexity of usage*: including issues as data ownership and Intellectual Properties (data, software, publications), permissions of use (data, software, facilities including computing), conditions of use (licence, acknowledgement, citation, payment and constraints on further actions);
- *Complexity of requests*: a request can be considered as a function of user, data, software, or facilities with constraints which are – in the real world – very complex.
-

The integrated environment dealing with the aforementioned complex issues will enable the User to perform several actions, described in detail in the "Use Cases" section. It is worth evidencing that EPOS will not provide *yet another tool* to browse and download data.

EPOS is more than data download, data mining, data discovery.
The goal is to provide an integrated environment where the user can browse, preview and/or select data, and then simply download them or perform processing and modelling directly online.

This ensures that the complex scenario outlined in the previous paragraph will not be shown to the final user, and – even more relevant – that the EPOS system is not just a duplication of already existing services, which mainly deal with data browsing and downloading.

EPOS ICT REQUIREMENTS

The term "Requirements" has a clear and established definition in the ICT domain which can be summarized as follows "*Requirements are the necessary attributes defined for a system before design development*"[1]. However, in the EPOS framework it has a slightly different interpretation, because the actors, the Users and the Providers, can actually play both roles at the same time (i.e. the Users can also be Providers and vice versa). Therefore, they influence the system design with both the requirements (provided by users) and the technology the services they offer is based on (provided by providers).

In this sense, taking into account the two main stakeholders involved in the requirements collection within the EPOS framework (the *Users*/*Providers* and the *System)*, the requirements can have a twofold definition or, better, a bi-directional definition:

1. *From the Users to the System*. The "Requirements" are the system features required by the scientists (Users/Providers) to improve their science. This is the classical ICT definition.
2. *From the System to the Users*. The "Requirements" are the whole bundle of technical definition, description of resources and any other elements that the scientists (Users/Providers) can provide in order to describe technically the resources they offer, which are going to be integrated into the Integrated Core Services.

By means of classical tools for requirements collection, as for instance the Use Cases, it is hence possible to obtain information about the two definitions of requirements just outlined, as already described in D6.2 M36.

USE CASES

Use Cases (UCs) and Requirements are usually mentioned together. As for the Requirements, UCs are used for multiple purposes. In order to harmonize their definition across all EPOS communities, stakeholders, and Working Groups (WGs) a definition was found out in a collaborative way:

"A Use Case is a description of a potential application targeted to specific group of users to respond to a specific question (scientific or societal) with two objectives: (i) to collect IT system requirements from data providers and facilities' managers and (ii) to interact with user groups to promote a common understanding of the core services. Use Cases are needed during the e-Architecture Design Phase".

1 "Discovering System Requirements", SANDIA REPORT SAND96-1 620 " UC-706 Unlimited Release Printed July 1996, available at http://prod.sandia.gov/techlib/access-control.cgi/1996/961620.pdf

In the EPOS framework the Use Cases were used with the following purposes:

- *Use Cases for ICT System Requirements*. In this first, classical meaning the main goal was to derive EPOS e-infrastructure requirements based on users' needs: a survey has been carried in order to describe different example situations in which different categories of users use or query the EPOS system with different types of requests. This enabled us to extract the key functionalities/features of the system. This goal can be classified as a "f*rom the Users to the System"* action.
- *Use Cases for community involvement.* UCs are also a powerful tool to promote a common understanding of the EPOS core services, because they can show to the stakeholders and to scientists what the system is likely to become following their directions.
- *Use Cases to collect missing requirements.* Once the general architecture of the system is in place and the Integrated Core Services (ICS) designed, yet the interaction and communication with the Thematic Core Services (TCS) needs to go through the compatibility layer (better described in the following paragraphs). To achieve this goal, technical details about the existing or envisaged TCS needs to be collected from Thematic Services and Data providers. This goal can be classified as a "*from the System to the Users"* action.

Further information about the use cases can be found in a previous deliverable (D6.2 M36)

From users to system

The e-Architecture of EPOS was designed and refined to match ICT, legalistic and strategic requirements. In order to model the detailed functional and non-functional requirements, a preliminary study of the stakeholders involved in the use of the system was carried out, allowing us to identify the following stakeholder categories which can interact with the system:

- Data and service providers from the solid Earth Science community, i.e. *Thematic nodes and Datacentres;*
- Scientific user community, i.e. *Scientists* (with a precise idea of the data (s)he is searching for and a well-defined knowledge of the data types that will be used; also high demand on analysis functionalities and need to download data);
- Governmental organizations, i.e. *Policy Makers* (with a low level of background knowledge and low demands on the analysis functionalities but with precise ideas about the information (s)he is searching for and high demands on visualization options);
- Other data and service providers and users, i.e. *Everybody;*

- General public (with a low level of background knowledge and low demands on the analysis functionalities).

