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Strategic Plan for a Scientific Cloud Computing infrastructure for Europe

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Contacts

Dr. Maryline Lengert
ESA - European Space Agency
Senior Advisor
Maryline.Lengert@esa.int
Tel +39 06 941 80430

Dr. Bob Jones
CERN – European Organization for Nuclear Research
IT department
Bob.Jones@cern.ch
Tel. +41 22 767 14 82

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OBJECTIVE OF THIS DOCUMENT

Here we present the vision, concept and direction for forming a European Industrial Strategy for a Scientific Cloud Computing Infrastructure to be implemented by 2020. This will be the framework for decisions and for securing support and approval in establishing, initially, an R&D European Cloud Computing Infrastructure that serves the need of European Research Area (ERA[1]) and Space Agencies. This Cloud Infrastructure will have the potential beyond this initial user base to evolve to provide similar services to a broad range of customers including government and SMEs. We explain how this plan aims to support the broader strategic goals of our organisations and identify the benefits to be realised by adopting an industrial Cloud Computing model. We also outline the prerequisites and commitment needed to achieve these objectives.

EXECUTIVE SUMMARY

This strategic plan responds to a growing need in Europe for building a European R&D Cloud Computing Infrastructure to serve intergovernmental and national R&D organisations and space agencies that represent key players of the European Research Area. It assesses the current situation in Europe and outlines a Cloud Computing Infrastructure for Science. It proposes a vision for Europe in 2020, identifies an overall strategic objective and four concrete programmatic goals to reach this vision:

Goal #1 Establish a Cloud Computing Infrastructure for the European Research Area serving as a platform for innovation and evolution of the overall infrastructure.

Goal #2 Identify and adopt suitable policies for trust, security and privacy on a European-level can be provided by the European Cloud Computing framework and infrastructure.

Goal #3 Create a light-weight governance structure for the future European Scientific Cloud Computing Infrastructure that involves all the stakeholders and can evolve over time as the infrastructure, services and user-base grows.

Goal #4 Define a funding scheme involving all the stake-holder groups (service suppliers, users, EC and national funding agencies) into a Public-Private-Partnership model to implement a Cloud Computing Infrastructure that delivers a sustainable and profitable business environment adhering to European-level policies.

For each of these goals, prerequisites and requirements have been identified together with measures to ensure that these goals can be reached and bring the vision into reality. After the endorsement of the main lines of this strategic plan, a set of milestones and checkpoints will be defined that represent a roadmap towards the establishment and operation of a European Scientific Cloud Computing Infrastructure for the European Research Area allowing Europe to participate as a leading partner in global scientific challenges.

1 STRATEGIC PLANNING METHODOLOGY

From its original goal of “prospecting ways to setup a European Cloud Computing platform and services aimed to serve ESA needs and more generally the European market (and space sector in particular) together with the EU relevant actors and the European industrial in space and IT sectors,” this initiative has been

[1] “ERA is composed of all research and development activities, programmes and policies in Europe which involve a transnational perspective.” See “2020 Vision for the European Research Area”, 16767/08 published by the Council of the European Union in December 2008

enlarged to include other inter-governmental research organisations (EIROforum members[2]) and national space agencies.

This initiative is consistent with and acts on the recommendations made by the EC Expert Group, which published a report in January 2010: "The Future of Cloud Computing - Opportunities for European Cloud Computing Beyond 2010"[3].

1.1 Stakeholders

The stakeholders identified in this initiative include:

- European national and intergovernmental technical organisations/agencies requiring such infrastructure;
- European IT industry and SMEs (small and medium enterprises) having business opportunities leading to increased competitiveness in global markets;
- European national governments and the European Commission, who have policy requirements and can act both as an enabler and as potential customers;
- The general public, who are the ultimate customer/user of the overall infrastructure ensuring sustainability.

In order to achieve an appropriate representation of the stakeholder community, the group authoring the strategic plan was originally composed of the following three sub-groups:

- The so-called ‘demand side’ grouping of potential users. These were first contacted to share the vision and join the initiative. Active participants from this group are CERN (European Organization for Nuclear Research), CNES (Centre National d'Etudes Spaciales), DLR (Deutsches Zentrum für Luft- und Raumfahrt) and ESA (European Space Agency),
- The so-called ‘supply side’ grouping comprising European IT industries having Cloud Computing offering or interests,
- The European Commission, in particular the Vice Presidency for the Digital Agenda, DG-INFSO (Directorate General for Information Society & Media) and DG-REGIO (Directorate General for Regional Policy). This group includes existing EC funded e-infrastructure initiatives, notably SIENA, that are serving the research sector and can contribute to the objectives of this initiative.

1.2 Schedule

A first draft of this plan was issued mid-May 2011 for review by the drafting group. A revised version including comments received from this group was distributed to all participants and to the European Commission in June 2011. A complete draft of the document was used to drive a tri-partite workshop held on 28-29 June 2011 at ESRIN (European Space Research Institute), Frascati, Italy. This final version of the document takes into account the feedback received and conclusions of the workshop in Frascati at which the following companies, research organisations and projects were present:

Research organisations: CERN, CNES, CNR, DLR, EMBL, ENEA, ESA.

Companies: Atos Origin, BT Global Services, Capgemini, CLOUDSIGMA AG, France Télécom, Interoute Communications, Logica, Orange, Thales, The Server Labs, Terradue Srl, T-Systems International.

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[2] Eiroforum Members: CERN, EFDA-JET, EMBL, ESA, ESO, ESRF, European XFEL and ILL.
[3] http://cordis.europa.eu/fp7/ict/ssai/docs/cloud-report-final.pdf

Funding bodies and their projects: European Commission, EGI, SIENA, StratusLab and OpenNebula.

The commitments made by these stakeholder groups towards this initiative during the workshop in Frascati were:

Research organisations (demand-side):

- The Demand-side is ready to support the strategy as outlined in the plan.
- We will identify a small number of lighthouse/flagship projects to which we will commit. A first example being in the domain of Earth Observation.
    - With free/open data access policy, needing significant scale of resources, federation/aggregation of data sets, long-term archiving of data and on- demand processing by global user community
    - IaaS is seen as the initial target for the required services bringing together multiple suppliers.
- The Demand-side organizations trust each other and will work together on these projects.
- The Demand-side can make these commitments but needs to be sure of supply-side support on a specified timeline and also sees the need for support of a research eco-system.

Companies (supply-side):

- The Supply-side is ready to support the strategy as outlined in the plan.
- The Supply-side commits to investigate a pooling/federating of existing resources for a period of two years and to take part in a co-financing proposal to the EU together with the users (e.g. CIP).
- The project should define a long-term perspective and the users must be able to commit a minimal set of pilots to ensure success stories.

