Challenges of Future e-Infrastructure Governance

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Abstract. A shift of interest of both providers and consumers from resource provisioning to a system of infrastructure services as well for a governance system for e-Infrastructures based on a user-centric approach is registered nowadays. Applying service level management tools and procedures in e-Infrastructure service provision practices allow users, service providers and funding agencies to investigate e-Infrastructure services in view of individual use cases. The shift should be sustained by legal structures, strategic and financial plans, as well as by openness, neutrality and diversity of resources and services. e-IRG as an e-infrastructure policy forum envisioned these trends and needs and expressed its position in its recent white paper that is shortly presented and discussed from a perspective of building future research agendas of individual teams.

Keywords: e-Infrastructures, governance, service-orientation.

1 Introduction

E-Infrastructure landscape is changing to comply with the service oriented paradigm, which enables increased innovation potential and cost-efficient access from a widening range of users, thereby strengthening the socio-economic impact. On another hand, sustainability of current e-Infrastructures has become a global concern and the key role is played by their governance. Efficient, effective, transparent and accountable operations are nowadays the main topics of e-Infrastructures governance. These trends are recognized at national and European levels, with forceful e-Infrastructure agendas or strategies to promote an efficient governance for the research ecosystem. Further strategic development of e-Infrastructures should respond to the demand for and the necessity of Green IT, the need for massive computational power (exascale computing), the increasing amount of data, the seamless access to services for users, the internationalization of scientific research and the involvement of the user communities in governance of e-Infrastructures. Aligned to these efforts and requirements, e-Infrastructure Reflection Group (e-IRG) has recently analyzed the structures as well as organizational and relational aspects of current e-Infrastructures together with the governance process, distinguishing strategic processes and operational management and the various functional aspects of governance, e.g. the supporting legal and financing structures.

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As remarked in the European Digital Agenda [1] (aiming to deliver sustainable economic and social benefits from a European digital single market based on fast and ultra fast Internet and interoperable applications), services are moving from the physical into the digital world, universally accessible on any device. Attractive content and services need to be made available in an interoperable and borderless Internet environment. This stimulates demand for higher speeds and capacity. In the e-IRG vision, the achievement of an open e-Infrastructure, that enables flexible cooperation and optimal use of all electronically available resources, will help narrow the digital divide in Europe and support cohesion by enabling improved inter-regional digital flow of ideas and technology. This vision is sustained at least by the current European Commission programmes FP7-ICT [2] and FP7-Infrastructures [3], as well by ESFRI [4].

Details about the e-IRG vision and recommendations, as reflected its recent white paper [5], will be revealed and sustained in what follows. e-IRG recommendations are mainly intended for national and international policy makers to support further advancement of e-Infrastructures, but they catch the state-of-the-art by expressing the needs of the user communities and the evolution in the markets for information and communication services. In this paper these recommendations are translated for the research communities with the aim to suggest topics for their future research agendas.

2 e-IRG Recommendations

The topics that are presented in the e-IRG's white paper address both several questions related to e-Infrastructure, like: (1) what are the appropriate governance models for e-Infrastructures; (2) how to advance research networks; (3) how to facilitate access; (4) how to deal with the increasing energy demands of computing; (5) what software is needed to fully harness the power of future HPC systems; (6) how to adopt and implement new e-Infrastructure services; (7) how to discover and share of large and diverse sources of scientific data. Each question is treated in what follows.

2.1 e-Governance Management

Governance policies are needed for the further strategic development of e-Infrastructures and they should support the free movement of knowledge across the world. An e-Infrastructures' ecosystem is needed in order to meet the challenge of governing such a system effectively and efficiently. This requires a deliberation of the strategies and involvement of all relevant stakeholders in order to realize a solid basis for the further developments. Moreover, the shift from mere resource provisioning to a system of infrastructure services will have a considerable impact on how such infrastructures are funded and financed. Then users current need is to have the choice for the best available services regardless of national boundaries, public or commercial commodity services, as well as to actively participate in strategic governance decisions concerning e-infrastructures. Therefore the e-Infrastructure governance should shift towards a user-driven approach. Different

technical, political and commercial developments, such as the virtualisation of services, the cloud computing, and the constant increasing need of leading edge user communities for services far beyond what the current e-Infrastructure can offer, drive this process.

In this context, e-IRG envisioned an user-centric approach in which timely e-Infrastructure innovation to serve user communities (ahead of what the commercial markets can provide) remain a public responsibility, while the funding of the use of e-Infrastructures services should be paid out of the budgets of users and their projects.