Such actors can use the system according to some use case; a subset of them is here reported as an example:

1. **Non-seismic data for seismologists**. One of the key functionalities of the EPOS Portal will be to integrate data from different scientific fields. This UC describes the integration of seismological data with GPS and geological data. Here, the user will (i) search for the data of interest, (ii) find related data from different scientific fields (seismology, geodesy and geology), (iii) select among the options: ‘download’ or ‘visualize’ or ‘process’.
2. **Synthetic policy-type use case for hazards information**. In this Use Case, a “Policy Maker” will access the system to acquire information that will help in the decision making process. The information available through EPOS will most likely be only part of the information required for the decision making process, additional information will be sourced from third parties outside EPOS (for example cadastral health habitation data).
3. **Surface change detection after eruption**. A scientist wants to know how the surface of a region has changed after a big volcano eruption. In order to get this information (s)he wants to access Satellite images of the area before and after the specific eruption. With these Satellite images (s)he can perform a “change detection” or other more advanced techniques (e.g. SAR-Interferogram) to get information about surface changes.

The following diagram (Fig. 2) shows the different steps and choices of UC 1, expressed in the Business Process Model and Notation.

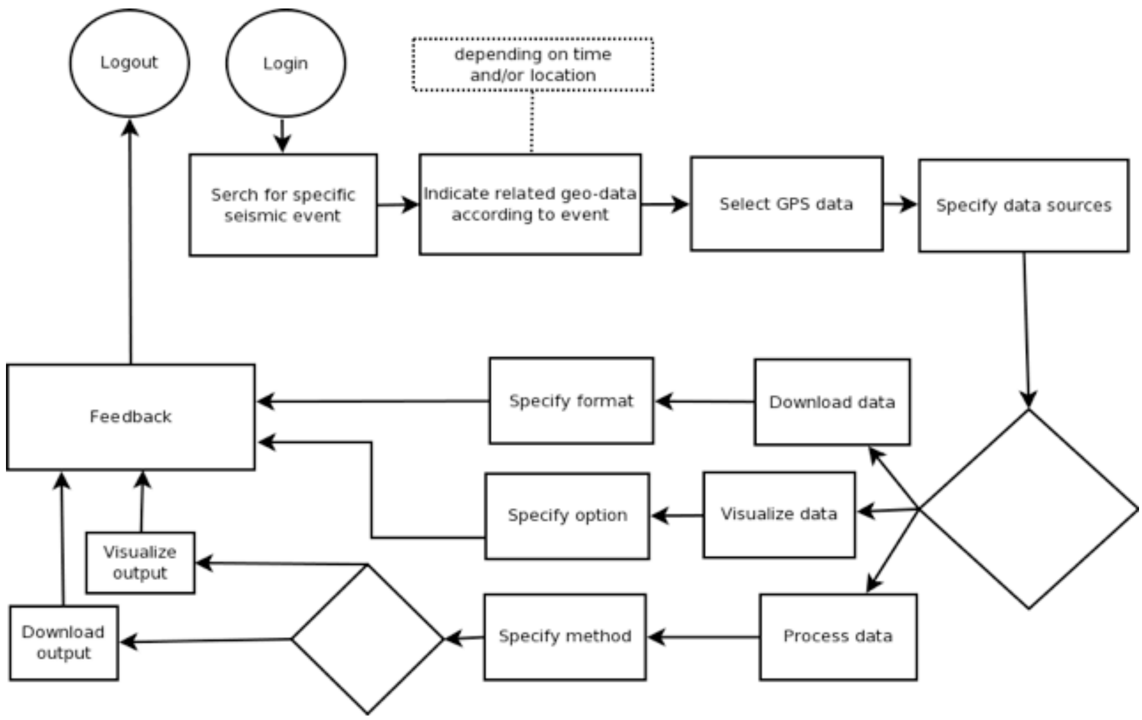

Figure 2: BPMN (Business Process Model and Notation) of the "Non Seismic data for Seismologists" Use Case

The UCs were described in detail by means of the UML description language and with additional documentation, and as an outcome the Functional and non-Functional requirements were outlined. It's out of the scope of this paper to describe them in detail; however it is worth evidencing that:

- *Functional Requirements* outline a system with strong integration functionalities: integration of data but mostly of services. Also, the idea of a personal area where the user can process and use its data on the cloud is expressed. Additionally, all features including users interaction as forum, help desk, social area, integration with local news are taken into account
- *Non Functional Requirements* outline a system with high performance on a distributed environment and ease of use. Of course complex actions including processing and other services can be carried out in an asynchronous way.

From system to users

Data providers were asked to contribute information explaining the resources they provide and the technical configuration of the services. This enabled the EPOS developers to properly define the interaction of the ICS with the external resources (as for instance TCS).

Information was obtained as follows:

- *RI metadata, which describes the RIs*: existing research infrastructures information stored in RIDE. This metadata were migrated into a formal metadata Catalogue based on CERIF (CERIF - Common European Research Information Format), described in the following paragraphs.

