

A business model for the establishment of the European Grid Infrastructure

A. Candiello¹, D. Cresti¹, T. Ferrari¹, F. Karagiannis², D. Kranzlmüller³, P. Louridas⁴, M. Mazzucato¹, L. Matyska⁵, L. Perini¹, K. Schauerhammer⁶, K. Ullmann⁶, M. Wilson⁷

¹ INFN, ² Independent consultant, ³ LMU, ⁴ GRNET, ⁵ CESNET, ⁶ DFN, ⁷ STFC

E-mail: {candiello,cresti}@pd.infn.it, {ferrari,mazzucato}@cnaf.infn.it, fkara@aub.gr, kranzlmuller@ifi.lmu.de, louridas@grnet.gr, ludek.matyska@cesnet.cz, laura.perini@mi.infn.it, {schau,ullmann}@dfn.de, michael.wilson@stfc.ac.uk

Abstract.

An international grid has been built in Europe during the past years in the framework of various EC-funded projects to support the growth of e-Science. After several years of work spent to increase the scale of the infrastructure, to expand the user community and improve the availability of the services delivered, effort is now concentrating on the creation of a new organizational model, capable of fulfilling the vision of a sustainable European grid infrastructure.

The European Grid Initiative (EGI) is the proposed framework to seamlessly link at a global level the European national grid e-Infrastructures operated by the National Grid Initiatives and European International Research Organizations, and based on a European Unified Middleware Distribution, which will be the result of a joint effort of various European grid Middleware Consortia. This paper describes the requirements that EGI addresses, the actors contributing to its foundation, the offering and the organizational structure that constitute the EGI business model.

1. Introduction

International research collaborations increasingly require secure sharing of heterogeneous resources owned by the partner organizations and distributed among different administrative domains. Examples of grid resources are data, computing facilities, storage space, metadata archives, scientific instruments, sensors, etc. In this framework sharing is enabled by grid middleware, i.e. software services which expose uniform interfaces designed to provide access according to user roles and local policies.

The European Grid Initiative (EGI) aims at realizing a sustainable pan-European *grid*, i.e. a software and hardware infrastructure for cross-organization sharing of resources that provides a dependable, consistent and pervasive access to high-end computation capabilities [1, 2].

The EGI pan-European grid infrastructure comprises various components, as illustrated in figure 1. These are:

- **Grid resources:** can be heterogeneous in nature and need to be shared by distributed communities of users. These are usually geographically distributed and belong to different

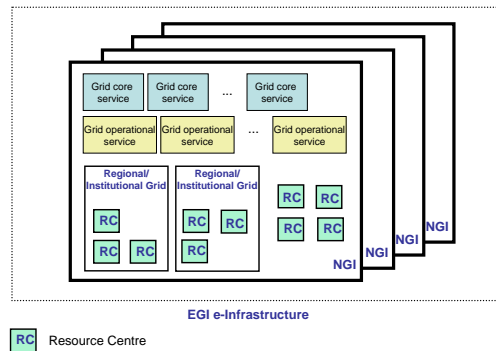


Figure 1. The EGI e-Infrastructure and its constituent parts

administrative domains under the control of resource providers and hosted by grid sites. Resources are funded and owned by the resource providers, which can either operate at a national or international scale.

- **Grid software services:** grid middleware services deployed and maintained at grid resource sites (*site-level services*) or centrally to constitute the grid backbone (*grid infrastructure services*).

Grid site-level services are needed for an interoperable and secure access to single resources, regardless of their specific fabric-layer characteristics. These are the gateways for the negotiation of the access and control of a given pool of resources. Conversely, grid infrastructure services provide coordinated access to multiple remote resources. They can be also be application-specific, in which case they are called *Virtual Organization (VO) grid services*.

- **Grid operational services:** complementary services needed to make the infrastructure more easily accessible and simpler to use, such as accounting, monitoring, the help desk for users and site managers, etc.
- **Grid middleware distribution:** the enabling software components that need to be developed, tested and certified before being deployed by the production infrastructure.
- **Policies:** the common basic rules and protocols to be endorsed by all parties for a secure and coordinated use and operation of the grid infrastructure.