More precisely, e-IRG's recommendations related to the e-governance management are resumed in the white paper as follows:

1. Establish a user-community-centric approach in strategic e-Infrastructure governance, including the appropriate funding mechanisms making distinction between the funding of service provision and of innovation activities.
2. Define the long-term financial strategy for e-Infrastructures aimed at a sustainable operation of services in a flexible and open environment that includes offers from commercial service providers.
3. Address the problems of barriers to cross-border service delivery and quickly remove as many of these as possible.
4. Introduce governance models that provide efficient and effective coordination mechanisms at all levels (regional, national, European, global) while providing the possibility for public and private research and cooperation.
5. Encourage important players in the use of e-Infrastructures, to investigate the impact of strategic changes in e-Infrastructure governance and financing on the operation of and access to international research infrastructures.
6. Investigate the effectiveness of legal structures for e-Infrastructures.

2.2 Future of Research Networks

e-IRG recognized that research networks are already available as a service, but the drive towards seamless access to all services, including the connected e-Infrastructure elements for computing or data storage as a fully integrated ecosystem, is new. Moreover, the availability of new technologies calls for the innovation of the networking infrastructure and its services. This is complemented by the emergence of new stakeholders in the research arena, creating a more competitive environment and a market opening for innovative actors such as brokers or the associations of users with similar interests.

Openness, neutrality and diversity should be the basic principles in developing the future networking infrastructures. Networking is inherently multi-domain and should be built in a federative and open approach, supplying connectivity based on globally accepted standards. Network services should be made available via a common user interface to allow integrated access to different e-infrastructure services.

1. Innovate in network provisioning and network governance to satisfy user demand and stay competitive at the global level.

2. Draft an innovation agenda for research networking usable by stakeholders.
3. Build the networks as a federative and open system, giving flexibility and worldwide connectivity to public and private researchers and with seamless integration with other e-Infrastructure service providers.
4. Rigorously investigate the causes of the digital divide between European researchers and combat this with the appropriate instruments.

2.3 Authentication, Authorization and Accounting

In the context of on open ecosystem functionality, one of the objective of the governance of an authentication and authorization infrastructure (AAI) is to establish and maintain the level of mutual trust amongst users and service providers. The current requirements are, according e-IRG study: (1) improved usability, lowering the threshold for researchers to use the services; (2) improved security and accountability (often conflicting with usability requirement); (3) leveraging of existing identification systems; (4) enhanced sharing, allowing users to minimize the burden of policy enforcement; (5) reduced management costs, freeing resources for other service or research activities, and providing a basis for accounting; (6) improved alliance with the commercial Internet, which also improves interaction between scientists and society.

In the case of identity recognition, there are several models. European NRENs operate identity federations, and provide services to a large number of users within academic and research communities. Based on open standards, these national identity federations focus on providing access to web-based resources, such as data repositories. The user typically acts as a consumer. A full e-Infrastructure should also allow the user to act as a producer of information. In this context, clear and simple mechanisms for accessing and managing authorization policies are required. Moreover, the connection between different national identity federations into a common identity space that supports real-time access to web resources across Europe is an ongoing task as the maturity of the national AAIs differs substantially between countries. On another hand, players outside academia include providers of user-centric identity management models (like OpenID used in web 2.0 applications), as well as governments offering identity infrastructures rooted to a legally recognized and authoritative framework.

Several other technical problems are needed to be solved fast: (a) support for the management of distributed dynamic virtual organizations; (b) robust and open accounting solutions to monitor e-Infrastructure services; (c) integration of user-centric and governmental infrastructures with academic AAIs.

In this context, e-IRG recommends:

1. Improve national infrastructures and their alignment with agreed standard procedures for identity management, accounting and assurance, with the objective of technical interoperability between all national AAIs.
2. Integrate different identity technologies.
3. Define access control policies and mechanisms in accordance with the standards and best practices adopted by the community.

4. Draw a roadmap to book progress for all stakeholders to replace existing authentication and authorization infrastructures based on national AAIs.

2.4 Energy and Green IT

While the major goals of Green IT are to reduce energy consumption, increase energy efficiency and minimize the influence on the environment, the currently work lacks a consistent vision on how to proceed globally. This also due to the large number of stakeholders who need to be involved in solving the problems: policy makers, hardware vendors, hardware/services providers, and end users. Trying to provide some guidance in this context, e-IRG recommends:

1. Decrease energy consumption of e-infrastructure components by optimizing the architectures and design more efficient software management procedures.
2. Develop more efficient ways of using energy by increasing the efficiency of the cooling systems and reusing the heat energy.
3. Analyze environmental impact of different energy maintenance approaches.
4. Provide more service management procedures.
5. Work out and promote Green IT standards at an international level.
6. Locate data centres at optimum locations in terms of the balance between green energy and energy efficiency.