- *Scientific metadata:* The scientific metadata are described by means of the metadata standard used in the community of interest as for instance web services. It corresponds to the detailed metadata layer in the three-layer metadata structure used in EPOS, described later in this document.
  In this context a very useful tool was the "**data taxonomy**", discussed and agreed by Working Groups in EPOS, which presents four levels (examples taken from seismology):
  Level 0*: Raw-data or basic data (e.g.: seismograms, accelerograms, time series);*
  Level 1*: Data-products coming from nearly automated procedures (e.g. earthquake locations, magnitudes, focal mechanism, shakemaps);*
  Level 2*: Data-products resulting by scientists' investigations (e.g. crustal models, strain maps, earthquake source models);*
  Level 3*: Integrated-data products coming from complex analyses or community shared products (e.g. hazards maps, catalogue of active faults).*

- *Technical TCS details*: Data providers also had to describe their infrastructure by means of technical details which facilitate the task of the ICS developers in understanding: *i) protocols to interface to the TCS*: how ICS should communicate to TCS systems, (compatibility layer described below); ii) *size and frequency of requests* that the integration layer can send to the TCS.

THE E-ARCHITECTURE

EPOS e-Architecture passed through three different phases: *strawman*, *woodman* and *ironman*. They represent incremental refinements of the starting architecture updated following discussion, collection requirements, Use Cases and other activities, including synergies with other EU projects and initiatives. The main concept is that the EPOS TCS integration is achieved into the ICS by means of a communication layer called the “compatibility layer”. This layer contains all the technology to integrate data, data products and services from a single community into a single integrated environment: the Integrated Core Services (ICS). The EPOS e-architecture has been then progressively refined taking into account requirements as they evolved, the information in RIDE, and the changing ICT environment, thus leading to a new functional architecture, depicted in Figure 3 and explained below.

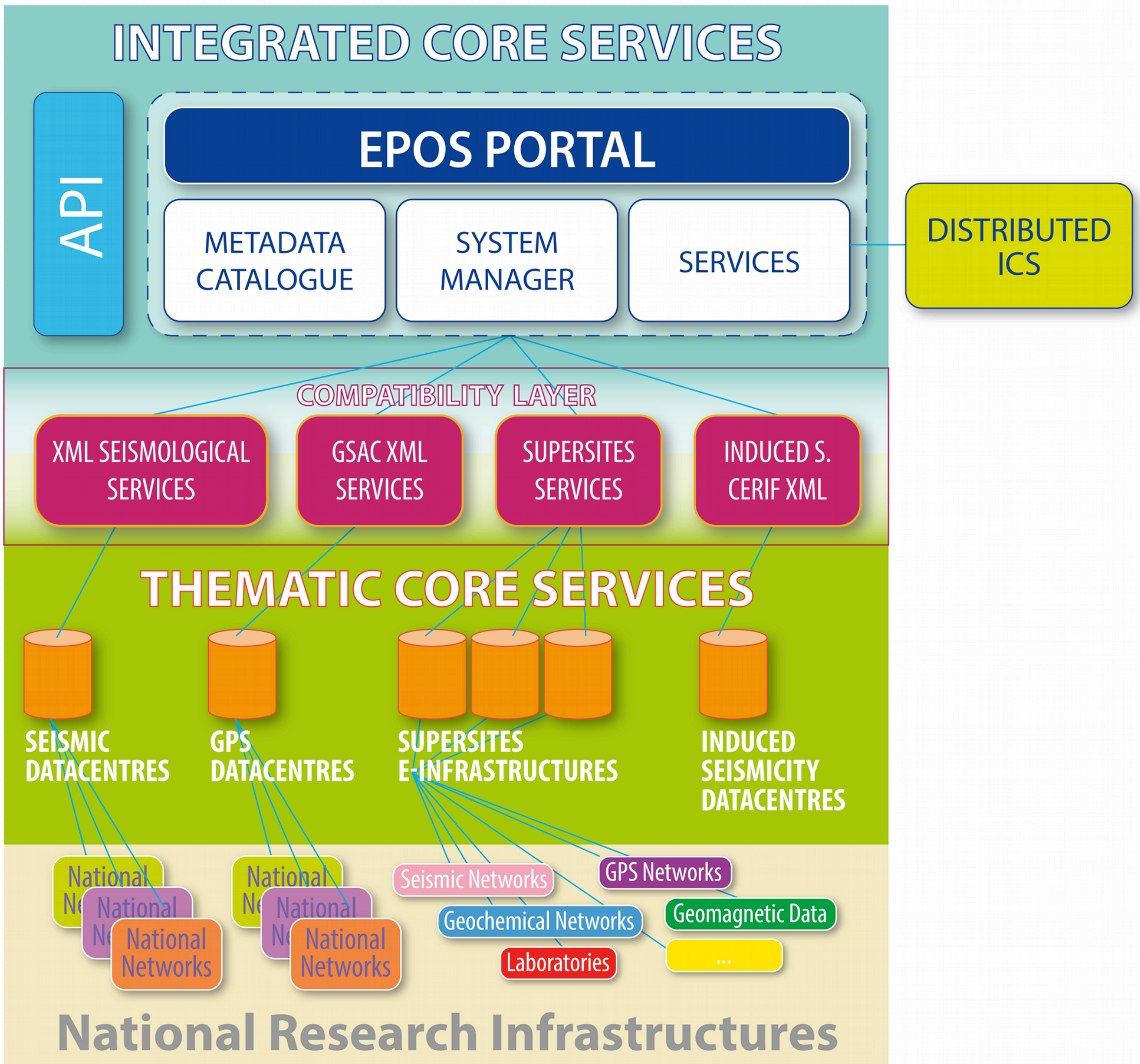

Figure 3: Functional Architecture

The key to this functional architecture is the **metadata catalogue**. It is enabling a complex query over all different domains under consideration of cross relations between datasets, research infrastructures, organisational structures and person. On top of that the metadata catalogue will provide all information about how to access the data and is therefore the core feature of the compatibility layer. A three-layer metadata structure was proposed and agreed as follows (see also Fig. 4):