European Commission and initiatives:

- The EC initiatives are ready to support and refine the strategy as outlined in the plan.
- The EC initiatives present commit to help clarify and align the plan to the existing efforts to provide additional leverage.
- We'll support any attempts to concentrate funding on aspects that only need initial funding to make sure that operations of any results are sustainable from the beginning.
- We commit to help the initiative to gain momentum by supporting it from within our current projects but we need some clarification and more transparency on the process.

2 CURRENT SITUATION

2.1 Where are we today?

Recent developments in IT have made it possible to consolidate IT infrastructure in a way that delivers increased flexibility and responsiveness to business needs while reducing costs. This change involves a move from IT being provided individually by organisations procuring their own separate IT infrastructure, to a new model in which IT is provided as a utility, which is known as "cloud computing." The National Institute of Standards and Technology (NIST[4]) defines cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

Since the late 1980's, all science domains have the following processes in common: data collection, processing, and analysis. This is applicable to the entire domain of laboratories or research environments and to the science community affiliated to them. Furthermore, for the data collection, extreme-scale laboratories, instruments such as LHC (Large Hadron Collider) or JET (Joint European Torus), satellites and molecular biology have their own large scale IT systems to collect, process and analyse their data. Until today, every player has been creating an enormous amount of duplicated IT infrastructure and data assets, and this is introducing barriers to collaboration and avoiding synergetic exploitation of data and models.

Over the last few years, consumer-facing firms delivering products in large volumes have actively adopted cloud computing. Commercial service providers are expanding their available cloud offerings to include the entire stack of IT hardware and software infrastructure, middleware platforms, application system components, software services and turn-key applications. The private sector has taken advantage of these technologies to improve resource utilisation, increase service responsiveness and accrue meaningful benefits in efficiency, agility and innovation. Similarly, for research organisations, cloud computing holds significant potential to deliver public value by increasing operational efficiency and responding faster to constituent needs.

By leveraging shared infrastructure and economies of scale, cloud computing presents a compelling business model. Organisations will be able to measure and pay for only the IT resources they consume, increase or decrease their usage to match requirements and budget constraints and leverage the shared underlying capacity of IT resources via networks. Resources needed to support mission-critical capabilities can be provisioned more rapidly and with minimal overhead and routine provider interaction.

European and national research centres and agencies are intensive users of IT infrastructure and are continuously adapting their IT systems to evolving technologies to provide services for science communities on a global scale.

Consequently, European intergovernmental technical agencies and national agencies have been testing some of these cloud computing offerings with success in their programmes. Individual European companies currently offer cloud related services and have significant capacity available but this is not generally visible at a European level nor available as an integrated, on-demand cloud offering. However today, the market is mainly dominated by non-European commercial companies and it is a concern that Europe has not yet developed an offering that has reached the scale of an infrastructure representing European values and policies. In particular, such an infrastructure will need to take into account the national polices and laws of European member states for terms of service, acceptable usage and security policies and data jurisdiction.

It is now the time for the European Research Area to take collective action. Today, Europe has a unique tool with its Intergovernmental and national R&D organisations, which cover an extensive field of competences with their own advanced technological assets and a global community of several tens of thousands of scientists that can help in defining and implementing a new European Infrastructure meeting research needs. This action will also implement high-priority European and national policy challenges while enabling European Industry to achieve global leadership by working together to offer world-class, innovative cloud services.

[4] National Institute of Standards and Technology: http://www.nist.gov/

2.2 Where do we want to go?

This Strategic Plan aims to pave the way for the development and exploitation of a Cloud Computing Infrastructure, initially based on the needs of European IT-intense scientific research organisations, while also allowing the inclusion of other stakeholders' needs (governments, businesses and citizens).

The Cloud Computing Infrastructure will ultimately provide physical and organisational structures and assets needed for the IT-related operation of research institutions, enterprises, governments and society. The scale and complexity of services needed to satisfy the foreseen needs of Europe's IT-intense scientific research organisations are beyond what can be provided by any single company and hence will require the collaboration of a variety of service providers.

To join this infrastructure, just like any other public infrastructure, a service provider must adhere to internationally recognised policies and quality standards that will be adopted by the governance structure involving all stakeholders..

Many cloud services are already being provided, however the quality is only maintained due to service level agreements (SLAs) between individual service providers and customers and not at a higher level with respect to compatibility with other providers and interoperability with other services. The proposed Cloud Computing Infrastructure will address these limitations. Thus it will provide interoperable services for computing, data dissemination, data archiving, application development platforms, large-scale open and free data-set management and libraries. To join the European Cloud Computing Infrastructure, a service provider will need to demonstrate compliance with quality standards, compatibility with other providers and adherence to security/integrity rules.

Such an infrastructure will be beneficial for both customers and service providers, addressing the high-priority issues according to the demand and supply side analysis conducted earlier this year (see Annex for a summary and conclusion).

2.2.1 Benefits for customers

Customers using the European Cloud Computing Infrastructure can be sure that they are not entering a vendor "lock-in" situation. The infrastructure will ensure interoperability and compliance of provided services. It will ensure a scale, diversity and quality of service that cannot be offered by any single supplier. Furthermore it will be considered a 'trusted' domain, since the regulations will be defined, implemented and monitored. Invoicing, payments and other accounting will be performed based on clear agreements providing full transparency, while respecting European privacy rules.

2.2.2 Benefits for service providers

Service providers will be part of the infrastructure in partnership and in synergy with other enterprises providing similar services. This infrastructure will provide a large production environment for services, and also easy access to a large test-bed environment targeting a set of commonly agreed flagship use cases for developing and testing new technologies and services, thereby ensuring business competitiveness and rapid evolution of offerings. The set of flagship use cases will be proposed by the demand-side with a clear scope, functionality and quality of service criteria, coupled with a commitment to use the procure cloud services.

The industry will benefit from the efforts in multiple dimensions:

- initial government funding that helps setting up infrastructure;
- innovative environment that allows development and testing of new services in close relationship with the users;
- guaranteed initial customer list (science community);
- promotion of new services that help complementing or leveraging existing products and services.

2.2.3 Data security – trusted environment

The European Cloud Computing Infrastructure will provide two key assets, which do not exist in current commercial offerings:

A secure data layer: Since data in the Cloud cannot be physically protected (stored on media and archived in a bank), Europe needs to ensure that the owner has control over the full life-cycle for data held in this infrastructure, regardless of where it is stored or from where it is retrieved. This secure data layer interoperable across all the member states, will be a key asset for the European Cloud Computing Infrastructure. This secure data layer will allow collaboration among scientists while at the same time it will also ensure security and privacy of data and information allowing the derivation of publications in a competitive environment and the establishment of commercial patents.

A science platform: Scientists and developers shall have access to a highly elastic operational e-infrastructure, providing interdisciplinary data on a very large scale as well as tools ensuring innovation and a permanent evolution of the products. Consequently, this science environment will help in defining and testing new cutting-edge technology and will also provide an "innovation engine" for the mass-market. By first focusing on science in order to catalyse innovation outside the traditional industrial structures, the European Cloud Computing Infrastructure can provide an environment allowing cross-fertilization, resulting in new, marketable ideas and innovative products.

