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CYber-Infrastructure for CiviL protection Operative ProcedureS

Research Strategies for the development of a Civil Protection E-Infrastructure *(Deliverable D16)*

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Executive summary

This document describes a proposal of research strategies to be followed for the design and implementation of a European Civil Protection E-Infrastructure. It reports the results of the analysis and studies carried out by CYCLOPS project highlighting the open issues where more R&D activities are required to implement services and tools for Civil Protection applications on the top of a Grid-infrastructure. As a first step an architecture for the European e-Infrastructure for Civil protection applications, the CYCLOPS Platform, is described. It is conceived as an architectural framework useful to guide further studies and discussions. basing on such architectural framework, five research themes are identified:

a) Grid Infrastructure Enhancement
b) Advanced Middleware For Cp Applications
c) Security And Data Policy
d) Civil Protection Applications Enablement
e) Interoperability

For each research theme, several particularly significant topics are selected and discussed in detail.

Objective

The present document aims to define the research themes and relevant research activities required for the design and development of a European e-Infrastructure for Civil Protection applications. This document is primarily targeted to R&D decision-makers and performers to make them aware about the specific requirements of the GMES and CP communities. It collects the outcome of the technical activities performed by the CYCLOPS Consortium and external experts providing one of the main output of the project. This deliverable is companion of the deliverable D15 "*Toward a Grid - Guidelines for Innovation Strategies for Civil Protection Systems*" which is mainly targeted to Civil Protection decision-makers to make them aware of the capabilities of recent achievements, namely in the field of Grid and Earth and Space Science Informatics technologies.

As a preliminary step this document defines a system architecture for the European e-Infrastructure for Civil Protection applications. It is not designed for implementation but as a conceptual framework to define and describe the research strategies. After that the main research themes and topics are identified and discussed.

Introduction

Civil Protection (CP) activities typically involve many different actors (e.g. Civil Protection systems, public bodies, research centers, data providers, etc.) who need to share information in a coordinate and effective way. Thus Civil Protection applications could gain great benefits from a strict integration with advanced research infrastructures providing heterogeneous and distributed resources (e.g. computing, data, services, knowledge, expertise, etc.) useful in the full cycle of emergency situations (i.e. forecasting, warning, management, assessment).

Fortunately, the advancement in several technologies provides the basis for the realization of such infrastructure. In particular the existing Grid technologies make possible to share computing power and data storage between the members of the so-called Virtual Organizations (VOs). Besides that, Geospatial information science and technology acquired a mature status enabling to share effectively the geospatial information which is the most important type of information exchanged in CP applications.

Nevertheless CP applications have specific requirements in terms of advanced functionalities and Quality-of-Service that existing infrastructure are not able to satisfy.

Adopted Methodology

To define the research strategies aimed to the design and implementation of an effective European e-Infrastructure for Civil Protection applications, the following methodology has been adopted:

1. Use-cases analysis: From the Business Process Analysis, detailing the procedures for natural and anthropogenic risk management in several European Civil Protection Agencies (see D6 "*Business Process Analysis*" [CYCLOPS-D6]), two specific use-cases were selected for further investigation. The selected use-cases (Flash Flood Emergency Management in France and Wild Forest Fire Risk Management in Italy) were detailed. The use-cases analysis results are described in D9 "*Use Cases*" [CYCLOPS-D9].

2. Requirement analysis: Functional and non-functional (performance) requirements for the two selected applications have been carried out. They have been extended taking into account planned and possible evolution of the applications. The results of this phase are reported in D9 "*Use Cases*" but they have been further detailed as part of the activities documented in the present deliverable.

3. System architecture definition: The architecture of a software system satisfying the functional and non-functional requirements has been defined starting from the preliminary architecture described in the original CYCLOPS Annex I (see CYCLOPS Annex I).

4. Prototyping activities: Prototypes of porting of the two selected applications have been developed following the previously defined system architecture. The results of this phase are: a) the G-RISICO prototype applications which was demonstrated at IberGrid 2008 (Porto) and EGEE Conference 2008 (Istanbul) and b) the G-SPC-GD prototype application. Preliminary outcomes from the prototyping activity were used to define the Request for Enhancements targeted to the EGEE community for providing basic support to Civil Protection Applications. They are documented in the deliverable D14 "*EGEE Request for Enhancement*".

5. Research strategies and innovation guidelines definition: Basing on the results of the prototyping activity, the system architecture has been revised and the open issues have been identified. Research strategies are proposed to cover open issues. The results of this phase are reported in the present document.

System Requirements

In this section the functional and non-functional requirements derived by Use cases analysis defined in the "*System Requirements*" document [CYCLOPS-D11] and revised according to the results of the following phases, are described. They represent the starting point for the definition of the System Architecture and the identification of open issues requiring further research.

Starting from the Business Process Analysis describing the internal working of European Civil Protection Agencies to support emergency management, and from the Use Case Analysis describing the management of real emergency situation, it is possible to define the technical and organization requirements for a Civil Protection e-Infrastructure. In particular the detailed analysis of two operational CP applications (namely the Italian RISICO application for wild fire risk assessment and the French SPC-GD application for flash flood risk estimation) provide valuable inputs for the definition of a possible CP e-infrastructure architectural framework.

1.1 Functional Requirements

Functional requirements describe "what" the system should be able to provide in terms of functionalities. They can be summarized as follows:

Id	Name	Description
F1	Geospatial information access	For CP applications the most important kind of information derives from spatial data. Therefore an advanced infrastructure for discovery and access of geo-information from data and services is required. The outcomes and prescriptions from significant international initiatives like GEOSS, GMES and INSPIRE or projects must be considered.
F2	Geospatial information publishing	The geo-information generated by CP applications must be published for presentation or further processing. As or F1 requirement the results of international initiatives and projects must be taken into account.

F3	Data Policy Support	The application needs to access and publish distributed information which could have a well-defined data policy (e.g. requirements for access). Support for different types of licensing and payment information must be provided.
F4	Authentication and Authorization	The system requires access control so that only authorized users can access to resources and services. Access control must be provided at different level with characteristics typical of dual system (civil/military).
F5	Storage On-demand	Raw and output data has to be stored for publishing and further processing. Since it is not possible to anticipate the storage capabilities requirements for a particular emergency situation (which could require multiple runs, high resolution, etc.), the availability of storage on-demand is required.
F6	Quality of Service negotiation	The system must make possible to define a resource prioritization and reservation in pre-alert phase (Start of vigilance phase). The resource required for model computation and/or data storage should be temporarily assigned to CP tasks and prohibited to other users of the infrastructure.
F7	Computational Power On-demand	To perform reliable modeling operations with several models, the mode ling platform needs to access computational power on-demand, since it is not possible to anticipate the required amount of computing power required.
F8	Workflow support	Complex CP application could be built as a workflow of basic modules. This approach enables the re-use of applications and the separation of concerns between model and algorithm experts and CP applications developers.
F9	Sensor interaction	CP applications require sensors access and planning for defining new acquisition strategies depending on the emergency situation.

1.2 Non-Functional Requirements

Non-functional requirements describe "how" the system should perform, that is the way it is able to provide its functionalities.

Id	Name	Description
NF1	Geospatial information	To access the huge amount of geospatial information available, the

	Standard interface	adoption of standard interfaces is required for both access (F1) and publishing (F2) geospatial data. In particular a harmonization with existing and planned geospatial infrastructures, such as those defined in the INSPIRE, GEOSS, GMES initiatives, or concluded and on-going projects is required.
NF2	Geospatial information Standard data formats	The system should accept and return data in standard formats. In particular a harmonization with existing and planned geospatial infrastructures, such as those defined in the INSPIRE, GEOSS, GMES initiatives, is required. Also widely spread community standards should be considered.
NF3	Bandwidth	The application needs to access geospatial information possibly characterized by big data amount. Although the grid approach promotes mobile code instead of moving data, bandwidth limitation should be avoided.
NF4	Real-Time	The application must process data in a pre-defined time to support decision makers. Models should provide partial or less accurate results if the timeout is reached before the task end. This non-functional requirement is supported by the F6 (QoS negotiation) requirement.
NF5	Resolution scalability	The application must be able to increase resolution without strongly affecting Time of Response. This non-functional requirement is supported by F5 and F7 requirements.
NF6	Storage	CP applications can require great amount of storage. Basing on prototyping activities has been estimated that, during an emergency situation, typical CP applications can produce 0,1-1 TB of raw and output data.
NF7	User-friendly interface	The interface to access CP applications should be made as friendly as possible and targeted to different users (decision-makers, CP operators, administrators).

1.3 Constraints

Constraints describe the pre-conditions that system must satisfy. They can be technological constraints or organizational constraints.

Id	Name	Description
C1	Addressing of technological heterogeneity	CP applications should be able to access resources available from diverse technological platforms. A model could run on a specific Grid middleware, some useful data could be accessed through a community standard service, etc. This heterogeneity can be (and should be) reduced as much as possible, but since the technological choices are often derived by specific system requirements the definition of a homogeneous technological platform for CP applications must be considered unfeasible.
C2	Adoption of standards	Standards and common specifications are the main solution for reducing heterogeneity. Several international initiatives and projects have defined or are defining standards and specifications for different contexts, such as Grid services, geo-information access and processing, and so on. Moreover many technological and scientific communities (e.g. meteorology, oceanography) have their own community “standards”. Moreover in some cases the adoption of standards is normative (e.g. the INSPIRE Directive). Therefore the adoption of standards at every level must be considered a constraint for the CYCLOPS Platform. The existence of C2 strengthens NF1 and NF2 requirements in the sense that standards should be adopted even in case where they do not seem to bring significant benefits.
C3	Organization boundaries	The resources accessed by the CYCLOPS Platform belong to different organizations. This characteristics must be considered significant in the sense that the architecture must take into account the existence of logical boundaries between different organization domains.

Architectural Framework

Basing on the System Requirements and constraints an architectural framework has been designed.

1.4 The approach

The functional and non-functional requirements of CP and GMES applications can be satisfied only developing an advanced enabling infrastructure to facilitate data sharing and Earth system analysis as required in complex CP applications. This implies to scale from specific and monolithic systems (data-centric) towards independent and modular (service-oriented) information systems [Woolf et al.]. In fact, such an infrastructure must provide scientists (as knowledge providers) and decision makers with a persistent set of independent high-level services and information that can be integrated into a range of more complex analyses. Making available such (high-level) service-based infrastructure, a reduction of complexity can be achieved through the separation of concerns. Scientists and researchers interested in individual disciplines can focus on developing and publishing related services (e.g. models); while scientists, researchers and decision makers interested in multidisciplinary (system level) phenomena can focus on integrating these services [Foster and Kesselman,2006].

According to the OASIS definition "*Service Oriented Architecture (SOA) is a paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. SOA is a means of organizing solutions that promotes reuse, growth and interoperability.*" [OASIS-RM]. The central focus of Service Oriented Architecture is the task or business function (e.g. getting something done). Indeed the central concept of SOAs is the service: a mechanism to enable access to a set of one or more capabilities. In respect of other architectural approaches for distributed systems, like Resource-Oriented Architectures, exposing only a predefined set of operations on the logical resources, SOA reflects the reality that ownership boundaries are a motivating consideration in the architecture and design of systems. Since in the typical CP use scenarios ownership boundaries impose architectural constraints (e.g. for data policy enforcement), a Service-Oriented approach seems the most appealing for the design of a European e-Infrastructure for CP applications.

To handle the complexity of the problem a stratified approach has been followed (Figure 1). In the stratified architectures each functional entity is assigned to a specific layer. Entities belonging to a layer can require services to the entities of the layer immediately below and provide services to entities of the layer immediately above.

In our general architecture three different layers with different concerns, functionalities and contributing communities have been identified:

RESOURCE PROVISION LAYER: This layer provides functionalities of basic resources sharing. Computational power, storage space, instruments access are provided to the upper layer with access control services . The satisfaction of low-level (near to the machine) functional and non-functional requirements (such as computational power and storage on-demand) is assigned to this layer. The GRID technologies are considered the corner-stone for the implementation. Therefore the GRID Community is the major contributor for the design and implementation of this layer. Grid Services allow the upper layer to view the below system as a unique system providing computational power and storage on-demand and access to instruments.