- an upper layer for discovery, using Dublin Core as metadata schema extended to include the capability to generate from the underlying contextual layer – in addition to Dublin Core – DCAT, INSPIRE and both CKAN and eGMS to allow integration with government open data (data.gov) sources;
- a middle layer as a contextual layer, using CERIF (Common European Research Information Format, recommended to the EU Member States as a tool to harmonize databases on research projects,);
- a lower layer, which includes detailed metadata standards by domain or even individual database for each kind of data (or software, computer resources or detectors/instruments) to be (co)-processed.

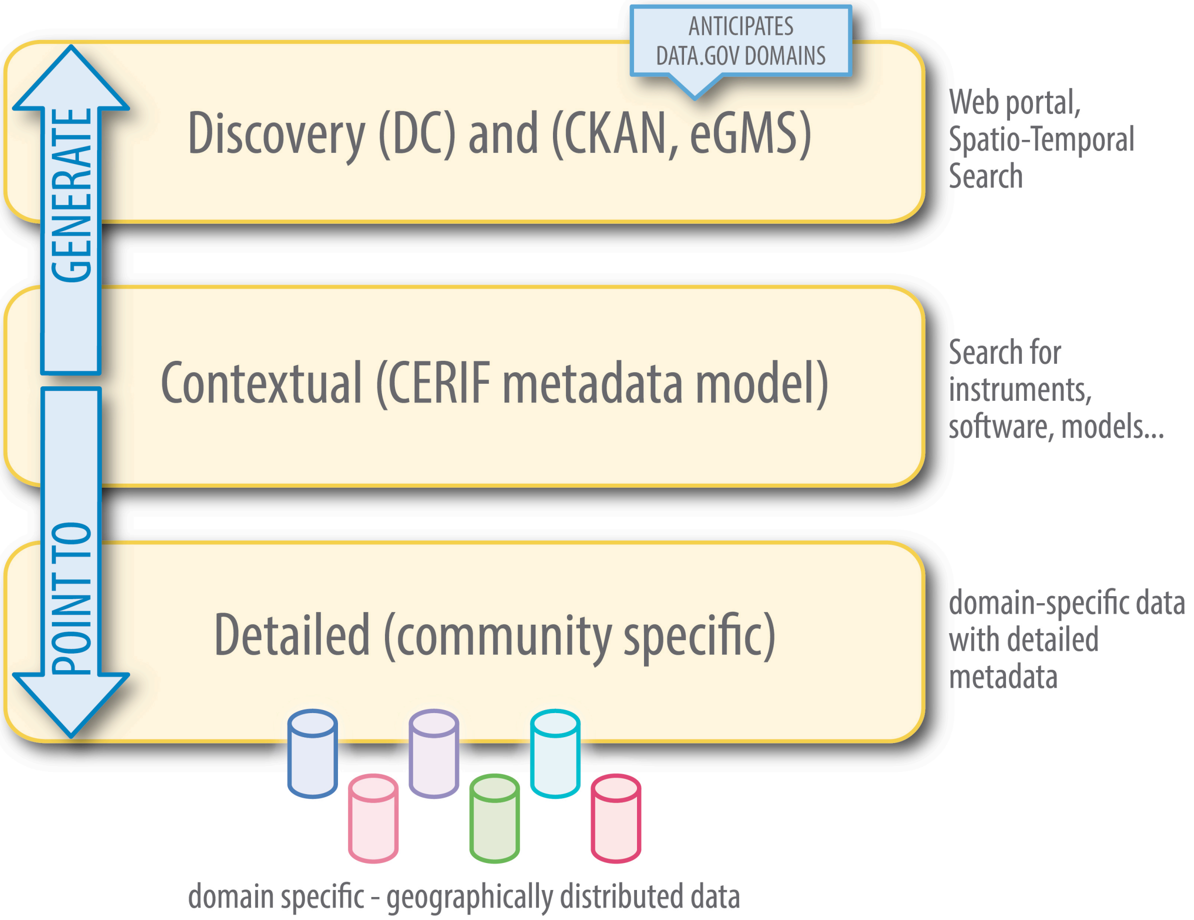

Figure 4: Three layer Metadata Architecture

The metadata describe not only datasets but also software services, users and resources such as computers, datastores, laboratory equipment and instruments. It is clearly understandable the need for extensive maintenance of this information in the catalogue. This could be done by human means but we propose to use a mix of human actions aided by appropriate software tools to keep the catalogue up-to-date and to ensure that all accesses and uses are appropriate. Indeed this is a typical task that is accomplished by what we call EPOS system manager.