Being the first user community targeted by this infrastructure, the scientific research sector will offer the following key contributions:

- requirements that are currently considered extreme (e.g. for Large Hadron Collider (LHC) or Sentinel data processing and service needs) but which are likely to become mainstream in the future;
- open environment where users are prepared to share their experiences in order to improve the services provided by the supply side (as opposed to closed competitive industries such as finance or automotive, where exchange of ideas and knowledge across companies is a rare phenomenon);
- extensive experience with in-house IT expertise that is prepared to work with the supply side in a collaborative way;
- generally collaborative working-style (e.g. sharing of data) that is typical for many business-to-business interactions;
- "photogenic" high-profile applications that can catch the public imagination and act as very visible use cases to encourage others to use the services;
- a global reach, which will ensure the European Cloud Computing Infrastructure can measure itself against services offered in other regions.

In the long run, additional potential stakeholders on the user side such as governments[5] and SMEs will benefit from the European Cloud Computing Infrastructure because it allows:

- improved operational efficiency;
- aggregation/federation of demand, faster response to stakeholder needs;
- leveraging EU/national assets and skills, improving service delivery to citizens;
- lowering adoption barriers for SMEs (e.g. IT infrastructure investments, availability of development platforms for value-added services);
- providing an exchange and collaboration platform between large enterprise and SMEs;
- availability of services in line with EU and national security and privacy regulations;
- wider consumer choice.

[5] See "G-Cloud Programme – Strategic Outline Case" UK Cabinet Office. http://www.cabinetoffice.gov.uk/sites/default/files/resources/03-G-Cloud-SOC.pdf

2.2.4 Addressing actions of the "Digital Agenda for Europe"

Finally, this strategic plan works towards implementing several actions of Europe's Digital Agenda:

- supporting the digital single market: building such a European Infrastructure will help create a single digital market for cloud computing;
- enhancing interoperability and standards: the European Cloud Computing Infrastructure will permit geographically dispersed and separately managed devices, applications and services to interact seamlessly;
- stimulating research and innovation: implementing this strategic plan will generate more private investment for IT research to develop a new generation of applications and services as well as reinforce the coordination and pooling of resources;
- Improving trust and security: it will also provide a coordinated European approach to security for cloud computing and adhere to rules on data protection.

2.3 What is at stake for Europe?

Today, Europe has not been able to develop a Cloud Computing Infrastructure that can be competitive on the global market, despite the fact that the World-Wide-Web was invented in Europe at CERN.

The European Union has a larger population and market than the USA[6] . However the different cultures and languages introduce a natural fragmentation, prohibiting any easy roll-out of IT services across the European market.

With the Lisbon Strategy, the EU aimed to create, "the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion"[7]. However it seems that only now, in 2011, that the technological assets and capacities are in place to make this happen. This is reflected in the EU Agenda 2020 by making "Digital Agenda for Europe"[8] a European Flagship initiative.

The EC has invested substantial resources in the Internet throughout the years and now these results need to be combined into a homogeneous infrastructure ecosystem supporting the "Digital Agenda." Policy makers and industry are urgently asking for action to enable Europe to achieve control of a new, 21st-century infrastructure that reflects European values, independence and competitiveness.

As outlined in *Science* magazine's special edition on data[9] , Europe's R&D environment is facing a change of paradigm whereby scientific innovation is becoming increasingly dependent on large-scale data collection (hundreds of petabytes), processing and access, thereby enabling interdisciplinary science. All research disciplines, e.g. climate research, microbiology, medicine, nanotechnology and more, are facing this "changing the culture of science"[10]. This would require an IT infrastructure that provides rigorous access to data and the capacity to run demanding simulations and processing on large-scale data sets. The benefits are outlined in the report from October 2010 by the High Level Expert Group on Scientific Data entitled "Riding the Wave - How Europe can gain from the rising tide of scientific data"[11].

It is already apparent today that science will rapidly move to an environment that provides this flexibility, at a reasonable cost, to ensure progress and innovation. Despite the fact that cutting-edge technology and assets exist in Europe, the large-scale infrastructure (which is pooling increasingly more data and intellectual resources) is under control of a very few non-European commercial companies. Due to the lack of a large-

[6] The CIA World Factbook https://www.cia.gov/library/publications/the-world-factbook/index.html
[7] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/00100-r1.en0.htm
[8] http://ec.europa.eu/information_society/digital-agenda/index_en.htm
[9] http://www.sciencemag.org/special/data/ - Vol. 331, 11 February 2011
[10] http://michaelnielsen.org/blog/the-future-of-science-2/
[11] http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/hlg-sdi-report.pdf

scale European offering in Cloud Computing services as a homogeneous infrastructure, Europe runs the risk of losing control of the scientific exploitation of its data despite having created an outstanding science infrastructure.

There is also a threat that scientific communities adhere strongly to the set of first-to-market tools and services offered and refrain from adopting more standardised offerings in the future, due to a lack of willingness to change or the cost. This, together with the lack of control of scientific data mentioned previously, highlights the strongest danger posed by the absence of a European Cloud Computing Infrastructure and in the worst case, this could mean the Digital Agenda goals will not be reached.

The importance of developing a European Cloud Computing Infrastructure is highlighted by recent examples in which Europe has failed to pursue technology innovation, leading to reduced employment (especially at the higher income levels), lowered competitiveness and higher consumer costs (see "Mobile Service Innovation: A European Failure"[12]).

In summary, and besides the business aspect (the global Cloud Computing market will go from $40.7 billion in 2011 to more than $241 billion by 2020[13]) where Europe should have a share, there is a fundamental element of autonomy related to keeping scientific knowledge, communities and potential produced in Europe under its own control.

2.4 SWOT analysis

The following SWOT table analyses the current situation and puts it into perspective with respect to the plan of this initiative outlined in section 2.2:

Strengths	Weaknesses
▪ Existence of the “Digital Agenda for Europe” ▪ Valuable results being produced by existing EC co-funded projects ▪ Momentum on many levels (demand, supply, governmental, etc.) ▪ Large demand side group representing research in Europe ▪ Existence of large-scale European research assets, data sets and science communities ▪ Large, existing players ready to engage ▪ Europe’s good reputation for its credible legal system (attractive marketplace for both demand and supply side)	▪ Heterogeneous market ▪ Heterogeneous regulations (reputation for red tape) ▪ This may be perceived as ‘Yet one more of many initiatives’ ▪ Centralized approach provides opportunities primarily for large incumbents only ▪ Not enough incentive to work together at the European level (specifically on the supply side) ▪ Difficult to achieve the goals without early success in standards and interoperability agreements of all parties
Opportunities	**Threats**
▪ Take advantage of current lead over emerging markets (technology, business processes and infrastructure) ▪ Leverage heterogeneity expertise (with respect to multiple national consumer bases, service providers and regulations) to access global market ▪ Expanding the user base to include more sectors	▪ The gap between the maturity of European and other Cloud computing markets is significant ▪ The rest of the world is catching up quickly ▪ Imposed *de facto* standards from first-to-market commercial services (notably security and privacy issues)

[12] http://www.sciencedirect.com/science/article/pii/s0308596111000310
[13] Forrester Research report April 2011

(corporations, SME, and mass market), potentially sustainable beyond funding cycle ▪ Concrete commercial setup planned (rather than research-driven framework only)	

3 VISION AND GOALS

3.1 Vision

In 2020, all scientists of all disciplines will choose the European Cloud Computing Infrastructure as their first option to store and access data, for data processing and analysis. This infrastructure will be considered as a natural infrastructure for the global science community similar to the road or telecommunication infrastructure for the general public today.

