P1.48 FEDERATING EOS HETEROGENEOUS AND DISTRIBUTED INFORMATION RESOURCES

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1. INTRODUCTION

Environmental and geographical data describing atmospheric or terrestrial phenomena are collected in digital form since three decades.

Geomatics, that is automatic management and processing of environmental and geographical information, is changing from a niche discipline to a horizontal application area, involving scientific as well as industrial and institutional bodies. Nowadays, in the "Internet Era", it is reasonable to expect this wealth of data to be accessible and shareable in a simple and coherent manner among the different actors of the geo-science arena, integrating the existing information systems with the ones that future missions and research activities are set to provide.

The key factor for these expectations to become reality is interoperability, which may be generically defined as "*system cooperation for the sake of information and process sharing*". Guaranteeing interoperability means to solve such problems as: domain ontology heterogeneity; data encoding mismatch; software application distribution and heterogeneity; data protection and accessibility.

In the geophysics sector, these questions are even more complex, because of the data inherent multidimensionality (e.g. spatial, temporal and sampling features).

In this overall picture, the Earth Observation from the Space (EOS) community is a cross-sector community encompassing Meteorology, Oceanography, and Hydrology, with specific needs for on-line cataloguing and interactive information processing, due to: the enormous amount of existing data, the present, ever-increasing data growth rate (caused by remote sensing technologies evolution, namely in satellite imagery) and the intrinsic heterogeneity level among data producers.

The EOS community has always faced problems such as acquisition, management and access to huge data amounts, implementing largely heterogeneous and autonomous solutions under the logical, the methodological and the technological point of view.

Today, distributed computation and networking technologies prove mature enough to allow standard connectivity and access to multi-medial *data*, but the real problem is the integration of higher level *information*, that is data along with their ontological and operational semantic significance.

There have been efforts in standardization of data types and methodologies, with various degrees of success and diffusion (see http://www.statkart.-no/isotc211, http://www.opengis.org), but their adoption on a large scale remains hindered by the actual difficulties to adapt any common model to the peculiarities of existing data collections.

2. THE ITALIAN EOS-COMMUNITY REQUIREMENTS

We addressed the needs and the requirements coming from the Italian scientific Community working in the EOS sector. It is possible to summaries these requirements as to develop the integration of existing legacy information system, considering the following mainly constraints:

- To preserve the autonomy of each data resource systems (both existing and future ones); especially, resource design and communication autonomy (Ozsu, Valduriez, 1999);
- To integrate heterogeneous data and metadata in a dynamical and transparent way;
- To make (multiple autonomous) distributed resource systems interoperable for data mining services;
- To adopt a distributed authorization policy and a single-sign-on approach.
- To elaborate a solution able to react on changes (i.e. flexible to evolution).

EOS datasets are multidimensional, and their structure and encoding is heterogeneous; often, data have no structure or implicit one (e.g. flat-files). Moreover, in order to fully and effectively utilize EOS datasets, their related metadata is essential. There are several different metadata categories: semantics, extension (e.g. spatial and temporal extent metadata), content, quality and so on. Metadata modeling and encoding are heterogeneous, as well.

As far as a general perspective is concerned, important requirements of the application domain were:

- To avoid data overloading, implementing semantic integration among heterogeneous data sources.
- To integrate legacy data sources and systems in an efficient and modular way;
- To device an architecture well-suited for evolution.

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3. THE DEVELOPED SOLUTION

We developed a solution to implement interoperability among legacy EOS-dataset information systems, mainly with regards to the crucial processes of information search and retrieval.

In extreme synthesis, the developed solution can be seen as a Visual Broker for On-line Catalogues of EOS information resources.

The solution goals were:

- to design a simple, extensible ontology for On-line Cataloguing of EOS Datasets and utilize such ontology as the Common User Model of a federated information system (*FIS*), which integrates multiple and disparate EOS information resources;
- to enable EOS information resources to join the FIS and publish their data and metadata in a secure way, without any modification to their existing resources and procedures and without any restriction to their autonomy;
- to enable Users to browse and query the FIS, receiving a combined result which incorporates relevant data and metadata from across different resources, in a transparent way and by means of standard Internet technologies;
- to accommodate the growth of such FIS, either in terms of its Users or of its information resources, as well as the evolution of the underlying data model.

In the following sections, we delve into the above points and the utilized approach to them, with special regards to the used data and metadata model as well as to the user experience and interaction.

Lastly, we briefly describe the technical aspects of an experimental implementation of the solution, along with the obtained results.

4. AN ONTOLOGY FOR ONLINE-CATALOGUING OF EOS INFORMATION RESOURCES

A FIS depends on models of resources and models of the user application needs. In accordance with Wiederhold and Genesereth (Wiederhold, Genesereth, 1997), we consider that, facing complex tasks, people categorize the processes and objects to be dealt with, so as to apply a divide-and-conquer paradigm. Hence, we introduced a hierarchical common model. The use of hierarchies also complies with the need for conceptual clarity.

The introduced common model lies at a conceptual level rather than at a database schema level. In fact, the presented system must mediate across complex sources, whose data may pertain to distinct EOS communities (e.g. oceanography and atmospheric communities). Therefore, the system mediated views were defined and worked out at the level of conceptual models rather than at the structural level.

The common conceptual model introduces a common ontology, according to which data sources are modeled. An ontology is the working model of entities and interactions in some particular domain of knowledge or practices, used to help humans share knowledge by creating an agreed-upon vocabulary for exchanging information.

To facilitate extensibility, we introduced a common conceptual model which was obtained as a simple profile of existing standard reference models for geo-data (i.e. ISO 19107; ISO/TC Geographic information/Geomatics 211, 2001; OpenGIS Consortium, 1999, topics 5, 6, and 11). That allows the integration of the most popular types of data models, addressing semantic and schema heterogeneity.

Figures 1 and 2 represent two RDF-based diagrams of the introduced ontology, dealing with the information resource conceptual model and the dataset conceptual model, respectively.

4.1 Metadata

Each data concept is characterized by a set of metadata that describe it completely. In particular the following metadata categories (ISO/TC Geographic information/Geomatics 211, 2001; Open GIS Consortium, 1999) are supported:

- *Constraint*: the restrictions placed on data
- *Content*: the content of a referring entity
- *Distribution*: the distributor of, and options for obtaining a dataset
- *Management*: the scope and the frequency of data updating
- *Data Quality:* a general assessment of the quality of the data, and the resources and production process used in producing the data entity
- *Extent:* the spatial and temporal extent of the referring entity
- *Localization:* the mechanisms used to represent spatial and temporal information in a dataset
- *Format:* the description of the computer constructs that specifies the data entity

Table 1 reports the used association between the utilized concepts of information resource of the EOS domain, and the Metadata types.