The System Manager can be considered as the “intelligence” of the system, and is basically a software which manages the whole system. The System manager takes advantage of the information contained in the catalogue (which is the “knowledge base” of the system) and makes proper decisions according to: (i) user requests, (ii) available resources, (iii) metadata contained in the EPOS metadata catalogue. Therefore, in a EPOS context, this is the place where the brokering techniques – but driven by the metadata in the catalogue rather than by program code in the software – will be effective.

The linkage of ICS to TCS is possible through the **compatibility layer**. The thematic core services (TCS) have been developed (or will be developed) independently by their respective communities. The problem facing EPOS e-infrastructure architects is how to integrate them most efficiently, ensuring timeliness of updated data but also presenting the EPOS end-user with a homogeneous access over the real-world heterogeneity of the systems. The TCS offer varying interfaces; usually just end-user services to discover appropriate datasets or software and –in some cases – limited processing. ICS can either (i) interface to the services (using entries in the EPOS catalogue) or (ii) to the datasets and separately the services providing appropriate data processing for those datasets or (iii) both kinds of access. It is this latter option we are pursuing.

The advantage of the three-layer metadata architecture is now apparent. From the top of the stack to the bottom heterogeneity increases. The middle – contextual – layer is the *lowest level of commonality across heterogeneous sources* and thus the integration or binding layer. Thus the integration of TCS into ICS is possible via a ‘compatibility layer’ which includes metadata to ensure appropriate context (including discovery) and mappings of data structures with associated convertors. In other geoscience project the compatibility layer represents the broker function coded in software, but in EPOS much of the functionality is common using the contextual metadata and so only the detailed-level metadata mappings with associated convertors have to be produced. The ‘compatibility layer’ is illustrated in Figure 5.

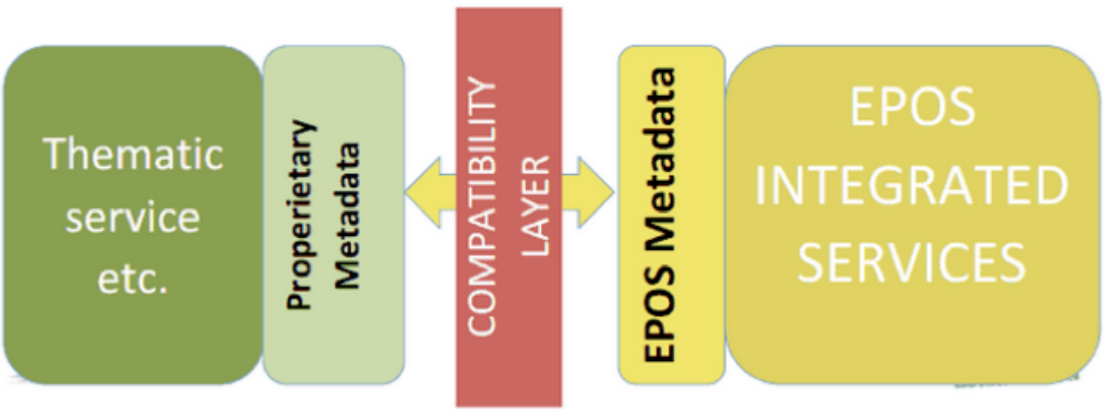

Figure 5: compatibility layer concept

Access to TCS data is usually through provided (web) services which are recorded in the EPOS catalogue. However, the same technique will also provide direct access to datasets if the TCS exposes the dataset URL or other navigational metadata.

The function of the compatibility layer is to get the resources requested by the user and translate it into a common format that can be managed by the system the user interacts with.

E-INFRASTRUCTURE AT WORK

As described previously in "non seismic data for seismologist" use case, a user might want to retrieve different data products: for instance get some geological map from a federated service (e.g. Onegeology) together with some seismic events plotted on the map. In this case the System Manager manages the compatibility layer so that it:

1. connects with a certain protocol (in this case Web Map Service - WMS) to Onegeology and get the desired maps

2. connects with a certain protocol to the seismic event service provided by community (e.g. quakeML)

The following sketch (Figure 6) shows the example with a simple diagram where it is evidenced that compatibility layer is a *translator* or *converter* of different protocols into a response format that the EPOS system can interpret.

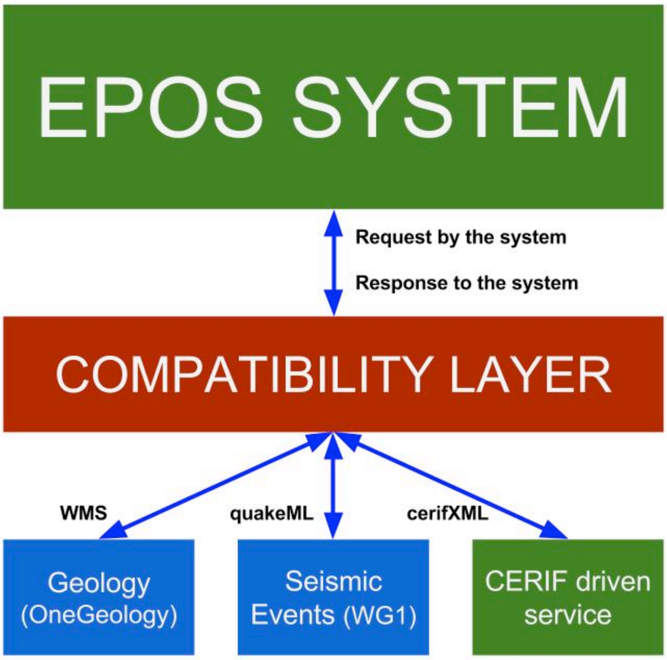

Figure 6: compatibility layer in action

As the EPOS Metadata Catalogue is based on CERIF, which also can expose metadata through cerifXML, then external services using a catalogue shaped with the CERIF data model can be considered 'natively compliant' with the whole EPOS system.