The aforementioned components constitute the EGI e-Infrastructure, which technically enables research teams (the users) grouped into VOs to uniformly access and share the allocated resources and data distributed among different administrative domains.

A new European organizational model is herein proposed to fulfill this vision of a sustainable grid infrastructure which satisfies the requirements of science in Europe. This relies on the establishment of NGIs, the participation of European International Research Organizations (EIROs), and a coordinating body called EGI.eu.

Section 2 and 3 set the scope of the EGI business model i.e. the organization by which EGI will sustain itself and the EGI positioning in the value chain. In the EGI context the business model [3] is intended to describe the added value achieved through EGI grid services for the various user communities. Section 4 details the business model in terms of customers, offering and infrastructure. Section 5 concludes the paper.

2. Requirements

An exhaustive collection of requirement was collected; the proposed EGI organization was designed to take them into careful account. The main requirements are categorized here.

2.1. User requirements

- **Resource sharing.** Research teams (RTs) typically collaborate on a temporary basis (at national, European or international level) within a VO and in the framework of research projects, which are usually approved by peer review committees (acting at national and/or European/international level) set up by the relevant research institutions or funding agencies that allocate the necessary funds (including those for IT resources).
VOs typically need to share specific IT resources, and are characterized by a particular usage model for a given set of EGI baseline services, such as authentication and authorization services, accounting services for NGIs and VOs, services for data sharing at different levels of abstraction, services for compute sharing for different types of resources, monitoring services, etc.
- **Resource provisioning.** Research teams often belong to different research institutions (universities, laboratories, applied research institutions etc). Resource provisioning needs to be organized depending on the VO requirements. For example, a VO may autonomously fulfill its resource needs by getting access to resources from its constituent institutions, or alternatively made available by external providers (e.g. external research institutions or commercial partners). The European grid infrastructure should be sufficiently flexible to accommodate a variety of combinations of resource provisioning models. In general, the grid e-Infrastructure should evolve in all its aspects to satisfy the requirements of existing and new communities of users.
- **Security.** An e-Research project needs to rely on a set of *software tools* which enable the *secure sharing* of local resources and data from many partner organizations and distributed over different administrative domains.
- **Heterogeneity.** The resources to be shared can be *heterogeneous*. These include CPU cycles of commodity clusters for data analysis, fast interconnected parallel systems for MPI applications from many scientific disciplines (computational chemistry, earth observation, life sciences, weather forecast etc.), files located in distributed storage systems for image visualization, metadata distributed among remote archive systems which are relevant to a large variety of applications, etc. However, despite this heterogeneity, access should be simple and transparent to the resource location and the resource specific properties.
- **Ease of use.** Given the distributed and transparent nature of resource access in grids, simplicity of use is of paramount importance. This is achieved on several fronts, such as through an adequate middleware layer, the sharing of expertise among user communities, the availability of tools to monitor and assess the status of the infrastructure and of the provided quality of service, the availability of help desk systems, user guides, gateways that expose general and custom services in a user-friendly way, etc.

2.2. Middleware requirements

- **Simplicity.** Middleware services need to be fully *interoperable*.
- **Completeness.** the national grid infrastructures need to be fully integrated with the rest of the EGI e-Infrastructure in order to address the needs of all VOs. For this reason, the middleware needs to offer a rich set of functional capabilities. A survey of requirements for the definition of the Unified Middleware Distribution project is ongoing at the time of writing.

- **Scalability.** Middleware components should be scalable to allow the management of resources and services in a grid e-Infrastructure for scientific user communities ranging from a few individuals to thousands of researchers.
- **Manageability.** The middleware should be easily *deployable*, i.e. simple to be downloaded and operated.
- **Extensibility.** Middleware should be easily extensible.

For more information about these requirements and the Unified Middleware Distribution please refer to [4].