GEOSPATIAL SERVICES LAYER: This layer provides functionalities of data and processing sharing introducing the required semantics for high-level applications. At the lower layer the shared resources are storage space and computing power. The resources are expressed in terms of files, database fields, jobs, streams directed to and from instruments. This semantics level is useful to build generic sharing services but it is too low for building complex applications like the ones required for CP. Therefore a middle layer is defined. Here users share logical resources like data and processing services characterized by meaningful properties such as their geographical area of interest, temporal extent, data type (rainfall, fire spread rate, and so on). This layer is based on a typical Web Service-Oriented Architecture (SOA) both for scalability, and extensibility requirements and for interoperability and harmonization with the main existing or planned geo-information sharing infrastructures. Although this layer accommodates several high-level services, the most important of them are relative to Earth Science resources provision. Therefore the Earth and Space Science Informatics (ESSI) Community is the main contributing community for the design and implementation of this layer. This layer provides a set of Web Services useful for building high-level CP and GMES applications.

STRATEGIC APPLICATION LAYER: This layer provides advanced functionalities targeted to build strategic CP and GMES applications. Using the Web Services provided by the lower layer as the building blocks, complex applications can be designed and implemented as a workflow. Input data can be searched and chosen, models can be run, output data can be visualized. GMES and CP communities are the main contributors for the design and implementation of this layer.

Layer	Logical Entities	Concerns	Main Technologies	Main Contributing Communities
Strategic Application	Emergency, Warning, Alert, Risk Estimate, Scenario, Forecasting	Civil Protection Business Process implementation	Web	CP, GMES
Geospatial Services	Dataset, Feature, Coverage, Map, Model, Algorithm, Sensor, Observation, Measurement	Sharing and processing of geo-information	SOAP Web Services	Earth and Space Science Informatics, Geospatial
Resource Provision	Storage space, Computational Power, Instrument, Jobs, Files, DB, Filesystems, Stream, File Name, Logical Filenames	Seamless sharing of basic resources, access control to basic resources	Grid, Internet, Web	Grid

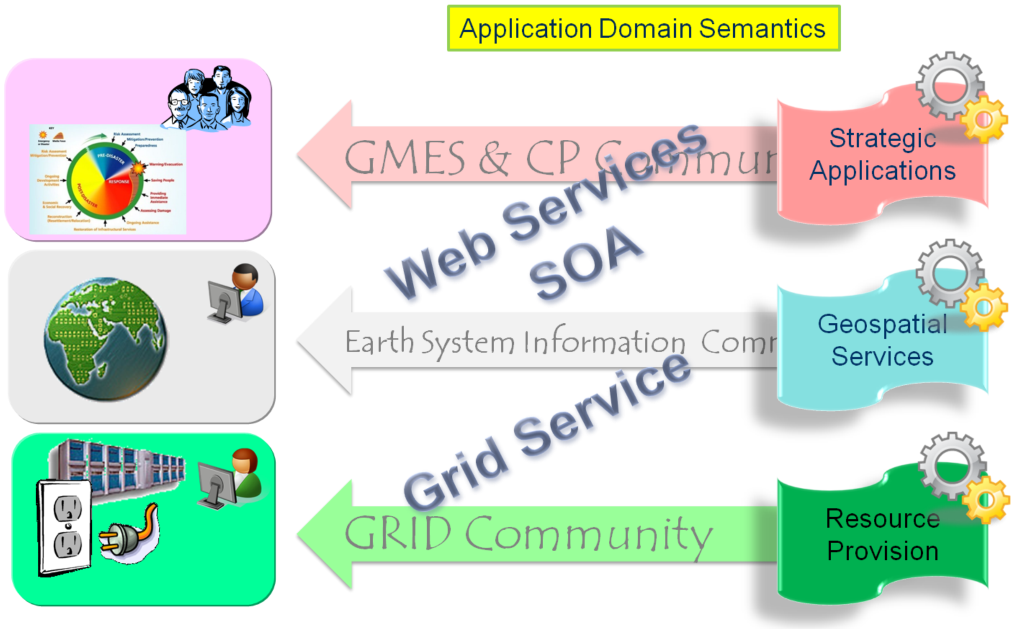

Figure 1 - Stratification for an e-Infrastructure for GMES and CP applications

Basing on the previous stratified approach and taking into account the functional and non-functional requirements deriving from the Use-cases analysis and also the experience from the prototyping activity, the overall System Architecture shown in Figure 2 has been derived. It is not intended for direct implementation but mainly as a guiding framework for the definition of research strategies needed for the detailed design and implementation of the system.

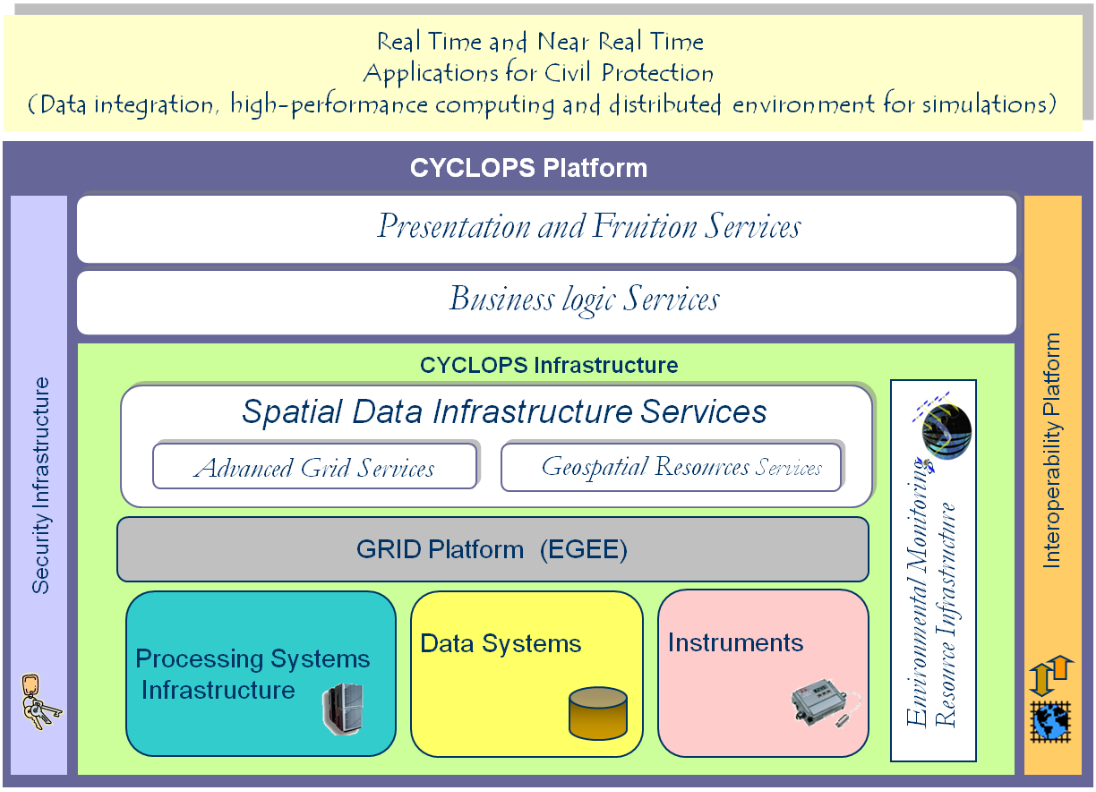

Figure 2 - Overall System Architecture for an European e-Infrastructure for CP applications

The proposed System Architecture is a layered architecture detailing the functionalities of the layers introduced in Figure 1.

At the bottom layer the basic resources are shown. They are processing systems (personal computers, workstations, clusters, etc.) providing raw computational power; data systems (disk space, tape and CD/DVD libraries, filesystems, databases, etc.) providing raw and semi-raw storage capabilities; and instruments providing acquired data as files and data streams. All these resources are geographically distributed and managed by different organizations.

Above them, a GRID Platform provides the virtualization services which makes a seamless integration of the previously described resources. Users, structured in the so-called Virtual Organizations (VO) can interact with the system with no concern about the physical location of the resources which are dynamically (on-demand) allocated to the requiring tasks. The users are provided with user-friendly interfaces (e.g. Web portals) but the semantics of the objects which they interact with is still very low. In fact the users operates with the grid in terms of files, jobs and data streams. In the CYCLOPS architecture the GRID Platform is the EGEE infrastructure. The middleware developed in the EGEE projects, named gLite, provides most of the functionalities required by this layer; moreover the EGEE infrastructure has proven to be highly scalable. Specific Request for Enhancements (RFE) were directed to the EGEE Technical Groups by the CYCLOPS Working Group to inform them about specific requirements of CP applications, which would not require further research but could provided by gLite with some modification and extension.

Above the GRID infrastructure a Web Service based layer has been introduced. It is made of advanced services for interaction with the Grid and specific Geospatial resource sharing services. While the former enrich the Grid platform providing services useful to interact with the Grid but considered of a level too high for being provided by the Grid infrastructure itself, the latter are specific services for discovery and accessing geo-spatial resources (data and services). They constitute the grid-enabled Spatial Data Infrastructure (SDI) Services which allow to develop a SDI which makes use of the Grid capabilities.

Another infrastructure for Environmental Monitoring Resource has shown beside the SDI Services layer and the Grid layer. It is made of services of different level to interact with sensors and acquisition systems. It is shown as a vertical layer since it is made of SDI level Web Services for sensor planning and observation, and low-level services for enabling different low-level interactions (e.g. notification, streaming) with sensors both inside and outside the Grid.

The resulting block (in light green in the figure) is the so-called CYCLOPS Infrastructure providing a set of Grid-enabled services for geospatial data and service sharing which can be considered the building blocks for advanced GMES and CP applications. On the top of the CYCLOPS Infrastructure a Business Logic Service Layer is defined. It is made of services for implementing the logic behind one or more CP and GMES Business Processes. In particular a workflow manager for integrating basic services provided by the layer below will be available. Above this layer the Presentation and Fruition Layer provides services for interacting with the system. Graphical applications distributed as thick or thin client could make use of the functionalities provided by this layer.

Besides this transversal (horizontal) layers two vertical layers are shown. On the left the Security Infrastructure Layer provides basic and advanced security services such as confidentiality, integrity, and so on. Particularly important is the access control functionality which should be able to support the complex data policy schemes which are characteristics of Earth Science and Civil Protection applications (licensing, billing, information masking, etc.). This layer is shown in vertical orientation because these security services must be provided at every level: at level of fruition (e.g. authentication to portals), Business Logic (e.g. authorization to participate in Business Processes), SDI Services (e.g. message-level confidentiality), GRID (e.g. authorization to data replication, or access control to Grid-enabled instrumentation). Particular attention must be paid to the integration of existing security services, e.g. to integrate a high-level authorization system with the VO Management System in the Grid.

Shown on the right of the picture the Interoperability Platform provides services for interacting with external infrastructures. The CYCLOPS Platform should not be considered as a stand-alone system, isolated by the external world. To realize an effective infrastructure for CP it is important to interact with existing or planned infrastructures which are not (and will not be) part of the CYCLOPS Platform which is targeted to a well-defined set of users. In particular the CYCLOPS Platform need to interact with other infrastructures at different levels, such as other Distributed Computing and Storage platforms, like other Grid infrastructures and research/commercial Cloud Computing systems (at the Grid level), e-Government and e-Business infrastructures (typically based on Web Services technologies), Security Infrastructures (e.g. PKIs).

As shown in the Figure 2 and in the following description, the main architectural choice is the integration of a Grid Infrastructure at the lower levels and a Web Services infrastructure at higher levels. This choice is based on architectural constraints and requirements. One fundamental constraint is that not all the resources can be made part of a Grid. The most important international initiatives for geo-information sharing, such as GEOSS, INSPIRE and GMES are based on Web Services architectures, therefore enabling the resource sharing only to Grid-connected resources is considered too restrictive. Indeed, following the previously mentioned initiatives, in the future many data and services will be published through Web Services but only a small part of them could also be made available through a Grid infrastructure. Therefore it is useful to provide a seamless way of accessing data and services outside the Grid provided that they are accessible through standard interfaces. On the other side a architecture based only on Web Services could not gain the benefits of high-scalable Grids. Indeed Grids fully based on Web Services have not yet proven the scalability of Grids based on other Internet technologies (as gLite has demonstrated with the EGEE production Grid). Moreover the separation of layers reflects a separation of concerns where the Grid provides services for coordinated sharing of basic-level resources, a task where it has proven to reach great scalability and performances. On the other hand Web Services are adopted for sharing higher-level resources where the Web technologies can provide the required extensibility and flexibility (data and services types are not predefined) as demonstrated by the experiences in the design and adoption of XML, SOAP, WS-* specifications in many fields of applications, such as e-Government and e-Commerce.