Summarising: the EPOS e-architecture is designed to manage heterogeneity.

After having considered alternative approaches – such as brokering or 'building block' services or even homogenised distributed database technology - EPOS uses a metadata catalogue with the CERIF format to allow (a) wide interoperation (b) succinct but accurate representation of the 'real world' to the lowest possible level where there is commonality across users, data, software and resources. In this way a homogeneous representation of heterogeneity reduces dramatically the combinatorial explosion of required services. As has been stressed in earlier sections, EPOS is not just about data but also the users, software services, laboratory services and IT resources surrounding that data.

EPOS is a confederation of institutional, national and TCS nodes integrated through the ICS. The nodes evolve and change as will the ICS based on user requirements. Flexibility is the key and EPOS is designed – by using the catalogue approach – to have one place where changes are recorded allowing dynamic and automatic reconfiguration of the rest of the system.

EPOS does not stand-alone; the project team are cooperating with other projects integrating various aspects of geoscience and – wider – environmental science. Additionally, EPOS is taking advantage of ICT research in relevant projects within the EC 7th framework programme and some national programmes.

EPOS Prototype

Actual prototype architecture

For the development of the prototype, software developed in the framework of collaboration with VERCE project was used. The prototype is programmed in Javascript and uses GeoEXT and the Sencha framework to organize the graphic user interface.

The Application integrates data from several different resources using different techniques. A detailed description of those different resources will be given in the following chapters.

The main visualisation element, the map of the application, is composed of multiple layers of Web Map Services (WMS) with adjustable transparency.

Depending on the selected products, a search request to the application triggers search requests to the EPOS extended CERIF catalogue. Additional queries are sent to community specific web services that return data in domain specific formats. The data are parsed and stored on client side. The data with spatial information are automatically visualised on the map.

Filters can be applied after the information is returned from all services. For seismic event data, filtering through some geodetic parameters– as crust thickness of the earth – can be applied. A full text search can be applied on all returned results. The filtered information is organized in a tabbed view and spatially characterized products are displayed on the map.

The Graphic User Interface

The user interface of the prototype is a Javascript application that is displayed with an internet browser (Fig 7). It collects and displays information of the extended CERIF catalogue and the result of embedded services. The browser window is splitted in four areas (see red numbers in figure 7).

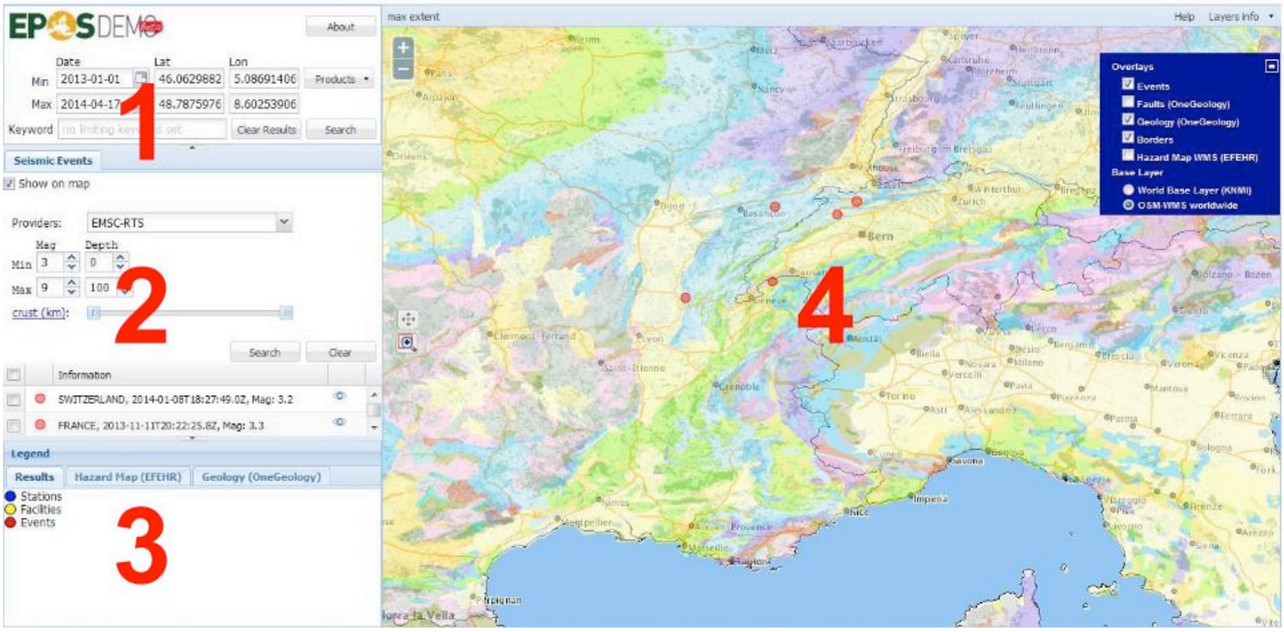

Figure 7: EPOS demonstrator screenshot

Area (1) in the upper left is used to generate a search request to the system. The user selects here EPOS-products from the products menu and generates a search request by entering information that should be common to all selected products. This common information could be spatial coverage, temporal coverage and keywords for the free text search.