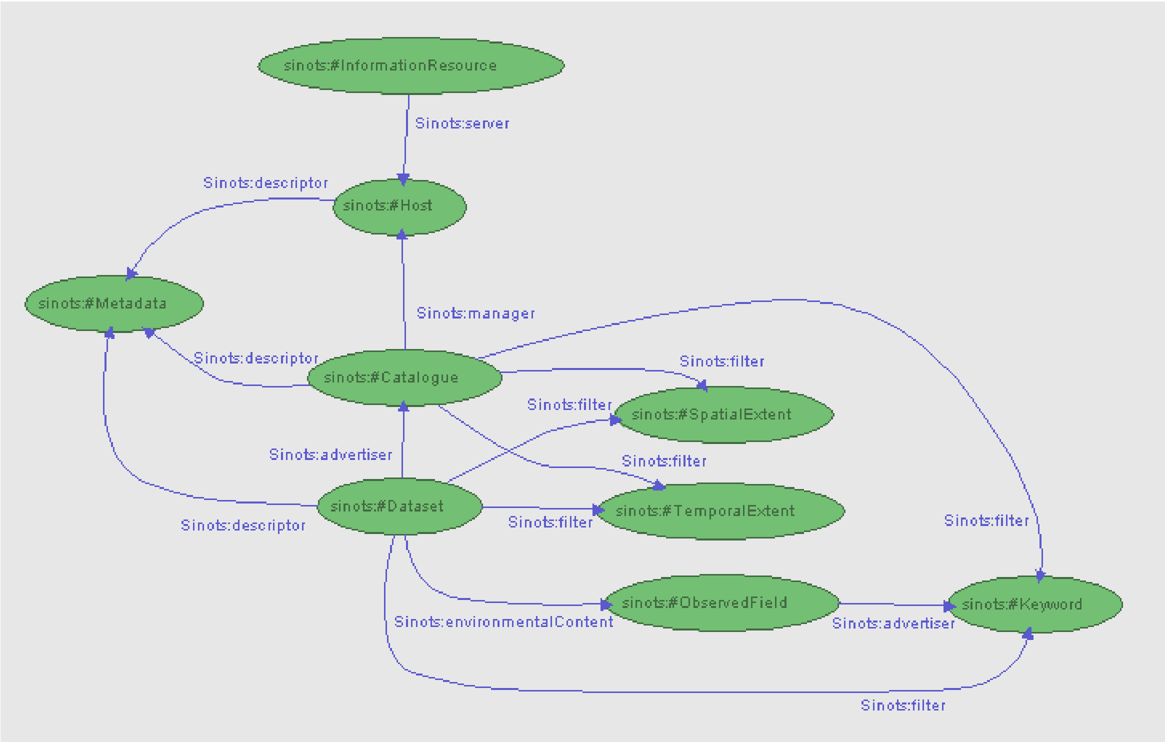

Figure 1: The introduced common ontology – information resources

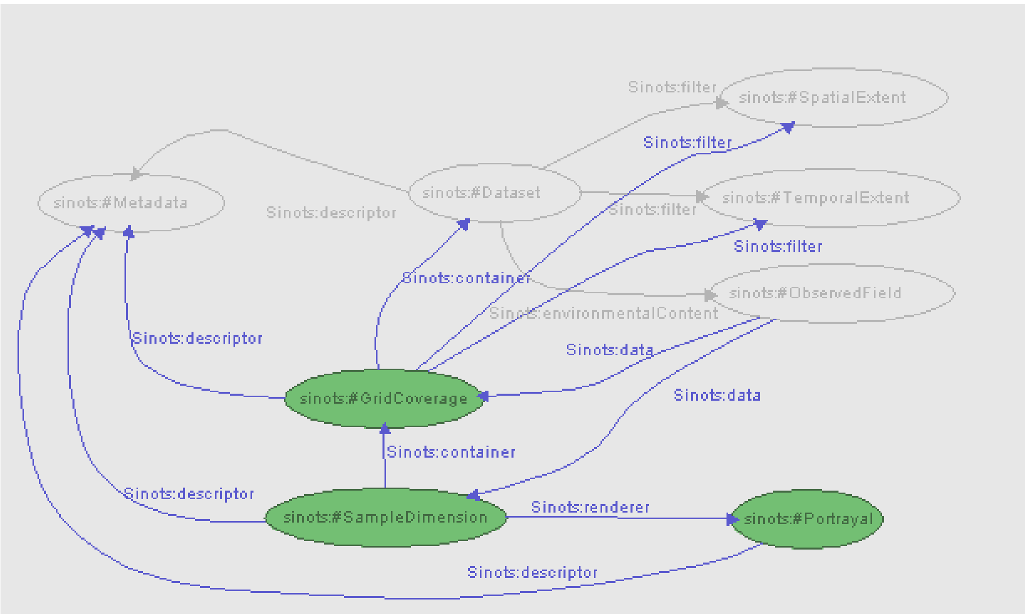

Figure 2: The introduced common ontology – Dataset

	Host	Catalogue	Dataset	GridCoverage	SampleDimension	Portrayal
Constraint		X	X	X		
Content		X	X			
Distribution		X	X			
Management	X	X				
Data Quality		X				
Extent		X	X	X	X	
Localization			X	X	X	
Format				X	X	X

Table 1: Metadata characterizing the different introduced domain concepts

5. A FEDERATION OF EOS INFORMATION RESOURCES

We reckoned that the best solution to our user requirements was a FIS, where the individual participants (i.e. EOS information sources) are self-contained autonomous systems, but together form a consistent wider picture: the federation, built around the hierarchical ontology of data and metadata discussed above.

We implemented a mid-tier integration approach, which utilizes the *wrapping* of parts of existing systems (i.e. EOS data sources) to form a Federated Information System (FIS).

The considered scenario is characterized by heterogeneous data sources, which are expected to be numerous and quickly evolving. We developed a model-based mediating system (Wiederhold, 1999), in which unified views are defined and executed at the level of conceptual models rather than at the structural level.

In order to guarantee data source autonomy, the developed FIS is a read-only system: the federation does not allow the updating (or insertion) of data into the participant resource systems, through the federation layer.

We adopted a top-down strategy for implementing the FIS: first we introduced the FIS unified information need, achieving the common model, then we plugged in the data resources, mapping their contribute to such need. In this process, the actual schema of data sources was not considered for the design of the common model schema: there was no need to include resource schemas completely, only unified view data was required. Moreover, there was no need to represent data on the federation level exactly as in the data sources, an abstracted representation is required.

The developed FIS implements a virtual integration architecture: it materializes query results only temporarily -at the time the query is posed, implementing a mechanism to translate queries against the common schema into several semantically meaningful and executable queries against data resources.

5.1 The Mediator-based Architecture

As depicted in Figure 3, the architecture presents three logical levels:

- The Presentation Level contains customer applications to access a set of heterogeneous data sources (i.e. federated EOS information resources) as if they were a single one, transparently and by means of standard Internet technologies, through the mediation of the Mediator-based Federation level. The architecture is flexible enough as to accommodate *thick client* (e.g. a customized application) or *thin client* (e.g. standard agents such as web browsers);
- The Mediator-based Federation Level is a middleware software layer offering a uniform access to the federated resources. Uniformity is reached by the adoption of the common ontology, the definition of a uniform query language and the use of metadata describing the EOS information sources currently joining the federation; this services are handled by the *Mediator*, a software component distributed among the different nodes, and by the Directory Agent, providing a late-bound list of the federation information sources to the other participants;
- The Foundation Level integrates the data sources into the federation infrastructure by means of *Wrappers*, that hide technical and data model heterogeneities. Wrappers guarantee autonomy to the data sources and are the only component needing careful deployment customization. Appropriate technological choices allow for easy accommodation of different data sources, structured (e.g. DB) or semi-structured (e.g. XML files, flat files), and of possible subsequent modifications to them.

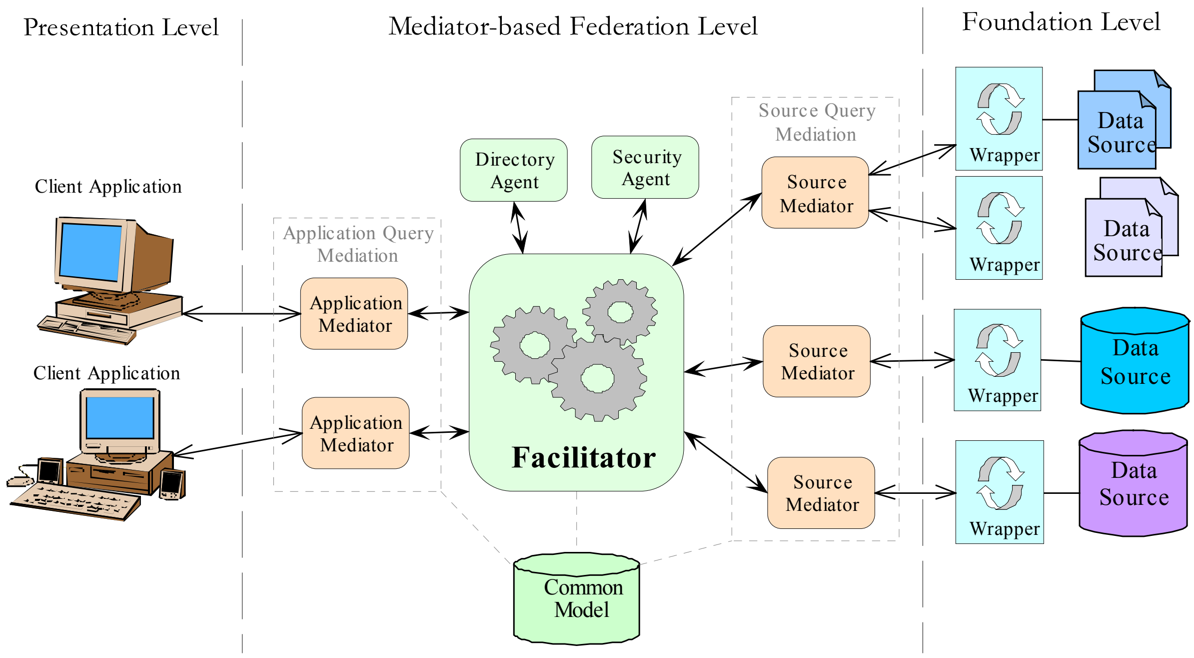

Figure 3: The adopted mediator-based architecture

5.2 The Security Infrastructure

Matching EOS-Community requirement, a sophisticated *security infrastructure* was implemented, featuring *Single- Sign-On (SSO)*, to protect EOS information providers whose datasets are under commercial license.