Research Themes

1.1 Research strategies

The definition of a general architecture is just a first step towards the design and implementation of an European-wide e-Infrastructure for CP and GMES applications. As previously mentioned it is intended only as a framework to guide further considerations. The objective of this document is to define which further research activities are required in order to: a) refine the proposed architecture and b) evaluate the feasibility of its implementation.

In the following, taking into account the CYCLOPS Architectural Framework several areas where further research is required are presented. They are collected in a few Themes which corresponds to the main layers of the CYCLOPS Architectural Framework. For each research theme, an introduction explains why it is considered to require further investigations while the Research Topics section collects the single research activities where the investigation should focus in order to make the CYCLOPS Platform feasible. For each topic the rationale, and relevant current activities are described.

Theme 1 GRID INFRASTRUCTURE ENHANCEMENT

The CYCLOPS architectural framework proposes the existence of a Grid infrastructure enabling virtualization of the basic resources provided by the underlying Computer and Network Infrastructure (CNI). In particular the gLite Grid middleware enabling the EGEE Test environment and the EGEE Production Grid has been tested. Although it has proven to provide high scalability, reliability and general performances, the gLite middleware design was based on requirements different from the CP applications ones. Some requirements can be easily satisfied with minor modifications and they have been subject of the deliverable D14 "*EGEE Request for Enhancement*" [CYCLOPS-D14], while others need to be addresse by specific research activity.

Topic 1.1 REAL-TIME AND NEAR-REAL-TIME SUPPORT

CP applications, especially those dedicated to the emergency management, can have strict requirements in terms of time-of-response. Very often in the emergency management cycle, especially during the Emergency Response phase, a less accurate response provided in time is more valuable than a more accurate response provided in late. Indeed in many CP applications a delay in the provision of the response can make it even useless. In terms of non-functional requirements it could be expressed as CP applications typically privilege time-of-response instead of accuracy.

Therefore in this context, Real-Time (RT) and Near-Real-Time (NRT), terms commonly used in Earth Science simulation and modeling, map to the corresponding Hard Real-Time and Soft Real-Time terms used in computer systems where the term Real-Time denotes "*any information processing system which has to respond to externally generated input stimuli within a finite and specified period.*" [Burns et al.]

The existence of a RT/NRT constraint (in the sense previously described) is possibly the main difference between Earth Science and CP applications. In Earth Science, simulations and modeling applications have no strict requirement in terms of time-of-response, and the accuracy is the most important requirement. In such context often RT and NRT refer to the capability of performing simulations at the same temporal scale of the simulated event, or simply to perform them "sufficiently fast".

The support of Civil Protection RT/NRT applications is a QoS requirement which affects both the enabling infrastructure and the application implementation. In particular the infrastructure should provide sufficient information about the estimated time for tasks completion, nodes workload, communication transfer times, and so on. Moreover it should provide notifications about job and data transfer status, etc. On the other hand the applications and the algorithms they are based on should provide incomplete/raw information after a threshold execution time is reached (progressive algorithms vs. nothing-or-all). Moreover to gain benefits from the parallel computation capabilities of the Grid, the algorithms should be designed to be easily split in different jobs.

Topic 1.2 JOB PRIORITIZATION

Situations demanding different priorities are typical in a Civil Protection context. For example during an emergency phase the normal daily computational load should be interrupted to gain more computer power to be dedicated only to Civil Protection tasks in order to be able to perform simultaneously many simulations and elaborations (involving the execution of jobs on the grid) focused on particular risks for population and environment. Although EGEE grid infrastructure provides specific resources for many organizations all around Europe at the same time, in emergency situations the resources required by the Civil Protection might not be available, at least in a short time. This scenario cannot be acceptable for the Civil Protection's jobs to be executed with very high priority. Thus, it would be very significant to be able to tune the job scheduling in order to assign special rights to Civil Protection for using available grid resources.

A set of relevant issues should be considered for an effective scheduling of resources in Grid environments: resource utilization, response time, global and local allocation policies and scalability. Under these circumstances, a simple job queue-based scheduling policy such as FIFO (First In First Out) is not good enough and a smarter, more flexible and efficient solution is necessary.

So, it is fundamental to further investigate the overall impact on the performances on a Grid system of different optimization techniques that can be adopted by local schedulers.

The main research objectives should be concentrated:

a) to identify a variety of features for local schedulers in Grid;
b) to develop intelligent scheduling models and algorithms for computation and data scheduling within a Grid system.

The Job Priority working group has already made significant progress in the development of an initial prototype for the management of priorities on the EGEE infrastructure. Following the requirements of two of the four LHC main experiments (CMS and Atlas) a solution has been developed using the VOMS mechanism to assign different roles to jobs in order to redirect them to specific share of the computing resources.

Preliminary tests should be conducted to verify the useful adoption of this solution in the Civil Protection context as well.

A different research group (Short Jobs working group) has already coped with the problems related to "short jobs". Short jobs are jobs that require only a few minutes of computation time to be executed, These are useful when the Quality-of-Service main requirement is the reduction of the overall latency.

The Short Deadline Job (SDJ) configuration provides a mechanism for low latency scheduling on the EGEE grid infrastructure.

This configuration tries to adhere QoS constraints on how submitted jobs are handled. In particular a SDJ is a job which should not be delayed by any other job (execution starts immediately) if there are available resources. If there are no available resources, the job is killed immediately. This means that the job will never wait for available resources (no enqueuing).

Moreover, it might be good idea to identify the amount of resources required by one's own short jobs (CPU time, actual global execution time and so on). This is especially important for urgent jobs in order to avoid to have jobs killed because they exceed imposed limits.

The amount of the resources usage reserved for SDJ is locally configurable dedicating a set of job slots for Short Deadline Jobs. Jobs in these job slots run concurrently with any other jobs scheduled on the same machine. When the SDJ slots are full on a site, the batch system will reject any additional new job and the resource broker detects the error. Via an automatic resubmission mechanism it is possible to try to reschedule the job on another resource.

The following actions have been identified to facilitate the use of the EGEE infrastructure by applications needing SDJ support:

a) Add a attribute in the JDL description which flags SDJ jobs
b) A new CE attribute should be created in order to identify SDJ CEs. Consequently a modification of the information model would be required

The Short Deadline Jobs are suitable for situations ranging from light interactive tasks to dealing with semi-emergency situation where a large fraction of the resources should be dedicated to a particular set of jobs. That conditions fit a possible scenario in Civil Protection context.

Topic 1.3 Advanced Job Management

Reducing time latencies and being robust respect to faulty situation may be a major issue in many situations. Having runtime information from jobs running in the WN permits to reduce unnecessary wait time and possibly to skip requests to Grid components (such as the Logging and Bookkeeping service) thus avoiding a possible point of failure.

The Notification idea is to implement a messaging mechanism from Grid Worker Nodes directly to a web service which collects these messages and makes them publicly available to authorized clients. This provides a runtime source of information regarding the current status of the ongoing workflow at Grid side. Since the web service is physically beyond Grid resources, it should also implement a secure authentication and authorization phase.

Thanks to this notification model an improvement in the interaction model between components outside the Grid (essentially job submitting components) and inside the Grid (essentially Worker Nodes, those actually running the submitted jobs) may lead to further reduction of time delays, by adding capabilities to the job submitter component: for the sake of example, when a “Job finished, output uploaded” message is received by the web service from a given Worker Node, a new task may be directly assigned as answer to that same WN which could then start computing a new piece of the overall workflow with no Grid submission delay at all. This would also permit to effectively run “urgent” tasks first (as soon as a job starts on a WN).

Topic 1.4 GRID Architecture for CP Applications

The studies and prototyping activities performed during the CYCLOPS Project have demonstrated that CP applications can gain great benefits from the existence of a Grid platform below a Web Services layer. In particular the gLite Grid middleware developed in the context of EGEE Projects has proven to be a reliable and effective solution to build such Grid layer. In the context of CYCLOPS Project, prototypes of CP applications were run and tested both in the EGEE Test environment and in the EGEE Production Grid with positive results. However in order to implement such applications in a pre-operative or operative context, more strict requirements have to be satisfied, in particular concerning infrastructure availability (see discussion in Theme 3 Security and Data Policy).

Therefore a specific research topic should be targeted to the design of a dedicated Computing and Network Infrastructure (CNI) for CP systems. It should take into account the organization model of national CP systems and it should be characterized by redundancy, prioritization, access control capabilities to address the strict requirements in terms of availability and security. This CNI should provide the basic resources to be included in the Grid infrastructure through the gLite middleware possibly enhanced to fully utilize the infrastructure capabilities. This CNI might be the core of the Grid infrastructure, which could be enhanced accessing computing power and storage space on-demand from other Grid systems like the EGEE Production Grid if and when available.

Theme 2 ADVANCED MIDDLEWARE FOR CP APPLICATIONS

Description

A Grid like the gLite-based EGEE infrastructure provides a complete platform for building high-performance applications. Several successful experiments of application porting even in the CP domain are described in the literature or have been demonstrated. However the Grid handles entities like files, jobs, filesystem, database, etc. which are close to the machine and far from the user who would prefer to speak in terms of logical dataset or even maps, alerts, warning and so on. This characteristics of working at a very low-semantics level is both a strength and a weakness of the Grid. As all low-level systems it is extremely flexible since almost every application can be expressed in terms of jobs accessing data. On the other side if the application is complex, it could be very difficult to decompose it at level of jobs and data. This is typical of many fields in the information science. For example it would be difficult to build a Graphical User Interface using directly an assembly language, because the GUI concepts (buttons, menus, canvas) are too different from the concepts handled by the assembly language (registries, jumps, etc.). The common solution is to provide an intermediate system which helps to map the higher-level to the lower one. For example an object-oriented programming language is a tool for expressing complex concepts to be translated in machine-language.

In the CYCLOPS Platform the same task is accomplished by an Advanced Middleware for CP Applications. At the implementation level it is made of a set of services which work utilizing the underlying Grid infrastructure and expose functionalities useful to build complex CP applications. At a conceptual level this Advanced Middleware abstracts from the low-level concepts handled by the Grid to provide resources at a higher semantics level. Since the concept handled in this specific Advanced Middleware are specific of domains useful for CP applications (such as Earth Science) this is the reason the layer is explicitly named as Advanced Middleware for CP Applications.

The existence of this layer allows to build applications using concepts like datasets, simulation algorithms, geographical and temporal extensions and so on. They are closer to the user-domain allowing to express more complex applications without decomposing them to the grid-level which in many cases could be practically unfeasible. The Advanced Middleware takes care of implementing high-level services using the Grid, therefore the applications built on top of this layer are automatically grid-enabled.

The Advanced Middleware for CP Applications is based on a Service-Oriented Architecture. This architectural choice is due both to requirements and constraints. The main constraint is the required interoperability with existing or on-going initiatives like GEOSS, INSPIRE e GMES which are based on SOAs.

The Advanced Middleware for CP Applications provides several services which could be grouped in two main categories:

a) Advanced Services: which are services for extending the platform capabilities. These are services which should not be implemented at Grid-level because either they are not part of the core functionalities of the Grid or they work at a level higher than the Grid. Workflow services and generic knowledge extraction services (inference engine, etc.) could be provided.

b) Geospatial Services: which are services for generating, access and sharing of data with spatial and temporal reference. Since CP applications refers to situations related to a specific temporal and spatial domain, is clear that they need to exchange geospatial information. Services for discovery, access, publishing and processing of geospatial data from storage and acquisition systems are provided.

Advanced Grid Services

In the CYCLOPS Platform architectural framework, the Advanced Grid Services provide functionalities required to implement high-level services for CP applications. Although the inclusion of some advanced services may be inferred by the general requirements for the CYCLOPS Platform, the precise definition of which services should be included will derive from other research activities. For example, the research activities in the field of application design for CP applications might suggest the need for workflow functionalities. Since they are common functionalities, but of a level higher than the Grid level, they might be part of the Advanced Services.