Area (2) in the middle left shows the results in tabs. There is one tab per product group. The visualization on the map can be toggled here. If applicable, further information can be entered to refine a search on the selected product group. If a result entry of a result tab is chosen, the associated marker of the map (Area (4)) is selected and displays full information in a popup window.

Area (3) in the left bottom is used to show a legend for the information displayed on the map.

Area (4) holds a map, which initially shows the European region. Visual information is organized in several layers. On the map the location of search results are displayed by using markers of different color. By selecting a marker the associated result tab entry in Area (2) is selected and further information is displayed in a popup window.

Involved resources

The development of the demonstrator was started with the contribution of several institutes from the Seismology, Geology and Geodesy domain. The different service-providers are listed in figure 8, together with the used specific connection technique.

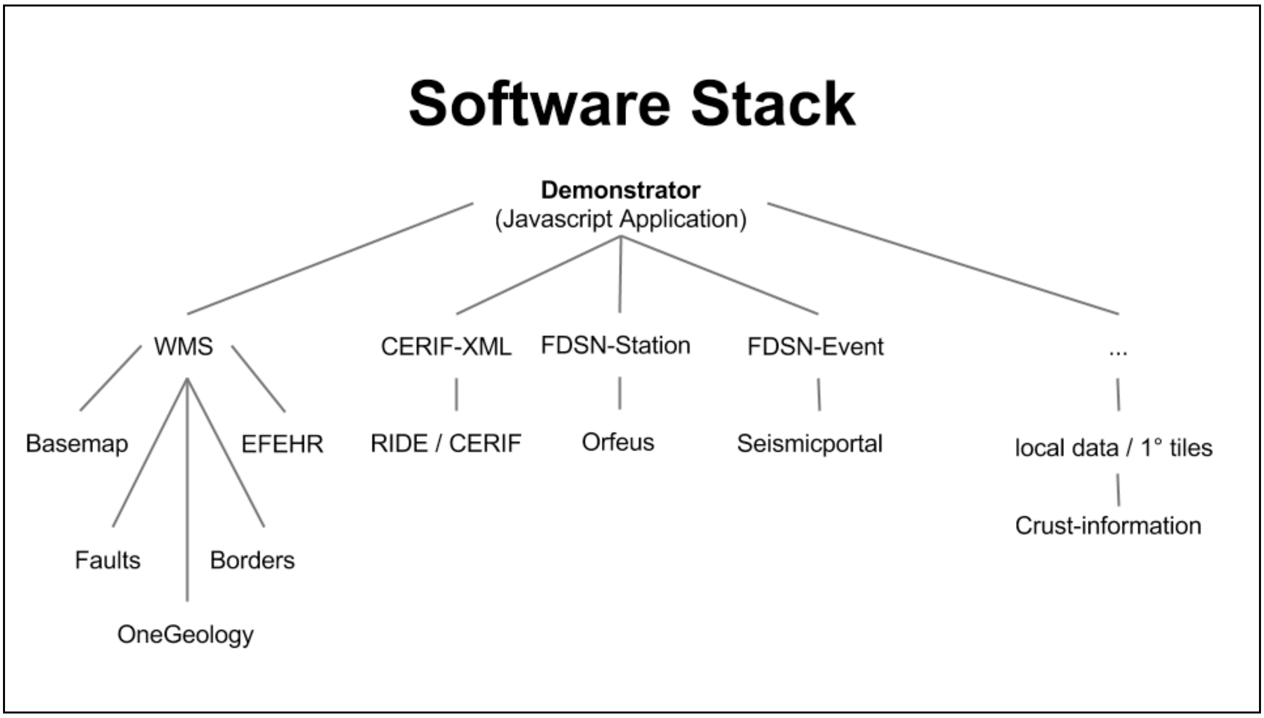

Figure 8: EPOS demonstrator actual software stack

The **EFEHR** project (European Framework for Earthquake Hazard and Risk) offers WMS with Hazard and Risk maps for Europe as products of seismological analysis, which are implemented as Map layer in the demonstrator.

The European network of geologic institution **OneGeology – Europe** is offering a common representation of the European geology as WMS which has also been implemented in the demonstrator.

The **Basemap**, **national borders** and a representation of **Faults** are also implemented as map-layers.

Information which is stored in the **CERIF** based central metadata catalogue, like person, RIs, etc., are accessed via the CERIF-XML services.

The project **Orfeus** (Observatories and Research Facilities for European Seismology) is offering a full list of station information of the **EIDA** initiative (European Integrated Data Archive) via the FDSN-Station Webservice.