This infrastructure will contain vast quantities of data, an unrivalled array of open source tools, and a literally infinite amount of computing power accessible and usable from any kind of computer, smart phone or tablet device. Science will make significant progresses by applying data sharing and interdisciplinary research using this infrastructure as the fundamental tool. Important articles for leading publications, such as *Nature* and *Science*, will be derived from this infrastructure and it will be the source of a drastic increase of patents in Europe.

This infrastructure will have such a reliability and worldwide recognition for its implemented security/privacy scheme that also commercial companies will be using this "high security area" to derive patents.

3.2 Strategic objective

The European Research Area shall drive the development and implementation of a secure and globally recognised European Cloud Computing Infrastructure, initially targeting science users. This infrastructure will become ‘the’ platform for Europe, under public governance, ensuring open standard and interoperability and adhering to European policies, norms and requirements.

3.3 Programmatic goals

Goal #1 Establish a Cloud Computing Infrastructure for the European Research Area (ERA) serving as a platform for innovation and evolution of the overall infrastructure.

Goal #2 Identify and adopt suitable policies for trust, security and privacy on a European-level can be provided by the European Cloud Computing framework and infrastructure.

Goal #3 Create a light-weight governance structure for the future European Cloud Computing Infrastructure that involves all the stakeholders and can evolve over time as the infrastructure, services and user-base grows.

Goal #4 Define a funding scheme involving the three stake-holder groups (service suppliers, users, EC and national funding agencies) into a Public-Private-Partnership model to implement a Cloud Computing Infrastructure that delivers a sustainable business environment adhering to European-level policies..

4 STEPS NEEDED TO ACHIEVE THE PROGRAMMATIC GOALS

4.1 Establish Cloud Computing Infrastructure

Goal #1 *Establish a Cloud Computing Infrastructure for the European Research Area (ERA) serving as a platform for innovation and evolution of the overall infrastructure.*

4.1.1 Current status

Europe already has a high density of data centres and many European companies offer related services though no single company offer the breadth and scale of cloud services at a European level. Adding capacity is possible and feasible, as a single data centre can provide services to any type of consumers, as long as the bandwidth in and out of the data centre is able to meet requirements. A clear added-value of this initiative is to bring together many of these companies to work in partnership and aggregate their services and capacity to present innovative services at an international scale.

Network infrastructure is available, however infrastructure specifically at the very high-bandwidth end, is clearly not yet able to meet needs. It may be feasible to create additional infrastructure between specific high-demand organisations, but it is unlikely that SMEs or even private users will provide sufficiently large business demand to justify investment in additional network infrastructure.

GEANT, EGI (European Grid Initiative) and PRACE (Partnership for Advanced Computing in Europe) are existing e-infrastructures heavily used by the research community and co-funded by the European Commission. Interoperability with these infrastructures is important to allow the research community to migrate their data and applications between all the infrastructures and combine them so that the most appropriate resource can be used in an efficient manner. GEANT could provide high-performance network connectivity to the European Cloud Computing Infrastructure. EGI is in the process of introducing virtualisation technology that would simplify interoperability with the European Cloud Computing Infrastructure. PRACE provides specialised and scarce capability HPC (High Performance Computing) facilities that can be coupled with more immediately available capacity-style storage and compute resources of the European Cloud Computing Infrastructure.

The typical Cloud services are assessed as follows:

- Infrastructure as a Service (IaaS): Services in Europe are starting to become available. Because this is expected soon to become a commodity service (driving prices continually down), large investments in infrastructure for undifferentiated infrastructure services are risky.

- Platform as a Service (PaaS): Interoperable platforms do not really exist anywhere except for very specific applications (e.g. map/reduce, web frameworks). Innovating in this area has strong potential, not just for Europe, but for the global market. Potential areas include interoperability and manageability from a user standpoint as well as engineering support to foster further collaboration.

- Software as a Service (SaaS): New and improved services will be introduced continuously. There is not much need for artificial incentive to drive innovation. The main challenges will be standardisation of APIs, specifically to get data in and out of the Cloud and so as to enable interoperability, fast adoption and preventing vendor lock-in.

The European Cloud Computing Infrastructure will build on all of these services in an incremental and iterative manner as each of them has a high potential to respond to the science communities' needs. The initial focus will be on IaaS which can be used to quickly support a small number of lighthouse/flagship use cases. These flagship use cases will be proposed by the demand-side and chosen for their scientific challenge with societal impact, ability to profit from existing services on the supply-side, community building aspects and innovation potential that will help form the private-public partnership. The flagship use cases will be implemented as part of an initial pilot phase lasting no more than two years.

Figure 1 below depicts the broad possibilities for all stakeholders to position themselves in the Cloud business model, covering potentially all possible assets, capabilities and skills, from hardware assets (networks, computers) or large-scale mass market services up to very specific niche market services/products. It shows that there is unlimited potential of business opportunities allowing everyone to contribute and benefit from this European cooperation.