2.3. Operational requirements

- **Availability and reliability.** Grid site managers and NGI operations centers need support for a highly available and reliable infrastructure.
- **Accountability, monitoring and service operation.** The relevant resource centers/providers are required by the VOs to operate the set of services which enable them to reach the aforementioned goal. To this end, a pan-European infrastructure for accounting, monitoring and operation is needed to support VO activities.
- **Standardization.** Resource providers have so far obtained the general grid middleware services they need to operate from external providers (EU projects or Middleware Consortia). Based on the need for simplified operations and having to offer a well-defined quality of service for multiple solutions, resource providers benefit from the coordinated action of EGI.eu, of NGIs and EIROs in moving towards a *progressively unified middleware solution*.

2.4. Financial requirements

- **Efficiency via service certification.** It is economically *convenient and efficient* for funding bodies to promote, support and fund the procurement and the operation of a shared, robust, secure and certified set of baseline grid services rather than a complex set of diverse tools that each VO may freely ask to develop and adopt. In addition, the use of a layer of services, shared by other VOs whenever possible, reduces operational costs and facilitates the development and, even more importantly, the seamless operation and maintenance of baseline services.
- **Efficiency via service integration.** An integrated set of services can be offered and operated by EGI.eu at European level and by EIROs and the NGIs at national level as part of the general EGI e-Infrastructure. In this way, past investments at European or national level can be re-used and very likely new VOs will also benefit from it. High-level special services that may still need to be developed, will consequently be less expensive and founded on a mature underlying middleware layer with better sustainability and wider user spectrum.

3. Actors

The aforementioned requirements are satisfied in EGI by a network of partners that join to offer the services needed to implement a global pan-European shared pool of resources. EGI comprises a number of stakeholders:

(i) EGI customers:

- **National Research Institutions (RIs):** universities, research laboratories, national research organizations, etc.

- **Research Teams** (RTs) operating throughout Europe and joining to constitute national and/or international VOs, whose members are the immediate users of the services offered by EGI.eu and NGIs/EIROs. Research teams can be an interdisciplinary or inter-institutional group of people, members can be consequently affiliated to different Research Institutions, as illustrated in figure 2. The main driver is the support of international VOs, while support of national VOs falls under the responsibility of the respective NGI.
- (ii) **National Grid Initiatives** (NGIs) and the related **Resource Providers** (RPs): a NGI is a legal organization responsible for the management of the national grid e-Infrastructure and for holding relationships with customers and the national RPs. A given NGI and the national/regional RPs join to form a national partner alliance to offer those services needed to implement a global pan-European shared pool of resources. Resources from resource providers in the country are made available to customers and distributed among Resource Centers (RCs).
 - (iii) **European International Research Organizations** (EIROs): CERN, ESA, EBI etc, are organizations that may be willing to contribute to EGI and be interested in the availability of a European grid e-Infrastructures.
 - (iv) **EGI.eu** is the organization proposed to offer those services that are of common interest to all NGIs/EIROs such as: the overall coordination of: tool development, operations and security, support activities, and the hosting of operational tools and critical services which are more conveniently run centrally.
 - (v) **Stakeholders with partnership status**: the **Middleware Consortia** (MC) are grid Middleware Service Providers [5]; they offer the open source middleware needed to implement the EGI e-Infrastructure (e.g. ARC, gLite, UNICORE) complemented by external components from additional middleware development initiatives). Maintenance and development work will be commissioned to those partners by EGI to guarantee a smooth transition to EGI and to fulfill the requirements of the user communities.
 - (vi) **Funding Agencies** supporting activities at the user and resource provider level.

EGI.eu, the NGIs, EIROs, the RPs and the Middleware Consortia constitute a partner network. The EGI offer is articulated in a set of integrated services offered by EGI.eu at the European level, by the NGIs/EIROs and the RPs at the national level. RP resources are made available to RTs directly through the relevant RIs, or indirectly through EGI.eu and/or the NGIs/EIROs depending on the user requirements. EGI.eu itself is the provisioning channel for centralized services, whereas the global EGI offer is channeled to Research Institutes and Teams via the partner NGIs/EIROs. The relationship between EGI and the funding agencies is beyond the scope of this paper, and is detailed in the EGI Blueprint [3], while the relationship between the customers and EGI is defined in the following section.