Geospatial Services

Civil Protection aims to protect people, their environment, property and cultural heritage in the event of major natural or manmade disasters. The fundamental approach to an effective civil protection operation relies on three key modes of action: Prevention, Preparedness & Response. [EU CP] Civil Protection applications are targeted to decision-makers to provide them with information useful for the emergency management during all of these three phases. They often present scenarios describing the actual or hypothetical situation in terms of a set of parameters for a well-defined spatial and temporal domain. To generate such high-level information an amount of data related to geographical, environmental, demographic, health, etc., variables need to be processed and aggregated. Most of these data and information have an implicit or explicit reference with space and time and is globally known as geospatial data and geo-information. In Civil Protection application these data need to be discovered, accessed, processed, published and visualized. Therefore the availability of a specific infrastructure providing basic and advanced services for geospatial data sharing, a so-called Spatial Data Infrastructure (SDI) is considered crucial for CP applications. Indeed, on the other side, the geospatial community recognized Civil Protection as one of the main benefit areas of SDIs, stating that "*Geographic information is vital to make sound decisions at the local, regional, and global levels. Crime management, business development, flood mitigation, environmental restoration, community land use assessments and disaster recovery are just a few examples of areas in which decision-makers are benefiting from geographic information, together with the associated infrastructures (i.e. Spatial Data Infrastructure or SDI) that support information discovery, access, and use of this information in the decision-making process*" [SDI Cookbook].

A SDI should then be part of the European e-Infrastructure for Civil Protection. It is noteworthy that the term “Spatial Data Infrastructure” denotes not only the technologies but also the “*policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general*” [SDI-Cookbook]. However in this context only the technological aspects of the integration of a SDI in a platform for CP applications are considered.

By a functional point-of-view a SDI should provide a basic set of services and specifications for handling geospatial data:

1. GEOSPATIAL DATA DESCRIPTION: Geospatial data must be documented with metadata to support discovery, evaluation, and use beyond the scope of the originating project and organization. Metadata is information about data such as spatial coverage, temporal extent, quality, etc. Data description is particularly useful for CP application where an information might result useful in context far from the originating one. For example a meteorological forecast originating from a weather forecast system could be useful to derive moisture content as input for a wildfires risk assessment model. Without proper description of the input data would be difficult to use it in the model.
2. GEOSPATIAL DATA CATALOGUE: Geospatial Data Catalogs publish data descriptions to support discovery. They can provide query services to search data basing on their characteristics, and can be enhanced with other services for updating through publishing or harvesting.
3. GEOSPATIAL DATA ACCESS AND DELIVERY: Access involves the order, packaging and delivery, offline or online, of the data specified. They are collected by the user for exploitation.
4. GEOSPATIAL DATA VISUALIZATION: In the context of SDIs, it is useful to provide mapped or graphical views of geospatial data through online mapping interfaces. In fact the visualization of data is often a simple method for a preliminary (qualitative) evaluation, and is useful for presentation purposes.
5. GEOSPATIAL DATA PROCESSING: Rarely data are useful for CP applications without processing. More often they are useful as input of simulation models. Moreover, in CP applications is common to use data for purposes different from the original one.

This means that data often requires also a pre-processing before to be passed to the simulation model or before to be visualized. Therefore in a SDI there is a need of providing processing services that is a set of pre-defined general-purpose services (such as interpolation, coordinate transformations, etc.) and a method for publishing specific services (such as models). This makes possible to generate output data as a chain of access and processing services.

As far as non-functional requirements are concerned, CYCLOPS studies and prototyping activities have demonstrated that geospatial data used in CP applications have specific characteristics which can be summarized as follows:

a) MULTIDIMENSIONALITY: data are often multi dimensional both in the domain and in the co-domain. They can provide multiple output parameters (e.g. physical and environmental parameters like rainfall, moisture, etc.) for several dimensions in space (e.g. 3D), in time (real and forecasting time axes), and in variables (e.g. sensor frequency channels). This characteristics depends on the fact that many data derive from remote sensors.
b) SIZE: sensors and simulation models usually provide a great amount of data, which are continuously updated, making the size of data to be handled large.
c) RESOLUTION AND EXTENT SCALE: CP applications work on very different spatial and temporal extents and resolutions. Some of them describe local situations with high resolution, others describe global scenarios at low resolution. The time extent can vary from few minutes (e.g. nowcasting) to several days and months (e.g. simulations).
d) UPDATE RATE: Data can have great variability going from quasi-static geographical information (e.g. cadastral data) to rapidly updated information (such as that from monitoring networks).

These characteristics introduce further complexity in the development of a SDI which is effective for CP applications.

Topic 2.1 GRID-ENABLED GEOSPATIAL DATA SHARING SERVICES

CP applications require to discover, access, publish and visualize geospatial data. In the last years standard solutions to support geospatial data sharing have reached a mature state. In particular ISO standards for metadata, OGC specifications for network services, complemented with global or community-wide de-facto standards for data formats and data access, provide a strong basis to support typical data sharing scenarios. However the specific characteristics of CP applications which handle data with extreme heterogeneity (in terms of dimensionality, size, spatial/ temporal resolution and extent, rate of update, and type of content) pose several challenges.

A Grid platform might help to address some of the problems of geospatial data sharing for CP applications. In particular, problems related to the handling of large amount of data could be solved or reduced combining distributed storage, high-throughput data transfer, and mobile code functionalities provided by the Grid.

However several open issues must be tackled for integrating geospatial standard services in the gLite-based EGEE Platform. Just to mention some of them:

a) ASYNCHRONOUS ACCESS SERVICES: The Grid is inherently based on an asynchronous architecture: service requests are processed in jobs asynchronously sent into the Grid. On the other side the Web is designed to support a synchronous interaction model where the requestor remains in wait for the response. Web Services technology supports an asynchronous interaction model (e.g. through WS-Notifications and related specifications), but a more complex architecture supporting message queuing would be needed. OGC Access Services which are based on Web technologies (SOAP Web Services and Plain-Old-XML HTTP Web Services) provide a basic support for asynchronous interaction model allowing to provide a reference to a status monitor as the response to a request. An investigation is needed to verify if and how the interaction with the Grid can be effectively implemented.

b) DATA REFERENCE: Geospatial services and the Grid work at a different semantics level. For example Geospatial services handle logical entities (Datasets, Dataset Collections, Coverages, Features, Maps) identified by URLs or query geospatial parameters (e.g. spatial bounding box, temporal extent), while Grid data are files or DB entries identified through a Logical Filename or DB query. To Grid-enable a geospatial access service, it is necessary to map the geospatial reference to the Grid reference. This is similar to the mapping between the geospatial reference and a filesystem or DB in a single-node implementation of a geospatial access service. However the distributed nature of the Grid poses new problems.

c) CATALOGS INTERACTION: Generally speaking, both the Grid and the Web are systems for accessing distributed resources. Moreover both the EGEE Grid architecture and the OGC geospatial services architecture are Service-Oriented. In the Service-Oriented approach there are three actors: the Consumer, the Provider and the Registry. The Registry publishes services offered by the Providers allowing the Consumer to discover them. In the EGEE architecture the LFC (Logical File Catalog) plays the role of the Registry for file-based data. In the OGC suite, OGC-CS/W defines an interface to access geospatial resources. An investigation is needed to define how these two registries can interact. Different approaches are possible. For example they could be maintained distinct. In that case a Geospatial Catalog provides a reference to a Geospatial Data Access Service. The interaction with the LFC is left to the Data Access Service implementation, once it has resolved the reference to one or more Logical File Names. Following another approach the Geospatial Catalog is implemented directly in the Grid Registries publishing not only file-related information but also geospatial metadata according to a well-defined schema.

d) ACCESS FUNCTIONALITIES SPLITTING: The processing capabilities of the Grid platform could be a valuable option to speed up some access functionalities. For example the creation of a map from a large dataset could be split in several sub-tasks (map sub-regions) assigned to different jobs. Tile-based approaches (for example used by Google Maps) could be easily implemented using a Grid Platform. Moreover OGC Data Access and Map Services (OGC-WMS, OGC-WCS and OGC-WFS) actually include basic processing capabilities (e.g. interpolation, subsetting, resampling, coordinate transformation, etc.). They might benefit from the distributed computing capabilities of the Grid (see Topic 2.2).

Relevant Initiatives

G-OWS

G-OWS WG (Grid-enabled Open-Geospatial Web Services Working Group) is a Working Group established as initiative of three consortia of EC-funded Projects (CYCLOPS, GENESI-DR and DORII) with the main goal of coordinating efforts and harmonizing solutions in the field of grid-enabled geospatial services. Its main objectives are:

1) To address the OGF standardization needs as far as the Earth and Space Science Community, GMES and GLite are concerned;
2) To establish an open forum to govern the implementation specification for OGC services on the GLite platform. This allows:
   a) Effective grid-enabled implementations leveraging GLite assets;
   b) Real interoperability among different implementations;
3) To contibute to the OGC-OGF initiative.

EUROGEOSS

EuroGEOSS (A European approach to GEOSS) is a FP7 Project funded in the Work Programme Topic *Environment (including climate change)*. The central concept of this project is to act as the European answer to the Cape Town Declaration (December 2007). The approach proposed by EuroGEOSS is based on following principles:

a) identify and connect (adopting INSPIRE and GEOSS specifications) only systems that are sustained and operated (or with institutional commitment to be operated in near future) by organisations with clear mandate and resources available;
b) enable these systems through interoperability arrangements and connect them together to provide new or improved services within a specific Societal Benefit Area (SBA) so creating de facto GEO SBA(x) components;
c) connect and interoperate these GEO SBA(x) components across multiple SBAs so creating new multidisciplinary cross-cutting applications;
d) assess costs and benefits and define the more appropriate scenarios (only when clear benefits are identified long term sustained operations can be ensured).

The focuses of this project is demonstrating the added scientific value of making existing systems and applications interoperable and used within the GEOSS and INSPIRE frameworks. The aim is demonstrable improved scientific understanding of the complex mechanisms linking the physical, chemical and biological processes which drive changes affecting our planet. Technological development is a means to achieve this end.

EuroGEOSS focuses primarily on the application areas, and the multi-disciplinary interoperability aspects to opening them up, linking them, and making them GEOSS components. EuroGEOSS will demonstrate that this process increases access to new forms of data and services, and as a result allows scientists to address new scientific questions, or address old questions in new and better ways. EuroGEOSS initially addresses three strategic thematic areas: Forest, Biodiversity, and Drought. It builds on systems that are already operational (Forest and Biodiversity/Protected Areas) or in development but with an institutional commitment and sustained funding over then next 5 years (Drought). For these reasons EuroGEOSS is not asking for funding to build the typical prototype that then gets shelved at the end of the project. EuroGEOSS focuses on extending existing systems as new INSPIRE-compliant components to GEOSS able to address societal benefit areas. The research needed to develop an advanced operational capacity in the GEOSS framework is central to the EuroGEOSS effort.

Topic 2.2 Grid-enabled processing services

CP applications require to process geospatial data. Processing can be at different levels: from simple data extraction and transformation for pre-processing purposes (e.g. resampling, interpolation, coordinate transformation, encoding transformation, etc.), to the implementation of algorithms for information extraction (e.g. calculation of environmental parameters from physical observables), up to the implementation of algorithms for complex simulations and complete decision support systems.

The OGC specifications address geospatial data processing in an uneven way. Some processing functionalities are included in the data access services (namely subsetting, resampling, interpolation coordinate system transformation), others are provided through specific services (e.g. OGC-WCTS: Web Coordinate Transformation Service), and, finally OGC-WPS (web Processing Services) provides a generic interface for processing.

In particular OGC-WPS "*defines a standardized interface that facilitates the publishing of geospatial processes, and the discovery of and binding to those processes by clients. 'Processes' include any algorithm, calculation or model that operates on spatially referenced data."* [OGC-WPS]

Because CP applications must handle large amounts of complex data and might implement complex algorithms, a Grid platform could a valuable resource. However the implementation of standard solutions for processing services on a Grid platform needs to be investigated. As the prototyping activities performed during the CYCLOPS Project have demonstrated, there are still many open issues.

a) OGC PROCESSING SERVICE EXPRESSIVENESS: The OGC-WPS defines a basic interface to access processing services. It *"provides mechanisms to identify the spatially referenced data required by the calculation, initiate the calculation, and manage the output from the calculation so that the client can access it.*" [OGC-WPS]. It does not support advanced capabilities like status monitoring, process interaction (pause, stop, restart, etc.) and so on. Moreover it "*offers a generic interface, it can be used to wrap other existing and planned OGC services that focus on providing geospatial processing services.*" [OGC-WPS]. This generality can be a weakness for interoperability, because all the semantics lies in the parameters. Therefore research is needed to evaluate if OGC-WPS is suitable for typical CP applications or it should be extended or modified. For example it is necessary to evaluate if CP applications can be effectively expressed according to the implicit OGC-WPS pipe line processing model.