Shared data may not be freely available, but instead provided under commercial license, or research centers could decide to provide data to selected users only and at different prices, etc.

Many other security problems may arise when information sharing through a system federation is involved. Data providers are particularly concerned with three main security issues:

1. Access Control: data should be accessed only by authorized users;
2. Confidentiality: data should be read only by the proper recipient;
3. Non-repudiability: data download order should not be repudiable.

Access Control requires the adoption of an *Authentication, Authorization, Accounting/Auditing (AAA)* framework, tailored to the needs of the EOS data providers. For example they dislike a centralized authorization system preferring to decide grants on their own. On the contrary authentication should be centralized to allow the implementation of a Single-Sign-On (SSO) solution. The security subsystem was designed to satisfy these user requirements on a widely heterogeneous architecture with different authentication schemes (i.e. challenge/response, digital certificate, etc.). Data providers have different DBMS, Web servers, operating systems, so no legacy solution for AAA and SSO could be adopted. The only assumption is the availability of standard Internet technologies.

Data transfer confidentiality problem is addressed resorting to SSL, but since it requires digital certificate management for every local server, its use is optional and the adoption decision is left to local servers' administrators.

Local administrators need also a log file for access monitoring and billing purposes. Non-repudiability is achieved resorting to common public key techniques. They require that user obtain his/her own digital certificate with on-line or off-line procedures. Each time a data download request set is performed the user is prompted for the certificate path and unlocking password and the request is then digitally signed. The server stores the signature along with the request as the evidence that it was really made by that specific user.

For example Figures 4 and 5 show the login phase and the result of local authorization control at the GridCoverage level (note the highlighted "locked" resources in the inner branch).

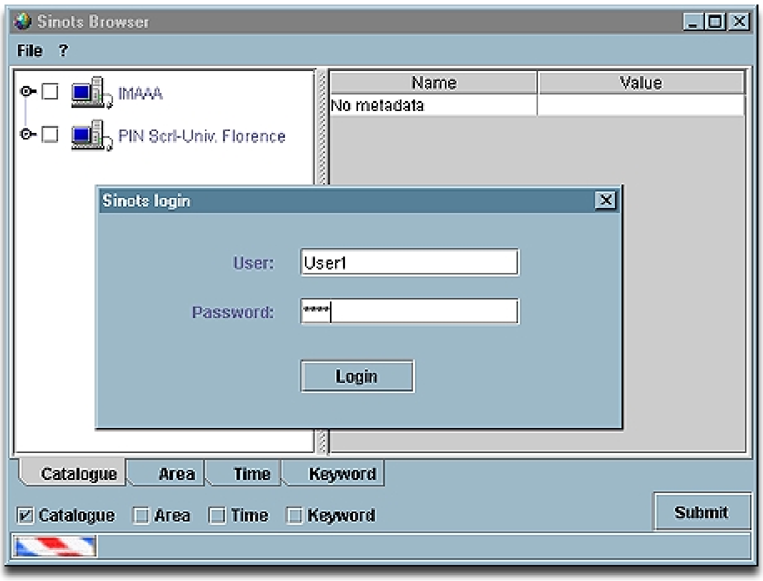

Figure 4: A User login interaction

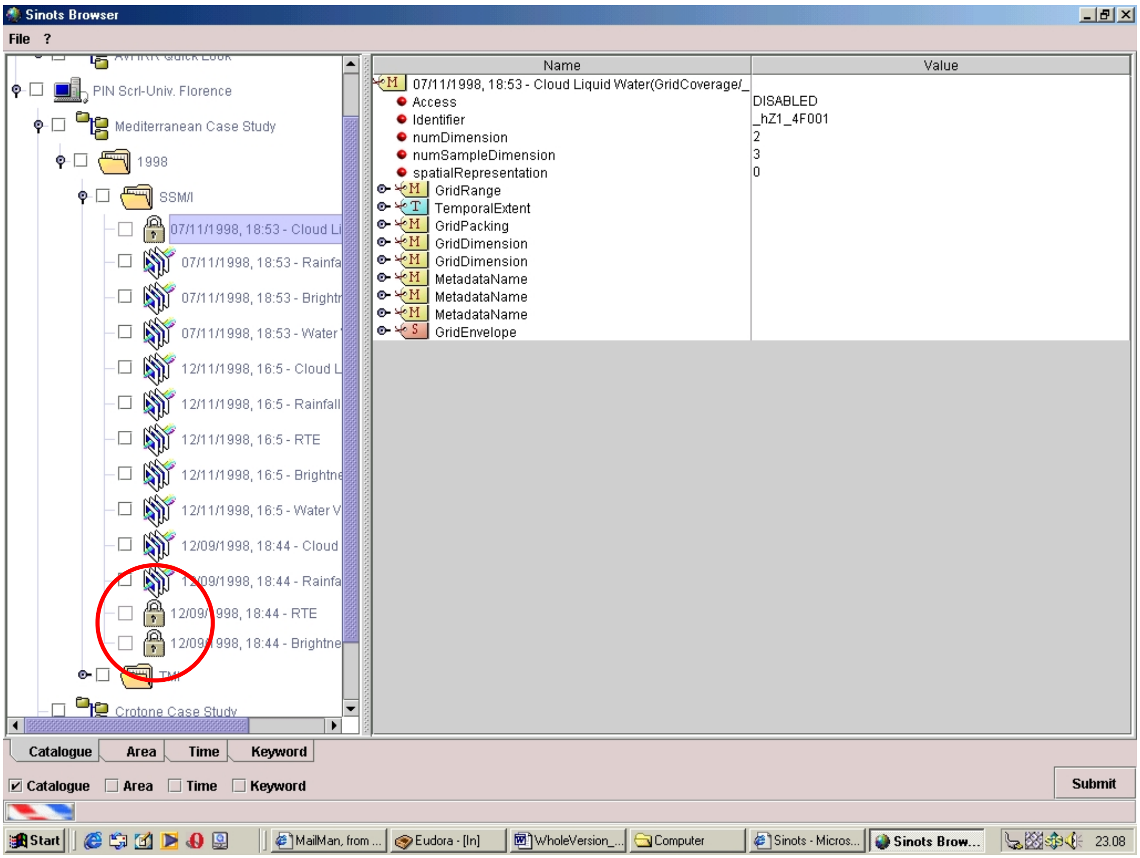

Figure 5: A possible User Interface rendering of locked resources

6. THE UNIFIED HUMAN COMPUTER INTERACTION MODEL

After the initial authentication phase, the federation presents the users a combination of browsing, querying and downloading services that may be requested contemporarily and asynchronously.

The interaction is completely driven by the federation unified view and integrates browsing and querying according to the tree-structured common model

An important open issue has been how to unify heterogeneous ontologies and human-computer interaction philosophies, which characterize our User Communities, in order to fully leverage the federation knowledge.

We decided to provide a relatively simple interface to ease user information discovery and navigation reducing the overhead of working with a potentially large number of resources.

We adopted two main approaches to address the reported issues, introducing a precise:

1. information space segmentation approach;
2. conceptual map navigation strategy.