3.1. Users and EGI

The relationship between users and EGI depends on the type of services considered. While for resource sharing and usage of grid middleware services every VO is characterized by specific requirements, other types of services concerning user support, application porting and other similar user-oriented services, can be more effectively and efficiently delivered to users by grouping them into discipline clusters. In the former case, a direct VO user-NGI relationship is foreseen, while in the latter, services are provided via what are called **Specialized Support Centers** (SSC) to groups of VOs operating in the same scientific field, as detailed below.

The former type of relationship – linking the users and EGI – is illustrated in Figure 2. In this scenario EGI grid middleware services and resources are made available to the customers

via the NGIs. The procurement of grid resources for users that do not own resources in the grid, concerning the negotiation of a resource quota to get access to, can be based on a negotiation between the users themselves (typically the legal entities that represent them such as the Research Institutes) and the RPs. Alternatively, the EIRO/NGI can assist users in the process of resource brokering if requested to do so. In this case, the NGI indirectly provides the resources and the negotiation involves the relevant NGI/EIRO and the RPs and the VO. In both cases, a bilateral Service Level Agreement between the RIs and the RPs is negotiated to define how expectations meet with obligations agreed between the provider and the consumer [6]. Whatever approach is chosen, the NGI is the contact point for any other matter, such as the issuing of user certificates, the access to user interfaces and the registration of the user to a VO.

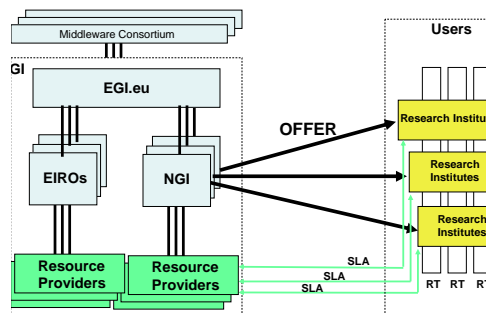


Figure 2. Relationship between EGI and the users for grid resource procurement

For shared user services delivered via a SSC, the two main organizational entities in EGI to provide representation and services to the user communities are the *EGI User Forum* and the Specialized Support Centers themselves. The former is established by the communities and is headed by a *Steering Committee* which interacts directly with the EGI management bodies.

The SSCs are established by the user communities, and assist in collecting and transferring requirements and feedback to EGI. An SSC could also include *Front Desk* services. This option would be particularly recommended for an SSC dedicated to new communities. A detailed description of the EGI User Community Services is provided in [7].

3.2. Middleware Consortia and EGI

The Middleware Consortia, as members of the EGI partner network, hold relationships with various EGI actors.

For what concerns EGI.eu, the central technical coordination of development efforts will be under the responsibility of EGI.eu, namely the EGI.eu Middleware Unit. The main objective of this Unit is to ensure the availability of the required middleware services at the pan-European level with the assistance of additional technical bodies, including the relevant experts appointed by the Consortia.

In addition to the Middleware Unit, the Middleware Consortia participate to the Middleware Coordination Board (MCB) as explained in [3], the EGI body responsible for setting technical priorities and of making all decisions concerning the maintenance and evolution of the middleware deployed. In addition to the Consortia representatives, the MCB includes members from the NGIs and the related RPs, who are responsible for representing the operational requirements of the EGI actors, and from the User Community Services teams, for representing the various user communities organized in thematic disciplines.

The Middleware Consortia and the NGIs collaborate via the Middleware Coordination Board, where the NGIs can bring their own middleware requirements to the developers. Other forms of collaboration are currently under discussion, and will be more precisely defined during the definition of the EGI project proposal. Other forms of direct technical and financial partnership depend on the agreements that the Middleware Consortia and the individual NGIs are willing to establish, and are out of the scope of this paper.