Topic 2.3 SENSOR SERVICES FOR CP APPLICATIONS

CP application require to access acquisition systems (single sensors, sensors networks and airborne and satellite-based remote sensing systems). They need to read data from different systems, and also to control the acquisition to adopt the best strategy for monitoring an event. For example a CP application for Flash Flood management could provide access to data from different sensors like weather radars and satellites, and could provide also the possibility of modifying the sampling time of a raingauges network depending on the characteristics of the observed phenomenon.

A complete suite of services for integrating sensors in a e-infrastructure should include:

- Discovery of sensor systems basing on the user's needs;
- Description of a sensor's capabilities and quality of measurements;
- Access to sensor parameters;
- Access to observations and coverages;
- Planning of sensors observations;
- Notification of alerts from sensors

One important point is that not all of the sensors are accessible using the same technologies, and this architectural heterogeneity cannot be reduced. In fact data acquisition systems are managed by different organizations and they are often part of existing data sharing systems based on several technologies (Web, Grid or proprietary and legacy technologies). Even if many initiatives are putting efforts in an architectural harmonization, it should be considered that at least in the next years, many acquisition systems will be accessible only using different technologies and systems. In particular concerning the CYCLOPS Platform, it is possible that some sensors are integrated in the Grid as Instrument Element, while others are not. In the proposed architectural framework (see Figure 2) this problem is addressed introducing an Environmental Monitoring Resource Infrastructure. It is dedicated to abstract sensors providing a unique Web-based interface to all sensors, grid-enabled or not. Research is required for the design of this Environmental Monitoring Resource Infrastructure. Several approaches are possible:

a) Sensors can be integrated in the Grid as generic (low-level) Instrument Elements, but their interface is extended according to Web Services standard solutions (e.g. Sensor Web Enablement Framework). This solution provides the high-level interoperability directly at the Grid level. A possible technological solution based on this approach is to extend the Instrument Element introduced in the GRIDCC/DORII architecture to support SWE.

b) Sensors can be integrated in the Grid as generic (low-level) Instrument Elements. The Grid virtualizes the sensor making it seamlessly available to higher services, but provides only basic instrument description, access and configuration services. More advanced services for description, observation and planning expressed with a higher level semantics are defined in the Advanced Middleware for CP Applications. Following this approach we have a full separation of concerns, much like what has be done for data access services, where the Grid provides virtualization and low-semantics services to access basic resources and the Advanced Middleware provides the higher-level view required for the CP applications and full interoperability.

Following the first approach, a functional prototype to provide Grid Civil Protection applications with data from a remote wireless sensor network was developed in the context of the CYCLOPS Project. A first version of the prototype was based on the utilization of the

GRIDCC/DORII middleware. This prototype was later improved with observations handling and services which are in conformity with the OGC SWE standards, O&M/SensorML and SOS respectively. SOS was implemented successfully, receiving XML requests and returning XML documents with the response. The use of OGC standards allowed to obtain the uniform access to heterogeneous resources making the sensors discovery, registration and access an easy task. With OGC services implemented it's rather easy to know the characteristics and potentialities of sensors and, most important, to have standard access and storage of data, making information consistent and available to others for the long term, so it can be used for statistic evaluation and forecasting of weather phenomena. Moreover OGC specification suite handles near-real-time alerting system via XMPP, E-mail or SMS. That is an important feature for Civil Protection people to handle emergency situations.
Although the first approach (OGC SWE enablement of Instrument Elements at the Grid-level) seems feasible it could pose problems for the Grid platform evolution. Indeed according to the architecture defined by the EGEE and related projects, the Instrument Element is a generic resource whose interface cannot be the SWE interface which is defined for environmental sensors and therefore has no meaning for others. Using the SWE interface for some instruments could generate a mismatch between grid-enabled instruments, because environmental sensors would be described according to the SWE interface and the other sensors with a different interface. Therefore the second proposed approach (OGC SWE enablement at the level of the Advanced Middleware for CP Applications), based on separation of concerns, although requiring more work dedicated to the integration between the Web-based upper layer and the underlying Grid platform, seems more promising. In this case the sensor is viewed as a generic Instrument Element at the Grid level, providing the same interface of other sensors, and as a environmental sensor at the upper layer thanks to SWE services providing the required semantics which is missing at the lower layer.

However this prototyping activity has demonstrated that for CP applications some open issues related either to the GRIDCC/DORII approach or to the OGC SWE should be addressed:

a) OGC SWE is based on the Web Service approach, therefore some adaption is required to integrate it in a Grid environment. In the future, a full and seamless integration of the OGC SWE framework could provide significant benefits. The results of the activities in the context of the OGC-OGF MoU, and the introduction of specific functionalities in a Grid-enabled Advanced Middleware (as in the CYCLOPS approach) might be an important contribution.

b) Access policies definition and enforcement is particularly important for sensors planning especially for CP applications during an emergency situation, therefore the integration of security services in the OGC SWE framework needs to be investigated.

c) Following the GRIDCC/DORII approach, alarms, warnings and general notifications are received through the Virtual Control Room (VCR) as usual for EGEE applications. For CP applications these notifications should be addressed to Decision Support Systems and other applications which could be not available through the VCR. In the CYCLOPS approach the CP applications are built on top of the CYCLOPS Platform making use of functionalities provided by the upper layers (Business Process and Presentation/Fruition). Therefore the notifications should be made available also outside the Grid through an interoperable and reliable notification system. Moreover this notification system should support multicast to provide alerts and warnings to multiple applications and users.

d) The concept of Instrument Element should be extended to fully support multi-element instruments, like a wireless sensor network and Sensor Webs. The activities of DORII, in particular concerning the Environmental Science Community could provide significant inputs.

Relevant initiatives

<u>OGC SWE</u>

The OGC Sensor Web Enablement (SWE) initiative is a framework of open standards for exploiting Web-connected sensors and sensor systems of all types: flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, Webcams, satellite-borne earth imaging devices and countless other sensors and sensor systems. Within the SWE initiative, the enablement of such sensor webs and networks is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services:

1. Observations & Measurements Schema (O&M)
2. Sensor Model Language (SensorML)
3. Transducer Markup Language (TransducerML or TML)

4. Sensor Observations Service (SOS)
5. Sensor Planning Service (SPS)
6. Sensor Alert Service (SAS)
7. Web Notification Services (WNS)

DORII

The "Deployment of Remote Instrumentation Infrastructure" (DORII) project is supported by the European Commission within the 7th Framework Programme (FP7/2007-2013) under grant agreement no. RI-213110. The project aims to deploy e-Infrastructure for new scientific communities, where on the one hand ICT technology is still not present at the appropriate level today, while on the other hand it is demanded to empower the communities' daily work. The main focus of the DORII project is on groups of scientific users with experimental equipment and instrumentation that are currently not or only partially integrated in the European e-Infrastructures. At present, following selected scientific areas are represented in the project:

- Earthquake community (with various sensor networks)
- Environmental science community
- Experimental science community (with synchrotron and free electron lasers)

SANY

"Sensors Anywhere" (SANY) is an IST FP6 Integrated Project. It focuses on interoperability of in-situ sensors and sensor networks. SANY architecture will provide a quick and cost-efficient way to reuse of data and services from currently incompatible sensor- and data-sources. The vision of SANY is to contribute to the long-term goal of the European Commission to create a Single European Data and Information Space for environmental ICT by developing a generic architecture and reference service implementations for sensor networks in this application domain. SANY shall simplify the task of integrating various in-situ and remote sensors into one information space and facilitate interoperation between a wide variety of sensor types.

OSIRIS

Open architecture for Smart and Interoperable networks in Risk management based on In-situ Sensors) is a Sixth Framework Programme Integrated Project of the European Commission, aligned with GMES (Global Monitoring for Environment and Security).

The OSIRIS Project calls for the definition, development and testing of services dedicated to surveillance and crisis management, thus significantly enhancing the overall efficiency of the related operations. OSIRIS provides a Service Oriented Architecture based on standards and delivering functions ranging from in-situ earth observation to user services. The programme is structured around four key areas of major environmental risk: forest fires, industrial risks, unexpected fresh water pollution and air pollution in urban areas.

The OSIRIS solution will be deployed in these areas, leading to four live experiments, complementary in:

- Environmental concerns.
- Time constraints.
- Sensors - based on mobile or fixed platforms.
- Data produced by the sensors.

Addressing smart deployment, use and reconfiguration of in-situ sensor systems, the OSIRIS proposed architecture is scalable to allow for easy integration of new sensor data to further improve the quality of service.

<u>ISTIMES</u>

“Integrated System for Transport Infrastructures surveillance and Monitoring by Electromagnetic Sensing” (ISTIMES) Project is funded under the EC FP7 Theme 4: ICT and Theme 10: Security.

The aim of the project is to design, assess and promote an ICT-based system, exploiting distributed and local sensors, for non-destructive electromagnetic surveillance and monitoring in order to achieve the critical transport infrastructures more reliable and safe. In particular it aims to fulfill the following specific scientific/technological objectives in the context of infrastructures for CP applications:

a) To develop an information and communications system able to remotely control a permanent distributed sensor network, and allow the processing of large amounts of electromagnetic data by means of innovative and efficient inversion algorithms;

b) To demonstrate the effectiveness of the overall monitoring ISTIMES system (ICT expert system plus electromagnetic sensing techniques) at different engineered sites such as a highway bridge and … identified by the end-users involved in the proposal;
c) To disseminate and promote the new technology including the demonstration results from the test sites.

Topic 2.4 EVENT-BASED SERVICES

To support different applications models and in particular to support RT/NRT applications the enabling infrastructure should be able to provide event notification to reduce the delays in the transmission of the meaningful information. This behavior should be implemented at every level, from the notification of job completion in the underlying Grid architecture, to the notification of high-level tasks in the middle layer (e.g. the completion of a geospatial query), and finally to the notification of alerts and warning situation targeted to the decision-makers in the upper layer. Unfortunately neither the Web nor the EGEE Grid are fully event-based systems. Actually the gLite middleware implements an asynchronous architecture, but not all the meaningful events are immediately notified. The results of the research activities proposed in the Theme 1 should provide basic services for notifications in the Grid infrastructure.
At the upper levels the Web in its different realizations is the core technology. Unfortunately the Web architecture was implicitly designed for a client-server system with client-initiated interactions. In the Web several solutions have been proposed both in the SOAP-based SOA with WS-Notification and related specifications, and in the traditional resource-based architecture. However more research is required to investigate:

a) the possible adoption of Web existing solutions in the CYCLOPS Platform
b) the interactions with the asynchronous services provided by the underlying gLite environment
c) Overall performances

Theme 3 SECURITY AND DATA POLICY

In the context of CP applications, security is one of the main issues. Security covers a wide range of aspects, from data access, to system availability and so on. To define security requirements and prepare a security plan and infrastructure, one generally accepted approach includes the following steps [RFC 2196]:

1. Identify what you are trying to protect.
2. Determine what you are trying to protect it from.
3. Determine how likely the threats are.
4. Implement measures which will protect your assets in a cost-effective manner.
5. Review the process continuously and make improvements each time a weakness is found.

As a study for the definition of research strategies, the present documents focuses on points 1 and 2 to identify which specific challenges CP applications pose in the design of an advanced e-Infrastructure.

A preliminary consideration is required concerning the point 2. We can broadly classify the threats into two categories: threats due to natural events (like floods, fires, earthquakes, etc.), and threats due to human actions (errors and attacks). This classification is useful to highlight a point that distinguish an infrastructure for CP application from many others. In fact for many applications, e.g. e-Business, e-Commerce or e-Government, human threats are the most important ones, because they are considered more probable. Therefore the corresponding infrastructures are designed to be protected mainly from these kinds of threats. On the contrary for CP applications, natural threats must be considered much more probable since they are the reason the infrastructure is developed. Therefore the infrastructure must consider what could happen to the resources located near the risk area under an emergency situation. The example of SPC-GD, for flood management is symptomatic of the vulnerability of these real-time and simulated data. More widely, events such as Gard 2002 which occurred important communications disconnections and crucial data exchange difficulties among the whole of involved actors, illustrated the important need to put under security these essential data in remote sites outside the hazard locations.