6.1 Information Space Segmentation

The overall federation information space was segmented according to a *4-W metaphor*: *What*, *When*, *Where*, *Who*. Hence, user can navigate through and interact with data (i.e. data, query and result-set navigation) in a four dimensional space. Users have fifteen selection criteria specifying a combination of as many as four intuitive information properties:

- one or more data keywords (e.g. "rain map", "brightness temperature map") in the federation data keywords list, that is collected and aggregated dynamically as the union of locally managed keyword lists;
- a time interval representing the temporal extent of acquisition of the requested data;
- a rectangular spatial extent representing the area where the requested data insist;
- the set of Hosts, Catalogues or Datasets managing the requested data.

Figure 6 represents an example of the information space segmentation.

6.2 Conceptual Map Navigation

We utilized concept maps to navigate vast amounts of information by organizing it in hierarchical structures. Concept maps represent the EOS research community knowledge in an informal way. Namely, they stem from the federation ontology model, using the intuitive *aggregation* relationship to connect concepts.

We introduced two concept maps represented as graphical trees: the *Catalogue tree* and the *GridCoverage tree*.

Figure 7 and 8 show the two concept diagram in UML notation.

With reference to Figures 7 and 8, the colored concepts are abstract ones, while white concepts are concrete ones.

Fundamentally, the *Coverage* data concept, -as well as the *EarthImage* one- provides a n-dimensional (where n is 2, or higher) *view* of spatially distributed features. Examples are: multi-band satellite imagery, aerial-photos, volumetric radar scans. In our setting, the view is geospatially related to the Earth. A specialized type of Coverage was considered: the grid cell coverages (i.e. the *GridCoverage* concept)(Open GIS Consortium, 1999).

A *Portrayal* is a possible rendering of a sample dimension: an acquisition component of a grid cell coverage (e.g. a satellite band sensing).

Other specializations can be easily supported to include present and future specifications, due to the further level of abstraction provided by our approach.

Referring to the federation model, Users can navigate the *Catalogue tree* and discover data catalogues, sub-catalogues, datasets and sub-datasets, down to the grid-coverage level. Going further would provide a huge amount of fine-grained information, which is very often useless and confusing for a first information discovery. Once user has selected a set of interesting grid-coverages, he/she can ask for their components and the *GridCoverage tree* is provided in order to discover coverage characteristics, their components and optionally to get a quick-look of them. Figure 9 represents the user scenario for such interaction.

Figure 10 shows the couple of implemented graphical trees, according to the introduced concept maps.