A list of seismic events is offered by **EMSC** (European-Mediterranean Seismological Centre) via the FDSN-Event Webservice.

A special filtering option at least for seismological events is available: it allows a user to narrow result list for specific range of **crustal thickness**. Due to the lack of Webservices which provide such information, the data are taken directly from a local file with 1° tiles over whole Europe. It is reported as an example of the possibilities that the integration of data and metadata will offer to user and data providers in the future.

The extended demonstrator: a use case

A way to test and to evaluate a theoretically planned architecture is to develop a prototype which is a first example of how the architecture could work. The demonstrator is one step before the prototype, it is simply demonstrating how people could use such a tool, but in contrary to the prototype, it is not totally fulfilling all planned architectural requirements. People should get in contact with the EPOS ICT ideas, and the benefits of such a tool must be pointed out, as already described in D6.5 M36

This first implementation focuses on only a few use cases and is therefore containing only a small number of features which are essential for those use cases. Since this first implementation is mainly based on Seismic, Geologic and Geodetic data form a selected group of datacentres, the use cases are also focusing on these domains.

One of the elementary features of the EPOS Demonstrator web application is to create intersections among different domains, i.e. the query results gets data from different disciplines. One of the already implemented use cases focuses on seismic and geodetic data.

The central function is to take the general attributes of data products as query parameter for a secondary search carried on in other domains. Specifically this means that the location and the time of a seismic event can be used to get also geodetic events or datastreams for the same geographic region at the same date/time.

Many different data portals exist which are offering geoscientific data; however the added value of the EPOS demonstrator is the combination of data from different domains, which simplifies the work of geoscientists who wish to use data from different domains for their research.

Future work

The next most important milestone will be to complete the EPOS prototype as part of the final deliverable.

The major improvement of the code so far will be the usage of the central catalogue as compatibility layer. Information about how the data can technically be accessible will be stored in the database more dynamically. We refer to this step as *vertical integration*.

Another improvement will be the extension of the number of the datacentres by Geodetic and Supersite Datacentres and eventually further more. This step then can be referred to as *horizontal integration*.

Besides such important tasks, also a number of central features like a text search or advanced filter options will be part of the EPOS prototype.

A PLAN TO ENHANCE INTEGRATION

Integration of data, data products and services is not something that happens independently from our efforts to achieve it. It is on the contrary the result of several parallel actions which are being carried on simultaneously in the EPOS plan. Many of them deal with fields different from ICT, for instance community building actions, outreach initiatives or the huge work dedicated to depict a legal framework and data policy access.

In such fields, a key to the integration is the involvement of the EPOS members in the different WGs. Under the technical point of view it has been one of WG7 main concerns since the beginning. Involvement of experts in information technology, metadata standards and handling of data is indeed a mandatory action when aiming at building together an infrastructure whose impact on Earth Sciences may go beyond any expectation.

At this stage the general feeling was that the TCS designers needed a stronger link with the ICS system designers in order to be sure that interoperability between TCS and ICS could be effective. For this reason a Recommendation Board was set up.

EPOS Recommendation Board

In order to work and guide TCS and community towards the integration of TCS into ICS, we created a recommendation board whose goal is to provide

(i) best practices examples,

(ii) recommendation and/or discussion about

   a. standards to be used (metadata standards, protocols, data sharing strategies)

   b. AAAI implementation strategies

   c. strategies to identify/manage digital objects (PIDs)

(iii) A TCS startup kit, which comprehends

   a. cookbook

   b. online support

   c. guidelines (recommendation board, wiki)

   d. open source technologies to build startup software

The board started its meetings and drafted a list of priorities among the suggested list of actions. At the moment challenging issues as IAAA have been tackled, and a research about the main available technologies has been carried on evidencing that powerful and open source standards are already available, for instance kerberos and openId.

Standardization

Through the constant programmed meetings, involving ICT contact persons from each working group, the Recommendation Board is carrying on a relevant action which will enhance the level of standardization of the communities. Indeed, through discussion technical experts from WGs, whose work is often confined into the boundaries of one discipline, can widen their technical view and understand, at a global level, the technical needs to achieve interoperability.

One of the very ambitious expectation from this board, which is getting reality, is indeed the adoption of common interoperable standards for data exchange and – with a more long-term view – common interoperable standards for data formats. This action is fundamental not only for a more efficient TCS-ICS connection: this is a vision towards a future where data-intensive science challenges will have to be faced.

CONCLUSION

As demonstrated in this report; the EPOS WP6 WG7 team and their co-workers have reached the stage of approaching the required prototype as the final deliverable. This has been done in steps in order to reduce risk and maximise on the work off the previous step, thus minimising resources used. The goal of EPOS is ambitious, and this necessitated an ambitious e-infrastructure architecture.

The demonstrator has shown feasibility and the prototype will demonstrate actual use with a higher degree of automation thus reducing the required actions off the end-user. The final production system will build upon this work in EPOS-PP to produce a virtualised environment, driven by the metadata catalog, so that end-users do not have to be concerned with the detailed technical aspects but just state what they require of the system and let the system provide it.

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Submitted and approved by:	Name of the person(s)

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[Closing Page – EPOS PP Deliverable n. 6.6 – 2014-04-30]

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