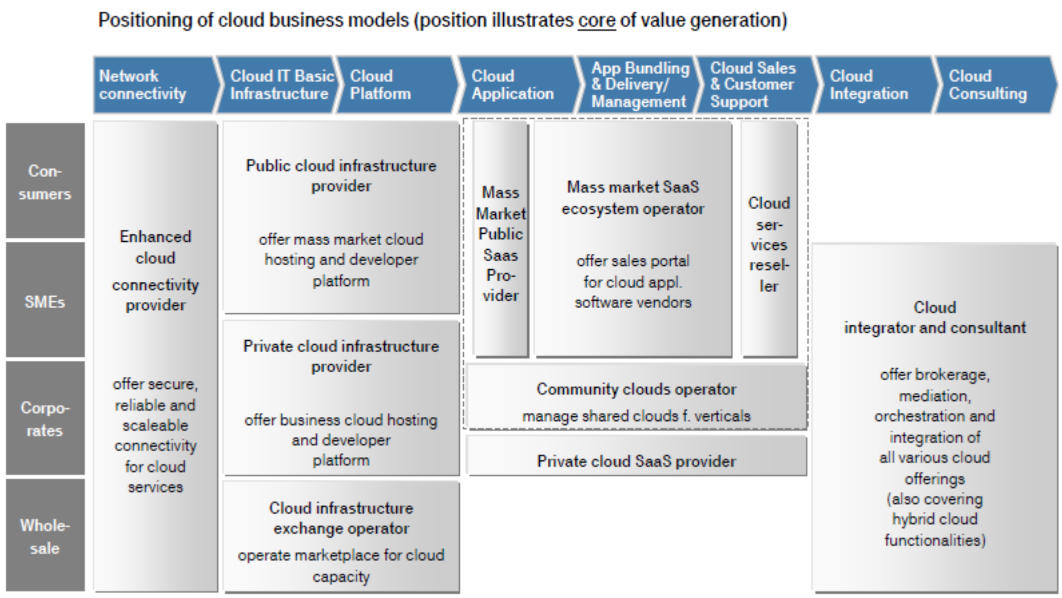

Figure 1: Positioning of Cloud business models (source Deutsche Telekom)

4.1.2 Existing experience

The demand side stakeholders (CERN, ESA, CNES, DLR, ENEA, EMBL, CNR, etc.) have large-scale experience in the use of distributed computing infrastructure for mission-critical applications.

Many research communities, including the LHC experiments, have made evaluations of currently available cloud services, such as those provided by Amazon, and have concluded that it is possible to make use of such services for significant portions of their computing needs. This work has also identified areas where the current services need to evolve (e.g. federated identity management, the ability to share resources and data between users, interoperability between service providers etc.) and where the costs must be reduced to make it economically advantageous compared to operating in-house IT facilities. In addition, a number of projects co-funded by the EC have created or exploited distributed computing infrastructures for support of various research groups across Europe and have gathered important experience and expertise.

4.1.3 Requirements

Different stakeholder groups have different needs that must be addressed by this initiative. Above all, standardisation and interoperability are the key issues to be solved, because most other requirements depend on these (see sections below).

The specific requirements (as already collected from the scientific users and from the industry) include:

- removal of limitations on the transfer of large data volumes due to transfer protocol restrictions even in high-bandwidth environments;
- avoiding vendor “lock-in” situations (due to absence of standards, single service providers create dependencies, which comprise a risk with unpredictable cost and sustainability in the long run);

- fine-grained access control by a group of collaborating researchers and full control over regional distribution and timely validity of data,
- the need for strongly coupled computing resources for high-performance computing.

In addition to the above requirements, there are some generic requirements for a Cloud Infrastructure that facilitate adoption by generic, governmental or mass-market users:

- easy accessibility;
- low initialization effort required;
- 'painless' implementation / adoption / switching from one service to another.

With respect to technology, all stakeholders expect new and improved services. The lists below are derived from the questionnaire sent to both demand and supply side in preparation of this Strategic Plan[14] :

The demand side expects the following new services:

- data archive services;
- data preservation services;
- data protection services;
- mobility solutions.

The supply side expects the following new services to leverage their own products and services:

- cloud service orchestration services;
- operating system with true hot swap CPU / RAM;
- open-source distributed block-storage systems;
- cost-effective scaling of very high-bandwidth networks (horizontal, vertical);
- content Delivery Network (CDN) for large volumes;
- flexible on-demand bandwidth;
- SaaS APIs (increased ability to integrate);
- preconfigured software architectures for public cloud;
- standardised software licensing and federated identity management;
- federation of resources;
- full transparent accounting and reporting.

An initial very rough estimate on the capacity needs for the scientific demand side was collected in January 2011 and gave the following results:

Requirement	Current	2015	2020
Concurrent CPU nodes	1'000 to >> 10'000	1'000 to >> 10'000	10'000 to >> 10'000
PB storage	< 10	10 to > 100	100 to >> 100

[14] Demand and Supply Side Analysis, Consolidation, 2011-05-18

Requirement	Current	2015	2020
Monthly distribution of large (> 1MB) files	1’000 to >> 1’000	1’000 to >> 1’000	>> 1’000
Hosted web sites/applications	50 to >> 100	50 to >> 100	100 to >> 100
TB monthly network traffic	10 to >> 10	>> 10	>> 10

(Note that the questionnaire was multiple choice and the highest value to select was ">> amount", which means "significantly larger than amount". In that sense, the figures in the table indicate a plausible lower bound on the needs, but not necessarily a sensible upper bound.)

4.1.4 Measures

There are requirements for governmental use of this infrastructure that have not yet been analyzed. It is therefore vital to ensure that the additional requirements of governmental bodies are collected and processed within this initiative. Hence, communication between all potential stakeholders is a key factor to success for this initiative, such as:

- fostering mutual exchange of requirements, needs, gaps, and expectations;
- providing an information exchange and communication platform;
- ensuring that the initiative’s agenda is set and coordinated so that all stakeholder inputs are considered properly.

Specifically for the technical requirements of the demand side, such as computing, storage, and bandwidth needs, together with a corresponding timeline, a process must be set up that allows plausible capacity planning of the Infrastructure.

4.2 Develop and implement European rules

Goal #2 *Identify and adopt suitable policies for trust, security and privacy on a European-level can be provided by the European Cloud Computing framework and infrastructure.*

4.2.1 Prerequisites

Awareness of all sides on the current limitations of Cloud Computing (specifically regarding security and integrity) is very important. Not all limitations and issues will be overcome immediately, but mutual awareness will help in taking measures to mitigate the associated risks. To this extent, the report issued by the European Network and Information Security Agency (ENISA) on “Security and Resilience in Governmental Clouds”[15] provides useful recommendations for public bodies deciding to move to Cloud Computing.

Thus, this initiative will build on existing solutions when available and existing efforts are leveraged, such as:

- Open Data Centre Alliance (ODCA[16]): The ODCA is an independent consortium comprised of leading global IT managers who have come together to resolve key IT challenges and fulfil cloud infrastructure needs into the future by creating an open, vendor-agnostic Usage Model Roadmap.

[15] http://www.enisa.europa.eu/act/rm/emerging-and-future-risk/deliverables/security-and-resilience-in-governmental-clouds
[16] http://www.opendatacenteralliance.org/

- Cloud Security Alliance (CSA[17]): The CSA is a not-for-profit organisation with a mission to promote the use of best practices for providing security assurance within Cloud Computing, and to provide education on the uses of Cloud Computing to help secure all other forms of computing. The Cloud Security Alliance is led by a broad coalition of industry practitioners, corporations, associations and other key stakeholders.

- CloudAudit[18] and the Automated Audit, Assertion, Assessment, and Assurance API (A6): The goal of CloudAudit is to provide a common interface and namespace that allows cloud computing providers to automate the Audit, Assertion, Assessment, and Assurance (A6) of their infrastructure (IaaS), platform (PaaS), and application (SaaS) environments and allow authorized consumers of their services to do likewise via an open, extensible and secure interface and methodology.