2.5 Exascale Computing and Related Software

Several requirements to make available the exascale computing where identified by e-IRG: (a) design of new hardware and software architectures efficient enough for exascale; (b) reduce the power consumption by using new technologies and heterogeneous architectures; (c) increase in concurrency to comply with the change in scale at the level of parallelism that must be exploited by the software; (d) resilient architectures, programming models and applications, which will ensure that the system produces acceptable results even in the presence of hardware failures; (e) development of new programming paradigms allowing the effective use of an exascale machine (better compilers, monitoring tools, hiding software complexity).

Moreover, a paradigm shift is foreseen in software for exascale computing. The main components of this shift are, according e-IRG studies: (i) design a new programming model, beyond MPI; (ii) establish a performance indicator over differing architectures that considers multiple parameters of a configuration beyond flops and execution time, e.g. cost per execution, memory usage, bandwidth; (iii) support heterogeneous computing by operating systems, software libraries, compilers, toolkits etc; (iv) establish testing procedures to verify the correctness of a highly parallel implementations; (v) setting technical, logistic, legal standards for community-based development; (vi) establish a practical approach to data safety and security.

In this context, the recommendations are the followings:

1. Develop European hardware technology in order to compete and cooperate with the current leading countries in HPC.
2. Study of new programming models, algorithms and languages, porting software libraries and software tools to exascale environments, and preferring open source software solutions to leverage existing know-how.
3. Identify new grand challenges able to utilise the exascale platforms.
4. Establish collaborations between users of exascale computing, industry, computer scientists and programming experts.
5. Create training materials, including robust and easy to use books for users who are not computer scientists.
6. Ensure knowledge dissemination, and engagement with the public, policy makers and industry, for promoting exascale computing.

2.6 e-Infrastructure Services

The emergence of e-Infrastructure as a service is requested and accepted by the users due to the promises additional benefits. The main challenge faced by the e-Infrastructure providers is to offer their service to users in a reliable, scalable, customised and secure setting. They face at least the following challenges: (a) upgrade/refine the present services; (b) develop/introduce new services; (c) improve the governance/management of e-Infrastructure operations offered as services; (d) extend/intensify cooperation and collaboration in the e-Infrastructure area; (e) establish and gradually introduce a sustainable business model for e-Infrastructure operation and services. Further challenges are discussed in more details in the next section.

Shortly, e-IRG recommends in this field the followings:

1. Involve user communities in the definition and exploitation of services.
2. Use virtualisation and service-orientation when developing and introducing new services wherever this is efficient.
3. Apply simplified access, transparent service offerings, customized support, standardization, improved governance models and sustainable business models in the definition and deployment of services.
4. Promote cooperation between public sectors in the e-Infrastructure arena, like government and healthcare, to exploit economies of scale and intensify the contribution of e-Infrastructures in facing societal challenges at large.
5. Boost innovation by public-private partnership activities through the joint creation of a market for e-Infrastructure resources and services.

2.7 Data Infrastructures

The massive increases in the quantity of digital data leads to the urgent need to integrate data sources in order to build a sustainable way of providing a good level of information and knowledge – this feature is currently missing from the

available e-Infrastructures. The vision of a Global Data Research Infrastructure, supported by e-IRG is that of a cost-effective, efficient collaborative data research environment built on an interoperable and sustainable governance model fulfilling user needs across geographical borders and disciplines. This ecosystem of data infrastructures should be composed of regional, disciplinary and multidisciplinary elements such as libraries, archives and data centres, offering data services for both primary datasets and publications, and should support data-intensive science and research.

Design, implementation, operations, funding, governance and sustainability models need to be defined to promote (a) new data management, exchange and protection paradigm or approach; (b) the process of embedding data infrastructure into e-Infrastructure; (c) the cooperation between data providers and users in exchanging information for better governance of data gathering and management or to fulfill legal requirements and sharing.

The technical issues related to assembling, securing, managing, preserving and making interoperable the huge amount of data that scientists should be solved. One such problem is how to address the data explosion by assuring the infrastructures scalability in terms of storage space, number of data objects stored, number of users concurrency accessing the data, and performance of data accessing and handling. Another problem is how to address the complexity, i.e. deal with different, domain-specific data organisations, formats, handling policies etc. Not at last, reaching the reliability and robustness, which have a specific meaning in the context of data exchange, sharing and long-term preservation, in the geographically distributed and complex infrastructure is also a big challenge.

In this context, the recommendations of e-IRG are the followings:

1. Develop an European data infrastructure gradually, addressing basic issues such as data persistency, accessibility and interoperability first, and leaving complicated issues such as privacy and legal matters (like cross-border exchange of sensitive data) for subsequent stages.
2. Implement strategy at different levels, including low-level services such as bitstream data storage, exchange in data infrastructures, content-related curation, preservation and data exploitation services, as well as activities aimed at interoperability and data access federation and openness.
3. Involve stakeholders of the data infrastructure including resource providers, existing infrastructures and initiatives and user communities in order to build reliable and robust data services suitable to real needs.