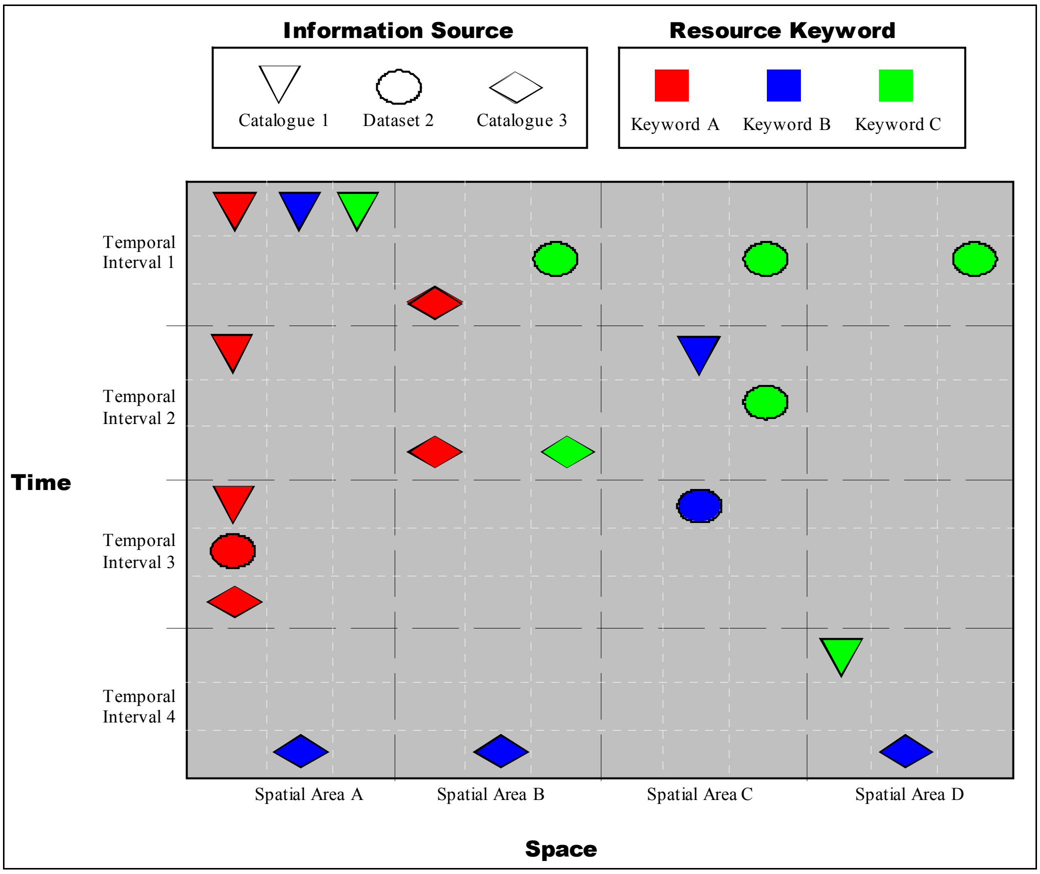

Figure 6: The adopted Information Space Segmentation approach

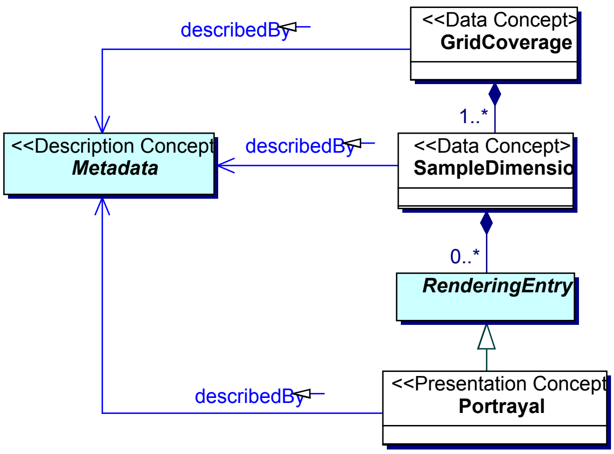

Figure 7: The first concept map diagram

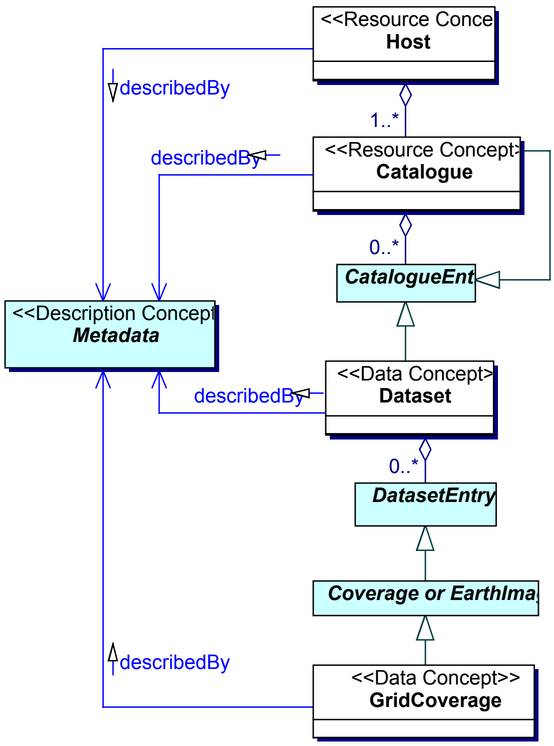

Figure 8: The second concept map diagram

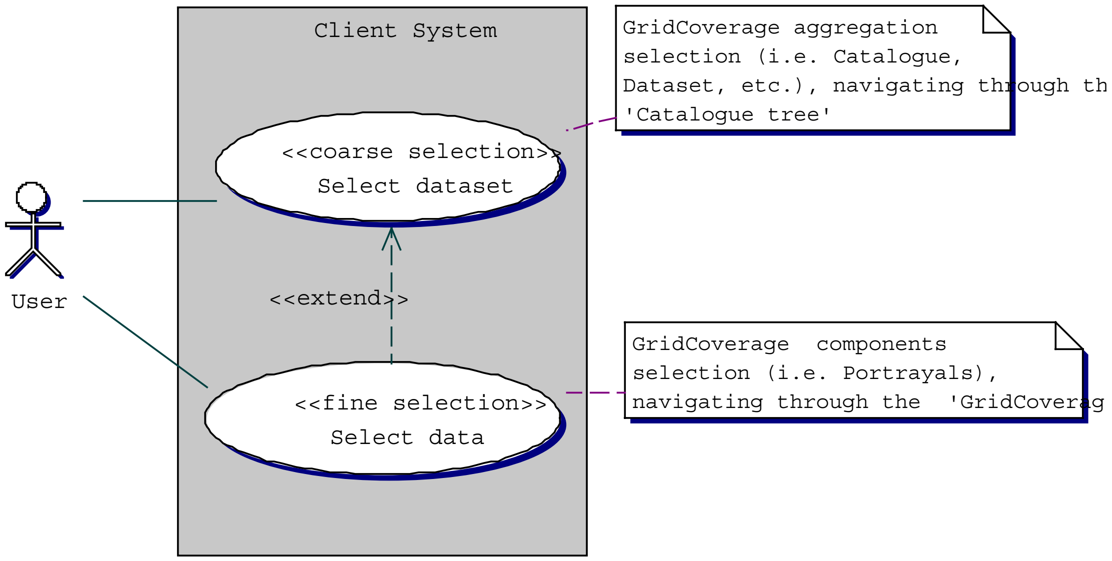

Figure 9: The adopted Conceptual Map Navigation strategy

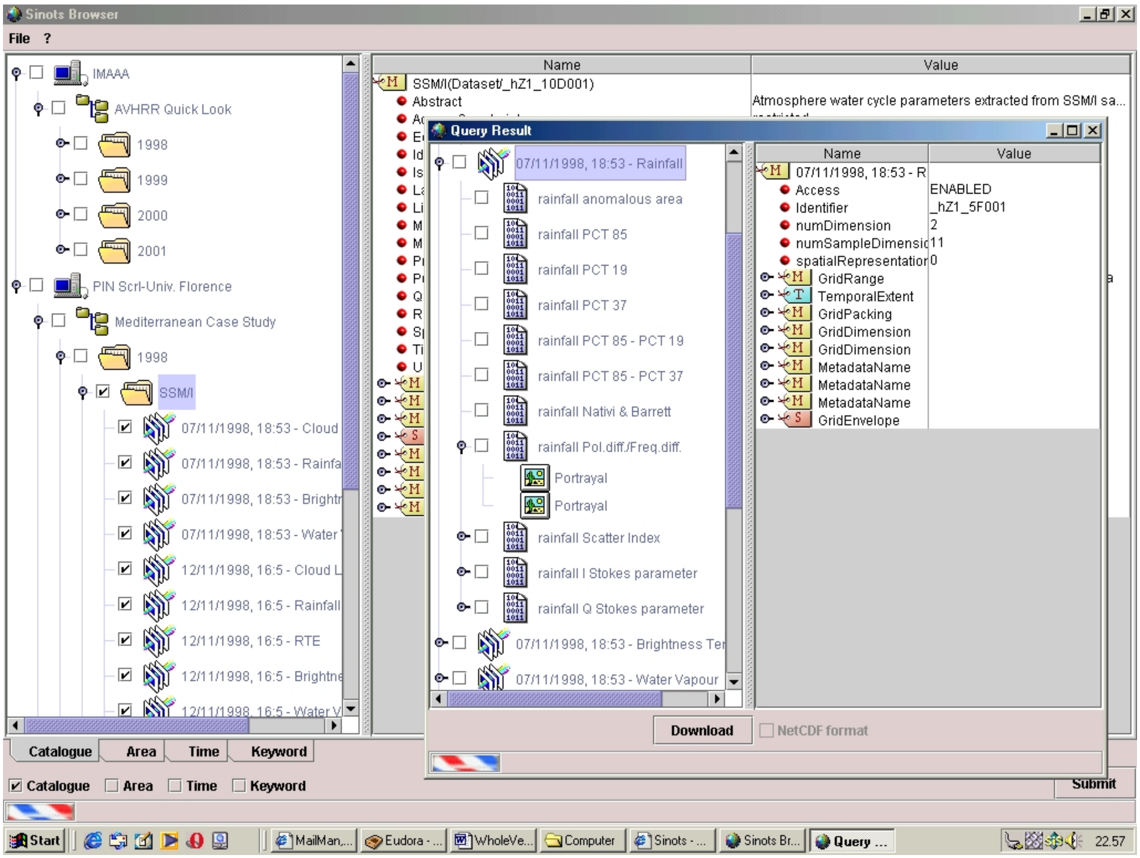

Figure 10: Graphical implementation of the couple of conceptual maps.

7. USER-SYSTEM INTERACTION

As shown in Figure 11, the typical user session may be split in several phases, as follow:

1. the user authenticates himself to the federation as a whole, according to the Single Sign-On paradigm, during the login phase (see Figure 12 for a screenshot of the prototype client application). This involves waiting for an answer from the federation;
   1.1. the federation presents to the user the list of the EOS information sources currently online and accessible by the user himself
2. the user may browse the Catalogue Tree and discover data catalogues, sub-catalogues, datasets and sub-datasets, down to the grid-coverage level (some entities may be forbidden to the user); the navigation causes transparent, asynchronous calls to the appropriate federated hosts, whose answers are awaited by the user interface;
   2.1. the requested hosts asynchronously answer providing the content and the metadata of the requested data aggregations;
3. the user may view the metadata associated to any of the entity in the Catalogue Tree; metadata are themselves hierarchically structured (see Figure 13 for a screenshot of the prototype client application: the Catalogue Tree is shown in the window left pane; the window right pane shows the metadata of the highlighted entity);
4. the user may select any set of entities in the federation ontology for a subsequent query of the contained coverages (see Figure 14 for a screenshot of the prototype client application);
5. the user may select a rectangular area of a map for a subsequent query of the coverages insisting on that area (see Figure 15 for a screenshot of the prototype client application);
6. the user may select a time interval for a subsequent query of the coverages acquired during that interval (see Figure 16 for a screenshot of the prototype client application);
7. the user may select any set of keywords in a list for a subsequent query of the coverages tagged by that keywords (see Figure 17 for a screenshot of the prototype client application); the list is created by dynamically aggregating locally managed keyword lists;
8. the user may issue queries combining or altering the above selection (point from 4 to 7) as needed; the client application and the federation infrastructure are able to take advantage of previously made requests so as to reduce network traffic and optimize the distribution of the query to the appropriate federated hosts, whose answers are awaited by the user interface;
   8.1. the requested hosts asynchronously answer providing the requested GridCoverages, that are shown in the user interface GridCoverage Tree (see Figure 18 for a screenshot of the prototype client application: the GridCoverage Tree is shown in the window left pane; checked items are marked for download; the window right pane shows the metadata of the highlighted entity; the small window on the right shows a quick look of the selected portrayal);
      8.1.1. the user may browse the GridCoverage Tree and discover their sample dimensions and portrayals;
      8.1.2. the user may view the metadata associated to any of the entity in the GridCoverage Tree; metadata are themselves hierarchically structured;
      8.1.3. the user may request quick look images of sample dimensions by selecting one of the associated portrayals;
      8.1.4. the user may select any set of grid coverages or sample dimensions for a subsequent download of the data;
      8.1.5. the user may request the download of the selected entities, possibly in netCDF format (if available);

8. THE EXPERIMENTAL PROTOTYPE

A first implementation and experimentation of the described solution has been conducted in the framework of a project funded by the ASI (Italian Space Agency) (Nativi, Mazzetti, Bigagli, Giuli, 2001; http://sinots.pin.unifi.it/sinots). It set up a federation of EOS information resources, located in the central and southern regions of Italy: the University of Florence in Florence, the PIN research center in Prato and the IMAAA of the CNR near Potenza.