4. Business model

There are various approaches in the literature to formally define a business model. The EGI business model belongs to the research category [5], which includes those that have been developed by universities and research centers and that are based on an open grid architecture, allowing several providers and consumers to be interconnected and to trade services.

The modeling approach proposed by A. Osterwalder in [8] is suitable in the EGI context, and is adopted in the following sections to define the EGI service offerings, the customers, the actors and the relationships.

The proposed business model breakdown structure includes: the *offering*, the *infrastructure*, the *customers* and, finally, the *finances*, as detailed below.

(i) Customers

- *Target customers*: the links a company establishes between itself and its possibly different customer segments.
- *Distribution channel*: the means by which a company delivers products and services to customers.
- *Customer relationship*: the target audience for the products and services offered.

(ii) Offering

- *Value proposition*: the products and services the business offers.

(iii) Infrastructure

- *Core capabilities*: the capabilities and competencies necessary to implement the business model.
- *Partner network*: the business alliances that are necessary to complement other aspects of the business model.
- *Value configuration*: the rationale which makes a business mutually beneficial for a business and its customers.

(iv) Finances

- *Cost structure*: the monetary representation of the means employed in the business model.
- *Revenue streams*: the way a the entity that runs the business, makes money through a variety of revenue flows.

In summary, the EGI services constitute the offer proposed to the EGI customers (the international user groups organized in VOs), which is provided through the EGI e-Infrastructure and partner network. This network is constituted by the RPs, the NGIs and EGI.eu, who collaboratively contribute to the service provisioning by providing complementary services.

The EGI core capabilities are distributed among the EGI partners, and are necessary to provide EGI services. The value configuration is the rationale which makes EGI services beneficial to its customers. In the following sections we detail the EGI customers, the offering, and the infrastructure, while information on the financial structure of EGI is provided in [3].

4.1. Customers

The EGI target customers are those entities interested in the sharing of distributed resources. Examples of such users are the Research Teams from multiple Research Institutions, such as universities, laboratories, applied research institutions, etc. Users belong to Research Teams. The usage of the EGI infrastructure can be extended to include resources and meet the requirements of other user communities interested in different application domains, and coming from the industry, and from public organizations such as Civil Protection, hospitals, etc.

4.2. Offering

The access to distributed resources is the primary offer of EGI. Resources can be dedicated to the VO users or shareable by users from different VOs. In the former case, EGI supports intra-VO sharing, while in the latter cross-VO sharing is performed. The primary mandatory purpose of EGI to satisfy the research communities is the enabling of intra-VO sharing, i.e. the possibility to get uniform standard access to the distributed pool of resources allocated to a given VO. However, inter-VO sharing is an important extension of usual grid economics based on intra-VO sharing, as illustrated in [9].

- *Secure sharing* of distributed IT resources and data
- *Middleware development and maintenance*: resource sharing occurs through grid services, which expose a uniform interface hiding the local diversities and allowing a distinct level of authorization according to roles and the agreed project policies. EGI collects requirements from the Research Teams via Application support centers and Resource Providers, and ensures that the middleware offered (originally provided by the Middleware Consortia), meets those requirements, is certified, and interoperates.
- *Application support and training*: User Community Services, such as application porting support and training are usually delivered via the SSCs.
- *Resource brokerage*: gathering resources from an international infrastructure can be challenging for small RIs who do not own resources. If requested, EGI can facilitate the process by connecting customers to the RPs via the relevant NGIs/EIROs.
- *Help desk*: EGI supports the grid site managers and the user communities.

4.3. Infrastructure: Core capabilities

The main **Resource Provider** function is the offering of resources to users. These can be brokered via different channels. For example, users may already own resources through the respective RIs. In this case the RI plays the role of resource provider to its users, and resource quotas are made available to the RTs according to well defined local usage policies. RIs procure own resources and use them for a limited amount of time and can share resources with other user communities. Finally, RIs may also sign a contract with external RPs, which guarantees an agreed resource quota according to a negotiated service level.