This availability problem concerns the general architecture of the system and since it involves the basic communication infrastructures deployment should be the subject of a specific study (see Topic 1.4). For example, some grid utilities could be implemented to ease replica management and automatic job submissions to enable other expertise by safe forecasting units (such as SCHAPI in France which can provide its own expertise on the whole of French territory).

With regards to point 1, in principle, all the resources shared through the infrastructure at different levels need to be protected: computing and storage resources, communication lines, network systems, data, sensors, processing services, etc. However this document focuses in particular on data and services that, in the context of CP applications, are often characterized by complex data policies.

In the context of CP applications types of exchanged data and their providers are characterized by great heterogeneity. For example Figure 3 shows the overall results from the Final Report of "Data Policy Assessment for GMES" [DPAG]. The table describes shortly the main data policy issues in terms of policy characteristics for different data providers.

The characteristics considered are six common policy characteristics:

a) OWNERSHIP, PRIVACY AND CONFIDENTIALITY which concerns who owns data and who can access them;
b) INTELLECTUAL PROPERTY RIGHTS AND ASSOCIATED LEGAL FRAMEWORKS which concerns the assignment of property rights through patents, copyrights and trademarks;
c) STANDARDS AND METADATA which concerns the adoption of common specifications for data formats, data quality and metadata;
d) LICENSING, DISTRIBUTION AND DISSEMINATION which concerns how data can be provided;
e) PRICING POLICY which concerns payments due for accessing and using data;
f) ARCHIVING POLICY which concerns data preservation;

They are considered respect to the main data providers for CP and GMES applications: statistical institutes, mapping agencies, institutes for natural resources, environmental monitoring and Earth Observation.

	Ownership, privacy and confidentiality	Intellectual property rights and associated legal frameworks	Standards and metadata	Licensing, distribution and dissemination	Pricing policy	Archiving Policy
Statistical Institutes	Most statistical institutes maintain ownership of data. Data relating to individuals strictly confidential.	Unrestrictive – redistribution often allowed if source is quoted.	Many follow international standards such as EUROSTAT, OECD	Basic data distributed widely as possible, few restrictions. Licences may govern sensitive data.	Free of charge via internet or at marginal costs. Individual requests may be at market price.	Often long-term in electronic and hard copy formats.
Mapping Agencies	Ownership maintained by organisation in most cases. Some restriction for national security.	Restrictive – strict copyright to prevent unauthorised redistribution in many cases.	Generally follow national, not international standards. Most agencies have metadatabases.	Distribution and dissemination generally controlled through licensing.	Generally at market price. Cost of licences often depends on proposed use of data.	Older map data often archived by national archives of respective countries.
Institutes for Natural resources	Ownership of data generally maintained by organisations, although most data is placed in the public domain.	Unrestrictive, although creators of data often given privileged access for a certain time.	Diverse range of projects and data regarding natural resources means there are no universal standards.	Most natural resources institutes distribute their data as widely as possible. Some restrict access to ensure it is used for research purposes only.	Most natural resources data is supplied free of charge. Some institutes charge if data is used for commercial purposes	Variable – usually dependent on perceived long-term usefulness of individual datasets.
Environmental Monitoring	Ownership maintained by organisations, although data is often in public domain. Ownership of meteorological data maintained by respective organisation	More restrictive for meteorological data, except in the case of 'essential data'. Generally unrestrictive for other environmental data.	Meteorological agencies follow international standards (WMO etc.) Other environmental data covers wide variety of topics – most aim to meet international standards.	Meteorological data highly influenced by international agreements. Other environmental data often distributed as widely as possible, particularly if publicly funded.	'Essential' met data is provided on free and unrestricted basis. Derived products often at market price. Publicly funded environmental data generally free of charge.	Met data is archived long-term for climate records etc. Variable for other environmental data sets – usually dependant on perceived long term usefulness.
Earth Observation	Ownership of EO data is strictly maintained. Access to data is sometimes restricted for reasons of national security.	Restrictive in many cases with strict copyright to prevent redistribution. Some US data (eg MODIS) has few restrictions.	Dependent on platform and organisation. Metadata is supplied with most datasets.	Licensing governs distribution of many EO data sets, although some are distributed freely with very few licensing conditions.	Price of licences often depends upon the proposed use and number of users of the data. Some US data available for free.	Most EO data has been archived for the duration of the associated mission. Access often dependent on age of data and storage media.

Figure 3 - Table showing different policies for GMES data (from [DPAG])

Several issues related to ownership, distribution, description, licensing and pricing are shown.

Basing on the previous analysis, taking into account the existence of different users/providers with different policies, the CYCLOPS Architectural Framework describes a distributed system characterized by sub-domains controlled by different organizations acting as users and/or providers. The existence of different data policies makes the boundaries between sub-domains significant. In fact each organization typically has its own security architecture made of services, rules, people, processes and procedures. Therefore these boundaries are both logical (where ownership and related data policies change) and technological (because data policies are enforced through different technological solutions). Actually the choice of a Service-Oriented-Architecture (SOA) for the CYCLOPS Platform was made taking into account these characteristics. Indeed SOA reflects the reality that ownership boundaries are a motivating consideration in the architecture and design of systems [OASIS-RM].

To make the CYCLOPS Architectural Framework feasible, the integration of the existing security infrastructures is required. Since the adoption of a new security infrastructure for all the users is unfeasible, a federated approach is adopted. A Federated System (FS) is a collection of independent and autonomous systems which allows sharing of data and services. In federated systems a cooperative approach is adopted: participants agree on a set of common specifications to be used for sharing data and services. The common specifications concerning data formats, metadata, interfaces and protocols are required only to participate in the federation. Out of the federation scope each participant can maintain its own infrastructure. This loose approach preserves the participants' investments and facilitate the sharing because the participants do not need to change their infrastructure, they only need to extend it for enabling federation services and common specifications adoption.

In the security context the federation can be established providing common specifications for:

a) Data (and services) policy description and exchange;
b) Security services to support data (and services) policies;

The CYCLOPS Platform is based on the EGEE infrastructure which provides a complete set of security services built around the concept of Virtual Organization. This means that all the resources shared through the Grid can be considered part of the same security sub-domain. Therefore another aspect that the security architecture of the CYCLOPS Platform should consider is the relationship between the CYCLOPS security services and the corresponding services provided by the underlying Grid.

Topic 3.1 DATA POLICIES FOR CP APPLICATIONS

The great heterogeneity of possible data policies in the domain of CP ad GMES applications previously described, require specific studies aiming to define a CP/GMES data policy model. This model should allow to express pre-conditions (e.g. authentication, license approval, etc.), rules based on requestor and resource properties (e.g. user's role/group, user's level of authentication, resource type, resource owner, etc.), and obligations (e.g. integrity, confidentiality, masking, etc.).

The possible encodings of these policies should be evaluated. Moreover how these policies are made public should be also evaluated. For example OGC geospatial data access services provide an operation for resource description (e.g. *describeCoverage*) whose response should contain the policy. It is necessary to evaluate if CP policies can be accommodate in the response data model or if an extension/modification is required.

Another problem to be investigate concerns the processing services policies which pose new challenges. For example a processing service could require several data in input, each subject to different policies. A decision must be made on how processing service policy, input data policies and output data policies integrate. Specific services for policy merging and integration should be defined.

Finally the trust chains must be defined and explicated. Trust chains enable patterns like:

a) The interaction between the three typical actors of CP applications: Resource User, Resource Provider and Resource Owner. The Owner can trust on the Provider who trust on the User, without direct trust relationship between Owner and User.
b) The interaction between User, Processing Service Provider and Data Access Services Provider. E.g. a Data Access Provider and Processing Service Provider can trust on the same User but no explicit trust relationship between the Providers exist.
c) Complex workflows including several Processing Services and Data Access Services.

Topic 3.2 Security Services to Support CP Data Policies

The Security Architecture of the OSI Reference Model [ISO-SEC] considers five main security services:

- *Authentication* which verifies the supposed identity of a user or a system;
- *Access Control* which protects the system resources against non-authorized users;
- *Confidentiality* which hides information to non-authorized users;
- *Integrity* which protects the data against non-authorized modifications, insertions or deletions;
- *Non-repudiation* which provides protection against the sender of a message that refuses to be it, or against the receiver of a message that denies to have received it

All these services presents peculiar characteristics for the implementation in CP and GMES applications.

AUTHENTICATION

The CYCLOPS Platform describes a Federated System which is made of several sub-domains with individual security realms with their own rules, policies, processes, procedures and technological solutions. In particular the access to every sub-domain is controlled by its own authentication services. This implies that to access the shared resources the requestor must authenticate using the owners' authentication service. Single-Sign-On (SSO) solutions provide means for transferring authentication credentials or proof of identity between realms. Two approaches are possible for implementing SSO authentication in federated systems:

- *Centralized Identity*: A federation-level authentication service (Identity Provider) is implemented. All users who want to access the resources provided by the federated system must authenticate through the centralized authentication service. The access can be made transparent, and the proof of authentication is used to access resources located in different realms. This approach has the advantage that different authentication schemes can be implemented extending the centralized authentication service, and that each provider must simply trust on the centralized authentication service provider. This means that the Trust Chain has a simple star topology where the peripheral nodes connect to (i.e. trust on) the central node.
- *Federated Identity Management*: No federation-level authentication service is implemented. The proof of identity provided by the authentication service of a realm is transferred to the other realms. This approach has the advantage that no central service needs to be implemented and managed, but it has the drawback that realms must define their trust relationships. The Trust Chains can be complex and therefore hard to be managed. The situation can be made more complex when the Trust Level depends on the authentication schema (e.g. the Realm A trusts on the Realm B authentication if it is based on a strong scheme but not if it is based on a weak scheme).

In the recent years many architectural solutions have been developed to address authentication problems. In particular several technologies for weak and strong authentication are available. Challenge/Response techniques using smartcards, hardware tokens, RFId and biometric data provides methods for implementing the strict authentication requirements of CP and GMES applications that can involve dual (civil/military) systems. In the context of Web Services the WS-* standards collection provides a complete suite for enabling identity management in a federated system. In particular WS-Trust, and WS-Federation specifications [WS-FED, WS-TRUST] define a model for the management of trust chains and identities. Different solutions mainly based on the same technologies are proposed by other Consortiums such as Liberty Alliance. An investigation is needed to evaluate which identity management model best fits to an e-Infrastructure for CP applications and if existing solutions like WS-Trust and WS-Federation are sufficient for implementing it or they should be extended/modified.

ACCESS CONTROL

In a distributed system for accessing data, information and services, Access Control services have particular importance. When the user's identity has been verified through the authentication services, the proper resource policy must be enforced through the access control services. To define a complete access control system several architectural and technological choices have to be done.

Access Control systems can be generally divided into two categories:

- *Digital Rights Management (DRM) Systems*. They allow to enforce access control during the full life-cycle of the information, from the access on the remote provider's system, to the storage and use on the user's local system. They have the advantage of a full control of the information/service enabling complex policies concerning the use, but they have the drawback of a greater complexity. In DRM systems the information accessed is stored in an encrypted format requiring enabled tools for reading and using. DRM systems are usually adopted for reserved media sharing (e.g. pay-per-view systems, etc.).
- *Remote Access Control Systems*. They enforce the access control only on remote accesses. When the information is accessed it can be used without control. These systems can be considered implementing a subset of the DRM systems functionalities. They are simpler than DRM systems and they have the advantage that the use of the accessed data and information does not require enabled tools. It is

noteworthy that Remote Access Control Systems do not pose limitation to policies, but only on which part of the policies is subject to technological enforcement.

In the context of CP and GMES applications the DRM solution seems to be particularly appealing, but an investigation is required to estimate its impact on the usability, in order to evaluate if the simpler Remote Access Control is a valid option at least as a first step towards a full DRM-enabled infrastructure.