4.2.2 Requirements

Services must adhere to Europe's data and security policies and to specific requirements of the stakeholders. In particular, adequate mechanisms shall be put in place to ensure that the EC communication "A comprehensive approach on personal data protection in the European Union"[19] can be implemented. Service level agreements (SLAs) are monitored by third parties ensuring compliancy and trust in the system.

4.2.3 Measures

On the political level, the following measures must be taken:

- influence regulation synchronization across Europe;
- make European and member state governing bodies aware of the stakeholders needs;
- encourage EC directives and regulations supporting a synchronized approach.

On the technical level, EC regulation must be converted into a comprehensive technical development programme. An independent mechanism for certifying conformity to adopted policies, quality of service levels and interoperability between individual suppliers will be progressively introduced.

4.3 Governance structure and standardisation body

Goal #3 *Create a light-weight governance structure for the future European Cloud Computing Infrastructure that involves all the stakeholders and can evolve over time as the infrastructure, services and user-base grows.*

A governance structure knowledgeable about its assets, gaps, potentials and all the stakeholder needs is required for European Cloud Computing Infrastructure. This body will cooperate with stakeholders to ensure that the identified policies are implemented and maintained for environments that require legal compliance (e.g. government, healthcare, financial).

Governance is not just about "who decides". The following different interpretations of the goals of governance need to be considered:

- Governance as a mean of encouraging desirable behaviour. A controlling body focuses on defining the initiative's vision, principles and goals, and governance is the way to align the initiative's stakeholders (user and provider institutions) with the achievement of those goals.
- Governance as assigning decision rights/accountability. This approach generally focuses on who contributes to decision-making and is driven by the questions "What decisions must be made to ensure effective management and provision/usage of a service?" and "Who should make these decisions?"

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[17] https://cloudsecurityalliance.org/
[18] http://cloudaudit.org/
[19] COM(2010) 609 final, http://ec.europa.eu/justice/news/consulting_public/0006/com_2010_609_en.pdf

- Governance as safeguard from catastrophe. This is the most common view of governance. In the current context, this means that governance on many levels enables the prevention as well as the mitigation the effects of a catastrophe. It addresses questions such as: “What happens to customers if services fail?” and “How best to prevent them from failing in the first place?”

4.3.1 Prerequisites

The governance body must include all stakeholders and be open to expand beyond the initial group of involved parties in this initiative. Specifically, governmental representation is needed to ensure that government needs are addressed. Generic customer and or mass-market needs must also be considered. The body will cover data governance issues, such as data access, separation, integrity, regulations, auditability and recovery standards, as well as ensuring higher-level governance Infrastructure evolution.

4.3.2 Requirements

The governance structure must identify and adopt standards for services, with which the Infrastructure being setup by this initiative must comply. It must provide recommendations for users of the Infrastructure, i.e. what to consider when evaluating the services and how to use them.

As a first draft, the recommendations given by NIST Special Publication 800-146[20] (chapter 9: General Recommendations) and e-IRG White Paper 2011[21] can be taken.

With respect to governance, the following requirements are evident and must be considered:

- the ability to respond to stakeholder needs;
- the ability to adapt to changes of environment;
- ensuring the strategic orientation of the initiative's activities;
- ensuring continuity and growth of activities;
- enhancing the levels of individual responsibility and accountability
- unlocking increased performance
- correction of what is not functioning optimally
- keeping up to date with global best practices

4.3.3 Measures

In addition to the strategic goals of governance to encourage desirable behaviour, the following tactical guiding principles shall be followed:

- easy things are easy, and difficult things are (at least) possible,
- common cases are targeted for optimisation (e.g. ease of use, implementation speed, efficiency, effectiveness, etc.),
- out-of-date or inadequately justified governance rules can easily be removed,
- controlling bodies believe in the policies they monitor,
- controlling bodies prefer informing and encouraging over confronting and whistle-blowing,
- consumers have incentive to be proactive rather than merely compliant,
- as soon as any of these statements is perceived to be untrue, it is reported and publicly addressed.

The governance body must be given the authority to lead the standardisation efforts and be able to cooperate with governments, encouraging legal compliance with the standards where required. It must include representatives from all stakeholder groups in sensible proportions:

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[20] DRAFT Cloud Computing Synopsis and Recommendations, NIST Special Publication 800-146, May 2011
[21] e-IRG White Paper 2011, v2.6, 5 April 2011

- scientific (R&D) demand side;
- government demand side;
- generic / mass market demand side;
- industry supply side (both large companies and SMEs).

All involved parties must commit to:

- adhering to the adopted standards;
- interoperability according to the standards.

The standards and rules to be adopted must cover:

- technical service interfaces, e.g. REST (Representational State Transfer);
- resource management interfaces;
- SLA standards;
- data storage interfaces;
- archive retrieval interfaces;
- metadata interfaces.

4.4 Funding scheme and operational management

Goal #4 *Define a short- and mid-term funding scheme based involving the three stake-holder groups (service suppliers, users, EC and national funding agencies) EC and national funds, into a and a Public-Private-Partnership model to implement a Cloud Computing Infrastructure that delivers a sustainable business environment adhering to European-level policies.*

4.4.1 Prerequisites

To create a proper funding scheme, the following prerequisites must be met:

- identification of needed investments;
- identification of current and planned publicly funded Cloud Computing projects at the national and European level;
- identification of current and planned commercially funded Cloud Computing projects, being possibly subject to a Public Private Partnership (PPP) funding scheme;
- commitment to minimum business volumes from the demand side;
- a survey, assessment and prediction of future markets

This will allow developing an overall business case for the European Cloud Computing Infrastructure permitting self-supporting business for the European industry, specifically, but not exclusively, the supply side stakeholders of this initiative.

4.4.2 Requirements

Innovative PPP models will be designed to bring together resources and expertise of diverse stakeholders. The Public sector (EC and national Governments) will play a role of facilitator and regulator, earmarking funds through European/national development schemes. The Private Sector (demand-side) will play a role in lining up sources of new funds, shaping risk management mechanism, federating and integrating existing assets and developing innovative technological solutions. R&D and space organisations (supply-side) on the other hand will act as test beds and mediators between the Public Sector, Private sector and communities to enable scaling up of initiatives.

The PPP models vary from short-term simple management contracts (with or without investment requirements) to long-term and very complex BOT (Build-Operate-Transfer) form, to divestiture. These models vary mainly by:

- ownership of capital assets,
- responsibility for investment,
- assumption of risks, and
- duration of contract.

In the framework of the Future Internet, the European Commission has evaluated possible organisational models in the implementation of PPP[22].