RPs are also responsible for operating grid resources and site-level grid technical services. The deployment of additional software components can be required at the site-level to support monitoring and resource accounting at the international level.

Complementary capabilities are required at a larger scale from **NGIs/EIROs**. These include:

- the cooperation with the partner NGIs, EIROs and EGI.eu to define common policies, middleware specifications and standards, common operational procedures etc.;
- the interoperation with other national and international grids both at the functional and operational level;
- the operation of grid core technical services;

- the rollout and deployment of grid middleware to the resource centers;
- the operation of a national infrastructure for monitoring and accounting, and of those support services and tools for the daily running of the NGIs/EIROs' operations centers;
- the support to national and international users and local site managers through a national help desk;
- the supervision of status of the EIRO/NGI infrastructure;
- the contribution to training of users and technical staff from the local resource centers;
- the resource brokerage of resources at the national and international level;
- the optional testing of grid middleware during its lifecycle in collaboration with the middleware providers;
- the operation of VO-specific services.

Some of the aforementioned capabilities can be considered services which in due time might be offered to users under periodic contract fees.

The **EGI.eu** capabilities include:

- the coordination of the technical activities required to ensure a fully functional pan-European grid infrastructure (the definition of quality criteria, standardization, the coordination of the definition process of policies, of support, of dissemination and training, etc.);
- the provisioning of EGI international tasks, i.e. the running of those technical functions that are required by all NGIs and EIROs for a seamless running at the pan-European level, and to complement those operated at the national level;
- the liaison with international organizations, standardization bodies, other grid e-Infrastructures, National Research and Education Networks, etc.

4.4. Infrastructure: Value Configuration

EGI ensures the long-term evolution of the grid e-Infrastructure according to the user needs, and drives the evolution of the technology.

From the point of view of the users, the EGI e-Infrastructure offers the capability to share resources within a user group, with only a limited user investment in the development, maintenance and operation of the tools and infrastructure needed for effective sharing. In addition, the EGI e-Infrastructure has an increased capability to offer an adequate amount of diverse resources to satisfy the user workload during peak hours thanks to statistical multiplexing of user access. EGI can thus attract those customers who have large demand peaks or need some type of resources not available from their own resource centers.

From the point of view of the RP, fair sharing techniques give the possibility to open the access at low priority to external user communities while still preserving the high-priority access rights when needed. RPs can consequently increase their offer to the respective RIs, as a much larger and heterogeneous resource pool can be offered.

EGI allows a reduction of OpEx and CapEx per user. In the former case, NGIs and RPs can count on a reduced cost of grid infrastructure operation. Thanks to the use of a common layer of grid technical services, the revenue of resource providers can potentially increase. As to CapEx reduction, it is economically much more convenient and efficient for the national and international funding agencies to promote, support and fund the procurement and the operation of a common, robust, secure, certified set of baseline grid services - which the EGI.eu and the NGIs/EIROs can offer and operate - rather than a heterogeneous set of incompatible middleware components and tools.

Finally, EGI fosters interoperability and certification through the gathering of novel requirements. The convergence to a common standard compliant, interoperable and certified layer of middleware services is thus facilitated.

5. Conclusions

The paper presents the business model of EGI to illustrate the requirements that motivate the creation of a sustainable organization for the implementation and operation of a pan-European grid infrastructure supporting research in Europe.

The related services, the actors and stakeholders and the infrastructure (capabilities, value, partner network, etc.) have been described. The EGI Blueprint, complemented by the related business model, has been prepared in the context of the *EGI_DS* project to describe the implementation of a sustainable e-Infrastructure in Europe, and will be the basis of the EGI project, to be completed by November 2009, and which will provide the final structure of the EGI organization.

The EGI organization and business model have been defined to ensure the long-term sustainability of the pan-European grid infrastructure by establishing a new federated model bringing together NGIs, EIROs and RPs, and by coordinating the integration and interaction between them.

Acknowledgments

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