The complex policies that characterize resources useful for CP and GMES applications pose significant functional and non-functional requirements for the access control services. In particular the following functionalities must be provided:

- *Licensing*: the resource access and use can be subject to particular conditions expressed as term-of-use documents, payment conditions, etc. Services for license approval are required; they must make use of Non-repudiation services;
- *Payment*: If it is required by the license, services for completing payments must be provided, possibly interacting with external e-Banking and e-Commerce infrastructures;
- *Policy Update*: The system must provide services to create, retrieve, update and delete policies. The resource provider should be able to define who can access the resource and how specifying license, and obligations (confidentiality, integrity, etc.).

A preliminary consideration concern the service distribution. As previously described the CYCLOPS Platform interconnects systems of different organizations that want to maintain full control on their resources. This means that the resource providers and owners want to define and change the resource policies on their own. Therefore, although the authentication service can be centralized, the authorization services must be maintained distributed.
By an architectural point-of-view the Access Control services can be implemented in two ways:

- *Central Point of Decision*: a single component provides the decision logic for the resources of a domain according to the resource policies. To access the resources, all the requests are routed to the central point of decision.

- *Gatekeeper*: each component providing access to resources has a specific decision point, the so-called gatekeeper.

The Gatekeeper approach has the advantage that is less invasive since the Gatekeeper can be implemented as a component that lies between the requestor and the provider (e.g. a proxy) without the need of changes on the requestor's and provider's systems. Moreover since a Gatekeeper controls few resources its internal logic is simpler. On the other side multiple resources require multiple gatekeeper implementations and deployment.

Research is required to evaluate the best architectural approach for Access Control services in an e-Infrastructure for CP applications.

GeoDRM defines a reference model for digital rights management (DRM) functionality for geospatial resources. As such, it is connected to the general DRM market in that geospatial resources must be treated as nearly as possible like other digital resources, such as music, text, or services [GeoDRM]. At the moment of writing [2008] only the RM-ODP computational, information and engineering viewpoints are defined. They specify a Gatekeeper approach for implementing a DRM system. The technology viewpoint is not defined but it could integrate WS-*, SAML and XACML technologies and architectures.

Another important point concerns the policies and policies rules description. Policies need to be described internally in the access control system to make enforcement possible. The eXtensible Access Control Markup Language (XACML) provides an architectural framework and an XML encoding for expressing rules. It is a common language for expressing security policy. Tools are available for building XACML-based access control systems.

The OGC "Geospatial eXtensible Access Control Markup Language Encoding Standard (GeoXACML)" defines a geospatial extension to the XACML. This extension incorporates spatial data types and spatial authorization decision functions based on the OGC Simple Features and GML standards. GeoXACML is a policy language that supports the declaration and enforcement of access rights across jurisdictions and can be used to implement interoperable access control systems for geospatial applications such as Spatial Data Infrastructures.

Research is required to define a complete architecture for access control services for CP and GMES application, and to evaluate the possible adoption and integration of existing solutions.

CONFIDENTIALITY AND INTEGRITY

Confidentiality and integrity are typical requirements for access services to restricted data. They can appear as obligations in data policies (i.e. a policy can state that a dataset can be accessed but it must be transferred confidentially). Confidentiality and integrity support can be provided by specific security services based on asymmetric cryptography. Investigation is required to evaluate how existing solutions for message-level security (e.g. WS-Security) and/or transport-level security (e.g. SSL/TLS) can be integrated in the CYCLOPS Platform, and how the corresponding obligations can be expressed in data policies.

NON-REPUDIATION

Non-repudiation is required for many CP application. As previously described many resource policies could include the acceptance of licenses (e.g. term-of-use) or even payments. In these cases it is important to assure that users cannot deny their acceptance, or that providers cannot deny to have received the payment. e-Commerce and e-Government domains provide mature solutions for this functionalities through the adoption of digital signatures. However it is necessary to study if this solutions are useful in the particular context of CP and GMES applications.

Theme 4 CIVIL PROTECTION APPLICATIONS ENABLEMENT

Several experimentations have demonstrated the feasibility of porting CP applications on top of Grid Platforms. The prototyping activity complementary to the studies performed during the CYCLOPS Project has also demonstrated the feasibility and usefulness of porting CP applications making use of an intermediate abstraction layer implemented as a Web Services based middleware. Although a straightforward porting of CP applications could be a valid strategy whenever the reuse of code is of primarily importance, to fully exploit the capabilities of the CYCLOPS Platform, CP applications should be designed and implemented taking into account some principles. First of all the availability of the computing power on-demand provided by the Grid can be generally exploited to run multiple instances of the same model for example to simulate different scenarios. But if the model is implemented to support parallelization other possibilities open up. As the prototypal implementation of the RISICO model during the CYCLOPS Project has demonstrated, supporting parallelization allow to increase the resolution and/or the spatial extent of the simulation without affecting the time-of-response.

Another important characteristics is the possibility of providing information after a certain time-of-response.

Relevant Initiatives

SAFER

"Services and Applications For Emergency Response" (SAFER) Project is funded under the EC FP7 Theme 9 (Space Research Call – GMES). It aims at implementing preoperational versions of the Emergency Response Core Service. SAFER will reinforce European capacity to respond to emergency situations: fires, floods, earthquakes, volcanic eruptions, landslides, humanitarian crisis.

The main goal is the upgrade of the core service and the validation of its performance with two priorities:

First priority is the short term improvement of response when crisis occurs, with the rapid mapping capacity after disastrous events, including the relevant preparatory services (reference maps).

The second priority is the extension to core service components before and after the crisis. It targets the longer term service evolution, through the provision of thematic products, to be added in the portfolio of services. The main performance criterion is the added-value of products with risk-specific information. In SAFER, thematic products will cover mainly the meteorological and geophysical risks.

SAFER includes also some transverse RDT actions, with the objective to increase added-value of the overall service chain.

LIMES

LIMES (Land and Sea Monitoring for Environment and Security) is an Integrated Project co-funded by the European Commission within the 6° Framework Programme – Aeronautics&Space/GMES Security. It has started on December 1st 2006, will end in 2010 and involves around 50 Partners.

The LIMES Project goal is to supplement the GMES (Global Monitoring for Environment and Security) program by providing expertise in the security area through the development of applications and services relating to security, applying innovative solutions based on Earth Observation systems and satellite Communication and Positioning technologies. LIMES goal is to define and develop prototype information services to support security management at EU and global level in the following areas of interest:

a) Organization and distribution of humanitarian aid & reconstruction.
b) Surveillance of the EU borders (land and sea).
c) Surveillance and protection of maritime transport for sensitive cargo.
d) Protection against emerging security threats (e.g. terrorism, illegal trafficking, and proliferation of Weapons of Mass Destruction).

The services developed by LIMES support the building up of a common cooperation framework between the major EU research and operational actors on security management.

EURORISK/PREVIEW

PREVIEW (PREVention, Information and Early Warning pre-operational services to support the management of risks) is an Integrated Project co-funded by the European Commission within the 6° Framework Programme – Priority 1.4 Aeronautics & Space.

PREVIEW aims to develop, at the European scale, new or enhanced information services for risk management in support of European Civil Protection Units and local or regional authorities, making the best use of the most advanced research and technology outcomes in Earth Observation.

PREVIEW addresses the definition, the development and the validation in pre-operational conditions of information services to support the management of: Windstorms, Forest fires, Plain floods and Flash floods, Earthquake and Volcanic risks, Landslides and Industrial accidents.

Based on the review of the operational needs and of the existing research assets, a Portfolio of Services is defined in close cooperation with end-users. Research developments are performed to transfer the most promising available results and blocks to operational use. The information services are developed, tested and validated at European scale with operational users on pilot test sites. A long term deployment plan of these services is established, proposing the best scenarios and programmatic for their European operational deployment and organization.

PREVIEW is organised in "hazard service platforms", each platform being managed with flexibility as a sub-project dedicated to the development of methodologies and services

related to a given type of hazard. For best project efficiency, these platforms are further grouped into "clusters" depending on the possible teaming synergies.
PREVIEW is led by the EURORISK Consortium, a multi-disciplinary European team of committed actors in the domain: civil protection and environmental bodies; scientific communities and service operators at national and regional level; bodies for meteorology, hydrology, seismology, vulcanology and GIS services based on space data; and industry.

Topic 4.1 *PARALLELIZATION STRATEGIES FOR CP APPLICATIONS*

To gain benefits from the parallel-computing capabilities provided by the underlying Grid infrastructure, the applications running on the CYCLOPS Platform must be split in multiple jobs whose output is then collected and integrated. This capabilities enables the satisfaction of RT/NRT requirements, since if the required Time-of-Response decreases, the number of jobs can increase to allow shorter processing times. However for better performances is necessary that each job is able to work autonomously from other jobs. This means that the computational task of each job can be performed without interacting with other jobs and possibly accessing a subset of the input data. This condition can be satisfied if the sub-task assigned to the single job is logically independent by the other sub-tasks. This possibility depends on the characteristics of the parallelized applications which in turns depend on the characteristics of the implemented models. The CYCLOPS prototyping activity provided some preliminary hints about this topic. For example the RISICO application, utilized by the Italian Civil Protection for wild fires risk assessment, is based on a model running on a regular grid of spatial points. The risk associated to each cell depends only on input data and parameters for that cell. Therefore each job can be safely assigned the computation of the fire risk for a set of cells. On the other side the SPC-GD application, utilized by the French Civil Protection for flash flood risk management, can also be split on cell-basis. The transformation from rainfall to water flow is produced for each cell and individually propagates to the outlet of the watershed. However, in case of parallelization, computation has to be organized in dependent jobs group motivated by the watershed domain.
Other applications could be parallelized on different forecasting scenarios, different hypothesis on the event progress (stories) and so on. A classification of possible approaches, and subsequent split and output merging strategies could help to provide

software libraries, and also tools for automatic or semi-automatic parallelization of applications.

Topic 4.2 APPLICATION DESIGN

In the context of Civil Protection, the importance of the information provided can change quickly. A risk map can be considered of vital importance before a strategic decision is made, but can be useless after that. On the other side a forecasting scenario based on unlikely conditions can be initially considered of little interest, but its importance could grow considerably if those conditions become real. This means that a deadline for information provision should be posed, but also that all the information although incomplete, or inaccurate, should be made available on request.

Therefore although the RT/NRT support allows to define deadlines for processing tasks, the information extracted should not be lost if the processing task is not completed before the deadline. To provide partial information two strategies can be adopted and mixed:

a) Soft deadlines. If the processing task is near to the conclusion, the deadline could be postponed to allow the task completion. This possibility should be specified as a QoS parameter in the Request.

b) Incremental algorithms. The simulation models and even single tasks should be realized adopting incremental algorithms instead of all-or-nothing algorithms. Using incremental algorithms the accuracy of the result (measured in terms of specific parameters such as spatial accuracy, spatial coverage, temporal extent, number of scenarios, and so on) increases with the time typically following a multiple step trend. On the other side, in all-or-nothing algorithms the accuracy is null until the processing is concluded, when it reach its maximum. This means that incremental algorithms can provide partial results during processing, while all-or-nothing ones, although generally faster, cannot. Examples of incremental algorithms are the pyramidal encodings for data.

Research is required to evaluate the feasibility of incremental implementations of risk models, and complete CP applications.

Topic 4.3 SIMULATION AND FORECAST MODEL WORKFLOW

Civil Protection applications can range from small environmental models to complete decision support systems mapping typical CP Business Processes. The availability of a workflow management system would allow to build CP applications as workflow of data access services, simulation models, presentation systems. This approach would enable the re-use of components and a full separation of concerns, with data centers providing access services, Earth scientist providing simulation models, and CP experts building risk management applications and scenarios. It also would greatly improve applications allowing to run simulations using different models on the same data, or alternatively the same model on different data, fully exploiting the Grid capabilities in terms of computing power and storage on-demand.

In SOA two possible approaches can be followed: orchestration and choreography. The terms orchestration and choreography describe two aspects of creating business processes from composite Web services. "*Orchestration refers to an executable business process that can interact with both internal and external Web services. The interactions occur at the message level. They include business logic and task execution order, and they can span applications and organizations to define a long-lived, transactional, multistep process model.[…]*

Choreography tracks the message sequences among multiple parties and sources—typically the public message exchanges that occur between Web services— rather than a specific business process that a single party executes." [Peltz] Therefore following in the orchestration paradigm the business process is implemented by a single controller (acting as the orchestra director) that coordinates services calls according to the business process description. In the choreography approach there is not a central controller: the Business process emerges from the actions of several actors following their instructions, much like a ballet emerges from the overall action of all the dancers. Several specifications have been designed to describe processes. In particular "Business Process Execution language for Web Services" (BPEL4WS) and W3C "Web Service Choreography Interface" (WSCI) are widely used for e-Business and e-Government application.