4.4.3 Measures

A business case that will be self-supporting will be created after the initial funding cycle. (Public subsidies must be reduced to zero over time, but the operation of the Cloud must remain sustainable.) Such a business case must include an estimate of the cost to the demand side of satisfying the agreed user cases using their existing provisioning mechanisms (in-house resources or tendered services). If these are in-house resources then the costing model should cover total cost of ownership. The supply side must also study the agreed use cases and estimate the cost at which they could offer such services to the demand side. A comparison of these costs will help determine if there is a case for a sustainable business model.

Additionally, the initiative must capitalize to a maximum on existing national and European assets and initiatives. This will avoid duplications, create synergy and ensure efficient use of resources. The recently formed EuroCloud[23] is the first pan-European network of SaaS and cloud computing vendors and industry participants, with a presence today in more than 22 European countries. EuroCloud has published a 16 point action plan for cloud computing in Europe[24] which is consistent with the challenges and objectives outlined in this document. As such, EuroCloud, may be a useful channel for interacting with a large number of supply side stakeholders.

4.5 Standards

Standardisation and interoperability are invaluable for the successful application of distributed computing. Clearly, interoperability cannot take place by itself but there are good examples of pairings between industrial partners in the telecommunication sector that show that it is possible to achieve interoperability in the absence of fully-developed standards. The current Standardisation Development Organisation (SDO) communities are key to the process of offering interoperable Cloud solutions. The SDOs survive by producing standards for implementation and uptake. Industry will only adopt open standards if the financial benefits of interoperability are made clear. By establishing a bridge between industry and eScience the SDOs could have the opportunity to engage directly in establishing where their standards are best deployed and offering solutions to any gaps.

The importance of the need for open standards to support interoperability goals is now well documented in the e-business world. Of particular relevance to the e-research and e-government communities are the statements made in the EICTA Interoperability White Paper of 2004[25] , the ETSI White Paper No. 3. "Achieving Technical Interoperability"[26] ; the EC's European Interoperability Strategy (EIS[27]) and Interoperability Framework (EIFv2[28]) documents of 2010.

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[22] A Public-Private Partnership (PPP) for the Future Internet, European Commission, April 2009, http://ec.europa.eu/information_society/activities/foi/library/docs/m-ppp.pdf
[23] http://www.eurocloud.org/
[24] http://www.optimis-project.eu/sites/default/files/EuroCloud%2016-PointForCloudComputingInEurope_rev1.pdf
[25] EICTA Interoperability white paper
http://www.digitaleurope.org/fileadmin/user_upload/document/document1166548285.pdf (In March 2009 EICTA was rebranded DIGITALEUROPE)
[26] ETSI White Paper No. 3 Achieving Technical Interoperability - the ETSI Approach, Hans van der Veer (Alcatel-Lucent), Anthony Wiles (ETSI Secretariat), 3rd edition, April 2008.

4.5.1 Clouds standards coordination

Cloud standardisation efforts led by the Distributed Management Task Force (DMTF), the Storage Networking Industry Association (SNIA) and the Open Grid Forum (OGF) are frequently cited as being enablers that could have a major impact on computing infrastructure in the future. Work on additional standards for various aspects of cloud-based services is under way in the Organisation for Advancement of Structured Information Standards (OASIS) and the Internet Engineering Task Force (IETF).

At the same time, market adoption of some of these standards is mixed, and different regions (US, China, Japan) are still evaluating their approaches to cloud standards, so it is difficult to predict whether consensus will emerge in the near term. The standards listed below that have emerged from analysis of use cases collected to date are being coordinated through an alliance between the OGF, DMTF and SNIA as well as through a cross-SDO cloud standards collaboration group[29].

4.5.2 Interoperability between Cloud providers

For operations such as transferring a virtual machine image and data between providers, standardised formats for the data being transferred, billing and identity management are needed. Some standards, (such as the Open Virtualization Format[30], a recognised ANSI standard categorized under IaaS, Interoperability, and the Cloud Data Management Interface (CDMI[31]), developed by SNIA[32], which defines the functional interface that applications use to create, retrieve, update and delete data elements from the cloud) have been developed, but further experience is needed to reduce the costs of interoperation among providers.

Moreover, the Open Cloud Computing Interface (OCCI[33]) developed by the OGF describes Application Programming Interfaces (APIs) that enable cloud providers to expose their services. It focuses on IaaS-based clouds and allows the deployment, monitoring and management of virtual workloads (like virtual machines), but is applicable to any interaction with a virtual cloud resource through defined http(s) header fields and extensions. While there are several open-source implementations, OCCI has not yet been widely adopted in commercial platforms. OCCI is also an input to the DMTF standard for cloud management.

OpenNebula[34] is an open-source platform for building IaaS clouds, offering features for cloud management and providing the integration capabilities that enterprise IT shops may need for internal cloud adoption. OpenNebula is used by organisations to build production-ready IaaS clouds. Additionally it is being used as a reference open stack for cloud computing in several large EU-funded research and infrastructure projects[35] . Since its first public release of software in March 2008, it has evolved through open-source releases and now operates as an open source project.

OpenStack[36] provides a collection of open source compute and storage technologies delivering a scalable cloud operating system. Many commercial and public entities are contributing to OpenStack.

Other standards may emerge that enable interoperability between clouds and grids. For example, the OGF GLUE[37] standard provides one information model for describing grid and cloud entities while the CIM model from DMTF[38] provides an alternative model used frequently in industry.

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http://www.etsi.org/WebSite/document/whitepapers/IOP%20whitepaper%20Edition%203%20final.pdf

[27] COM(2010) 744 final, Annex 1 http://ec.europa.eu/isa/strategy/doc/annex_i_eis_en.pdf

[28] COM(2010) 744 final, Annex 2 http://ec.europa.eu/isa/strategy/doc/annex_ii_eif_en.pdf

[29] See the summary at http://www.ogf.org/standards/; the Cloud Standards Wiki is available at http://cloud-standards.org

[30] http://dmtf.org/standards/ovf

[31] http://www.snia.org/tech_activities/standards/curr_standards/cdmi/

[32] SNIA has joined the DAPS38 Technical Committee (which is responsible for Cloud Computing, among other technology standards) of INCITS – the primary U.S. focus of standardisation in the field of IT. The SNIA has also requested a Category A Liaison relationship with the ISO/IEC JTC 1 SC38 subcommittee for Distributed Application Platforms and Services (DAPS).

[33] http://occi-wg.org/ http://www.occi-wg.org/

[34] http://OpenNebula.org

[35] http://www.opennebula.org/community:users

[36] http://www.openstack.org/

In 2011, the WS-Agreement Negotiation v1.0[39] was submitted as a specification that is one approach for using service level agreements in distributed service-oriented environments. It allows service consumers to dynamically create service level agreements with service providers in order to acquire services with a well-defined quality of service.