The experimentation has been successful and led to the confirmation of the presented solution for the achievement of a wide federation made up of archives managed by Italian academic and CNR (National Research Center) institutes.

8.1 EOS Information Resources

As far as data heterogeneity is concerned, the experimentation concerned two main kinds of data archives, which are considered to be very important for such federation purpose:

- *Sensor imagery archives*: the historical archive of a given sensor acquisitions, on a certain spatial region, which is managed by an expert center;
- *Case Study archives*: the archive of a set of disparate processed data that constitute a case study.

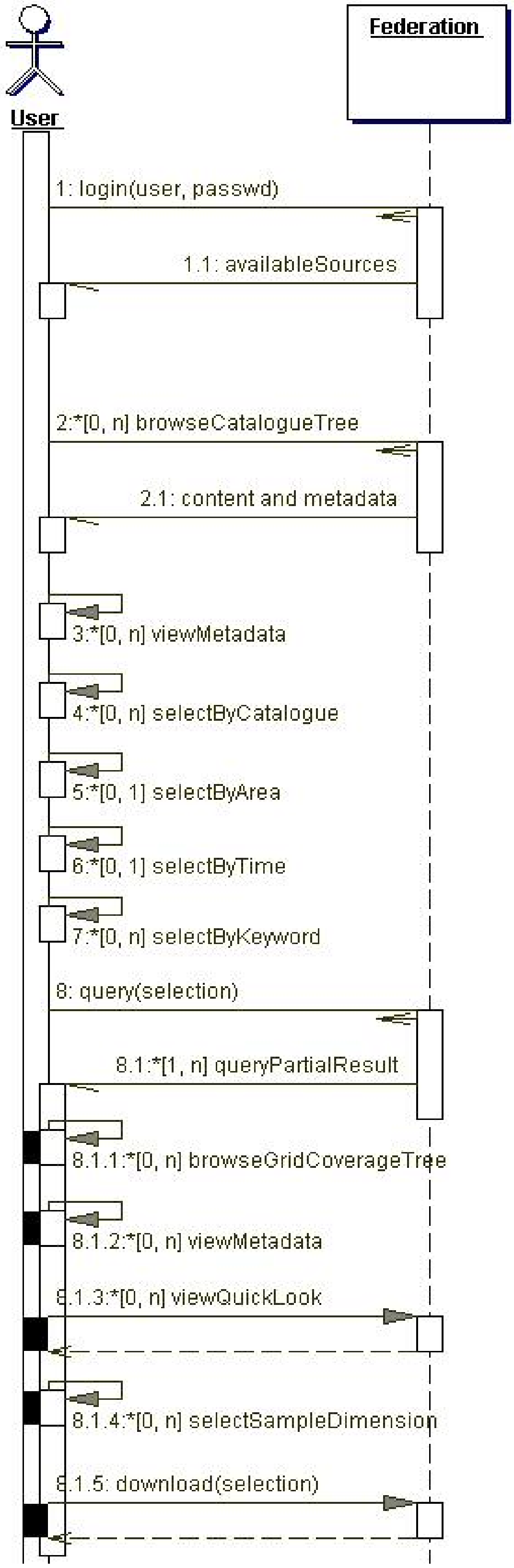

Figure 11 - Typical session sequence diagram

Hardware Platform	*Operative System*	*Resource Management System*
SUN Sparc 4	Linux 2.2	DBMS: MySQL
Intel Pentium 3	Windows 2000	DBMS: MS Access 2000
SUN Sparc Ultra 1	Solaris 2.5	DBMS: Informix/MySQL

Table 2 - Configuration of information systems utilised for the testbed

The initial testbed has involved three heterogeneous information resources managing remotely-sensed data (i.e. satellite and ground-based radar datasets) located in the central and southern regions of Italy. These resources, as well as their operative systems, remained completely autonomous and independent.

Table 2 shows repositories main hardware and software components.

8.2 Enabling Technologies

For component integration technology we used E-business enabling technologies. These middleware and software components removed the technical heterogeneity and addressed syntax heterogeneity of data encoding, by using XML-dialects; the result of any query, as well as the query itself is an XML document. Such technology is essential:

- to expand the traditional client-server model to fully leverage the power of web-based systems;
- to overcome the client-server-based architecture constraint of being heavily dependent on the type of hardware and software used and calling for the client to be very aware of the server and vice-versa;
- to leverage the benefits of open standards and network openness;
- to use Internet technologies to develop an application that extend beyond the traditional space and organizational borders.

In fact the true value of an E-Business architecture lies in its ability to provide integration with back-end systems and databases (Koushik, Joodi, 2000).

The prototype is based on the following technology base features:

- All developed components are written in Sun Java 2 language, which allowed their easy deployment in multi-platform environments (i.e. Windows NT, Linux, and Unix).
- For component integration technology we used the Web Services enabling technology (i.e. SOAP/XML and HTTP protocols).
- We utilized the Java WebStart technology as reliable deployment technology.
- Database access is performed with JDBC/ODBC technology.
- The adoption of a web-delivery architecture involves some issues: to strengthen the security issue and to define a generic protocol to make client and resource mangers communicate.

8.3 Web Services

The Source and Application Mediators invoke a facilitating transfer service to exchange encoded dataset each other. The transfer service follows a transfer protocol which specifies packaging and transport rules. The transportation was considered only over an on-line communication medium.

We adopted SOAP (Simple Object Access Protocol) to implement the transfer services. SOAP specifies a general, asynchronous message messaging service as well as a simpler synchronous RPC service, the latter built upon the former. Although the SOAP-RPC service would suit the read-only nature of the federation data model, that basically leads to a one-way query/response data flow, we decided to implement the transfer service by means of SOAP general messaging.

This design choice increases to some extent the complexity of the facilitator component, but guarantees an effective decoupling of servers and clients with respect to their implementation language. On the other hand, a RPC strategy, by actually dictating the return value types, would possibly impose a particular language binding.

8.4 Implemented Software Components

For the experimental prototype the following main software components were developed and deployed:

The Central Server

It logically represents the overall federation; it contains a web server users must connect to, in order to subscribe/unsubscribe and start-up an interactive client session. The central server is also in charge of delivering –where necessary- the client application components to the client station: the Java Web Start technology was used; it extends the traditional Java Applet, allowing less effort in the programming phase.

A Thick Client

User’s client station is a PC or a UNIX workstation using a Web browser. Users utilizes a Web session to contact the central web server in order to download the Java client (only when a new version is avail-able) and starts it.

The Federal Host Gateway

Each federated information resource presents a gateway to the federation. It implements the Source Query Manager, the Source Facilitator and the Wrapper components. It contains a web server, the thick Client application mediator directly interact with, for querying the resource.

9. CONCLUSIONS AND FUTURE WORK

We developed a web service architecture in order to implement a distributed mission-critical application and federate existing –and future-heterogeneous EOS information systems. The introduced solution allows the National EOS Scientific Community to leverage their investments in existing systems, integrating them by means of an innovative process.

That architecture utilizes a thick-client to deliver services through the Web, according to a critical requirement of our User Community.

The introduced solution was conceived to provide the following operational benefits: scalability to support a large number of users; capability to handle volume loads that can vary enormously over time; acceptable transaction response times under most conditions; a secure environment that protect valuable information from unauthorized access; continuous system extension capability.

A prototype has been developed and experimented in the framework of a national project. It provides the flexibility to move the application to different platform as we adopted open standards and technologies. The fully-distributed developed prototype provides the flexibility to segment the application workload.

The main lessons learned from the experimentation and the consequent planned developments are:

1) The information resource wrapper and mediator components proved to be critical components and their customization process is tightly coupled with the local environment and schema. Besides, several international standard specification initiatives issued interface specifications to achieve such tasks (e.g. ISO TC 211 and OpenGIS OWS). Therefore, future development should replace these components specifications adopting a standard interface, This choice should simplified the overall federation process and system interoperability.
2) Existing information resources are seldom characterized by all the required metadata, therefore a time-demanding effort was dedicated to complete the datasets metadata. An Internet-based tool has been developed to ease such process and allow information resource administrators to load (either interactively or programmatically) the needed metadata. Such tool is made up of by a thin client (i.e. a browser application) and a PHP server which interfaces the information resource management system (e.g. a SQL-based DBMS).
3) As far as the general responsiveness performance of the prototype is concerned, the experimentation suggested some improvements to be implemented on the server side, such as: the caching of the most common queries, namely navigation queries; tuning of the security framework (e.g. SSL encryption, API performances).