Research is required to evaluate if this approach is still valid for CP applications taking into account their specific requirements. Moreover BPEL and WCSI describe the Business Process in terms of multiple steps accomplished by calling Web Services. It is possible that the implementation of Web Services could be considered too complex for Earth scientists without advanced technological skills or staff. Therefore the integration of REST and POX-HTTP (Plain-Old-XML over HTTP) services achieved through the so-called "mash-up" services could be in some cases a valid alternative.

Theme 5 INTEROPERABILITY

The proposed CYCLOPS Platform must not be considered as a closed system. On the contrary it is conceived as an open architectural framework which is able to provide in principle coordinated access to every resource useful for CP applications. This means that a valuable resource (data, service) should not be discarded because it is not part of the platform (e.g. it is not Grid-enabled). In fact this requirement would be too restrictive since the resource could be already provided through an existing platform (e.g. a e-Government infrastructure) which could not be changed. Therefore the architectural framework must allow a seamless accommodation of external resources. This is obtained through interoperability which can be defined as "*the ability of two or more systems (computers, communication devices, networks, software and other information technology components) to interact with one another and exchange information according to a prescribed method in order to achieve predictable results.*" [ISO/IEC (2002:12)] Therefore interoperability is achieved through an agreement between the interacting parts. By the CYCLOPS Platform point-of-view this means that not all the external resources could be accessed, but only those that are served in agreement with some interoperability standard. In this view the adoption of an interoperability standard is a sort of expression of interest to share the resource by the owner. If a provider does not adopt an interoperability standard this means that he/she wish to share the resource only with a very limited community. On its side the CYCLOPS Platform should try to accommodate the greatest number of external resources, integrating with the most widespread interoperable platforms.

In the layered approach of the CYCLOPS Platform interoperability should be achieved at each level:

1. GRID INTEROPERABILITY: External Grid infrastructures could provide basic resource useful for CP Applications such as computational power, storage space, data stored in files and DBs, or provided by instruments, etc. The interaction with these infrastructures could be necessary for CP emergencies outside of Europe where the use of "local" resources could be profitable.
2. GEOSPATIAL SERVICES INTEROPERABILITY: Many data access, processing and sensor services could be provided through external platforms (e-Government, e-Commerce, scientific data centers, etc.). These resources could be extremely valuable for CP applications.

3. CP APPLICATIONS INTEROPERABILITY: Existing CP or generally e-Governments infrastructures could provide high-level services, e.g. for notifications of alerts, messaging, coordination of emergency squads, etc. The CYCLOPS Platform should be able to interact with these infrastructures at high level, providing input to those systems.

Research is required to evaluate the state-of-the-art in terms of definition and adoption of interoperability solutions (existence of initiatives for the interoperability, existence of de-facto standards, etc.), and to evaluate the feasibility of the integration with the CYCLOPS Architectural Framework.

Topic 5.1 GRID INFRASTRUCTURES INTEROPERABILITY

The final goal of Interoperability is to provide Grid users a transparent way to access distributed computing resources based on different middleware implementations.
Different middleware flavors exist, providing efficient and production ready environments for distributed computing, and efforts have been made to make them able to work together. As a positive side effect, the final Grid user gains freedom to choose services that are deployed in different Grids and the selection of them would be based on their functionality rather than on their deployment in a particular Grid. Cyclops use cases have been developed and tested on top of the gLite middleware stack and they are in this sense tied on this architecture. Of course different Grid stacks may be located on wide geographical areas and wide users communities may feel more comfortable adopting other middleware than gLite. A Civil protection agency operating in a geographically area where a non gLite Grid is more common may thus encounter greater difficulties when trying to adopt their distributed computation model. The effort provided by the Interoperability task forces become then crucial in order to permit an almost transparent use of Grid resources of any kind. Interoperability is complex and requires significant time to understand the different middleware stacks and their underlying concepts. What follows in this paragraph is a short description of achieved results in the interoperability field.

INTEGRATION WITH ARC GRIDS

The Nordugrid project is a Grid Research and Development collaboration aiming at development, maintenance and support of the free Grid middleware, known as the Advance

Resource Connector (ARC). ARC provides a reliable implementation of the fundamental Grid services, such as information services, resource discovery and monitoring, job submission and management, brokering and data management and resource management. Most of these services are provided through the security layer of the GSI.

The goal of the ARC interoperability activity is to enable seamless job-submission from gLite user interfaces to ARC based resources.

A gLite grid uses the Glue schema for its information service (this service provides both static and dynamic information about Grid status and components) which differs from the one adopted by ARC. To fill this gap a prototype ARC information system schema to Glue schema translator has been implemented as well as a reverse translator. ARC based sites are nowadays published in the EGEE information system. Furthermore scripts have been produced to enable the glite-CE to submit jobs to ARC Ces. gLite WMS may be used to address ARC sites as demonstrated since march 2008. ARC sites are available during the match making process and jobs can be submitted to ARC CEs. Minor open issues have been addressed and assigned to partners for completion, so that interoperability is expected to be considered in a mature state quite soon.

INTEGRATION WITH UNICORE GRIDS

UNICORE (Uniform Interface to Computing Resources) offers a ready-to-run Grid system including client and server software. UNICORE makes distributed computing and data resources available in a seamless and secure way in intranets and the internet.

Interoperability with UNICORE is in a less mature state in respect with ARC since their model differs in a heavier way and only partially covers the EGEE use cases. Furthermore, no much interest on integration arose from users community expressing interest in using both infrastructures in a transparent way.

OPEN SCIENCE GRID (OSG)

OSG is a consortium of software, service and resource providers and researchers, from universities, national laboratories and computing centers across the U.S., who together build and operate the OSG project. The project is funded by the NSF and DOE, and provides staff for managing various aspects of the OSG. Its middleware is based on the Virtual Data Toolkit (VDT). Seamless interoperability with OSG both on the technical and operations level was already achieved throughout a strict collaboration with the EGEE project. Some VOs are heavy users of this capability.

GRID INTEROPERABILITY NOW (GIN)

This is not actually a Grid flavor. Grid Interoperability Now is a task force in the context of the Open Grid Forum (OGF) who concentrates efforts on the integration of a Grid component which have fundamental importance to interoperability: the Information system.

An attempt was made to translate information from all the existing production grid infrastructures in order to populate a single gLite like Information System that contained all the information from all Grids in the Glue Schema format. The result was a BDII that contained information from 9 production grid infrastructures (EGEE, OSG, NDGF, NAREGI, Teragrid, Pragma, DEISA, NGS, APAC).

An effort is underway to defined Glue 2.0 completely under the scope of OGF. This group brings together many experts from the different grid projects in order to define a common schema which is acceptable to all.

Topic 5.2 INTEROPERABILITY WITH INSPIRE, GEOSS, GMES INITIATIVES

In the recent years several European and international initiatives have been started to address specific problems related to geospatial data sharing. Three of them have particular importance and will have presumably great impact in the near future: INSPIRE, GMES and GEOSS.

The "Infrastructure for Spatial Information in Europe" (INSPIRE) initiative is intended to trigger the creation of a European spatial information infrastructure that delivers to users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. The target users of INSPIRE include policy-makers, planners and managers at European, national and local level and the citizens and their organizations. Possible services are the visualization of information layers, overlay of information from different sources, spatial and temporal analysis, etc.

The “Global Monitoring for Environment and Security” (GMES)[1] initiative focuses on the implementation of information services dealing with environment and security. It represents a concerted effort to bring data and information providers together with users, so they can better understand each other and make environmental and security-related information available to the people who need it through enhanced or new services.

“Global Earth Observation System of Systems” (GEOSS) is a global system of systems that will support more an accurate monitoring of changes in land use, air quality, and other environmental parameters by enabling the integration of existing and future information services into one overarching system architecture.

All of these initiatives are of great importance for CP applications. Civil Protection is explicitly recognized as one of the main services for GMES: it is one of the three main application domains of one of the first services in pre-operational mode (“Support to Emergencies and Humanitarian Aid”). INSPIRE will provide a standard infrastructure to access information from legally-mandated organizations in Europe, which could be really useful for CP applications: for example cadastral and land use maps will be available in Europe through standard interfaces from their authoritative sources. Finally GEOSS will provide a common infrastructure to access Global Earth Observation data.

Therefore the integration of GMES, INSPIRE and GEOSS compliant systems must be considered strict requirement for a e-Infrastructure for CP applications. Fortunately all these three initiatives share a common architectural view, based on a federated and service-oriented approach and on the principle of building upon the existing technologies. However since their objectives are different an integration and harmonization is required. The European FP7 GIGAS Project is currently working on this topic with the participation of a large number of stakeholders involved in the three initiatives. Therefore the outcomes of GIGAS should be considered a fundamental input for research concerning the interoperability of an e-Infrastructure for CP applications with INSPIRE, GMES and GEOSS. However research should be targeted to evaluate the integration according to the specific requirements of CP applications (e.g. RT/NRT support, service reliability, etc.).

Relevant initiatives

[1] GMES is now called KOPERNIKUS. However to preserve consistence with referred previous works, in this document we maintain the old name of GMES.

GIGAS

"GEOSS, INSPIRE and GMES an Action in Support" (GIGAS) is a Support Action funded under the 7th Framework Programme of the European Commission. It promotes the coherent and interoperable development of the GMES, INSPIRE and GEOSS initiatives through their concerted adoption of standards, protocols, and open architectures. Given the complexity and dynamics of each initiative and the large number of stakeholders involved, the key added value of GIGAS is bringing together the leading organizations in Europe who are able to make a difference and achieve a truly synergistic convergence of the initiatives. Among them, the Joint Research Centre is the technical coordinator of INSPIRE, the European Space Agency is responsible for the GMES space component, and both organizations together with a third partner, the Open Geospatial Consortium play a leading role in the development of the GEOSS architecture and components.

ORCHESTRA

ORCHESTRA is an Integrated Project partly funded by the European Commission's 6th framework program, under the priority 2.3.2.9 "Improving Risk Management". It is designing and implementing the specifications for a service oriented spatial data infrastructure for improved interoperability among risk management authorities in Europe, which will enable the handling of more effective disaster risk reduction strategies and emergency management operations. The ORCHESTRA Architecture is open and based on standards.

Topic 5.3 Interoperability Standards for Risk Business and Application Logic

It is known that "*on a world wide basis, the civil protection arrangements are very heterogeneous. What exists also is often organizationally complex and poorly integrated, both internally and externally. […] To a considerable extent, all the existing structures for and functions of civil protection simply reflect the prevailing political/economic/cultural patterns of different societies.*" [QUARANTELLI]. This is confirmed by the CYCLOPS Business Process Analysis [CYCLOPS-D6] for a subset of European Civil Protection systems. The CYCLOPS Existing Analysis [CYCLOPS-D8] showed that, as a result, in order to support emergency related applications CP agencies have developed their own Risk Management infrastructures. These solutions are characterized by a great technological heterogeneity both internally and externally. Internally, different applications are sometimes provided through different infrastructures and tools, and there is often heterogeneity between the different organizational levels (from local to national). Externally there is poor interoperability between the existing infrastructures in Europe.

In the recent years several initiatives and projects aimed to establish a common framework for interoperability between Civil Protection systems at European level. They address several open issues for the design and implementation of a European Disaster and Emergency Management System ranging from the definition of common plans, to the design of a common architecture for supporting Emergency Management Business Process.

In particular, from an architectural point-of-view, the OASIS Common Alert Protocol (CAP) provides the basis for alert messaging.

Relevant Initiatives

WIN

“Wide Information Network” (WIN) is an Integrated Project partly funded by the European Commission's 6th framework program, under the priority 2.3.2.9 "Improving Risk Management". It is targeted to the development of a interoperable info-structure that will be a major element of the future Single European Information Space for what concerns the environment and risk management.

WIN high interoperability directly results from the compliance of WIN info-structure with existing and emerging standards (ISO, OASIS, W3C, OGC) and the collaboration established with several other projects launched by EC or ESA.

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