4.5.3 International co-ordination

It is essential for the European research community to be able to complete their scientific objectives that the cloud computing infrastructure proposed in this document can interoperate with similar structures around the world. Work on the SIENA roadmap, an EC funded support project which looks to deliver a European Roadmap on Grids & Clouds Standards for eScience and beyond (2010-2012), complements that of the far larger US National Institute of Standards and Technology (NIST) Cloud Computing Programme[40] and Roadmap[41]. A US Federal Cloud Computing Strategy document has been released outlining the federal government's approaches to cloud computing[42]. The SIENA project is concerned with e-infrastructure for research including grids and clouds. The NIST programme is concerned with government use of cloud computing. The NIST SAJACC (Standards Acceleration to Jumpstart Adoption of Cloud Computing) initiative[43] is developing cloud system use cases to drive the formation of cloud computing standards.

Similar work is going on in Japan[44], China[45] and other countries. The NIST programme in the US, GICTF (Global Inter-Cloud Technology Forum) in Japan, and CESI (China Electronics Standardisation Institute) in China are all potential partners in evaluating possible cloud standards relevant to European e-infrastructure.

4.5.4 Moving forward in Europe

To maximize investments made in Europe in the past ten years within the distributed computing infrastructure community, one activity moving forward could be to initiate a solicitation (or collection of already existing) requirements from the following potential users with the following taxonomy:

I. eScience community;

II. eGovernment (small, regional, national level);

III. user (consultants/service providers, developers, end user SMEs, end-user large companies).

This is the basis both for Europe’s participation in the standard-setting environment and in defining which elements/assets can be put together to provide a solution for roll-out to market. SDOs may examine the results to determine where their standards could be effective to address issues of interoperability.

For the eScience community, requirement collection activities have already separately begun inside the so-called DCI (Distributed Computing Infrastructure) projects (EGI-InSPIRE[46], VENUS-C[47], StratusLab[48], EMI[49], IGE[50], EDGI[51]) in order to drive the specific technological choices that satisfy these requirements. The

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[37] GLUE Specification v. 2.0, by S. Andreozzi (INFN); S. Burke (RAL); F. Ehm (CERN); L. Field (CERN); G. Galang (ARCS); B. Konya (Lund University); M. Litmaath (CERN); P. Millar (DESY); JP Navarro (ANL). March 2009 http://www.ogf.org/documents/GFD.147.pdf
[38] http://www.dmtf.org/standards/cim
[39] http://forge.gridforum.org/sf/go/doc16194;jsessionid=64AE2BC480FD0F6B5E8817E4811D705D?nav=1
[40] http://www.nist.gov/itl/cloud/index.cfm, http://collaborate.nist.gov/twiki-cloud-computing/
[41] http://collaborate.nist.gov/twiki-cloud-computing/pub/CloudComputing/StandardsRoadmap/NIST_CCSRWG_092_NIST_SP_500-291_Jul5.pdf
[42] Federal Cloud Computing Strategy - Vivek Kundra U.S. Chief Information Officer, February 8th 2011, http://www.nist.gov/itl/cloud/
[43] http://www.nist.gov/itl/cloud/sajacc.cfm
[44] See www.gictf.jp/index_e.html and the presentation “Smart Cloud Strategy in Japan” by Yasu Taniwaki, Division Director, ICT Strategy Division, Japanese Ministry of Internal Affairs and Communications, November 2010: http://items-int.eu/IMG/pdf/1011_Smart_Cloud_Strategy_Global_Forum_.pdf
[45] http://www.en.cesi.cn
[46] http://www.egi.eu
[47] http://www.venus-c.eu
[48] http://www.stratuslab.eu
[49] http://www.eu-emi.eu
[50] http://www.ige-project.eu
[51] http://www.edgi-project.eu

SIENA consortium has analysed such requirements in the last year and discovered similarities and possible ways of coordinating these activities in order to avoid duplication of efforts. The final goal of the consortium is to provide support to the definition of a profile for clouds, an activity which was already initiated in OGF. Further EC projects of relevance include BonFIRE[52], OPTIMIS[53] mOSAIC-Cloud[54] and contrail[55].

The breadth of expertise in European research projects, the range of open solutions and the requirements from the National Grid Initiatives is unrivalled in industry. It is this knowledge asset that can be harnessed to meet the needs of eGovernment and through collaboration with industry which may become self-sustainable.

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[52] http://www.bonfire-project.eu/
[53] http://www.optimis-project.eu/project
[54] http://www.mosaic-cloud.eu/
[55] http://contrail-project.eu/start

ANNEX: SUMMARY OF DEMAND AND SUPPLY SIDE ANALYSIS

The European Space Agency (ESA) together with other European research organisations and national space agencies, such as CERN, CNES, and DLR, are collaborating on an initiative called "Cloud Computing in Europe 2020". These demand side organisations have been questioned about the current and future challenges they face with respect to Information Technology in general and Cloud Computing in particular.

The resulting requirements were presented to a selection of European service providers (supply side) together with a questionnaire attempting to get a view on the position of the supply side in the context of the demand side requirements.

All in all, four demands side organisations and eleven service providers have answered the questionnaire and they are all interested in contributing to the initiative at least in the form of participating in the workshop planned in June 2011. Together with additional EIROforum members that complement the demand side stakeholders, the selection of supply side stakeholders allows a broad coverage of the spectrum to initiate this initiative. At an early stage however, EC representatives have to be invited to extend the list of stakeholders in this area. The following summarised analysis of the findings from the collected answers to the questionnaires allows focusing the initiative on the most prominent issues shared between the demand and supply side.

Highest priority technological gaps to fill:

- interoperability between commercial cloud providers (add flexibility and avoid lock-in);
- guaranteed SLA from EU provider for specific applications (compliance with EU policy);
- data transfer and storage limitations (large volume, high speed, archiving…).

Accordingly, the demand side expects the following new data-related services to appear or improve:

- data archive services;
- data preservation services;
- data protection services.

The top challenges to address when filling the above gaps and creating the new services:

- security;
- performance;
- manageability;
- availability;
- governance.

The Cloud delivery models will slowly shift from IaaS to PaaS, where Cloud management has to be automated in the mid to long term. Thanks to the expected interoperability, brokering will become an issue allowing the users to choose and exchange services in the short-term.

The supply side players have to leverage their products and services to not only become interoperable, but also become more flexible and faster in adopting and developing improvements. This can provide a competitive advantage to attract and retain customers despite the fact that they can switch services more easily.

For this to become possible, the supply side expects the following new products and services:

- cloud service orchestration services allowing federation of resources;
- cost-effective scaling of very high-bandwidth networks (horizontal, vertical) with flexible on-demand bandwidth;
- operating system with true hot swap CPU / RAM and open-source distributed block-storage systems;
- CDN for large volumes;
- SaaS APIs (increased ability to integrate);
- preconfigured software architectures for public cloud;
- standardised software licensing and federated identity management;
- fully transparent accounting and reporting.