Presently, the developed solution has been taken as the foundation of a nation-wide interoperability solution in the framework of a project funded by the Ministry of Environment.

Moreover, the presented solution will be further enhanced in the framework of a National Operational Plan project funded by the Ministry of Education, University and Research. The IMAAA institute of the CNR will implement a first experimentation of such new system.

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APPENDIX A – PROTOTYPE APPLICATION SCREENSHOTS

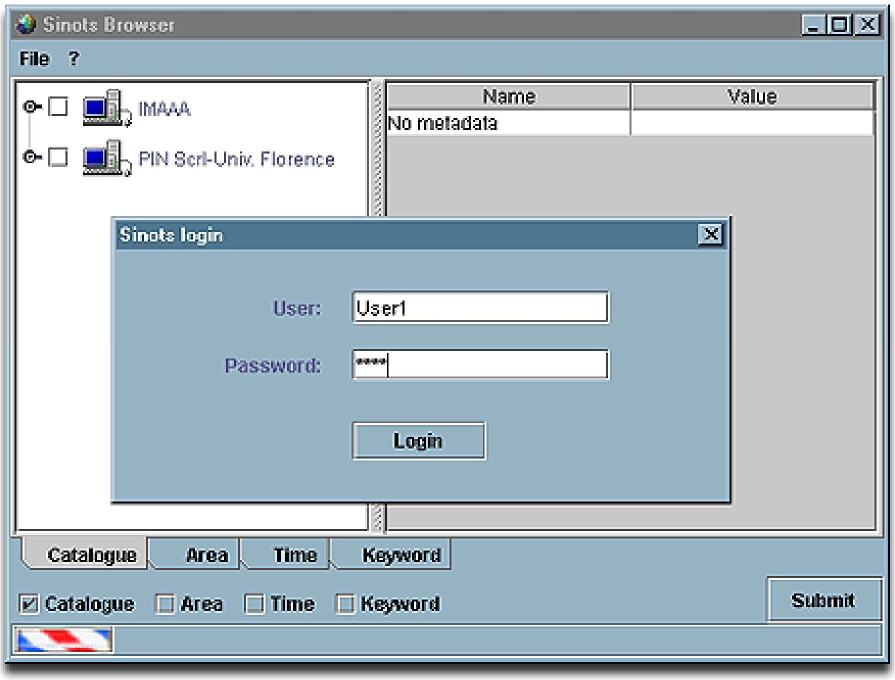

Figure 12 - Login phase

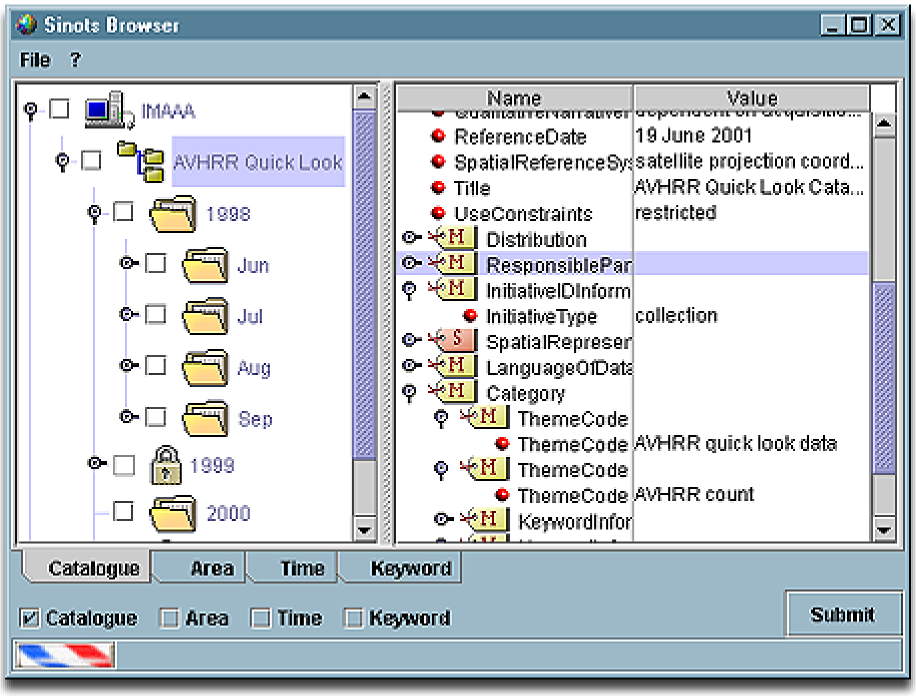

Figure 13 - Catalogue Tree and metadata navigation

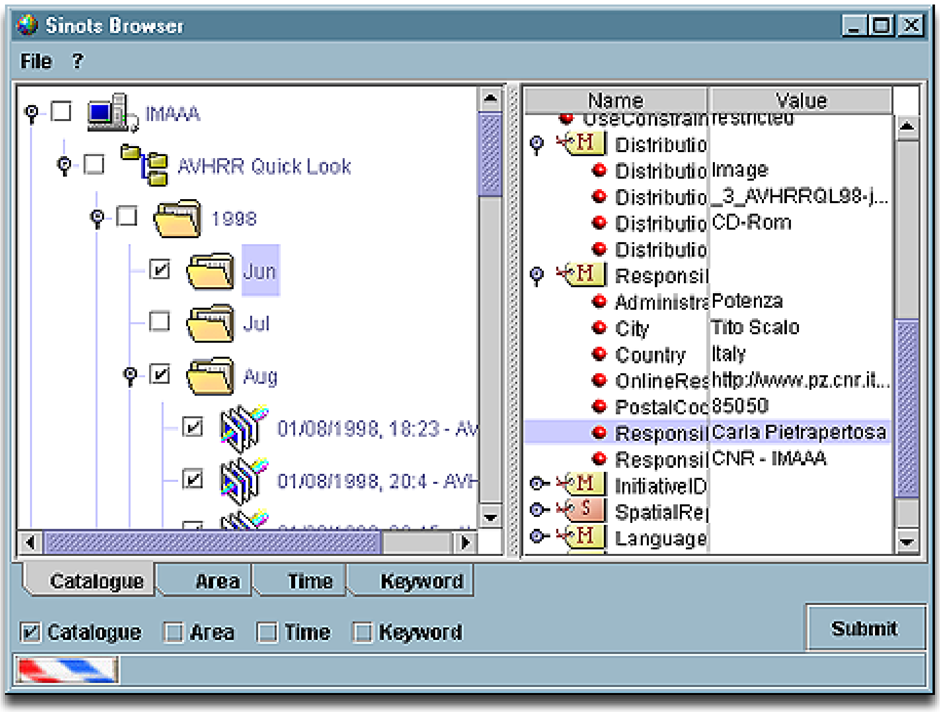

Figure 14 - Selection by entities

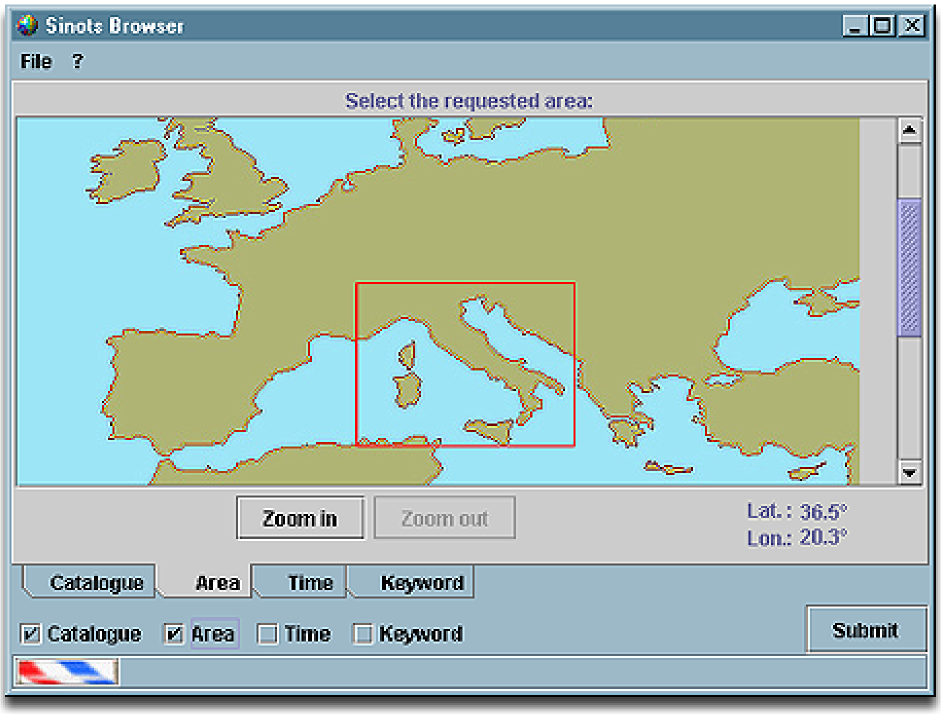

Figure 15 - Selection by area

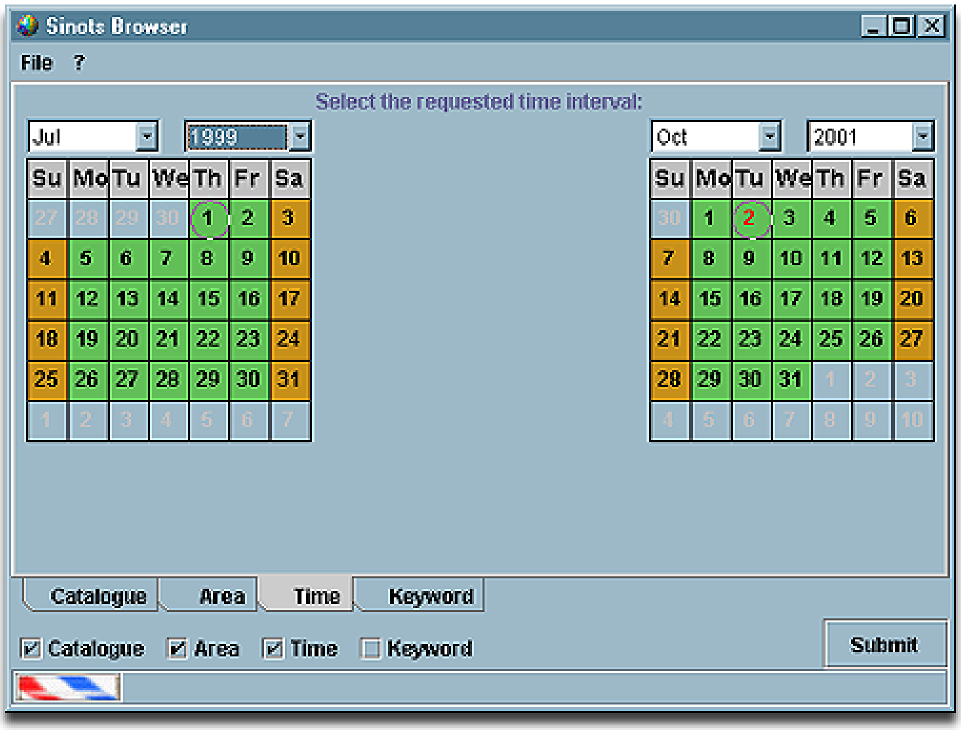

Figure 16 - Selection by time interval

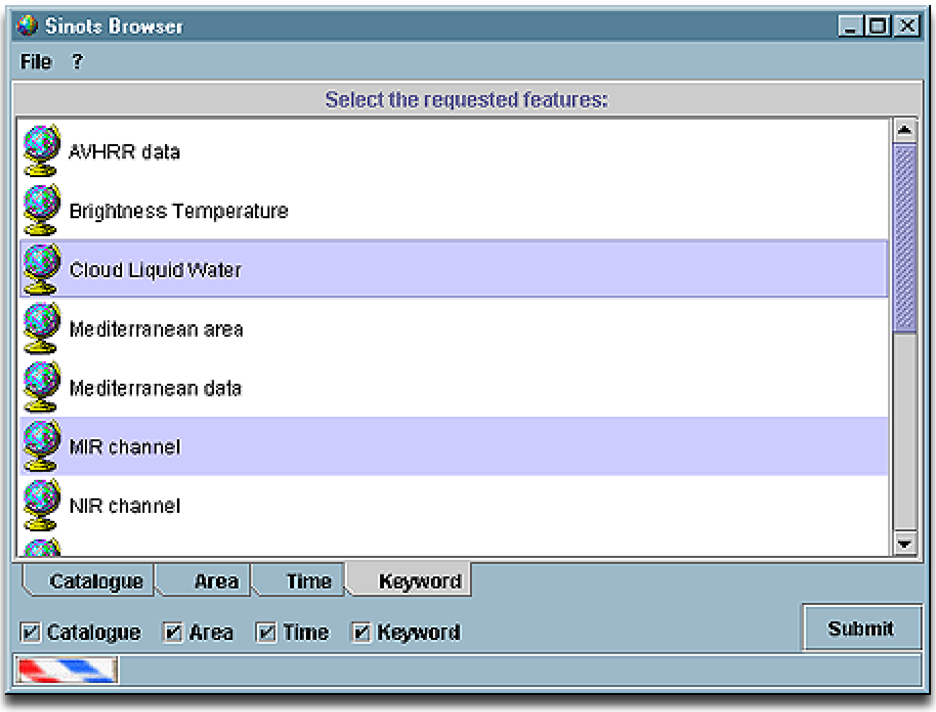

Figure 17 - Selection by keywords

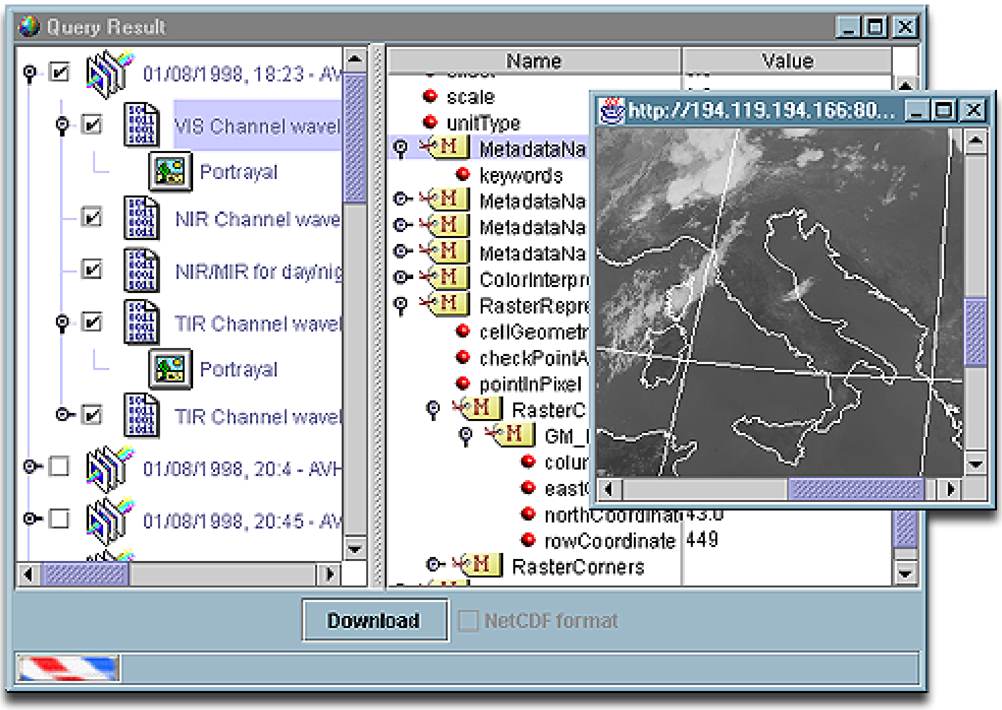

Figure 18 - GridCoverage Tree and quick look windows