3 Service-Orientation of the Future Open e-Infrastructures

Services are important part of e-Infrastructure offer. Users are not interested in the pure infrastructure part but rather in the services that are provided by the e-Infrastructures (which services are delivered and with what quality). If not simply the resources, but rather a combination of services running on various

resources spread world-wide is requested by the users, creates the premises to bring researchers together in international, virtual teams and organizations.

Basic e-Infrastructure services, such as computing, security and authentication, communication and conferencing, have been provided for more than two decades. These services were developed as individual services based on dedicated equipment and unique software components and their interoperability has became a problem. The changing requirements, like the increasing need for shared international access to remote resources, increased security, economies of scale for shared use, and more recent emergence of virtualization techniques gradually led to federated services in the Grid, service-oriented architectures, and the provision of sophisticated on-demand access to different shared resources, like hardware, software, infrastructure etc. Infrastructure-as-a-Service (IaaS) is emerging in both academic research and industry to exploit the opportunities provided by the Cloud paradigm. It provides an on-demand provision of requested resources for a widening spectrum of applications, and also stimulates a service-oriented approach to software development and deployment. An important feature of the on-demand provisioning is that most of the higher-level complex services are based on well-defined interoperable and distributed lower level services.

As e-IRG has identified, a major implication of the services shift appears in the changing division of responsibilities between the user and the supplier: the responsibility of linking the service demand to the user need is moved to the supplier (it means widening the distance of the users to the physical resources).

The white paper of e-IRG has underline in different chapters several needs, challenges and recommendations in building e-Infrastructure services:

1. The governance system should be supported by an elaborate system of metrics to establish the value and costs of the services and delivery systems.
2. Formalizing the quality and management aspects of service provision practices and complementing these with tools and procedures from the established IT service management discipline is urgently requested.
3. Cross-organizational service level management need to be supported by governance structures.
4. Open and adaptable standards for using the heterogeneous e-Infrastructure services should be developed, promoted and supported on all functional levels and in all application areas.
5. Integrated user access to the various international e-Infrastructure services.
6. Services need to be application-oriented, easily accessible, open and flexible so be able to adapt to technological changes and evolving user needs.
7. Network services should be made available via a common user interface to allow integrated access to different e-infrastructure services.
8. Robust and open accounting solutions for the e-Infrastructure are needed to monitor the services and allow for comprehensive service level management.
9. Virtualisation should be used to build virtual research environments and virtual research communities.
10. Improved friendliness of access, adapted customisation of services, and tailored support and training are needed to attract new user communities.

11. Multi-tenancy of services should enable sharing of e-Infrastructure resources and costs across a large number of users, improved resource utilization, increased peak-load capacities, operating resources in locations with low costs.
12. Special services are to be offered by establishing service portals or centres dedicated to specific user communities, specialized service providers and specific large-scale projects.
13. Coordination should result in exchanging services and sharing service portfolios among co-operating e-Infrastructure providers, as well as in joint tendering or licensing by them.
14. Stability and sustainability of the infrastructure are to be improved by developing and gradually introducing fair and straightforward business models, business standards and charging practices.
15. Contentious governance issues that impact the adoption of IaaS must be addressed: include transparency, privacy, security, availability, performance, data protection, adoption of open standards.
16. Applying service level management tools and procedures in service provision practices allow users, service providers and funding agencies to investigate e-Infrastructure services from a perspective of individual use cases.
17. Exchanging services, sharing service portfolios, and other forms of improved cooperation by and between national e-Infrastructure service providers should be exploited for better geographic and disciplinary coverage.
18. Innovative development of e-Infrastructure services should be protected by involving research and education users in the development of services.
19. Non-commercial e-Infrastructure providers should be proactive, rather than simply copying commodity services already offered by commercial providers.
20. Fair and transparent business models are to be introduced in order to increase integration and sustainability of e-Infrastructure services and to guarantee a fair distinction between commercial and non-commercial services.
21. Similarities between e-Infrastructure services and services required by other sectors, such as government, health etc should be investigated by exchanging experiences and transferring knowledge from research sector to others.
22. Appropriate services and mechanism should extend, improve and facilitate (automate) the data handling, preservation, curation and exploitation leading to (a) one-stop shop delivery of data services, (b) federated access to data, (c) assurance that valuable data will be accessible, protected, preserved and curated over decades, (d) reduced costs by exploiting economies of scale thanks to a critical mass of resources providers, data storage and processing resources and users.

4 Conclusions

While the topics presented in this paper are referring a variety of concerns related to future e-Infrastructures, a general trend towards service orientation can be concluded. Only this orientation can ensure that future e-Infrastructures will reach a wider European community of users. This vision has been catch in

e-IRG's recent white paper that was exposed and re-interpreted in this paper from the perspective of the researchers to be involved in develop, deliver or use the future e-Infrastructures.

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